SAKARYA
UYGULAMALI BİLİMLER
ÜNİVERSİTESİ

GOVERNING THE TWIN TRANSITION: DIGITALIZATION, CIRCULAR ECONOMY AND RESILIENT INDUSTRIAL ECOSYSTEMS

International Conference of REUSE Jean Monnet Module
2-3 June 2026

PROCEEDINGS BOOK



REUSE

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Publisher
Kürşat ÇAPRAZ
e-ISBN:978-625-92035-9-1

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Publisher
Kürşat ÇAPRAZ, InTraders Academic Platform, Türkiye

e-ISBN: 978-625-92035-9-1

Book Title
Governing The Twin Transition: Digitalization, Circular Economy And Resilient Industrial Ecosystems International Conference of REUSE Jean Monnet Module Proceedings Book

Edition: First Edition, 22 September 2026, Kırklareli, Türkiye
Language: English, Türkçe

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This publication was prepared as part of the Jean Monnet Module REUSE (Project ID: 101126874). This project is;

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Bu yayın, REUSE (Project ID:101126874) adlı Jean Monnet Modülü kapsamında hazırlanmıştır. Bu proje;

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GOVERNING THE TWIN TRANSITION: DIGITALIZATION, CIRCULAR ECONOMY AND RESILIENT INDUSTRIAL ECOSYSTEMS

DATE and PLACE

2-3 June 2026

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TARİH ve YER

2-3 Haziran 2026

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Papers that have been submitted to our conference in accordance with the submission guidelines and approved by the Scientific Committee will have the opportunity to be presented online.

To deliver your presentation, please join the session through the provided Google Meet link.

Each presentation is allocated 10 minutes. Presenters are kindly requested to join the session before their scheduled presentation time.

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TECHNICAL INFORMATION

Participants must have a computer with a functioning microphone.

Participation certificates will be sent to participants in PDF format after the conclusion of the conference.

ÖNEMLİ

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Evrak Tarih ve Sayısı: 01.06.2026-E.225680

T.C.
SAKARYA UYGULAMALI BİLİMLER ÜNİVERSİTESİ REKTÖRLÜĞÜ
Uygulamalı Bilimler Fakültesi Dekanlığı

Sayı : E-95649561-903.07-225680 01.06.2026
Konu : Kongre Düzenleme Kurulunda Görev Alma
(Prof. Dr. Asena BOZTAŞ)

İLGİLİ MAKAMA

Fakültemiz Uluslararası Ticaret ve Finansman Bölümü öğretim üyesi Prof. Dr. Asena BOZTAŞ, 02-03 Haziran 2026 tarihlerinde Sakarya Uygulamalı Bilimler Üniversitesi ev sahipliğinde Sakarya, Türkiye'de gerçekleştirilecek "Digitalization and the Circular Economy: Building Resilience and Sustainabilitiy Through Policy in the EU-REUSE" projesi kapsamında düzenlenen "Governing The Twin Transition: Digitalization, Circular Economy and Resilient Industrial Ecosystems" Konferansında Üniversitemiz adına Akademisyen Temsilcisi olarak görev almıştır.

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Prof. Dr. Sinan ESEN
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Unvanı: Birim Evrak Sorumlusu

INTERNATIONAL CONFERENCE OF REUSE JEAN MONNET MODULE

GOVERNING THE TWIN TRANSITION: DIGITALIZATION, CIRCULAR ECONOMY AND RESILIENT INDUSTRIAL ECOSYSTEMS

2-3 June/2026 (Online)

SAKARYA/TÜRKİYE

CONFERENCE PROGRAM

Opening Ceromony

9:50-10:00 **2 June 2026** (Online)

Prof. Dr. Asena BOZTAŞ, Sakarya University of Applied Sciences, Türkiye

Assoc. Prof. Dr. N. Ceren TÜRKMEN, Project Coordinator, Sakarya University of Applied Sciences, Türkiye

Keynote Speakers

Prof. Dr. Mehmet SARIBIYIK, Rector, Sakarya University of Applied Sciences, Türkiye
10:00-10:15 **2 June 2026** (Online)

Prof. Dr. Shahrokh Waleck Dalpour, University of Maine-Farmington, USA
10:15-10:30 **2 June 2026** (Online)

Prof. Dr. Rashmi Gujrati, Director- Ludhiana Group of College, India,
10:30-10:45 **2 June 2026** (Online)

Prof. Dr. Tulus Suryanto, Universitas Islam Negeri Raden Intan Lampung, Indonesia
10:45-11:00 **2 June 2026** (Online)

Prof. Dr. Henrietta Nagy, Milton Friedman Egyetem-Hungary
11:00-11:15 **2 June 2026** (Online)

Prof. Dr. Adriana Burlea Șchiopoiu, University of Craiova, Romania
11:15-11:30 **2 June 2026** (Online)

University Lecturer PhD Mihaela POP, "Titu Maiorescu" University of Bucharest, Romania
10:00-10:15 **3 June 2026** (Online)

Prof. Dr. Sinan ESEN, Dean, Sakarya University of Applied Sciences, Türkiye
10:15-10:30 **3 June 2026** (Online)

Online Program (GMT+3)

2 June 2026

Time	Abstract No	Session Chair
11:30 – 12:30	9-10-11-12-13-14-113	Asst. Prof. Dr. Ömer YAZICI
12:30 – 14:00	30-31-32-33-34-35-36-37-38	Assoc. Prof. Dr. Ceren TÜRKMEN
15:00 – 16:30	43-105-106-107-108-109-110-111-112	Assoc. Prof. Dr. Ceren TÜRKMEN

REUSE- 02.06.26 Session1-2 : https://meet.google.com/tbc-hauy-zuf
The Link will be active for whole Day

Parallel Sessions

Time	Abstract No	Session Chair
11:30 – 12:30	15-16-17-18-19-20	Asst. Prof. Dr. Muhammed SALAH UDDIN
12:30 – 14:00	21-22-23-24-25-26-27-28-29	Prof. Dr. Asena BOZTAŞ
15:00 – 16:00	39-40-41-42-44-115	Prof.Dr. Sedat DURMUŞKAYA
16:00 – 17:00	45-46-47-48-114-116-118	Asst. Prof. Dr. Dilek SÜRMELİ

REUSE- 02.06.26 Session3: https://meet.google.com/huz-gsvy-eqf
The Link will be active for whole Day

3 June 2026

Time	Abstract No	Session Chair
11:00-12:00	50-51-52-53-54-55	Asst. Prof. Dr. Ömer YAZICI
12:00-13:00	68-69-70-71-72-73	Asst. Prof. Dr. Hayri TANRIVERDİ
13:00-14:00	80-81-82-83-84-85	Assoc. Prof. Dr. Selma KILIÇ KIRILMAZ
14:00-15:00	86-88-89-90-91-92	Assoc. Prof. Dr. Dilşad TÜRKMENOĞLU KÖSE

REUSE 03.06.2026 Session 1-3 : https://meet.google.com/qyb-bxnq-kxz
The Link will be active for whole Day

Parallel Sessions

Time	Abstract No	Session Chair
11:00-12:00	56-57-58-59-60-61	Assoc. Prof. Dr. Selma KILIÇ KIRILMAZ
12:00-13:00	62-63-64-65-66-67	Prof. Dr. Füsun ÇELEBİ BOZ
13:00-14:00	74-75-76-77-78-79	Asst. Prof. Dr. Mustafa YILMAZ
14:00-15:00	93-94-95-96-97-98	Assoc. Prof. Dr. Mustafa Abdül Metin DİNÇER
15:00-16:30	49-87-99-100-101-102-103-104-117	Asst. Prof. Dr. Huriye YILDIRIM ÇINAR

REUSE 03.06.2026 Session 2-4: https://meet.google.com/nxh-egru-mkg
The Link will be active for whole Day

02.06.2026

TÜRKİYE Local Time: 11:30 – 12:30

Session Chair: Asst. Prof. Dr. Ömer YAZICI

Title	Author	University	Country
POLITICAL ECONOMY AND GLOBAL PRODUCTION IN THE TWIN TRANSITION	Bhasake Ambadas Laxman	PAH Solapur University	INDIA
NEUROSOVEREIGNTY: CIVILISATIONAL POWER AND THE ALGORITHMIC REWRITING OF GLOBAL TRADE	MEHRAJ HUSSAIN PARA	Dr. Babasaheb Ambedkar Marathwada University	INDIA
COLONIAL CIRCUITS: DIGITAL POWER AND GLOBAL TECHNOLOGICAL INEQUALITY	MEHRAJ HUSSAIN PARA	Dr. Babasaheb Ambedkar Marathwada University	INDIA
SUSTAINABILITY IN THE 20TH-CENTURY ROMANIAN RURAL CULTURE	Marinică Tiberiu Şchiopu	University of Delhi	INDIA
AI-DRIVEN PREDICTIVE MAINTENANCE IN SMART MANUFACTURING USING IoT SENSOR DATA	Brajesh Kumar, P. Prasant	SRM Institute of Science & Technology	INDIA
ENGINEERING DATA ANALYTICS AND MANAGEMENT: INNOVATIONS AND APPLICATIONS	Brajesh Kumar, P. Prasant	SRM Institute of Science & Technology	INDIA
GOVERNANCE, INDUSTRIAL TRANSFORMATION AND SOCIETAL IMPACTS OF THE TWIN TRANSITION IN INDIA	Bhasake Ambadas Laxman	PAH Solapur university	INDIA

02.06.2026

TÜRKİYE Local Time: 12:30 – 14:00

Session Chair: Assoc. Prof. Dr. Ceren TÜRKMEN

Title	Author	University	Country
MAPPING ISLAMIC CORPORATE GOVERNANCE RESEARCH ON THE FINANCIAL PERFORMANCE OF ISLAMIC BANKS IN INDONESIA: A SYSTEMATIC LITERATURE REVIEW	Kastriyana, Olivia Fadila, Ransi Sintia Welda	Faculty of Business & Islamic Economics, UIN Raden Intan Lampung	INDONESIA
AFRICA IN THE AGE OF THE TWIN TRANSITION: DIGITAL TRANSFORMATION, GREEN INDUSTRIALISATION AND GLOBAL VALUE CHAINS	Asena BOZTAŞ, Dilşad TÜRKMENOĞLU KÖSE	Sakarya University of Applied Sciences	TÜRKİYE
DOES CORPORATE GOVERNANCE DRIVE CIRCULAR ECONOMY AND WASTE MANAGEMENT DISCLOSURE? EVIDENCE FROM BANGLADESH'S READY-MADE GARMENT (RMG) SECTOR	Afsana Sultana Shimu, Elmas Yaldız Hanedar, Biddut Talukdur	Sakarya University of Applied Sciences	TÜRKİYE
THE GEOPOLITICS OF THE TWIN TRANSITION: EU GREEN INDUSTRIAL STRATEGY, DIGITAL SOVEREIGNTY AND GLOBAL POWER COMPETITION	Asena BOZTAŞ, Dilşad TÜRKMENOĞLU KÖSE	Sakarya University of Applied Sciences, Sakarya University	TÜRKİYE
DIGITAL TRANSFORMATION AND MANAGEMENT APPROACHES IN THE CIRCULAR ECONOMY TRANSITION: A FOCUS ON SUSTAINABLE SUPPLY CHAIN MANAGEMENT	Amınuddın ARMEEN, Asena BOZTAŞ	Sakarya University of Applied Sciences	TÜRKİYE

02.06.2026

TÜRKİYE Local Time: 12:30 – 14:00

Session Chair: Assoc. Prof. Dr. Ceren TÜRKMEN

Title	Author	University	Country
FROM WASTE MANAGEMENT TO CIRCULAR ECONOMY: COMPARATIVE INSIGHTS FROM TÜRKİYE'S DOA FRAMEWORK AND DENMARK'S DANSK RETURSYSTEM	N. Ceren TÜRKMEN	Sakarya University of Applied Sciences	TÜRKİYE
GEOPOLITICAL SHOCKS AND DIGITAL SOVEREIGNTY: ASSESSING THE IMPACT OF THE U.S.–IRAN CONFLICT ON PAKISTAN'S DIGITAL TRANSFORMATION, DATA GOVERNANCE, AND PLATFORM ECONOMY	Shakeel Shahzad	Bahria University	PAKISTAN
THE IMPACT OF ENVIRONMENTAL, SOCIAL AND GOVERNANCE CRITERIA ON FIRM PERFORMANCE	Aruzhan BAKYTBEKKYZY, Harun KIRILMAZ, Almas KURALBAYEV	Khoja Akhmet Yassawi International Kazakh-Turkish University, Sakarya University, Khoja Akhmet Yassawi International Kazakh-Turkish University	KAZAKHSTAN
DIGITAL TRANSFORMATION AND COMPETITIVE ADVANTAGE: A RESOURCE-BASED VIEW	Ayazhan ABİLKASSYM, Harun KIRILMAZ, Almas KURALBAYEV	Khoja Akhmet Yassawi International Kazakh-Turkish University, Sakarya University, Khoja Akhmet Yassawi International Kazakh-Turkish University	KAZAKHSTAN

02.06.2026

TÜRKİYE Local Time: 15:00 – 16:30

Session Chair: Assoc. Prof. Dr. Ceren TÜRKMEN

Title	Author	University	Country
SMART CITY DIGITALIZATION AND ENVIRONMENTAL SUSTAINABILITY: COMPARATIVE EVIDENCE FROM TÜRKİYE AND GERMANY	Hafizullah AKBARI	Sakarya University of Applied Sciences	TÜRKİYE
BEYOND TECHNOLOGY ADOPTION: GOVERNING THE TWIN TRANSITION FOR CIRCULAR AND RESILIENT INDUSTRIAL ECOSYSTEMS	Agus Kurniawan, Moh. Bahrudin, Syamsul Hilal	Postgraduate Program of UIN Raden Intan Lampung	INDONESIA
IS SUSTAINABLE BUSINESS FINANCING BY STATE-OWNED SYARIAH BANKS CAPABLE OF REALIZED SUSTAINABLE DEVELOPMENT GOALS (SDGs)? A CRITICAL LITERATURE REVIEW	Ahsanal Huda, Erina Pane, Muhammad Iqbal	Postgraduate Program of UIN Raden Intan Lampung	INDONESIA
THE ROLE OF EXTRACURRICULAR TAHSIN MANAGEMENT IN ENHANCING STUDENTS' QUR'ANIC READING PROFICIENCY: EVIDENCE FROM STATE ISLAMIC ELEMENTARY SCHOOLS IN INDONESIA	Siti Musfiroh. Junaidah	Postgraduate Program of UIN Raden Intan Lampung	INDONESIA
NEGOTIATING QIWĀMAH IN CONTEMPORARY MUSLIM FAMILIES	Asep Holis Nur Jamil	Postgraduate Program of UIN Raden Intan Lampung	INDONESIA
STRATEGIES FOR MANAGING EMOTIONAL DYNAMICS IN INTERFAITH MARRIAGES IN INDONESIA: A PSYCHOLOGICAL REVIEW	Muhammad Asadurrohman, Wiwiq Alawiyah	Postgraduate Program of UIN Raden Intan Lampung	INDONESIA

02.06.2026

TÜRKİYE Local Time: 15:00 – 16:30

Session Chair: Assoc. Prof. Dr. Ceren TÜRKMEN

Title	Author	University	Country
THE RECOGNITION OF 'CAREGIVING' AS A BASIS FOR INHERITANCE CLAIMS: A COMPARATIVE REVIEW OF ISLAMIC LAW IMPLEMENTATION IN INDONESIA AND MALAYSIA	Habib Ismail, Linda Firdawaty, Habib Shulton A, Muhammad Azhad Al-Bohari	Ma'arif University Lampung, Postgraduate Program of UIN Raden Intan Lampung, Islamic Science University of Malaysia	INDONESIA
MODEL OF CONVERSION DEVELOPMENT BY RELIGIOUS EXTENSION WORKERS IN REALIZING MASLAHAT FAMILIES IN LAMPUNG PROVINCE	Eti Karini, Pasca Aulia Fadhilatul Hukkam	Postgraduate Program of UIN Raden Intan Lampung	INDONESIA
IMPACT ON DIGITALIZATION ON MODERN MARKETING	Ms.Jaismeen Kaur, Ms.Navjot Kaur	Ludhiana Group of Colleges	INDIA

02.06.2026

TÜRKİYE Local Time: 11:30 – 12:30

Parallel Session Chair: Asst. Prof.Dr. Muhammed SALAH UDDIN

Title	Author	University	Country
BUILDING RESILIENT AND SUSTAINABLE TRANSPORT SYSTEMS IN MODERN SUPPLY CHAINS	Ms. Ramandeep Kaur, Mr. Anshul Sharma	Ludhiana Group of Colleges	INDIA
DIGITAL TRANSFORMATION AND GREEN INNOVATION: IMPLICATIONS FOR CONSUMER BEHAVIOUR	Gurkirat Singh Dhillon, Gurpreet Singh Supra	Ludhiana Group of Colleges	INDIA
INFLUENCE OF INDUSTRY 4.0 TECHNOLOGIES ON SUSTAINABLE CONSUMER EXPERIENCES	Rajdeep Kaur, Shagun Thakur	Ludhiana Group of Colleges	INDIA
DIGITAL TECHNOLOGIES SUPPORTING CIRCULAR ECONOMY	Simran Sudhar, Ishika Gupta	Ludhiana Group of Colleges	INDIA
DATA TRANSFORMATION, DATA GOVERNANCE & PLATFORM ECONOMICS	Barjinder Kaur, Manpreet Kaur	Ludhiana Group of Colleges	INDIA
RESEARCH PAPER ON AI AND IOT ENABLED SMART WASTE MANAGEMENT FOR CIRCULAR ECONOMY	Harmandeep Kaur, Ms.Harrpreet kaur	Ludhiana Group of Colleges	INDIA

02.06.2026

TÜRKİYE Local Time: 12:30 – 14:00

Parallel Session Chair: Prof. Dr. Asena BOZTAŞ

Title	Author	University	Country
ARTIFICIAL INTELLIGENCE IN MEDICAL DEVICE REGULATORY PROCESSES: OPPORTUNITIES AND RISKS UNDER THE EUROPEAN MDR FRAMEWORK	Maciej Kacprzyk	Military University of Technology in Warsaw	POLAND
INTERSECTIONS OF CLIMATE CHANGE, ENVIRONMENTAL DEGRADATION, AND MATERNAL HEALTH: A SYSTEMATIC REVIEW OF HEALTH SYSTEM RESILIENCE AND POLICY IMPLICATIONS	Aghesna Rahmatika Kesuma, Samsul Bakri, Ratna Dewi Puspita Sari, Yeni Susanti, Reza Ronaldo, Arsyad Sobby Kesuma	STEBI Lampung University, Lampung University, Raden Intan Lampung State Islamic University	INDONESIA
ANALYSIS OF ENVIRONMENTAL LAW ASPECTS REVIEWED FROM POSITIVE LAW AND SHARIA MAQASHID	Sinta Bela, Andri Arzali, Wandi, Tejo Waskito	STEBI Lampung University	INDONESIA
THE DEVELOPMENT OF THE DIGITAL ECONOMY: AN ANALYSIS OF CHALLENGES AND INNOVATION IN THE TECHNOLOGICAL ERA	Mutiara Eka Putri, Meilia Risna, Novita, Putri Yolanda, Kiara Basmala Putri, Yuli Saputri	STEBI Lampung University	INDONESIA
ANALYSIS OF DETERMINANT FACTORS OF MUDHARABAH DEPOSIT VOLUME: A SYSTEMATIC LITERATURE REVIEW	Elsya Aprila, Icha Listiyana, Jeni Marlina	Faculty of Business & Islamic Economics, UIN Raden Intan Lampung	INDONESIA
GREEN BANKING IN THE PERSPECTIVE OF ISLAMIC SUSTAINABLE FINANCE: LITERATURE REVIEW ON IMPLEMENTATION CHALLENGES AND RISKS	Dea Nanda Puspita, Gita Restania Putri, Laili Fitri	Faculty of Business & Islamic Economics, UIN Raden Intan Lampung	INDONESIA

02.06.2026

TÜRKİYE Local Time: 12:30 – 14:00

Parallel Session Chair: Prof. Dr. Asena BOZTAŞ

Title	Author	University	Country
REGULATORY FRAMEWORKS FOR AI-DRIVEN DIGITAL HEALTH MANAGEMENT SYSTEMS IN TURKIYE: OPPORTUNITIES AND CHALLENGES	Fatimah Akanbi, Souad Ezzeroulı	Sakarya University, Dhofar Unıversıty	OMAN
TECH INTELLIGENCE IN WOMEN-LED STARTUPS: PAKISTAN'S RURAL VS. URBAN COMPARISON USING NEURAL NETWORKS & FUZZY LOGIC	Ambreen KHURSHEED, Syed Shoaib NAZİR, Romel JOHN	Forman Christian College (A Chartered University), School of Management	PAKISTAN
UNPACKING CARBON DISCLOSURE DYNAMICS: THE ROLE OF CORPORATE TRANSPARENCY, DOUBLE MATERIALITY, AND FINANCIAL PERFORMANCE LINKAGE	Prima Ayu Novita, Dedy Iswanto, Anak Agung Gde Satia Utama, Dian Novita	Universitas Airlangga, Universitas Muhammadiyah Mataram, Universitas Airlangga, Universitas Teknorat Indonesia	INDONESIA

02.06.2026

TÜRKİYE Local Time: 15:00 – 16:00

Parallel Session Chair: Prof. Dr. Sedat DURMUŞKAYA

Title	Author	University	Country
VERGİ İDARESİNDE YAPAY ZEKÂ KULLANIMI: DİJİTAL MALİYE YÖNETİMİNİN GELECEĞİ	Yunus Köse	Sakarya University	TÜRKİYE
DİJİTAL MUHASEBE VERİLERİNDEN YEŞİL PAZAR GÜVENİNE: İKİZ DÖNÜŞÜMDE KOBİ DÖNGÜSEL PERFORMANS AÇIKLAMASI VE TÜKETİCİ TEPKİSİ	Aydın BAĞDAT, Aykut YILMAZ	Sakarya University of Applied Sciences	TÜRKİYE
DİJİTAL GÜVEN, YEŞİL İDDİALAR VE DÖNGÜSEL EKONOMİDE TÜKETİCİ TEPKİSİ: BLOKZİNCİR DESTEKLİ ŞEFFAFLIĞIN ROLÜ	Aykut YILMAZ, Aydın BAĞDAT	Sakarya University of Applied Sciences	TÜRKİYE
DİJİTAL EKONOMİNİN VERGİLENDİRİLMESİNDE YENİ PARADİGMA: BEPS EYLEM 1 KAPSAMINDA KÜRESEL VERGİ DÖNÜŞÜMÜNÜN DEĞERLENDİRİLMESİ	Yunus Köse	Sakarya University	TÜRKİYE
ENDÜSTRİYEL SÜRÜCÜ SİSTEMLERİNDE İKİZ DÖNÜŞÜM: ENERJİ VERİMLİLİĞİ İZLEME VE KESTİRİMCİ BAKIM İLE DÖNGÜSEL EKONOMİNİN DESTEKLENMESİ	Mustafa Can İŞLER	Sakarya University of Applied Sciences	TÜRKİYE
ENDÜSTRİYEL EKOSİSTEMLER, ENDÜSTRİ 4.0 VE AKILLI ÜRETİM: DİJİTAL DÖNÜŞÜM, SERVİTİZASYON VE SÜRDÜRÜLEBİLİRLİK ÜZERİNE KAPSAMLI BİR ARAŞTIRMA RAPORU	Onur Anıl Bozkurt	Sakarya University of Applied Sciences	TÜRKİYE

02.06.2026

TÜRKİYE Local Time: 16:00 – 17:00

Parallel Session Chair: Asst. Prof. Dr. Dilek SÜRMELİ

Title	Author	University	Country
ULUSLARARASI TİCARETTE İKİZ DÖNÜŞÜM: TÜRKİYE VE STRATEJİK RAKİP ÜLKELERİN HAZIRLIK DÜZEYLERİNİN KARŞILAŞTIRMALI ANALİZİ	Dilek SÜRMELİ	Sakarya University of Applied Sciences	TÜRKİYE
YENİLENEBİLİR ENERJİ VE DÖNGÜSEL EKONOMİ İLİŞKİSİ: KÜRESEL LİTERATÜRÜN BİBLİYOMETRİK ANALİZİ VE SİSTEMATİK LİTERATÜR TARAMASI	Ali APIK, N. Ceren TÜRKMEN	Sakarya University of Applied Sciences	TÜRKİYE
YEŞİL PARA, YENİ GÜÇ: AB SÜRDÜRÜLEBİLİR FİNANS POLİTİKALARI KÜRESEL SİSTEMİ NASIL ŞEKİLLENDİRİYOR?	Şener FİLİZ, Asena BOZTAŞ	Sakarya University of Applied Sciences	TÜRKİYE
ATIK YÖNETİMİNDEN SİSTEM DÖNÜŞÜMÜNE: AB POLİTİKALARI GERÇEKTEN BAŞARILI MI?	Rana MİRHAJ	Sakarya University of Applied Sciences	TÜRKİYE
SÜRDÜRÜLEBİLİR İLETİŞİM PERSPEKTİFİNDEN ULUSLARARASI TİCARETTE YEŞİL YIKAMA RİSKLERİ: ANONİM VAKA TEMELLİ BİR DEĞERLENDİRME	Dilek SÜRMELİ, N. Ceren TÜRKMEN	Sakarya University of Applied Sciences	TÜRKİYE
SİVİL SAVUNMADA DİJİTALLEŞME VE DAYANIKLILIK: AFETLERE HAZIRLIKTA YENİ YAKLAŞIMLAR: KÜRESEL LİTERATÜRÜN BİBLİYOMETRİK ANALİZİ VE SİSTEMATİK LİTERATÜR TARAMASI	Ali APIK, N. Ceren TÜRKMEN	Sakarya University of Applied Sciences	TÜRKİYE
TÜRKİYE'DE SIFIR ATIK YÖNETİMİNİN DÖNGÜSEL EKONOMİ PERSPEKTİFİNDEN DEĞERLENDİRİLMESİ	Sinan TEMİR, N. Ceren TÜRKMEN	Sakarya University of Applied Sciences	TÜRKİYE

03.06.2026

TÜRKİYE Local Time: 11:00 – 12:00

Session Chair: Asst. Prof.Dr. Ömer YAZICI

Title	Author	University	Country
DIGITAL TRANSFORMATION OF ISLAMIC MICROFINANCE (BMT) AND ITS IMPACT ON FINANCIAL INCLUSION IN INDONESIA	Ariyanto, Moh. Fakhrurozi, Multi Rahmah, Nurul Ulfa Kurnia Annisa, M. Djidin	STEBI Lampung University	INDONESIA
ANALYSIS OF OBSTACLES AND STRATEGIES FOR IMPLEMENTING FINANCIAL TECHNOLOGY IN ISLAMIC BANKING SERVICES: A CASE STUDY OF BSI KC JAKARTA SAHARJO, SOUTH JAKARTA	Rifal Rinaldi, Pertiwi Utami, Anjali Sriwijbant	STEBI Lampung University	INDONESIA
SUSTAINABLE CONSUMPTION BEHAVIOR: A PLANNED BEHAVIOR THEORY PERSPECTIVE	Maya Meilia, Umi Khulsum, Angela Yohana Safitri, Diki Saputra	STEBI Lampung University	INDONESIA
ISLAMIC VIEWS ON CRYPTOCURRENCY	Adolfo Sanjaya, M. Adam Wijaya, M. Yacub Ariya	Faculty of Business & Islamic Economics, UIN Raden Intan Lampung	INDONESIA
GOOD CORPORATE GOVERNANCE FROM A SHARIA PERSPECTIVE IN FINANCIAL INSTITUTIONS: SYSTEMATIC LITERATURE REVIEW AND BIBLIOMETRIC ANALYSIS	Reny Ameliana, Ketty Nabila Nurul Husna	Faculty of Business & Islamic Economics, UIN Raden Intan Lampung	INDONESIA
ANALYSIS OF CRISIS COMMUNICATION STRATEGY AND RESTORING CUSTOMER TRUST FOLLOWING THE BYOND APPLICATION DISRUPTION BY BSI	Baina Leha, Habibah, Rani Putri Ramadhani	Faculty of Business & Islamic Economics, UIN Raden Intan Lampung	INDONESIA

03.06.2026

TÜRKİYE Local Time: 12:00 – 13:00

Session Chair: Asst. Prof. Dr. Hayri TANRIVERDİ

Title	Author	University	Country
THE ROLE OF SHARIA ECONOMIC INSTRUMENTS IN SUPPORTING A MAQASID SHARIA-BASED GREEN ECONOMY IN INDONESIA: A SYSTEMATIC LITERATURE REVIEW	M. Ramadhan Caesar, Raditya Aldiansyah, Sefda Aulia	Faculty of Business & Islamic Economics, UIN Raden Intan Lampung	INDONESIA
ANALYSIS OF THE POTENTIAL ELEMENTS OF GHARAR AND USURY IN ELECTRONIC MONEY MECHANISMS AND THEIR IMPLICATIONS FOR THE VALIDITY OF TRANSACTIONS FROM THE PERSPECTIVE OF ISLAMIC ECONOMICS IN INDONESIA	Patricia Ika Sari, Sari Hidayah, Yolanda Agustin	Faculty of Business & Islamic Economics, UIN Raden Intan Lampung	INDONESIA
THE INFLUENCE OF DIGITAL MARKETING, SHARIA E-COMMERCE, AND SHARIA FINANCIAL LITERACY ON NATIONAL INCOME FROM AN ISLAMIC ECONOMIC PERSPECTIVE 2015–2024	Dava Saputra, Deka Anasta Putri, Nabila Sapitri	Faculty of Business & Islamic Economics, UIN Raden Intan Lampung	INDONESIA
ANALYSIS OF ISLAMIC DIGITAL SERVICE QUALITY, CUSTOMER TRUST AND SHARIA COMPLIANCE PERCEPTIONS ON THE LOYALTY OF SHARIA MOBILE BANKING SERVICE USERS	Elisa Fitri Nazarani, Gina Sonia, Selina Muthmainah	Faculty of Business & Islamic Economics, UIN Raden Intan Lampung	INDONESIA
ARTIFICIAL INTELLIGENCE GOVERNANCE IN SHARIAH AUDIT: A SYSTEMATIC LITERATURE REVIEW ON RISKS, CONTROLS, AND ETHICAL BOUNDARIES	Andin Mezashika Fortuna, Seliya, Sintina Khoirun Fiqolbi	Faculty of Business & Islamic Economics, UIN Raden Intan Lampung	INDONESIA
BLOCKCHAIN AND SMART CONTRACTS FOR TRANSPARENCY AND ACCOUNTABILITY IN ZAKAT MANAGEMENT: A SYSTEMATIC LITERATURE REVIEW	Muawanah Husna, Nova Amanda Putri Dika	Faculty of Business & Islamic Economics, UIN Raden Intan Lampung	INDONESIA

03.06.2026

TÜRKİYE Local Time: 13:00 – 14:00

Session Chair: Assoc. Prof. Dr. Selma KILIÇ KIRILMAZ

Title	Author	University	Country
İKİZ DÖNÜŞÜM MÜ, İKİZ KRİZ Mİ? AVRUPA BİRLİĞİ'NDE DİJİTALLEŞME VE YEŞİL POLİTİKANIN ÇATIŞAN DİNAMİKLERİ	Elif BİCAN	Sakarya University of Applied Sciences	TÜRKİYE
TÜRKİYE'DE ÜRETİLEN GELENEKSEL PEYNİR ÇEŞİTLERİ: GASTRONOMİK VE KÜLTÜREL BİR DEĞERLENDİRME	Seda Nur TOPAL DOĞAN, Hamza BOZKIR	Sakarya University of Applied Sciences	TÜRKİYE
TÜRKİYE'DE ÜRETİLEN PEKMEZ ÇEŞİTLERİ	BAYZA NUR GİRGİN, Hamza BOZKIR	Sakarya University of Applied Sciences	TÜRKİYE
TÜRKİYE'DE ÜRETİLEN SİRKE ÇEŞİTLERİ VE ÜRETİM YÖNTEMLERİ	Kardem YILMAZ, Hamza BOZKIR	Sakarya University of Applied Sciences	TÜRKİYE
TARLADAN POLİTİKAYA: AVRUPA BİRLİĞİ ORTAK TARIM POLİTİKASININ DÖNÜŞÜMÜ – ÇEVRESEL SÜRDÜRÜLEBİLİRLİK, EKONOMİK KAYGILAR VE SİYASAL STRATEJİLER EKSENİNDE BİR LİTERATÜR İNCELEMESİ	Yücel TOPRAK, Hatice SARIALTIN	Sakarya University of Applied Sciences	TÜRKİYE
CORPORATE SUSTAINABILITY PRACTICES in THE COSMETICS INDUSTRY: A CASE STUDY ON FLORMAR	Selma KILIÇ KIRILMAZ, Ecesu Yılmaz, Yasemin Şen, Moumouni Hassane Mohamadou BASSIR, Muhammet Abdi KİBAR	Sakarya University of Applied Sciences	TÜRKİYE

03.06.2026

TÜRKİYE Local Time: 14:00 – 15:00

Session Chair: Assoc. Prof. Dr. Dilşad TÜRKMENOĞLU KÖSE

Title	Author	University	Country
GÜNEY KAFKASYA'DAKİ YENİ STATÜKO KARŞISINDA AVRUPA BİRLİĞİ'NİN KARABAĞ POLİTİKASI	Rashıd SADIGOV	Azerbaijan State University of Economics (UNEC)	AZERBAIJAN
YEŞİL ENERJİ Mİ YOKSA GİZLİ KORUMACILIK MI? AVRUPA BİRLİĞİ'NİN YEŞİL MUTABAKATI'NIN JEOEKONOMİK YÜZÜ	Bünyamin Yılmaz	Sakarya University of Applied Sciences	TÜRKİYE
DİJİTAL DÖNÜŞÜM: KÜRESEL EĞİLİMLER VE SİYASAL SONUÇLAR	Dilşad TÜRKMENOĞLU KÖSE	Sakarya University	TÜRKİYE
DİJİTALLEŞMENİN SİYASAL EKONOMİSİ: DEVLET, PİYASA VE DÖNÜŞEN İKTİDAR İLİŞKİLERİ	Dilşad TÜRKMENOĞLU KÖSE	Sakarya University	TÜRKİYE
ÇAĞDAŞ YÖNETİM YAKLAŞIMLARI EKSENİNDE KADIN LİDERLİĞİ: DÖNÜŞÜMCÜ LİDERLİK ROLÜ VE KAPSAYICI YÖNETİŞİM BAĞLAMINDA BİR DEĞERLENDİRME	Hacer AK	Sakarya University of Applied Sciences	TÜRKİYE
ADİL GEÇİŞ Mİ, SOSYAL MALİYET Mİ? AB YEŞİL DÖNÜŞÜMÜNÜN GÖRÜNMEYEN YÜZÜ	Selcan SAĞINÇ	Sakarya University of Applied Sciences	TÜRKİYE

03.06.2026

TÜRKİYE Local Time: 11:00 – 12:00

Parallel Session Chair: Assoc. Prof. Dr. Selma KILIÇ KIRILMAZ

Title	Author	University	Country
THE INFLUENCE OF SUSTAINABLE MARKETING STRATEGY ON CUSTOMER TRUST AND LOYALTY OF GENERATION Z CONSUMERS FROM THE PERSPECTIVE OF SHARIA BUSINESS MANAGEMENT	Adelia Pratiwi, Dalia Nurul Utami, Bintang Aris Sunandar	Faculty of Business & Islamic Economics, UIN Raden Intan Lampung	INDONESIA
THE ROLE OF CUSTOMER RELATIONSHIP MANAGEMENT (CRM) IN INCREASING CUSTOMER SATISFACTION AND LOYALTY FROM A SHARIA BUSINESS PERSPECTIVE IN LOCAL MSMES	Chandra Asta Wijaya, Chintya Putri Dhena Pela, Nadisa Melya Putri	Faculty of Business & Islamic Economics, UIN Raden Intan Lampung	INDONESIA
PROTEAN CAREER ORIENTATION, LIFELONG LEARNING, AND HUMAN RESOURCE DEVELOPMENT STRATEGIES FOR A FUTURE-READY WORKFORCE IN HIGHER EDUCATION	CD Ainer, Munieleswar.R, A Albattat, Ravindra Kumar Perumal, G Manickam	Asia Pacific University of Technology & Innovation	MALAYSIA
THE GREEN PREMIUM: INVESTIGATING GEN Z'S WILLINGNESS TO PAY FOR SUSTAINABILITY	Kousar Zaheer, Reema Frooghi, Sobia Jamil	Jinnah University for Women, Iqra University, Institute of Business Management	PAKISTAN
TÜRKİYE'DE İŞLETMELERİN DİJİTAL DÖNÜŞÜM KAPASİTESİ: TÜİK VERİLERİ ÜZERİNDEN BETİMSEL BİR DEĞERLENDİRME	Selma KILIÇ KIRILMAZ	Sakarya University of Applied Sciences	TÜRKİYE
İŞLETME BÜYÜKLÜĞÜNE GÖRE ÇEVRESEL SÜRDÜRÜLEBİLİRLİK FAALİYETLERİ: TÜİK VERİLERİ ÜZERİNDEN BETİMSEL BİR DEĞERLENDİRME	Selma KILIÇ KIRILMAZ	Sakarya University of Applied Sciences	TÜRKİYE

03.06.2026

TÜRKİYE Local Time: 12:00 – 13:00

Parallel Session Chair: Prof. Dr. Füsun ÇELEBİ BOZ

Title	Author	University	Country
ANALYZING THE RELATIONSHIP BETWEEN ENVIRONMENTAL SOCIAL GOVERNANCE (ESG) AND CORPORATE PERFORMANCE: A SYSTEMATIC LITERATURE REVIEW AND META-SYNTHESIS	Adinda Resya Fatimah, Siti Wulandari, Suherni Dwi Listiani	Faculty of Business & Islamic Economics, UIN Raden Intan Lampung	INDONESIA
INTEGRATION OF MAQASID SHARIAH IN ESG REPORTING: A SYSTEMATIC LITERATURE REVIEW ON SHARIA ENVIRONMENTAL ACCOUNTING	Nur Ashrina Rizka Yudha, Oktavianisa	Faculty of Business & Islamic Economics, UIN Raden Intan Lampung	INDONESIA
ANALYSIS OF THE ROLE OF ARTIFICIAL INTELLIGENCE IN DIGITALIZING ZAKAT MANAGEMENT TOWARDS TRANSPARENCY AND ACCOUNTABILITY: A SYSTEMATIC LITERATURE REVIEW	Sagita Rahmawati, Siti Aisah, Thamara Putri Andini	Faculty of Business & Islamic Economics, UIN Raden Intan Lampung	INDONESIA
UTILIZATION OF ARTIFICIAL INTELLIGENCE IN SHARIA BUSINESS PRACTICES IN THE FIELD OF E-COMMERCE: BIBLIOMETRIC ANALYSIS AND SYSTEMATIC LITERATURE REVIEW	Adya Mega Zelda, Rahmat Mustopa, Alfina Jantika	Faculty of Business & Islamic Economics, UIN Raden Intan Lampung	INDONESIA
ESG RESEARCH TRENDS IN ISLAMIC BUSINESS MANAGEMENT: BIBLIOMETRIC ANALYSIS AND SYSTEMATIC LITERATURE REVIEW USING VOSVIEWER	Dini Adelia, Resti Sukmawati, Egi Wahyu Pratama	Faculty of Business & Islamic Economics, UIN Raden Intan Lampung	INDONESIA
UTILIZING FINTECH TECHNOLOGY TO INCREASE THE COMPETITIVENESS OF ISLAMIC BANKING IN THE DIGITAL ERA	Adi Irawan, Abdilah Afwarizalul Rizki, Daffa Ilyasa Aras	Faculty of Business & Islamic Economics, UIN Raden Intan Lampung	INDONESIA

03.06.2026

TÜRKİYE Local Time: 13:00 – 14:00

Parallel Session Chair: Asst. Prof. Dr. Mustafa YILMAZ

Title	Author	University	Country
E-TİCARETTE YEŞİL LOJİSTİK VE BT YETKİNLİĞİ: ÇEVRESEL BELİRSİZLİKTEN STRATEJİK ÇEVİKLİĞE GEÇİŞTE KAVRAMSAL BİR MODEL	Ebubekir KIZIL, Mustafa YILMAZ	Sakarya University of Applied Sciences	TÜRKİYE
DÖNGÜSEL EKONOMİ POLİTİKALARI EKSENİNDE AB VE ÇİN ARASINDAKİ KÜRESEL GÜÇ REKABETİ	Serhat EVLİOĞLU	Sakarya University of Applied Sciences	TÜRKİYE
KARŞILAŞTIRMALI ÜSTÜNLÜK TEORİSİ AÇISINDAN LOMÉ LİMANI'NDA TRANSİT TİCARET	Barış Can ÖZKIR	Sakarya University of Applied Sciences	TÜRKİYE
STRATEJİK DENİZ GEÇİTLERİNDE KESİNTİ RİSKLERİNİN KÜRESEL TEDARİK ZİNCİRLERİNE ETKİSİ: HÜRMÜZ VE BABÜLMENDEP ÖRNEĞİ	Barış Can ÖZKIR	Sakarya University of Applied Sciences	TÜRKİYE
YEŞİL DÖNÜŞÜM VE KÜRESEL ÜRETİM: AB STANDARTLARININ ETKİLERİ ÜZERİNE BİR BİBLİYOMETRİK ANALİZ	Emre Koçak, Sinan Esen	Sakarya University of Applied Sciences	TÜRKİYE
DÖNGÜSEL EKONOMİNİN SÜRDÜRÜLEBİLİR KALKINMADAKİ ROLÜ	Ingkar SABIT	Sakarya University of Applied Sciences	TÜRKİYE

03.06.2026

TÜRKİYE Local Time: 14:00 – 15:00

Parallel Session Chair: Assoc. Prof. Dr. Mustafa Abdül Metin DİNÇER

Title	Author	University	Country
MACROECONOMIC IMPLICATIONS OF DIGITALIZATION & CIRCULAR ECONOMY	Argjira Sahiti	International Balkan University	NORTH MACEDONIA
NAVIGATING TWIN TRANSITION PRESSURES: AI AND SUSTAINABLE PRODUCTION IN THE POLISH FILM SECTOR	Tomasz Zontek	Warsaw University of Life Sciences	POLAND
GREEN WORDS, GREY DEEDS? SYMBOLIC VERSUS SUBSTANTIVE ESG DISCLOSURE AND GREENWASHING IN TÜPRAŞ SUSTAINABILITY AND INTEGRATED REPORTS: A MAXQDA CONTENT ANALYSIS	Afsana Sultana Shimu	Sakarya University of Applied Sciences	TÜRKİYE
DIGITAL ESG COMMUNICATIONS AS DUAL-TRANSITION INFRASTRUCTURE: A COMPARATIVE ANALYSIS OF RUSSIAN AND TURKISH RETAIL AND PLATFORM-BASED COMMERCE COMPANIES	Gadel Damirovich Mukhammadiyev, N. Ceren TÜRKMEN	Sakarya University of Applied Sciences	TÜRKİYE
THE EVOLUTION OF GREENWASHING RESEARCH (2012–2026): A COMPREHENSIVE BIBLIOMETRIC MAPPING AND FUTURE AGENDA	Muhammad Murtadha, Hilal ALPDOĞAN	Sakarya University of Applied Sciences	TÜRKİYE
STRATEGY OF DIGITAL TRANSFORMATION AND INTELLIGENT ASSET MANAGEMENT IN THE OIL AND GAS INDUSTRY	Taras MARTYN, Vitalii NITSENKO	Ivano-Frankivsk National Technical University of Oil and Gas	UKRAINE

03.06.2026

TÜRKİYE Local Time: 15:00 – 16:30

Parallel Session Chair: Asst. Prof. Dr. Huriye YILDIRIM ÇINAR

Title	Author	University	Country
SMART CIRCULARITY AT THE END OF THE LINE: INTEGRATING INDUSTRY 4.0 TECHNOLOGIES INTO ROBOTIC PALLETIZING AND PACKAGING SYSTEMS FOR RESOURCE-EFFICIENT INDUSTRIAL ECOSYSTEMS	Ömer Dağlı	Sakarya University of Applied Sciences	TÜRKİYE
MACROECONOMIC EFFECTS OF DIGITALIZATION ON ECOLOGICAL SUSTAINABILITY: EVIDENCE FROM TÜRKİYE	Hakan EYGÜ, Seda EYGÜ	Atatürk University	TÜRKİYE
DIGITAL TRANSFORMATION, GLOBAL VALUE CHAIN INTEGRATION AND LABOUR MARKET OUTCOMES IN AFRICA UNDER THE TWIN TRANSITION	Afolabi Ibikunle JOSEPH, David Sunday OYERINOLA	Ajayi Crowther University, University of Ilorin	NIGERIA
FINANCING THE FUTURE: GREEN INVESTMENT AND AFRICA'S TRANSITION TO A LOW-CARBON ECONOMY	Afolabi Ibikunle JOSEPH, Adetunji Olayemi SIJUWOLA	Ajayi Crowther University	NIGERIA
DIGITAL FINANCIAL INCLUSION AND MONETARY POLICY EFFECTIVENESS FOR NATION BUILDING IN DEVELOPING ECONOMIES	Abdul-Azeez Abubakar, Aminu Muhammad Fagge, Mohammad Sabo Bello	Federal University Dutse, Federal University Dutse, Sule Lamido University	NIGERIA
EXTENDED PRODUCER RESPONSIBILITY FOR ELECTRONIC WASTE MANAGEMENT: A COMPARATIVE ANALYSIS OF REGULATORY FRAMEWORKS AND IMPLEMENTATION IN NIGERIA, INDIA, AND THE UNITED KINGDOM	Maryam BAYERO-JIMOH, Janet Oluwakemi OWODUNNI	Al-Hikmah University	NIGERIA

03.06.2026

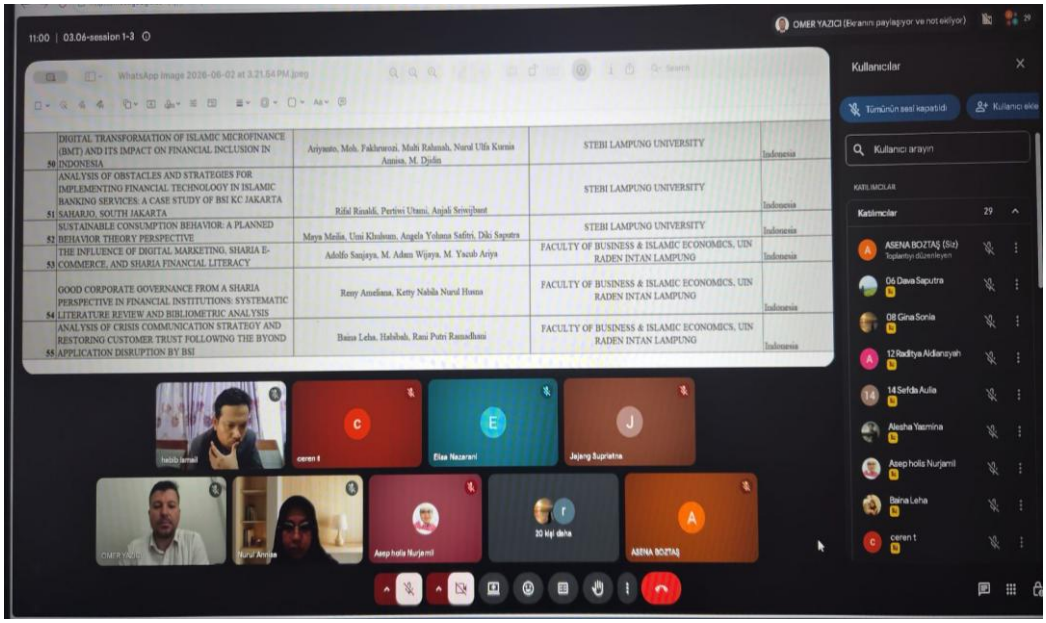
TÜRKİYE Local Time: 15:00 – 16:30

Parallel Session Chair: Asst. Prof. Dr. Huriye YILDIRIM ÇINAR

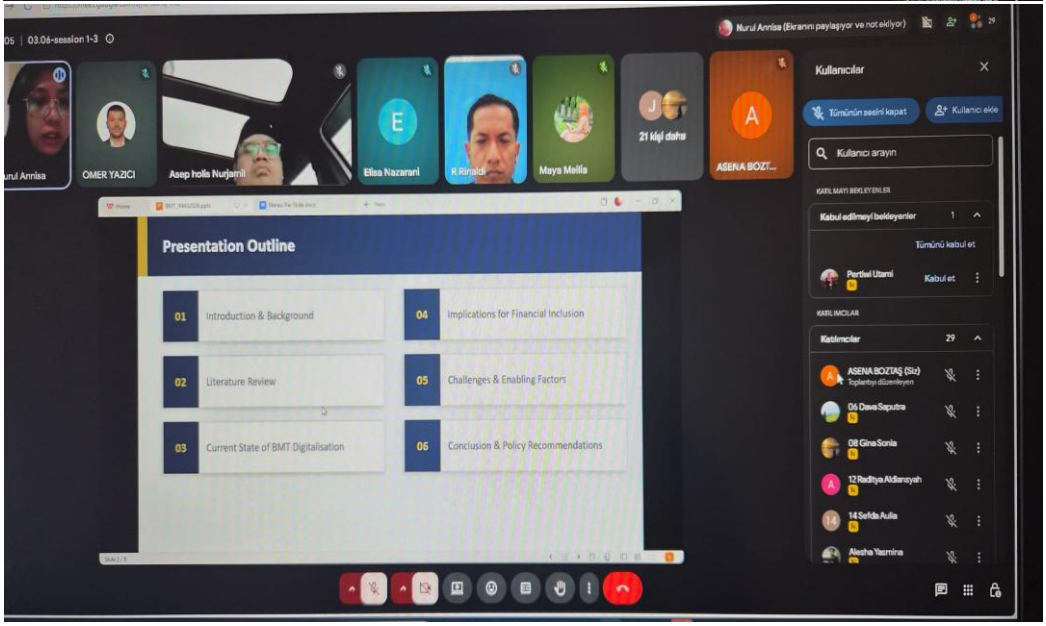
Title	Author	University	Country
FROM GREEN ENERGY TO GREY ZONES: CRITICAL MINERALS, SUSTAINABILITY DILEMMAS AND CONFLICT DYNAMICS IN AFRICA	Huriye YILDIRIM ÇİNAR	Van Yüzüncü Yıl University	TÜRKİYE
ARTIFICIAL INTELLIGENCE GOVERNANCE AND THE CIRCULAR DIGITAL ECONOMY IN AFRICA: LEGAL AND POLICY PERSPECTIVES UNDER THE AFRICAN UNION AI STRATEGY	Barbara Ntambırwekı, Tajudeen Sanni, Pelucy K. Ntambırwekı	Uganda Pentecostal University	UGANDA
FINANCING THE GREEN TRANSITION: EVIDENCE FROM EUROPE	Çisem BEKTUR	Sakarya University	TÜRKİYE

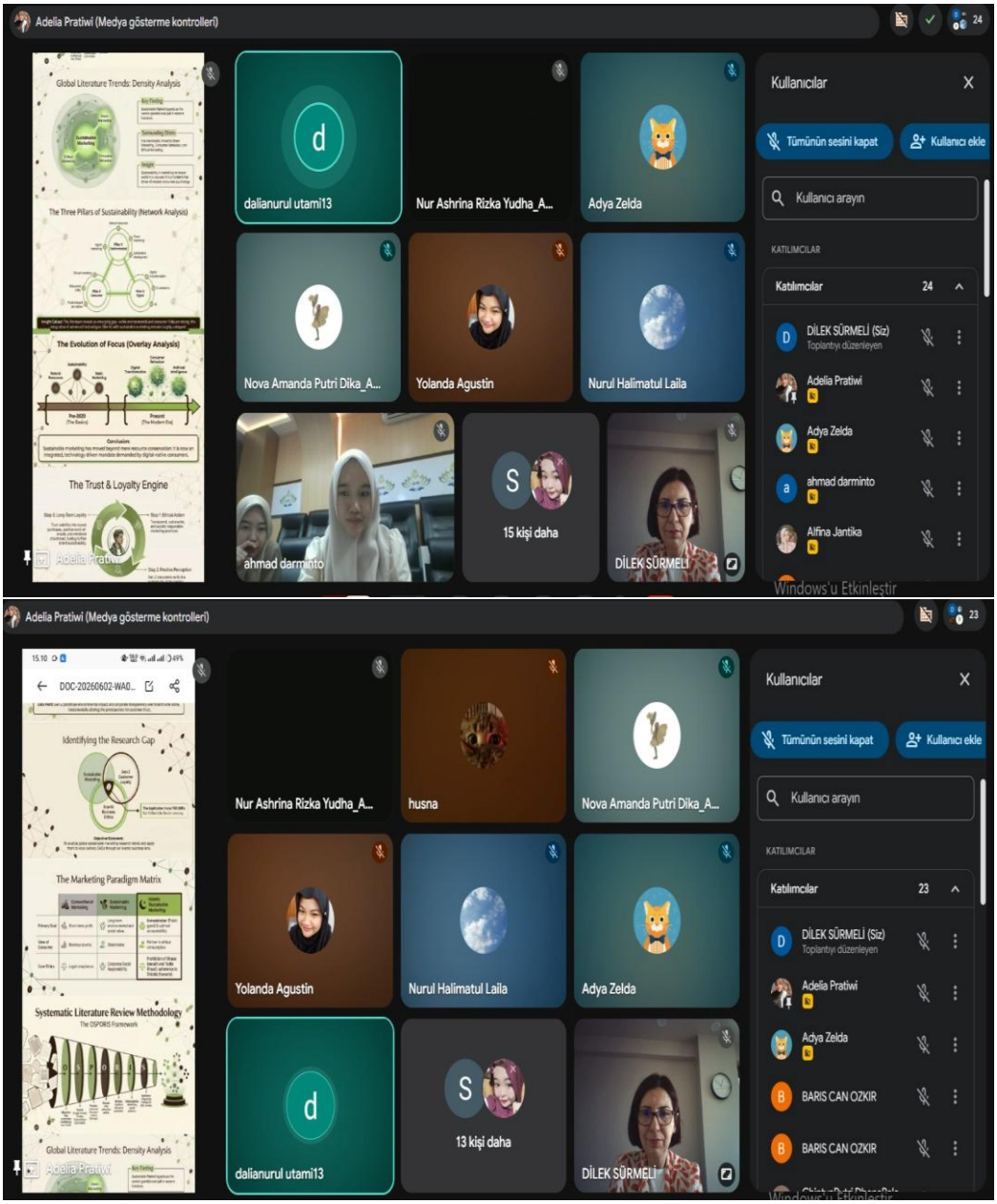

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SELMA KILIÇ KIRILMAZ
SİNAN ESEN
Pop Mihaela
ASENA BOZTAŞ
10:03 | 03.06-session 1-3
SİNAN ESEN
Pop Mihaela
ASENA BOZTAŞ

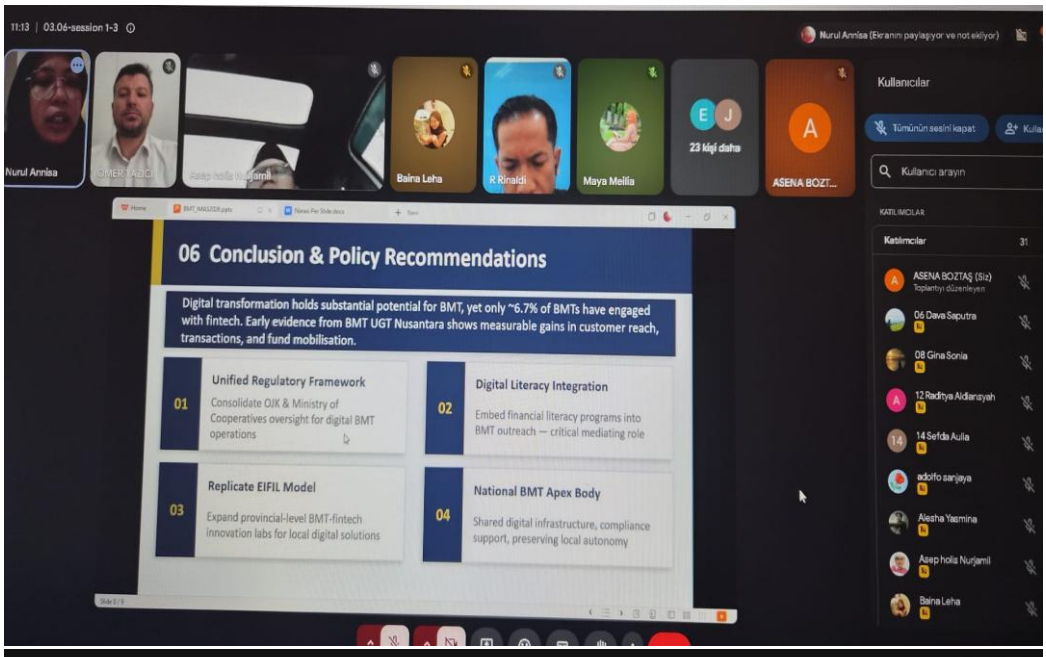

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ASENA BOZTAŞ
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SİNAN ESEN
Yücel Toprak
T
Takhmina Gulova
N
Navjot kaur
I
J
5 kişi daha
SELMA KILIÇ KIRILMAZ

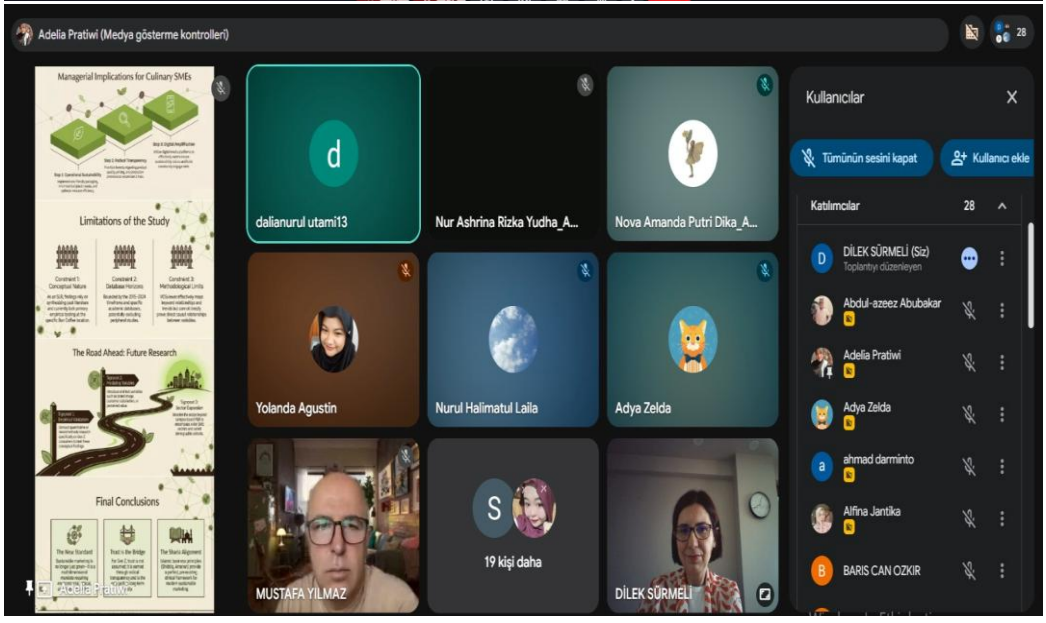

11:00 | 03.06-session 1-3
OMER YAZICI (Ekranını paylaşıyor ve not ekliyor)
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06 Dava Saputra
08 Gina Sonia
12 Raditya Aidianzyah
14 Sefda Aulia
Alesha Yasmina
Asep holis Nurjamil
Baina Leha
ceren t
DIGITAL TRANSFORMATION OF ISLAMIC MICROFINANCE (BMT) AND ITS IMPACT ON FINANCIAL INCLUSION IN INDONESIA
Ariyanto, Moh. Fakhurozi, Muhi Rahmah, Nurul Ulfa Kurnia Annisa, M. Djidin
STEBI LAMPUNG UNIVERSITY
Indonesia
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Rifal Rusdi, Pertiwi Utami, Anjali Sriwijaisut
STEBI LAMPUNG UNIVERSITY
Indonesia
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STEBI LAMPUNG UNIVERSITY
Indonesia
THE INFLUENCE OF DIGITAL MARKETING, SHARIA E-COMMERCE, AND SHARIA FINANCIAL LITERACY
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FACULTY OF BUSINESS & ISLAMIC ECONOMICS, UIN RADEN INTAN LAMPUNG
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Remy Amelissa, Ketty Nabila Nurul Husna
FACULTY OF BUSINESS & ISLAMIC ECONOMICS, UIN RADEN INTAN LAMPUNG
Indonesia
ANALYSIS OF CRISIS COMMUNICATION STRATEGY AND RESTORING CUSTOMER TRUST FOLLOWING THE BYOND APPLICATION DISRUPTION BY BSI
Baina Leha, Habibah, Rasi Putri Ramadhani
FACULTY OF BUSINESS & ISLAMIC ECONOMICS, UIN RADEN INTAN LAMPUNG
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Elias Nazarani
Jojang Supriatna
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Nurul Annisa
Asep holis Nurjamil
30 kişi daha
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11:02 | 03.06-session 1-3
International Conference of REUSE Jean Monnet Module
Governing The Twin Transition: Digitalization, Circular Economy and Resilient Industrial Ecosystems.
2-3 June 2026, Sakarya, Turkiye
Digital Transformation of Islamic Microfinance (BMT)
and Its Impact on Financial Inclusion in Indonesia
Ariyanto · Moh. Fakhrurozi · Multi Rahmah · Nurul Ulfa Kurnia Annisa · M. Djidin
Sekolah Tinggi Ekonomi dan Bisnis Islam Lampung, Indonesia
International Multidisciplinary Academic Studies | Economics Track
Nurul Annisa
Asep holis Nurjamil
R Rinaldi
Elisa Nazarani
20 kişi daha
ASENA BOZTAŞ


Presentation Outline
01 Introduction & Background
02 Literature Review
03 Current State of BMT Digitalisation
04 Implications for Financial Inclusion
05 Challenges & Enabling Factors
06 Conclusion & Policy Recommendations
OMER YAZICI
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21 kişi daha
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Adelia Pratiwi (Medya gösterme kontrolleri)
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Adya Zelda
ahmad darminto
Alfina Jantika
dalianurul utami13
Nur Ashrina Rizka Yudha_A...
Nova Amanda Putri Dika_A...
Yolanda Agustin
Nurul Halimatul Laila
15 kişi daha
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The Three Pillars of Sustainability (Network Analysis)
The Evolution of Focus (Overlay Analysis)
The Trust & Loyalty Engine
Windows'u Etkinleştir
Adelia Pratiwi (Medya gösterme kontrolleri)
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Kullanıcı arayın
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Adelia Pratiwi
Adya Zelda
BARIS CAN OZKIR
BARIS CAN OZKIR
Nur Ashrina Rizka Yudha_A...
husna
Nova Amanda Putri Dika_A...
Yolanda Agustin
Nurul Halimatul Laila
Adya Zelda
dalianurul utami13
13 kişi daha
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The Marketing Paradigm Matrix
Systematic Literature Review Methodology
Global Literature Trends: Density Analysis


11:13 | 03.06-session 1-3
Nurul Annisa (Ekranını paylaşıyor ve not ekliyor)
Nurul Annisa
Baina Leha
R Rinaldi
Maya Mellia
23 kişi daha
ASENA BOZT...
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08 Gina Sonia
12 Raditya Aldiansyah
14 Sefda Aulia
adolfo sanjaya
Alesha Yasmina
Asep holia Nurjamil
Baina Leha
06 Conclusion & Policy Recommendations
Digital transformation holds substantial potential for BMT, yet only ~6.7% of BMTs have engaged with fintech. Early evidence from BMT UGT Nusantara shows measurable gains in customer reach, transactions, and fund mobilisation.
01
Unified Regulatory Framework
Consolidate OJK & Ministry of Cooperatives oversight for digital BMT operations
02
Digital Literacy Integration
Embed financial literacy programs into BMT outreach — critical mediating role
03
Replicate EIFIL Model
Expand provincial-level BMT-fintech innovation labs for local digital solutions
04
National BMT Apex Body
Shared digital infrastructure, compliance support, preserving local autonomy


Adelia Pratiwi (Medya gösterme kontrolleri)
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Limitations of the Study
The Road Ahead: Future Research
Final Conclusions
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Adya Zelda
MUSTAFA YILMAZ
19 kişi daha
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Adelia Pratiwi
Adya Zelda
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Alfina Jantika
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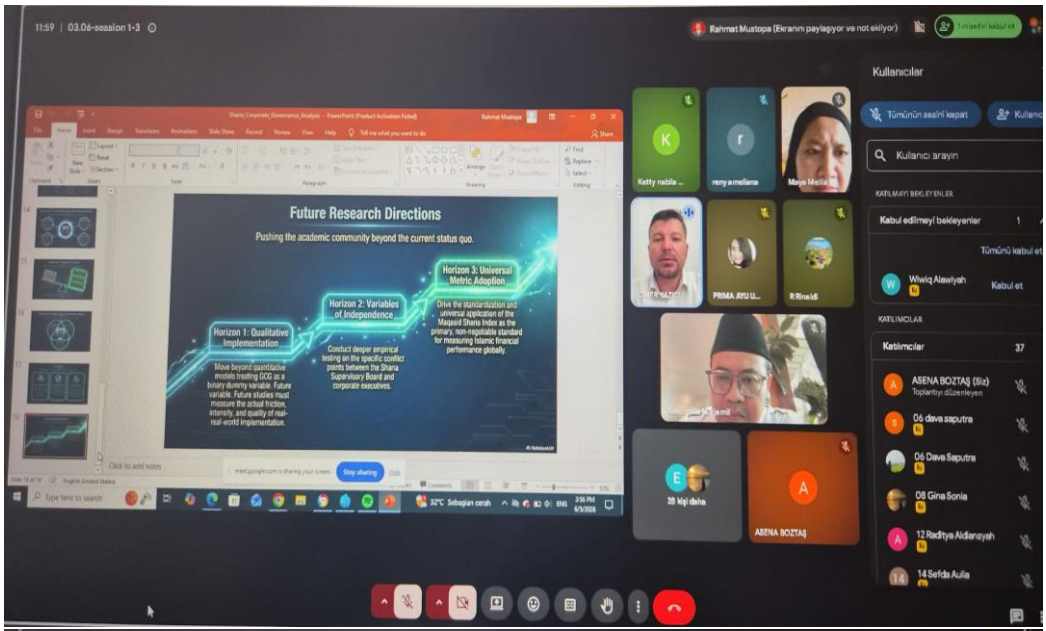
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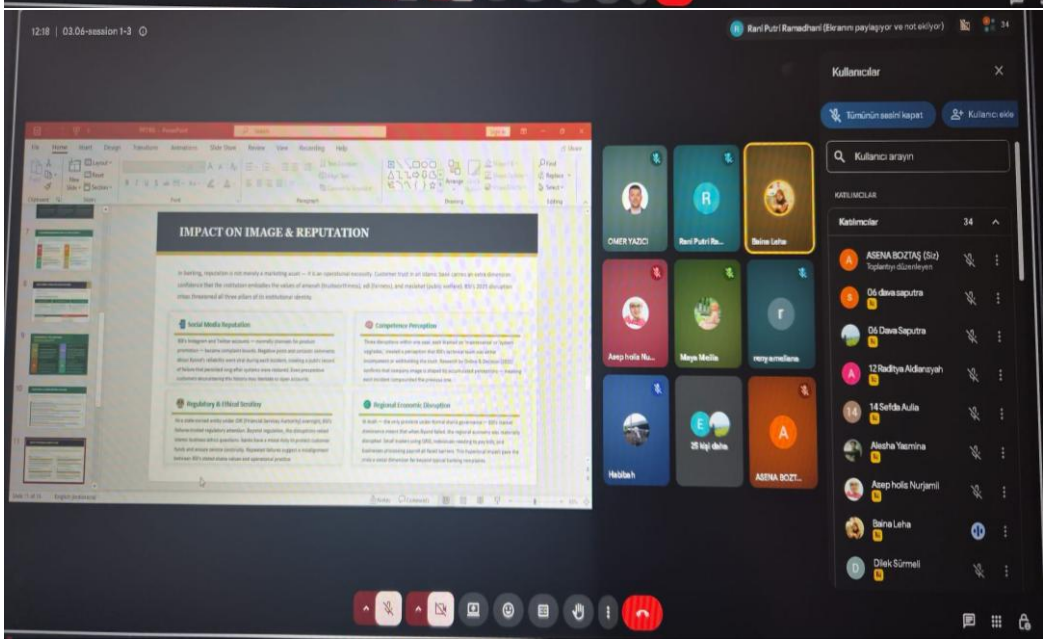
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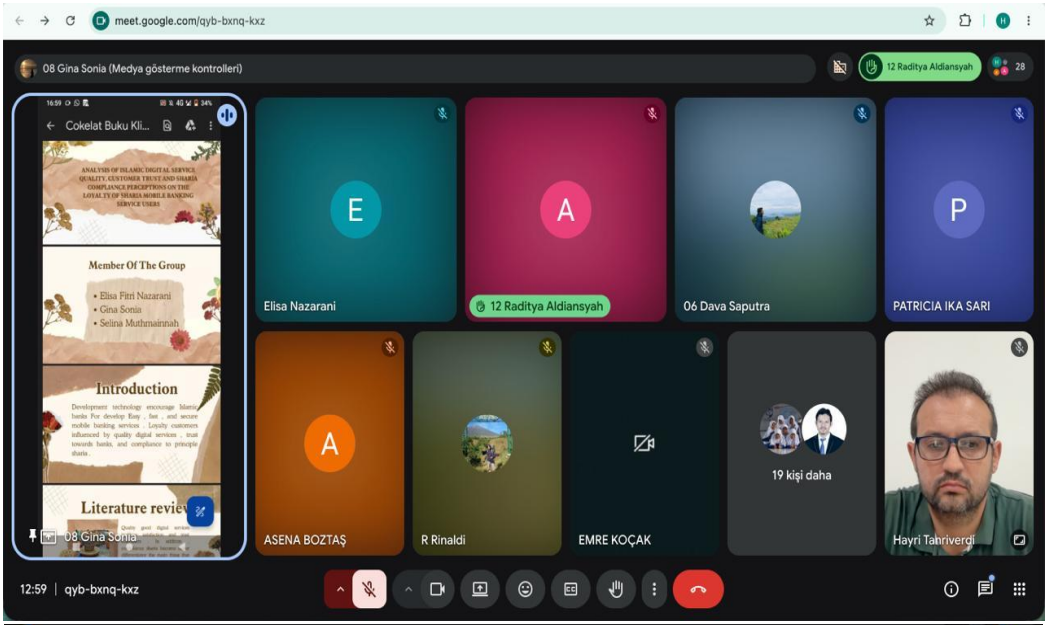
INTERNATIONAL CONFERENCE OF REUSE JEAN MONNET MODULE

GOVERNING THE TWIN TRANSITION: DIGITALIZATION, CIRCULAR ECONOMY AND RESILIENT INDUSTRIAL ECOSYSTEMS

2-3 JUNE 2026 (ONLINE)

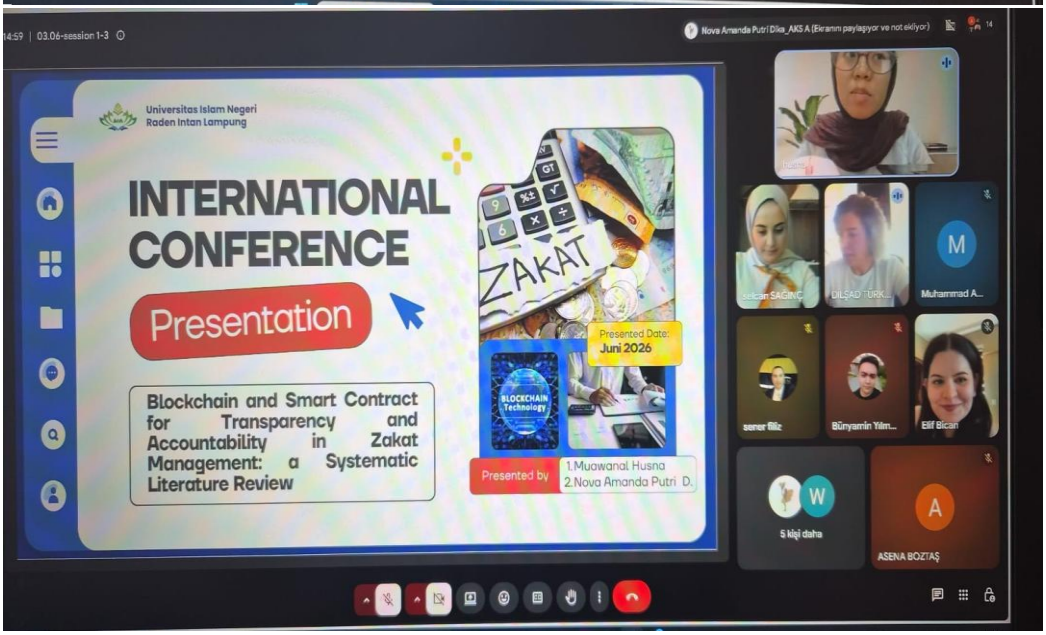





meet.google.com/qyb-bxnq-kxz
08 Gina Sonia (Medya gösterme kontrolleri)
12 Raditya Aldiansyah
Cokelat Buku Kli...
Member Of The Group
• Elisa Fitri Nazarani
• Gina Sonia
• Selina Muthmainnah
Introduction
Literature revie
08 Gina Sonia
Elisa Nazarani
12 Raditya Aldiansyah
06 Dava Saputra
PATRICIA IKA SARI
ASENA BOZTAŞ
R Rinaldi
EMRE KOÇAK
19 kişi daha
Hayri Tahriverdi
12:59 | qyb-bxnq-kxz


BARIS CAN OZKIR (Ekranını paylaşıyor ve not ekliyor)
Karşılaştırmalı Üstünlük Teorisi Açısından
Lomé Limanı'nda Transit Ticaret
BARIŞ CAN ÖZKIR, ASENA BOZTAŞ
YÜKSEK LİSANS ÖĞRENCİSİ ULUSLARARASI TİCARET VE LOJİSTİK (TEZLİ YÜKSEK LİSANS) SAKARYA UYGULAMALI BİLİMLER ÜNİVERSİTESİ
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E-POSTA: 2350250504@SUBU.EDU.TR
2026
MUSTAFA YILMAZ
BARIS CAN OZKIR
Ebubekir KIZIL
BARIS CAN OZKIR
Sanni Tajudeen
Andin Mezashika ...
8 kişi daha
DİLEK SÜRM...


14:19 | 03.06-session 1-3
Hakan Eygü (Ekranını paylaşıyor ve not ekliyor)
Dijitalleşmenin Ekolojik Sürdürülebilirlik Üzerindeki Makroekonomik Etkileri: Türkiye Örneği
Macroeconomic Effects of Digitalization on Ecological Sustainability: Evidence From Türkiye
Hakan EYGÜ
Hakan Eygü
DİLŞAD TÜRKMENOĞLU KÖSE
Yücel Toprak
Hacer Ak
habib ismail
Wiwiq Alawiyah
sener filiz
2 kişi daha
ASENA BOZTAŞ


14:59 | 03.06-session 1-3
Nova Amanda Putri Dika_AKS A (Ekranını paylaşıyor ve not ekliyor)
Universitas Islam Negeri Raden Intan Lampung
INTERNATIONAL CONFERENCE
Presentation
Blockchain and Smart Contract for Transparency and Accountability in Zakat Management: a Systematic Literature Review
ZAKAT
BLOCKCHAIN Technology
Presented Date: Juni 2026
Presented by 1.Muawanal Husna 2.Nova Amanda Putri D.
Muhammad A...
sener filiz
Bünyamin Yılm...
Elif Bican
5 kişi daha
ASENA BOZTAŞ

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KEYNOTE

GOVERNING THE TWIN TRANSITION: DIGITALISATION, CIRCULAR ECONOMY AND RESILIENT INDUSTRIAL ECOSYSTEMS

Rector, Prof. Dr. Mehmet SARIBIYIK

Sakarya University of Applied Sciences

Dear Academicians, Researchers and Participants, Distinguished Guests, Ladies and Gentlemen,

It is a great pleasure and honor for me to address you today at this valuable international conference.

Firstly, I would like to sincerely thank the organizing committee for bringing together scholars, researchers, and professionals from different countries and different universities around such an important theme.

I also would like to express my appreciation to all participants who contribute to this meaningful academic platform through their knowledge, experience, and vision.

Today, we are discussing one of the most important transformations of our century: the Twin Transition. That means the combination of green transition and digital transition. But in reality, this issue is much bigger than technology, much bigger than industry, and much bigger than pure economics. Because what we are actually discussing today is the future of humanity.

The world is changing faster than ever before. We are living in a period shapen by climate change, energy challenges, resource limitations, artificial intelligence, digital transformation and global uncertainty.

Day by day, technology develops rapidly. Production systems are changing. Economic structures are transforming. Social expectations are evolving. And universities are standing at the center of this transformation.

Nowadays, universities are no longer institutions that only transfer knowledge. In other words, universities must produce solutions, guide society, develop innovation, and prepare humanity for the future. Therefore, the role of higher education institutions is becoming more important than ever before.

As all these changes are taken into consideration; sustainability is no longer optional, green transformation is no longer optional, and digital transformation is no longer optional. This interdependence explains the growing global significance of the Twin Transition concept. A green transition that is not supported by effective digital systems may face substantial

challenges in terms of implementation, monitoring, coordination, and scalability. Conversely, a digital transition that is pursued without adequate consideration of environmental and social sustainability may generate new forms of ecological, economic, and societal risk. The two transformation processes should therefore be designed and implemented in an integrated and mutually reinforcing manner. Digital technologies should function as strategic enablers of sustainability, while sustainability principles should provide the normative and policy framework guiding technological development and deployment.

Green transformation encompasses a broad range of objectives, including environmental protection, the efficient use of natural resources, the reduction of carbon emissions, and the development of sustainable economic and production systems. Digital transformation, in turn, refers to the integration of advanced technologies such as artificial intelligence, big data analytics, automation, smart manufacturing, and intelligent systems into economic and social processes. When these two transformation pathways are effectively aligned, they can generate significant synergies and contribute to the development of societies that are not only technologically advanced, but also environmentally sustainable, resource-efficient, and more resilient to economic, social, and environmental disruptions.

Distinguished participants,

Resilience constitutes one of the central dimensions of the ongoing transformation process. Recent global crises, circumstances after COVID-19 pandemic, energy supply disruptions, global supply-chain bottlenecks, and persistent economic uncertainty, have demonstrated that countries, institutions, and production systems must enhance their capacity to adapt to rapidly changing conditions.

In this context, resilience refers to the ability to respond effectively to shocks, maintain essential functions under adverse circumstances, and manage structural change without undermining long-term stability. It therefore extends beyond short-term crisis management and includes preparedness, institutional flexibility, adaptive capacity, and strategic continuity.

Accordingly, future industrial ecosystems should not be evaluated solely in terms of productivity and efficiency. They must also be designed to remain flexible in the face of disruption, sustainable in their use of resources, and resilient against economic, environmental, technological, and geopolitical shocks.

Dear participants,

Another fundamental concept shaping contemporary sustainability debates is the circular economy. For many decades, prevailing production and consumption systems were largely organized around a linear model based on extracting resources, producing goods, consuming

them, and ultimately disposing of them as waste. However, this "take–make–consume–dispose" model is no longer environmentally or economically sustainable.

Natural resources are finite, while continuously expanding patterns of production and consumption place increasing pressure on ecosystems, supply chains, and future generations. It is therefore neither feasible nor responsible to pursue unlimited consumption within a world of limited resources.

The circular economy offers an alternative framework by seeking to preserve the value of products, materials, and resources for as long as possible. It focuses on preventing and reducing waste, extending product life cycles, reusing resources, recovering and recycling materials, and improving resource and energy efficiency across production and consumption systems.

Nevertheless, the circular economy should not be understood solely as an economic or environmental model. It also possesses important ethical and cultural dimensions. Within our cultural tradition, wastefulness has historically been regarded as unacceptable, a principle commonly expressed through the understanding that "İSRAF HARAMDIR" —wastefulness is morally impermissible. For generations, the careful use of food, water, energy, materials, and other resources has been associated with responsibility, moderation, and respect for both society and nature.

This cultural understanding continues to shape our contemporary perspective on sustainability. In this sense, the circular economy does not represent an entirely unfamiliar or externally imposed concept. Rather, it provides a modern economic and policy framework for principles of resource responsibility, moderation, and waste prevention that have long existed within our collective values.

In Türkiye, the Zero Waste Movement has emerged as a significant national initiative aimed at promoting resource efficiency, waste prevention, recycling, and environmental responsibility. The initiative has received strong high-level support and has been closely championed by First Lady Emine Erdoğan. Through this institutional commitment and public visibility, the Zero Waste approach has expanded across public institutions, universities, businesses, local administrations, and wider society.

However, from our perspective, the concept of waste should not be limited to the inefficient use of materials or natural resources. Waste may also take the form of unutilized human potential. When young people do not receive adequate education, when individual talents remain undiscovered, or when knowledge cannot be transformed into production, innovation, and social value, societies also experience a profound form of loss.

Universities therefore carry a substantial responsibility. Their role is not merely to transmit theoretical knowledge, but also to identify talent, develop capabilities, create opportunities, and enable individuals to contribute meaningfully to economic and social development. Preventing the waste of human potential should consequently be regarded as an integral dimension of sustainable development.

Distinguished guests,

At Sakarya University of Applied Sciences, education is understood as a process that must remain closely connected to real-life practices, industrial production, technological development, and societal needs. As an applied university, our educational philosophy is based on experiential learning and the principle of learning by doing.

Students acquire knowledge not only within classrooms, but also through direct engagement with laboratories, production environments, industrial organisations, workplaces, and real-world projects. This approach enables theoretical knowledge to be tested, contextualised, and transformed into practical competencies.

Within this framework, our university implements the "+1 Education Model." Under this model, students spend one full semester in a workplace or industrial organisation as an integral part of their formal education. This period is not treated as an additional or peripheral internship. Rather, it constitutes a structured component of the curriculum designed to strengthen the connection between academic education and professional practice.

Through the +1 Education Model, students gain professional experience, workplace awareness, problem-solving capacity, communication skills, and sector-specific competencies before graduation. They also become familiar with organisational culture, professional responsibilities, and the practical challenges encountered within their respective fields.

At the same time, the model strengthens cooperation between universities and industry. Academic knowledge becomes more responsive to labour-market and production needs, while industrial organisations gain access to emerging talent, current knowledge, and opportunities for collaborative innovation.

The resulting ecosystem establishes a stronger and more dynamic relationship among education, production, innovation, and employment. In this way, applied education contributes not only to graduate employability, but also to institutional resilience, regional development, and the more effective use of human capital.

Dear colleagues,

We also regard this educational model as an important contribution to the circular economy and sustainable development. The transition towards sustainable production systems cannot be achieved solely through technological investment or regulatory reform. It also requires a highly qualified, adaptable, and sustainability-oriented workforce.

Green transformation depends on professionals who possess the knowledge and skills required to implement environmentally responsible practices. Digital transformation requires graduates who can adapt to rapidly changing technologies and organizational structures. Similarly, resilient industries depend on individuals who are capable of integrating technical knowledge, practical competence, critical thinking, and sustainability awareness.

Universities must therefore move beyond the conventional function of awarding degrees. They must educate individuals who are competent, responsible, innovative, adaptable, and solution oriented. Graduates should not only understand existing systems, but should also be capable of improving them, responding to emerging challenges, and contributing to sustainable economic and social development.This is precisely the educational objective pursued at Sakarya University of Applied Sciences.

Distinguished participants,

Our university places strong emphasis on applied research, digital transformation, smart production systems, green technologies, and university–industry cooperation. These areas are approached not as separate institutional priorities, but as interconnected components of a broader transformation agenda.

Students are actively encouraged to participate in technology competitions, innovation projects, scientific research, sectoral collaborations, and interdisciplinary teamwork. Such activities provide opportunities to translate theoretical knowledge into practical outcomes, develop problem-solving capacity, and engage with complex challenges that cannot be addressed through a single disciplinary perspective.

Innovation rarely emerges through isolated theoretical work. It develops through collaboration, experimentation, practical application, and continuous interaction among universities, industry, public institutions, and society. For this reason, the university seeks to establish learning and research environments in which students can participate directly in processes of technological development, knowledge production, and social innovation.

Our sustainability efforts also extend to campus operations and institutional practices. Work is being conducted in areas such as energy efficiency, waste prevention, resource management, recycling, and environmental awareness. These initiatives reflect the

understanding that sustainability should not remain confined to strategic plans, policy documents, or institutional reports.

Sustainability must become an integral part of institutional culture. It should shape everyday decisions, organizational behavior, educational practices, research priorities, and the use of resources. Only through such institutional integration can sustainability move from formal commitment to measurable and lasting practice.

Dear participants,

Artificial intelligence and advanced digital systems are currently creating significant opportunities for economies, industries, and public institutions. Smart technologies can support the optimization of production processes, improve energy and resource management, reduce waste, process large volumes of data, strengthen forecasting capacity, and enable more informed decision-making.

These technologies can also accelerate the transition towards more efficient, responsive, and sustainable production systems. Artificial intelligence, automation, digital monitoring, and data analytics can help institutions identify inefficiencies, anticipate risks, and allocate resources more effectively.

However, technology alone cannot guarantee positive social or environmental outcomes. Technological development that is disconnected from ethical principles, social responsibility, and inclusiveness may deepen existing inequalities and generate new economic, social, and institutional risks. Unequal access to digital infrastructure, skills, and opportunities may exclude certain groups from the benefits of transformation. Similarly, the uncontrolled use of data and automated decision-making systems may create concerns regarding privacy, accountability, transparency, and fairness.

The digital and green transformation must therefore remain human-centered. Technological systems should be designed and implemented in ways that respect human dignity, promote inclusion, support equal opportunities, and contribute to social well-being.

Ultimately, the purpose of technology should not be technological advancement for its own sake. Its principal function should be to improve human life, strengthen societal resilience, support sustainable development, and contribute to a more equitable and responsible future.

Distinguished colleagues,

International cooperation constitutes another essential pillar of sustainable and inclusive transformation. The challenges confronting contemporary societies transcend national borders and cannot be addressed effectively through isolated action. Climate change affects

humanity as a whole, digital transformation reshapes all economies, and sustainable development requires shared responsibility across countries, institutions, and sectors.

Universities and other knowledge-producing institutions must therefore strengthen international partnerships, collaborative research, student and academic mobility, and the exchange of knowledge, experience, and good practices. Such cooperation enables institutions to combine complementary expertise, develop more comprehensive solutions, and respond more effectively to complex global challenges.

Conferences such as this one are particularly valuable because they create spaces for dialogue, mutual learning, professional networking, and the development of new forms of collaboration. They allow researchers, educators, policymakers, and practitioners to move beyond institutional and disciplinary boundaries and to identify areas of shared concern and collective action.

The importance of such cooperation will continue to increase in the future. As Sakarya University of Applied Sciences, we remain open to international collaboration, joint academic initiatives, research partnerships, student and staff exchanges, and interdisciplinary projects. We firmly believe that a sustainable and resilient future cannot be constructed through fragmented efforts. It can only be built through cooperation, shared responsibility, and collective commitment.

Dear colleagues and friends,

I would also like to emphasise that future transformation will require far more than engineers, data specialists, and technical experts. Although technological competence will remain indispensable, successful transformation will also depend on ethical leadership, responsible policymaking, innovative education, social awareness, and the capacity to evaluate the broader consequences of economic and technological change.

This implies that education systems themselves must undergo substantial transformation. Universities must become more flexible in responding to emerging needs, more innovative in their teaching and research practices, more interdisciplinary in their institutional structures, and more closely connected to society, industry, and public policy.

Most importantly, higher education must prepare younger generations not only for the occupations that currently exist, but also for the uncertainties, disruptions, and responsibilities that will define the future. This requires the development of adaptive capacity, critical thinking, creativity, ethical judgement, digital literacy, and sustainability awareness. Graduates must be equipped not merely to enter existing labour markets, but also to navigate change, create new forms of value, and contribute constructively to societal transformation.

Before concluding, I would like to underline one final point. The future is not an outcome that will emerge automatically. It is shaped through the choices, institutions, and actions created today. Decisions taken in education, technology, industry, environmental policy, and resource governance will directly influence the opportunities and living conditions available to future generations.

Our responsibility is therefore considerable. Universities, governments, industries, researchers, civil society organizations, and international institutions all have a role in ensuring that transformation remains sustainable, inclusive, ethical, and human-centered.

Nevertheless, there are strong grounds for optimism. When academic institutions, researchers, policymakers, industries, and international organizations cooperate around shared objectives, meaningful transformation becomes achievable. Knowledge can be translated into practice, technological progress can be aligned with social priorities, and sustainability commitments can be transformed into measurable outcomes.

I believe that gatherings such as this conference represent important steps towards that common future. They strengthen dialogue, create new partnerships, and remind us that the challenges we face are shared—and that the solutions must also be developed together.

Finally, I would like to express my sincere appreciation once again to the organising committee, all contributors, and every participant who has contributed to the success of this valuable international event.

I hope that this conference will strengthen institutional and academic cooperation, generate new ideas and perspectives, establish lasting partnerships, and contribute meaningfully to the development of greener, smarter, more inclusive, and more resilient societies.

The future we are discussing today is not a distant or abstract possibility. It is a shared responsibility that will be shaped by the decisions we make, the knowledge we produce, and the partnerships we establish.

Let us therefore continue to work together to transform dialogue into cooperation, knowledge into action, and common aspirations into sustainable outcomes. Thank you very much for your kind attention.

KEYNOTE

INVESTMENT RESILIENCE FRAMEWORK (IRF): A STRATEGIC MODEL FOR STRENGTHENING INVESTMENT CLIMATE AND ECONOMIC RESILIENCE AMID GLOBAL ECONOMIC FRAGMENTATION

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Abstract

Global economic fragmentation driven by geopolitical tensions, trade protectionism, supply-chain disruptions, climate uncertainty, and digital transformation has significantly reshaped international investment patterns and challenged economic stability worldwide. As global investment flows become increasingly volatile, strengthening investment resilience has emerged as a strategic priority for sustaining economic growth and long-term development. This study aims to develop an integrative framework for strengthening investment climate and economic resilience amid global economic fragmentation. The research employs a Systematic Literature Review (SLR) using the PRISMA protocol by synthesizing peer-reviewed articles indexed in Scopus, Web of Science, and ScienceDirect published between 2015 and 2025. A total of 428 articles were identified, and 74 studies met the inclusion criteria. Secondary data indicate that global Foreign Direct Investment (FDI) flows declined by 2% to approximately US$1.3 trillion in 2023 due to geopolitical tensions and slowing economic growth. Meanwhile, ASEAN demonstrated strong resilience by attracting a record US$230 billion in FDI in 2023, maintaining its position as the leading FDI destination among developing regions for three consecutive years. The findings reveal that regulatory quality, institutional effectiveness, political stability, infrastructure development, digital transformation, economic openness, and global connectivity are the primary determinants of investment resilience. Based on the synthesis, this study proposes the Investment Resilience Framework (IRF) consisting of four interconnected dimensions: Regulatory Resilience, Institutional Resilience, Economic Resilience, and Global Resilience. The framework positions investment as a strategic mechanism for strengthening adaptability, competitiveness, and sustainable economic development under conditions of global uncertainty. The study contributes theoretically by integrating investment climate theory, institutional theory, and economic resilience theory into a unified conceptual framework while providing practical policy recommendations for governments and international organizations.

Keywords: Investment Resilience Framework, Investment Climate, Economic Resilience, Global Economic Fragmentation, Foreign Direct Investment

KEYNOTE

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Distinguished guests, esteemed scholars, and dear participants,

Welcome to the International Conference of the REUSE Jean Monnet Module hosted by Sakarya University of Applied Sciences. It is a great pleasure to have you with us today.

This conference brings together highly important themes such as digitalization, circular economy, sustainable industrial ecosystems, governance, and resilience within the framework of the Twin Transition.

Today, the world is undergoing a profound transformation shaped simultaneously by technological change and sustainability challenges. In this process, universities and academic communities have a critical responsibility — not only to analyse global developments, but also to contribute to innovative and sustainable solutions.

As an applied sciences university, we strongly believe that knowledge should create practical impact for society, industry, and future generations.

I hope this conference will foster valuable academic discussions, international collaborations, and new research opportunities for all participants.

I would like to sincerely thank the organizing committee, keynote speakers, researchers, and all participants for their contributions.

I wish you all a productive and inspiring conference.

Thank you very much.

KEYNOTE

PRIVATE INTERNATIONAL LAW IN THE TWIN TRANSITION: JURISDICTION AND APPLICABLE LAW IN THE DIGITAL AND CIRCULAR ECONOMY

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Abstract

This study takes into consideration the issues of jurisdiction and applicable law under private international law in the context of the twin transition toward digital and circular economies. It argues that traditional territorial connecting factors are increasingly contested by cross-border digital services, online platforms, data flows, and circular economy practices involving the reuse, repair, recycling, and redistribution of goods as well as materials. The paper reviews how jurisdiction may be established in digital transactions through criteria such as domicile, place of performance, substantial activity, technical presence, targeting activities toward a specific forum or through forum-selection clauses. It also discusses the limitations of national courts (arbitration), alternative disputes resolution mechanisms in offering predictable results for transnational disputes.

The article further details choice-of-law problems in digital contracts, data governance, platform responsibility, user-generated content, product liability, environmental obligations and circular supply chains with particular reference to mandatory rules on public policy concerning cross-border environmental impact assessments on liability issues and access to redress. Circularity makes legal allocation more complex because goods, materials, data, and responsibilities can pass through multiple jurisdictions during the life cycle of a product.

Fragmentation is identified as a major barrier to legal certainty by comparing common law, civil law, and regional regulatory strategies. It concludes that private international law is still necessary for organizing rights, duties, and remedies within the digital economy as well as within the circular economy. Coherent principles regarding jurisdiction harmonized standards of applicable law interoperable regulatory frameworks together with effective access to justice are critical for sustainable innovation cross-border trade as well as legal predictability within the framework of twin transitions.

Keywords: Private International Law, Jurisdiction, Applicable Law, Digital Economy, Circular Economy

JEL Classification: |K33, K12, L86, Q56, K23|

INTRODUCTION

The twin transition towards a digital and circular economy resonates throughout the contemporary economy, with profound implications for actors, interfaces, and materials. The transition raises pivotal questions concerning jurisdiction and the applicable law that transcend borders and require the collective attention of the legal community (P. Stewart, 2011). Private international law, which governs jurisdiction and the applicable law governing cross-border private relationships, occupies a crucial position in arbitrating these critical issues - especially when national jurisdictional contests arise in the context of transnational digital activity and the applicable law for materials engaging circular economy considerations is in question. The following sections accordingly explore jurisdiction and applicable law concerning materials in the overarching digital and circular economy debate.

The analysis on jurisdiction begins with an examination of the territorial nature of jurisdiction and its enduring relevance to digital activity. The inquiry proceeds to evaluate connective criteria typically employed to ascertain jurisdiction in cross-border digital-service situations, highlighting domicile, place of performance, and substantive activity. The dialogue culminates with an appraisal of forum selection and jurisdictional forums pertinent to e-commerce and platform economies, considering arbitration, national courts, and alternative dispute-resolution mechanisms. The discussion of applicable law in a broadly borderless context first inspects conflict-of-laws queries arising in digital contracts and data-governance initiatives, identifying leading conflicts and harmonization opportunities. The focus then shifts to circular economy considerations and the rules that determine the allocation of substantive legal regimes, notably regarding product liability, contracts, and the environment. The analysis concludes with an exploration of mandatory rules and public policy, investigating their spectrum, hierarchy, limitations, and enforceability across borders.

Understanding the twin transition hinges on grasping the importance of circular and digital economies, along with their interdependence and systemic effects. Put simply, the digital economy involves value-generation, exchange, and asset creation through electronic channels; a circular economy entangles product design, remanufacturing, resource recovery, recycling, and resource retention. Industrial relations, digital platforms, and data-protection legislation exemplify circular-economy and digital-economy intersections. The dialogue addresses regulatory tools available under jurisdiction and conflict-of-law regimes concerning both the circular and digital economies, narrowing down jurisdiction’s territorial and connective rules and applicable law’s choice-of-law criteria amid industrial evolutions that challenge firm, material, and asset definitions.

1. CONCEPTUAL FRAMEWORK: PRIVATE INTERNATIONAL LAW IN THE DIGITAL AND CIRCULAR ECONOMY

The twin transition, encompassing both the digital and circular economy, profoundly influences public and private international law. Private international law increasingly regulates commercial interactions that transcend national borders. It includes transmission of data, goods, and services, as well as obligations to monitor, verify, or control processes beyond domestic jurisdictions. Within this expansive sphere, jurisdiction and applicable law are core issues at the heart of the theoretical and practical underpinnings of private international law and play a vital role in legal order.

Jurisdiction refers to a state's legally acknowledged competence to govern entities or concepts within a territory or beyond in transnational dynamics. Applicable law encompasses the substantive and procedural legal norms determined by jurisdictional choices or by preselected and subsequently binding provisions. Private international law functions on one hand, to provide framework conditions regarding jurisdiction and applicable law when the transnational dimension is engaged in the spheres of the digital and circular economy.

A digital economy comprises multiple activities and transaction types of non-residential nature. It spans diverse sectors from digital services, content, and payments to integrated hardware, software, or data applications. Digital activities can thus create legally relevant links across multiple jurisdictions either within the same phase or throughout the overall supply chain. A circular economy refers to productivity enhancement through the reuse or recycling of products that ensures resource conservation and minimization of waste while sustaining economic active and fostering innovation. Consequently, a user-oriented flexible analytical framework for discernment of jurisdiction and applicable law is developed to identify the diverse digital and circular facets, activities, relevant actors, linkages and the interplay among them as well as the impelling overarching regulatory stimuli (P. Stewart, 2011), (Selvadurai, 2013).

1.1. Defining The Twin Transition and Its Jurisprudential Implications

The twin transition encompasses the shift towards both a circular and a digital economy, together pursued to foster sustainability and resilience. Both transitions have agriculture, industry, and services in common. The concept of the twin transition places focusses on their intersections while illustrating their uniqueness. The "digital economy" defined as an economy that is dependent on digital technologies, includes a variety of platforms, such as those enabling e-commerce (e.g., Amazon), access to services (e.g., Uber), and user-generated content (e.g., YouTube). The parallel transition towards a circular economy promotes resource preservation by designing materials intended for disassembly and reassembly, as well as designing products and processes with a view to reusability and treatability. The

circular economy covers horticulture, industry, and consumer behaviour. The twin transition, thus, poses a universal challenge for private international law in both circular and digital contexts because territorial borders are irrelevant to both.

Private international law, jurisdiction, and applicable law constitute connecting concepts cross-cutting both transitions. Jurisdiction concerns under which country's legal authority situations may be addressed. Applicable law pertains to what rules govern. Both dimensions are essential since they shape actors' legal environment in rights, obligations, and risks. Private international law provides the fundamental rules underpinning jurisdiction and applicable law. It seeks to delineate each state's domain of jurisdiction, the law governing cross-border situations, and whether or not the state's own normative principles prevail in cases raising conflicting demands.

The concept of a circular economy - its fundamental principles, definition, and legal aspects - illustrates intuitive challenges for private international law. Waste may be generated when a substance intended for recycling is transformed into something of little residual value. Highly valuable materials might change ownership several times before being reallocated consistently with circularity. The dual regime necessarily requires a mechanism for determining the law governing material allocation in circular settings. Understanding these issues forms an entry point for undertaking a comprehensive assessment to locate the twin transition within jurisdictional and choice-of-law frameworks.

1.2. Core Challenges for Jurisdiction and Applicable Law

The digital transformation and growing focus on sustainability raise fundamental questions about private international law and jurisdiction in a cross-border context. Jurisdiction and applicable law are core aspects of private international law that remain unresolved in relation to the twin transition. These issues are prominent in the circular economy, which engages innovative actors across numerous sectors. Digital technology and engagement enable business activity, including the dissemination of circular economy goods and information, irrespective of physical boundaries. The digital economy encompasses a vast range of goods and services, from tunes to videos, e-learning to telework services, and e-textbook to firmware apps. Access to the relevant goods and services depends on the appropriate digital device with internet connectivity.

Jurisdiction and applicable law are critical components of law that become increasingly relevant with the emergence of the digital economy. In e-commerce, individuals and companies can offer goods for sale on a web page established in different jurisdictions. One must rely on police and laws from various countries to know about obligations. The selection of the jurisdiction may depend on the purpose of using the contractual basis. Code and contract laws often require the participating parties to designate the choice of jurisdiction clause. The

effective electronic dissemination of circular economy-related goods depends on clarifying parts of these two areas. Exploring jurisdiction also forms the core topic of international commercial mediation (Selvadurai, 2013).

2. JURISDICTION IN THE DIGITAL AND CIRCULAR ECONOMY

The private international law concept of jurisdiction describes the ability of a sovereign actor to regulate acts and events involving market actors located outside that sovereignty. As jurisdictions overlap, actors conducting cross-border activities must determine which regime rules apply to a specific context (whether a governing law clause has been correctly selected or party conduct satisfies the requirements for a particular jurisdictional forum). The analysis considers broad jurisdictional issues - notably the effects of jurisdictional sovereignty in the digital and circular economy - and a narrower focus on the impact of private international law jurisdictional considerations on the formation, performance, and termination of cloud and digital services contracts (Soler Pedroza & Guillermo Jiménez, 2014).

Contemporary private international law jurisdictional analysis is rooted in the nature of the economy and the technology that supports major cross-border commercial, contractual, and regulatory transactions. The structure of these transactions reflects the distinctions and boundaries identified by the technology underpinning them and these, in turn, remain shaped by the sovereignty of the applicable law. Each of the regimes involved in establishing jurisdiction ties with key structural attributes that define jurisdictional selection and demand consideration when determining which rules govern and how these rules relate to one another in the substantive and regulatory control of cloud and digital services arrangements (Jerker B. Svantesson, 2012).

2.1. Territoriality and Digital Activity

When physical property crosses national borders, territoriality poses few difficulties in establishing jurisdiction. The same cannot be said for transnational digital activity, such as video calling or virtual sales, in which technical interfaces operate across persistent, interactive ‘space’ (i.e. chat and transaction windows) irrespective of geographical co-ordinates. Many private-sector regulatory approaches, particularly in the e-commerce and platform economies, target transnational digital conduct predominantly through national frameworks for governance (Selvadurai, 2013).

Economic and legal actors, when faced with multi-territorial digital interfaces that ignore official frontiers, are often nettled by the persistence of national doctrine. Questions of legal governance are generally expressed in territorial terms - e.g. domicile, place of performance, or significant activity - yet approaches can either ignore or defer the digital dimension. Prioritizing the interface over the transnational service itself aligns governance with the

constraints present in other sectors, such as broadcasting or aviation. For many economic connections, choice of law remains frustratingly indeterminate because of such divergences.

2.2. Connective Criteria in Cross-Border Digital Services

The traditional analysis of jurisdictional rules in a digital environment is conditioned on the geographical location of a service, the focus being on the service provided rather than on the service as a medium. Business is meant to gravitate to the party pursuing an activity, which is where the centre of gravity lies. B2C services destined for private individuals at a specific location give rise to a minimum threshold of domicile to permit the investigation of a forum. In the B2B environment, the placement of matters of jurisdiction remains uncertain and could pass under a different regime. The emphasis in the approach to such activities would then be on location connects rather than focused on a mere B2C distinction (Wang, 2008).

Four criteria can be proposed for connecting digital business services:

(1) Hubs where the electronic B2B services are sold,

(2) Technical (PES) substantial presence of hardware and software located at the user's side,

(3) Centre of gravity based on activities such as all cable/telecom operators that accommodate activities over wide areas globally. Physical routing of cables to carry such intricated connectivity will be increasingly difficult to trace,

(4) Technical substantial presence or location of data routing and logs associated digital service (Carullo, 2016).

2.3. Forum Selection and Jurisdictional Forums in E-Commerce and Platform Economies

The paradigm of e-commerce has significantly transformed the business landscape, prompting radical adjustments to traditional business models and a new understanding of territoriality in commercial activity. Jurisdictional questions arise about the appropriate forum for disputes. Commercial parties actively seek to select an appropriate forum when entering transnational contracts. The parties may address various potential risks. Legislative efforts to clarify jurisdiction and applicable law for digital contracts continue.

Arbitration remains a preferred dispute resolution mechanism, although parties contemplate the availability of statutory courts. The twin transition reinforces these considerations. New types of cross-border exchanges prompt an additional assessment of governing law and jurisdictional liability. Although resolution through private international law remains broadly effective - digital data exchanges, platform-party liability for user-generated content, accessibility of third-party data, and environmental impact analysis for circular transactions remain the focus - technology has begun to diverge from earlier patterns. Emerging digital

and circular economy issues restrict leverage over jurisdiction and the selection of substantially relevant legal frameworks, particularly in regions adopting strict regulatory measures (Wang, 2008); (Selvadurai, 2013).

3. APPLICABLE LAW: CHOICE OF LAW IN A BORDERLESS CONTEXT

A functional economic definition of circularity entails "restorative and regenerating" systems that close loops while avoiding environmental "damage to or depletion of the earth's physical and natural resources". Proposals based on this definition have emerged, yet the range of substantive legal regimes potentially implicated in circularity remains to be mapped. Product liability, contractual, and environmental obligations may govern circular economy activities, raising questions of which rules apply across jurisdictions.

In cross-border transactions, choice of law becomes particularly consequential. Rules defining connectives that allocate substantive regimes determine the governing legal order. Digital contracts often encompass provisions on choice of law, whereas circular economy arrangements may not - superimposing additional uncertainty (A., 2014). The 1991 Convention on the Law Applicable to Contractual Obligations provides guidance for contracts but does not cover data or product governance issues; a complementary framework addressing these topics remains lacking.

Flexibility and adaptability are desirable attributes for regulatory instruments targeting evolving shared digital and circular concerns across jurisdictions. A multitude of national legal orders actively interact in both domains, and solutions that permit modular accommodation of diverse yet interdependent approaches would enhance disclosure and compliance throughout these intricate, cross-border ecosystems. For incoming new products, platforms characteristically require completion of supplementary fields pivotal to regulatory conformance across jurisdictions.

3.1. Conflict of Laws in Digital Contracts and Data Governance

Jurisdictional conflicts in the digital economy primarily arise in two contexts: the provision of digital services and the use of online platforms (Wang, 2008). Incorporating digital elements into cross-border transactions enhances operational flexibility and jurisdictional complexity, especially with respect to the applicable law. The distinction between digital contracts that constitute the sales transactions as such (e.g. license agreements or the sale of digital goods) and contracts for the provision of digital services (e.g. cloud computing or internet delivery of digital services) is often unclear. Digital contracts - notably, cloud computing, e-commerce, films, music and news - can therefore involve both the supply of services and the provision of goods at the same time. A similar situation arises with respect to data governance, where both the supply and the use of data may take place across borders.

Depending on the business model, different contractual arrangements (e.g. for access, ownership or free use) can be applicable. To this end, companies active in the circular economy seek to clarify the legal regime (contract law and pertinent environmental focus) governing circular economy business models, cross-border transactions, and the assurance of enforceability by analysing the interfaces existing at the supply-usage juncture and the underlining governance-regulatory pressures.

3.2. Rules Governing The Allocation of Substantive Legal Regimes for The Circular Economy

Rules governing the allocation of substantive legal regimes for the circular economy provision are relevant whenever goods or services subject to a circular economy regulatory regime are traded between two or more States. Circular economy rules are becoming a key consideration in determining the regulatory regime for cross-border transactions, especially when a regulatory regime does not provide for extraterritoriality. For example, the European Union has a circular economy action plan that is expected to evolve into a comprehensive regulatory framework for the circular economy.

Circular economy rules can be embedded in a myriad of substantive legal regimes. At the present time, three regulatory regimes that incorporate circular economy principles are the obligation to ensure product safety (e.g. product liability), the regulation of contracts (e.g. the need to maintain quantity, quality, and availability of goods) and the imposition of environmental standards (e.g. environmental protection, sustainability, and circular economy requirements) (P. Stewart, 2011).

Where regulations or regulatory criteria exist in a State of arrival, it is of fundamental importance to examine mandatory rules and public policy on such regulations; the extraterritorial reach of the mandatory rule; and the possibility of enforcement (where regulations are not extraterritorial).

3.3. Mandatory Rules, Public Policy, and Their Reach in Cross-Border Transactions

Mandatory rules and public policy significantly influence cross-border transactions. The territoriality principle ties jurisdiction to national boundaries, asserting jurisdiction over acts occurring within a territory or having effects there. Internet content disputes are often transnational, challenging the applicability of territorial principles. Such disputes typically occur across borders without a clear territorial connection. The subjective territorial principal bases jurisdiction on where the activity occurs, while the objective principle considers where the activity’s primary effect takes place. A balance between predictability and international uniformity is vital for effective regulation of international internet transactions (Selvadurai, 2013).

The Internet's borderless nature increases legal disputes across jurisdictions. When a court in one jurisdiction issues a judgment, questions of recognition and enforcement in other jurisdictions arise, especially when the losing party's assets lie outside the original court's territory. These issues affect predictability, efficiency, and legal certainty. Recent developments (1999-2009) in the recognition and enforcement of judgments within the EU involve instruments such as enforcement orders for uncontested claims, payment orders, and small claims procedures. Private international law plays a crucial role in facilitating legal cooperation and ensuring judgments are recognized and enforced across borders to support the internal market and legal protections in cross-border transactions (Kloza, 2010).

4. PRIVATE INTERNATIONAL LAW AND DIGITAL PLATFORMS

The twin transition to a circular economy and a climate-neutral society challenges private international law in several ways. It raises complex questions about jurisdiction and applicable law that differ significantly from the traditional focus of the field on these topics in the context of the digital economy. Transactional and regulatory private international law interacts with a wide range of cross-border, cross-platform transfers and systems related to digital elements such as data, content, and design. Solutions often depend on fragmented, user-driven, cross-cutting sourcing and ownership governance, which depends on a diverse set of access to, control over, and other intangible rights in analytic platforms, federated platforms, cloud-based services, distributed ledger technologies, and other digital structures and instruments requiring insight into what constitutes a digital platform and its status as a non-transactional or transactional participant (Lund-Sørensen, 2018). The circular economy also raises jurisdiction and applicable law issues for cross-border situations governed by conflicting substantive rules of different legal regimes, including design protection, copyright and registerable rights, product liability, and aspects of climate incentives, (Selvadurai, 2013) alongside all the relevant digital economy parameters.

Companies offer an extensive range of digital platforms (particularly for design elements) and take a wide spectrum of different positions in relation to access to, ownership of, and rights over data between these elements. Digital platforms can thus constitute participants in the circular economy of intermediating access to, ownership of, and underpinning transnational rights to, secondary-data design. Furthermore, the capacity to acquire and implement the circular economy, especially from the design perspective, is hampered by jurisdiction and applicable law limitations in cross-border situations where transnational data design is situated in a platform that is not simultaneously transactional and a fronthaul or backhaul platform.

4.1. Platform Responsibility, Governing Law, and Jurisdictional Liability

The content that follows analyses platform responsibility, governing law, and jurisdictional liability, particularly examining terms of service, fractional liability, and governance frameworks.

Digital platforms offer the possibility to enter into a contract between parties who do not know each other, are not located in the same country, and interact solely via the platform. Nonetheless, as long as the platform itself complies with its regulatory obligations in its country of origin, it may argue that it has little or no responsibility for these transnational relationships. The digital platform is not a party to the contract and, in principle, the conclusion of the contract is entirely at the discretion of the users. In addition, as platforms do not participate nor intervene in the contract - they just provide the means facilitating the transaction (e.g. preparation, negotiation, or execution) - and "supply only the technical service enabling the communication or disclosing the advertisement". Platforms therefore may assume that they are exempt from all liability that may arise from a transnational contractual relationship and liability can be further narrowed down to the qualifying of the liability of the user.

The following list reflects the core challenges posed by platform economy governance identifiable within both the digital and circular economy: excessive focus on rules of conduct after A has completed the transaction; absence of the necessary tools to assess governance ex ante; and a fragmented and country-by-country evaluation of platform economy governance. The focus on ex-post rules makes it extremely difficult to orient towards a governance strategy and consequently appropriate regulatory solutions. Similarly, the medium or long-term analysis of platform governance should be complemented or replaced by an examination of these platforms at the point of entry into the marketplace. The current lack of global, regional or even multi-country regulatory co-operation on this topic further hampers the analysis.

4.2. User-Generated Content, Data Ownership, and Cross-Border Rights

Understanding private international law in the digital and circular economy requires comprehending connectivity, platform processes, data, and the implications of user-generated content. The digital economy is characterised by physical, intangible, and content-free products reaching customer interfaces and with few distributors or opponents (A., 2014). Data accompanies every activity across direct, personal, public, shared, or proprietary grounds, and platforms are core enablers of data and finalisation processes. Establishing the ownership of data used during platform interactions is crucial and raises sovereignty, territoriality, and cross-border rights or access issues. The circular economy entails progressively circular products with varying ownership structures across private, intermediate, direct, and business-to-business interactions. Imparting conditional usage enables external access, notably for

repair, refurbishing, or remanufacturing, capacity greater than before becomes requisite (Mudau, 2014).

Under the European Regulation 2017/1128 and the Directive 2021/782, Member States must guarantee the applicability of contracts concerning user-generated content to protect people from cross-border social networks, platforms, or search engines offering a greater degree of information, services, or both. Respecting compliance with local content remains paramount since losing the right or capacity to cross-link, interact, share, or inform local citizens and residents remains constitutionally guaranteed.

4.3. Interoperability, Standardization, and Transnational Regulatory Convergence

Interoperability, standardization, and transnational regulatory convergence are essential for coherent governance of digital and circular markets and their infrastructures (Selvadurai, 2013). Convergence of technology and service provision blurs the lines between traditionally distinct sectors, creating interdependencies that jeopardize effective regulation. Digital and circular economies rely on interconnected devices, platforms, and networks yet are governed by separate rules, overlapping frameworks, and divergent approaches. A minor sector-specific instance of fragmentation obstructs overall coherence and clouds regeneration pathways. Digital contracts are subject to separate materials from the broader circular economy regulatory landscape, which lacks systematic alignment with existing guidelines on digital services, data, and the metaverse. Upstream or enabling services may broadly pertain to several sectors, such as energy or construction, while including cross-sectoral components that impact diverse industries. For example, the digital economy encompasses tools, components, systems, networks, and content that support circular activities or systems - previously unrelated concepts now connected by technology. Ownership, access, control, and rights hinge upon information yet fall outside material circulation.

Establishing baselines, simplifying regulatory architecture, clarifying the existing state of play, and promoting modular action enable timely convergence within priority markets. Digital and circular transitions drive global regulatory frameworks that regulate the global flow of products, services, and data across economies. Regulatory coalitions have emerged in various sectors to foster transnational alignment of flexible, interoperable standards, tools, and approaches for all forms of sustainable innovation. Standardization enjoys a central role in supporting circularity through technical specifications, implementation strategies, and activity criteria for asset-based, platform, product-life, and usage-oriented circular business models. The preceding structures - digital, circular, and standard - have yet to converge synergistically (Carullo, 2016).

5. SUSTAINABILITY, CIRCULARITY, AND CONFLICT RULES

Private international law and the circular economy - like other cornerstones of human rights, environmental protection, international trade, and peace and security - traditionally fall within the scope of public international law. Yet the circular economy also intersects with private international law principles in other ways, especially concerning the governance of materials that circulate across borders. As circular initiatives become borderless, assessing the need for legislative frameworks in foreign markets remains crucial. Scientific standards for conducting and disclosing environmental impact assessments prior to cross-border circular transactions may also arise. Such standards would address harmonization and enforcement gaps in domestic jurisdictions with limited preventative measures. Innovative liability and redress mechanisms must ensure that businesses engaged in circular activities across jurisdictions can still invoke remedies in their home markets. Circularity thus raises core private international law challenges that, together with digitalization, constitute the twin transition's overarching impact on jurisdiction and applicable law systems (Arauzo-Carod et al., 2022); (P. Stewart, 2011).

5.1. Distinguishing Private International Law From Public International Law In Environmental Regulation

In recent years, the multilateral character of the 2030 Agenda for Sustainable Development, adopted by the UN General Assembly in September 2015, has gained increasing relevance in the context of Private International Law (PIL). The Agenda caters to the broader need for sustainability and securing a better future for humanity in a world facing significant environmental challenges (P. Stewart, 2011). The challenges posed by sustainability goals relate to both Private International Law and Public International Law, which is often the focus of a wider spectrum of pluralistic sustainability regulations, including circularity (Castel, 2001). The procedures of cross-border regulation relating to the environment - even in the context of Private International Law - gain interest in parallel to the twin transition toward the digital and circular economy (Selvadurai, 2013). It is important to distinguish the scopes of Public International Law and Private International Law relating to sustainability. Public International Law relies on the explicit creation, display, and recognition of a shared, global, and systemic societal demand for sustainability that is acknowledged to have been violated once an environmental issue arises. By contrast, Private International Law is grounded on the constructive solution of competing legal orders in national, regional, and global societies and relies on a much prescriptive and practice-oriented definition of sustainability.

The environment now figures high on the agenda of Private International Law, albeit from a different orientation than that of Public International Law. The challenge of cross-border environmental protection under Private International Law revolves around the policies of

managed competition among multiple potential Regulatory Authorities over potential damage to the environment from e-commerce. The environmental focus does not alter the structural approach to Private International Law but rather influences the choice of problems addressed through that structure. In applying this approach to the environment, three major issues relevant to the cross-border environment appear pertinent: cross-border Environmental Impact Assessments (EIAs), the applicable Law of cross-border Environmental Damage Liability, and the Liability and REMEDE for cross-border Environmental Damage.

5.2. Cross-Border Environmental Impact Analyses And Choice Of Law

Private international law governs cross-border civil disputes that arise from private or non-governmental relationships, such as those arising from damage to the environment and the circular economy (Mucmataj, 2016). In the case of environmental questions with a cross-border dimension, the jurisdiction of courts in the EU is primarily governed by the Brussels Ibis Regulation, which is applicable only to civil or commercial matters. Jurisdiction is normally determined by the domicile of the defendant; in the framework of environmental requirements, the domicile of the defendant may fall outside the EU, thus hindering access to justice with regard to civil and commercial matters.

As an additional policy issue, there is no provision in the Brussels Ibis Regulation for the obligation to conduct an environmental impact assessment when damage to the environment is under consideration. In most Member States and certain private arrangements, the obligation to conduct such an assessment has been extended to other related environmental criteria - including liability for environmental damage - and a declaration regarding the assessment conducted forms part of the disclosure duties expected from the relevant parties (Kloza, 2010). Because no such obligation is governed by the Brussels Ibis Regulation, providing an acceptable methodology for a cross-border environmental impact analysis is a prerequisite for securing jurisdictional access under the Civil Procedure Regulation and ensuring a high degree of certainty for the parties involved.

With regard to circular-economy disclosure duties, the General Court of the European Union has recognised a significant difference between the scope of public international law and the scope of private international law, underlining that cross-border proceedings with a private law context do not adopt, nor play a part in, such political business. Discussions on the circular economy represent an obligation imposed on private companies across the EU to adopt, integrate, and monitor implementation (Lund-Sørensen, 2018). The prevailing choice-of-law Determination System has shown its overwhelming but low-impact character, owing to an over-central aspect that accumulates environmental legislative initiatives but impedes interpretational or structural alignment; therefore, a more balanced methodology between public and private law is advocated for further consideration.

5.3. Liability And Redress Mechanisms Across Jurisdictions

Increasing awareness of global sustainability issues has promoted regional and worldwide regulatory initiatives. Jurisdictional and applicable law questions are crucial yet largely unexplored issues of private international law (PIL) that arise in a circular setting (Krvavac, 2011); ((Liesbeth) Enneking, 2017). Actors in the circular economy may seek to clarify which laws enable environmental objectives to be met. Data necessary for modelling circular economies travels round the globe; where data ownership is disputed, such decisions are sensitive to applicable laws in multiple jurisdictions. Intellectual property acts as a funnel to permit transnational circulation of circular economy data, corresponding efficiently with the relevant legal orders. Consequently, circularity is pursued across borders through engagement with data and governance across multiple jurisdictions. Clarifying governing laws enhances the functioning of the circular economy.

Limited research has been devoted to cross-border liability and access to redress in relation to digital and circular activities. International oversight of liability techniques is often considered extraterritorial. Liability arises within a variously regulated world, focused on accessibility, enforceability, or recognition. The modelling of digital liability remains surprisingly nascent despite dialogue concerning the proposed European Digital Liability Directive. Access to a range of circuit-based impressions on circular liability is similarly limited.

The liability mechanisms and access to redress are examined in different jurisdictions dealing with digital activities and the circular economy. Transition promoting insights from across the globe shed light on the obstacles involved in transnational access to redress and highlight trends and practices adopted in other regions and at international level.

6. COMPARATIVE PERSPECTIVES AND REGIONAL TRENDS

An overview of common, civil, and regional private international law strategies for the digital and circular economy clarifies trends and provides complementary perspectives. In common law systems, courts examine activities that trigger jurisdiction under the state's law of tort, contract, or equity. All approaches emphasize different doctrinal elements, reflecting regional digital economy risk profiles (P. Stewart, 2011).

In civil law jurisdictions, law-makers examine digital economy challenges through statutory codes, court decisions, and international legal developments. Total harmonization of substantive regulatory frameworks is unlikely; countries seek cross-border cooperation, alignment of surface rules, and equally important interpretive harmonization (Selvadurai, 2013). Jurisdictional aspects figure prominently in official regulatory program documents, have inspired codifications and interpretive guidelines (the Common Frame of Reference, the

Draft Common Frame of Reference, the Draft Principle on the Digital Economy), and pervade various codes.

Regional private international law instruments address cross-border challenges associated with the digital economy. The European Union's 2000 E-Commerce Directive, the 1998 Brussels Regulation and its 2012 recast version focus primarily on jurisdiction and the service provider's role in the dissemination of user-generated content. The United Kingdom's 2020 National Data Strategy and Government Response to the Data: A New Direction and the United States' 2022 National Cybersecurity Strategy further pursue cooperative approaches.

6.1. Common Law Approaches To Jurisdiction In Digital Economies

Internet jurisdiction and its applicability to online commercial activities are relevant and necessary topics not only in the aftermath of the WIPO Internet Domain Name Report but also in the context of the emerging digital economy. One of the primary considerations in the determination of jurisdiction over Internet transactions is the manner in which jurisdiction is projected by the regulatory authority, whether this be by way of the classic strict territoriality principle or the more recent targeting approach. The latter seeks to extend the prescriptive reach of national regulations over trans-border conduct occurring outside of national territory, based on contact points for instance, to residents of that jurisdiction. The Internet's unique characteristics - including its relative anonymity and the ease with which material can be disseminated - have significantly complicated the global projection of governmental authority. Such complexities have proven very challenging to jurisdictions in both Europe and the United States, neither of which has yet completed the formation of a satisfactory jurisdictional approach per se (Wang, 2008).

Jurisdiction is a threshold issue which must be resolved early in the litigation process. It governs whether a court has the authority to exercise sovereignty over a person or subject matter, and whether a defendant can be legally compelled to appear before that court. Typically, jurisdictional issues arise in 'cross-border' situations, which is a term that may be broadly construed in the context of trans-national intermediaries, networking, imitative non-compliance, and market injection. A more concretely defined scenario occurs where cross-border activity is performed in the digital domain - such as e-mail, the Internet, or telecommunications - using equipment that resides in, and is operated out of, multiple jurisdictions (Jerker B. Svantesson, 2012).

Jurisdictional rules governing the Internet have evolved primarily in the United States and Europe, with the scope of this discussion limited to these two jurisdictions. The doctrine currently extant in each is compared and analysed. The rules developed in the US are reviewed first, where the US Constitution and the federal system of government impose a certain degree of separation between the doctrine of territorial and personal jurisdiction, recognised as a state

function. In contrast, Europe follows a more unified approach, relying upon the doctrine of 'Community Law,' predicated on a very different set of historical experiences. Both North America and Europe manage to preserve the core principle of "governing the author and not the manuscript". Jurisdictional approaches in the United States and Europe in respect to the dissemination of trans-border content via the Internet are compared (Selvadurai, 2013).

6.2. Civil Law Methodologies And Harmonization Efforts

The digital economy has spawned unprecedented forms of commerce, giving rise to innovative digital platforms that provide services globally. Brazil has adopted measures to facilitate such commerce while targeting content featuring child exploitation, terrorism, and other abuses, causing tensions between protectionism, freedom, and the digital economy - a tension reflected in the global debate on privacy and protection laws. In parallel, environmental catastrophes have contributed to climate change and increased pressure for circular economies where products are kept in the economy longer, waste is reduced, and disassembly systems enable repair and reuse for multiple cycles. Norms regarding resource recoverability and environmental diligence, preventive measures, liability for non-compliance, and governance have all developed, seeking to avoid further global environmental damage and foster a sustainable economy with a lower footprint. Each normative extension triggers new forms of digital economy activity in search of suitable jurisdictions and laws, necessitating further inquiry into the consequences of these activities (Danov & Beaumont, 2016).

6.3. Regional Instruments And Cross-Border Regulatory Cooperation

Various jurisdictions are currently negotiating separate, cross-regional arrangements on the transnational evolution or deployment of regulatory standards. To streamline compliance efforts, regulators and policy makers across several G20 member countries are collaborating on an initiative that seeks to harmonise policies, approaches and capacity-building efforts on the digital economy, focusing on cross-border flows of information, data-protection frameworks, electronic contracts, and online-dispute resolution, among other topics (Danov & Beaumont, 2016). Similarly, a cross-regional regulatory-cooperation agreement developed by ASEAN, the EU and the Organisation for Economic Co-operation and Development (OECD), aims to facilitate co-operation among regulators to improve the regulatory environment for cross-border trade, investment and other forms of collaboration in the digital economy. Through the negotiation of legal instruments that focus on a single subject matter, such as regulatory co-operation agreements or framework agreements, countries can link multiple existing or planned international legal instruments that touch upon various economic or regulatory dimensions or extensive co-operation partnerships on the same technical subject.

In the area of applicable law, the EU remains at the forefront of cross-border regulatory co-operation on the digital economy rather than cross-border jurisdiction. Since the adoption of the General Data Protection Regulation (GDPR), the EU has engaged in a series of bilateral dialogues with third countries and regions, including Brazil, Japan and the Republic of Korea, to discuss issues linked to transboundary data flows with a view to enhancing regulatory co-operation, such as regulatory equivalence or interoperability.

7. POLICY IMPLICATIONS AND REFORM PROPOSALS

The twin transition to digital and circular economies offers both challenges and opportunities for the operation of private international law. Amidst these developments, jurisdictional rules and rules for determining applicable law should be approached in a coherent manner. The current condition is that the twin transition generates uncertainty for private international law, in relation to both jurisdiction and applicable law.

Coherent jurisdictional rules are needed to clarify the technological and methodological uncertainty created by the twin transition. Such rules should aim to be clear, predictable, and efficient. A single unifying principle may not be feasible, given the diversity of contexts, actors, and regulatory models. Nevertheless, a set of relevant principles for jurisdiction in the digital and circular economy can be articulated to guide the search for jurisdictional solutions.

Applicable law rules should be set on a harmonised basis, taking territoriality and basic connective criteria into account. Substantial convergence exists between existing regional frameworks; a broader global consensus on applicable law for the circular economy could therefore promote convergence within a wider circle. In addition, a modular approach to conformity with existing frameworks should enhance the possibility of applicable law convergence on a broader basis. Automatic travelling rules should also be specified instead of attaching options or designations to the operation of circular economy activities.

A reliable legal environment encourages active participation in digital and circular economy activities and fosters interest in their widespread adoption. Access to justice, and hence legal certainty, remains an underlying consideration for the growth of the digital and circular economy. Efforts to safeguard jurisdiction in a context where broad governance principles are under discussion and proposed should therefore be vigilant to ensure the maintenance of access to effective routes, a key element of legal machinery. Further, the cost and complexity of undertaking cross-border digital economy activities - including dispute resolution - remain significant deterrents to participation. Among the lowest-cost form of dispute resolution available, arbitration nevertheless requires initial outlay of formal text; regulations for the imposition of additional stages, multi-party arrangements, or other structural requirements can add to this burden. In the absence of systematic efforts to contain such costs, continued

reliance on developing national options - rather than engagement with competing cross-border proposals - appears likely.

7.1. Principles For Coherent Jurisdictional Rules In The Twin Transition

Jurisdiction governs a state's power to hear a dispute, arising mainly from an international obligation imposed by principles of comity in a transboundary context. An action falls within a state's jurisdiction if it is subject to its controlling authority, which is not restricted to conventional territorial power (Selvadurai, 2013). A state's exercise of jurisdiction is unnecessary if the parties are not entitled to access its courts or if their rights are protected against the state's actions or conduct. Jurisdiction depends on whether the state has a legitimate authority to regulate the matter, rather than whether a national court has a mandate or is obliged to clarify state governance.

7.2. Recommendations For Harmonized Applicable Law Standards

Ensuring adherence to a single, predictable, and efficient legal regime facilitates cross-border transactions. Formal harmonization mechanisms vary in speed and applicability. Consequently, various initiatives promote convergence, deliberately setting modular conditions. By espousing a common governing-law approach, rules invite partial adoption.

The digital economy and circular economy, the twin transitions, drive regulatory responses. Jurisdictional solutions seek clarity, supporting legal and commercial actors. Inclusive frameworks balance legal certainty with technical neutrality (P. Stewart, 2011).

7.3. Access To Justice And Predictable Legal Environments For Digital And Circular Economy Actors

Actors in the digital and circular economy require access to justice and a predictable legal environment to facilitate financing and investment, technological adoption, and transitions towards environmentally friendly enterprise models. A coherent framework addressing jurisdiction and applicable law for private international law is critical to providing this predictability and connectivity (Kloza, 2010) and to informing the efficient resolution of disputes. Stakeholders benefit from timely dispute avoidance and resolution, and cross-border interactivity increases significantly (Selvadurai, 2013). Complexity arises across private international law principles encompassing dispute settlement, forum selection, and the harmonization of obligation types and operation. A constellation of parameters surrounds market demand, contract formation, and liability assignment, while the circular economy adds challenges related to temporary possession, responsibility assignment, and reverse activities. The substantive scope of private international law therefore remains critical across areas like copyright, e-commerce, taxation, personal data protection, product liability, the internet of things, sustainability, technology convergence, the circular economy, and trade.

8. CONCLUSIONS

The dual challenges of the twin transition - climate change and digitalization - are exerting pressure to rethink private international law. The shift to a circular economy aims to overcome the linear 'take-make-dispose' model and the associated environmental burden. Its objective coincides with equal access to, and control over, data to navigate the digital economy while respecting privacy and confidentiality and thus maintaining the competitive edge. Jurisdiction and applicable law interact repeatedly and are subject to various pressures based on technical, economic, and legal tenets. Owing to ongoing changes, assessment remains dependent on targeted concepts, objectives, and actors. Consequently, no general solution can be prescribed or even envisaged in isolation. Climate change and digitalisation challenge society across economic areas and jurisdictions, triggering disruptive developments. Every corner of the planet feels the repercussions. Private international law remains critical in such matters.

Jurisdiction-based approaches continue to explore contemporary issues without overwhelming consensus or converging on universally applicable rules; common ground is essential, not universal solutions. Moving further into the uncharted regulatory territory accompanying jurisdiction and applicable law in respect of the circular economy and digital economy raises diverse, often educating questions. Addressing such questions broadens the perspective on a polycentric normative system for commerce, trade, and finance and on law in the digital economy. Academic inquiry and operational activity extend beyond legislative scrutiny of topical economic sectors to jurisdictional, international, regulatory, digital, and circular fields aggregate insights and produce converging concepts and rules. Public international law pursues sustainability governance beyond environmental constraints, striving for efficient and equitable allocation of natural resources, the circular economy plays a significant role within selected territorial boundaries, efficient and equitable occurrence of movement regulation via internet-based systems is critical for law all-over sustainable development, and thereby the grounds assume importance again on systems intended to contribute to. Suppression of knowledge mobilises attention on much broader issues.

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POLITICAL ECONOMY AND GLOBAL PRODUCTION IN THE TWIN TRANSITION

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Abstract

This paper studies the governance of the twin transition, which combines digitalisation and the green transition. It focuses on international trade, global value chains (GVCs), and macroeconomic changes. The study aims to understand how digital technologies and sustainability policies are changing global production systems. The paper uses a conceptual and analytical approach to examine how value is created and shared across countries. It highlights the role of circular economy practices and digital transformation in shaping trade and production. The findings show that while digital technologies improve efficiency and support sustainable production, they can also increase resource use and environmental pressure if not properly regulated.

The study also finds that changes in supply chains toward resilience and sustainability are affecting global competition. Developed countries may gain more benefits, while developing countries may face challenges. At the macro level, the twin transition is changing jobs, investment patterns, and productivity.

The paper concludes that better international coordination is needed. Policies should connect trade, finance, and industrial strategies to ensure fair and inclusive growth.

Keywords: Twin Transition, Digitalisation, Green Economy, Global Value Chains, International Trade, Circular Economy, Macroeconomics, Sustainability Governance

NEUROSOVEREIGNTY: CIVILISATIONAL POWER AND THE ALGORITHMIC REWRITING OF GLOBAL TRADE

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Abstract

The emergence of artificial intelligence as a structural force in global economic systems has introduced a new paradigm of power that transcends conventional understandings of sovereignty, trade, and geopolitical competition. This paper introduces and develops the conceptual framework of NeuroSovereignty — defined as the strategic capacity of state and non-state actors to govern, deploy, and leverage algorithmic infrastructures, data architectures, and cognitive economic systems as instruments of civilisational power. Drawing on interdisciplinary scholarship from international trade theory, AI governance, digital political economy, and civilisational studies, the paper examines how intelligent trade systems are rewriting the foundational logics of global economic governance. It critically analyses the European Union's digital strategy, ongoing World Trade Organization debates on e-commerce, semiconductor supply chain geopolitics, and the consolidation of platform monopolies as vectors of asymmetric structural power. The paper argues that NeuroSovereignty represents not merely a technological upgrade to the existing international order but a qualitative shift in civilisational competition — one in which algorithmic control functions as the new currency of geopolitical authority.

Keywords: Neurosovereignty, Algorithmic Governance, Digital Sovereignty, AI Political Economy, Global Trade Architecture

INTRODUCTION

The geopolitical imagination has long been shaped by the classical instruments of power — territory, capital, military capacity, and diplomatic leverage. Yet the twenty-first century has introduced a fourth layer of geopolitical contestation that operates neither at the border nor on the battlefield, but within the architecture of intelligent systems. Algorithmic infrastructures, machine learning platforms, data ecosystems, and semiconductor supply chains have quietly become the load-bearing pillars of contemporary economic power. Their significance is not merely technological; it is civilisational in the deepest sense. Nations that govern these architectures effectively do not simply participate in global trade — they define its rules, rhythms, and long-run hierarchies.

It is within this context that the present paper introduces the concept of NeuroSovereignty, a theoretical framework designed to capture the qualitative transformation underway in global power structures. *NeuroSovereignty* refers to the strategic capacity of states, supranational bodies, and dominant platform corporations to architect, regulate, and leverage cognitive-algorithmic infrastructures — encompassing AI systems, data governance regimes, intelligent industrial platforms, and digital trade corridors — in ways that produce durable geopolitical asymmetries. Unlike conventional notions of digital sovereignty, which focus primarily on jurisdictional data control, NeuroSovereignty encompasses the deeper political economy of intelligent systems: their role in reshaping comparative advantage, restructuring global value chains, and generating novel forms of structural dependence between nations.

The urgency of this analysis cannot be overstated. The global digital economy is expanding at a pace that existing international governance frameworks are ill-equipped to manage. United Nations Conference on Trade and Development (2022) has documented how cross-border data flows now generate more economic value than traditional goods trade in several advanced economies, while the World Trade Organization's e-commerce negotiations — ongoing since the 2017 Buenos Aires Ministerial Conference — remain chronically incomplete. Meanwhile, the European Union has embarked on an extraordinarily ambitious legislative programme — the AI Act, the Digital Markets Act, the Data Act, and the European Chips Act — seeking to establish Brussels as the regulatory anchor of the global digital order. The United States and China, for their part, are engaged in an escalating contest over semiconductor dominance, AI research leadership, and the geopolitical routing of data infrastructure. These developments together constitute what this paper characterises as the algorithmic rewriting of global trade.

The paper proceeds through a sequence of analytically interlocking sections. Following a critical literature review and the elaboration of the NeuroSovereignty framework, it examines how algorithmic systems function as geopolitical instruments, how the EU and

WTO are emerging as contested arenas of techno-political restructuring, how platform capitalism generates structures of data hegemony, and how the green digital transition introduces new dimensions of algorithmic power and dependency. The paper concludes with a set of forward-oriented policy recommendations designed to foster more equitable and resilient intelligent trade governance.

1. LITERATURE REVIEW

The scholarly terrain relevant to this paper spans several disciplines, each contributing partial but indispensable insights into the phenomenon under investigation. International trade theory has undergone significant revision in the digital age. Baldwin (2016) demonstrated that information and communication technologies had fundamentally altered the geography of global value chains, enabling firms to fragment production across borders in previously impossible ways. Yet Baldwin's framework, grounded in goods trade and manufacturing, struggles to capture the strategic dynamics of data-driven, platform-mediated commerce. More recent contributions have sought to address this gap. Rodrik (2021) has argued that the political economy of globalisation must now contend with powerful distributional consequences that digital trade intensifies rather than resolves, particularly in economies with limited AI absorption capacity.

The literature on digital sovereignty has grown substantially since the mid-2010s. Pohle and Thiel (2020) offer a foundational typology of digital sovereignty, distinguishing between state-centric, market-liberal, and multi-stakeholder approaches. Their work reveals that sovereignty in the digital domain is not a fixed condition but a contested political project, shaped by divergent normative commitments and institutional capacities. This insight aligns with the broader work of Grewal (2008) on network power, which demonstrated that structural positions within networked systems confer forms of authority irreducible to conventional state capacity. The actor who occupies a central node in a critical network exercises a form of governance power that no formal sovereignty claim adequately captures.

Platform capitalism has been theorised most rigorously by Srnicek (2017), who identifies the platform as the dominant business model of contemporary capitalism — a digital infrastructure that extracts and processes data as its primary raw material. Zuboff (2019) extends this analysis through the concept of surveillance capitalism, arguing that behavioural data has become the central commodity around which a new economic logic of prediction and control has been organised. Both frameworks carry significant implications for trade governance, revealing how privately governed platforms have become the de facto infrastructure of international commerce. The complementary work of van Dijck, Poell, and de Waal (2018) on the platform society illuminates how these dynamics extend beyond purely economic registers into the broader fabric of social and political life.

On the geopolitics of technology, Farrell and Newman (2019) developed the seminal concept of weaponised interdependence, demonstrating how states strategically exploit their central positions in global networks — financial, digital, and informational — to coerce rivals and reward allies. Their framework has been widely applied to semiconductor export controls, cloud computing restrictions, and data localisation requirements. Miller (2022) provided a detailed historical account of how a small number of firms and fabrication facilities in Taiwan, South Korea, the Netherlands, and the United States constitute critical chokepoints in the global production of intelligent machines, revealing the material foundations of the NeuroSovereignty contest.

The governance of artificial intelligence has attracted a rapidly expanding scholarly literature. The Organisation for Economic Co-operation and Development's AI Principles (2019) and the EU's Artificial Intelligence Act (European Commission, 2021) represent the most institutionally significant attempts to develop binding AI governance frameworks, though scholars have noted significant implementation gaps and regulatory asymmetries across jurisdictions (Roberts et al., 2021). Mazzucato (2021) provides an important counterweight to market-centred accounts, arguing that strategic state leadership in AI infrastructure is essential to prevent the concentration of cognitive capacity in a small number of private actors. Castells (2010) established that power in the network society flows through informational architectures rather than through territorially bounded states, while Bratton (2015) extended this insight through his concept of The Stack — a planetary computational architecture through which digital infrastructure constitutes a new form of sovereignty overlapping with, but not reducible to, existing state authority. What the existing literature has not yet provided is a unified conceptual framework integrating these threads into a coherent analytical paradigm suited to the current historical moment. NeuroSovereignty is offered precisely as that framework.

2. THEORETICAL FRAMEWORK

The concept of NeuroSovereignty rests on three constitutive pillars, each capturing a distinct but interrelated dimension of algorithmic power in contemporary international relations.

The first pillar is cognitive infrastructure control. This refers to the capacity of an actor — whether a state, supranational body, or dominant platform — to own, regulate, or decisively influence the systems through which economic intelligence is generated and distributed. Cognitive infrastructure encompasses the hardware layer (semiconductors, data centres, undersea cables), the software layer (AI models, algorithmic trading systems, automated logistics platforms), and the data layer (the accumulation and processing of commercially, strategically, and politically significant information). The actor who commands cognitive infrastructure commands not merely a technological advantage but a structural position of

interpretive and predictive power — the capacity to anticipate, shape, and sometimes predetermine the economic behaviours of others.

The second pillar is algorithmic trade architecture. International trade has always been shaped by rules, standards, and institutional frameworks — from the General Agreement on Tariffs and Trade to the WTO's trade facilitation agreements. In the digital age, however, a new and less visible layer of trade architecture has emerged: the algorithmic systems that determine search rankings, price formation, logistics routing, credit scoring, risk assessment, and market access. These systems are not politically neutral. They embed the preferences, assumptions, and strategic interests of their designers. A logistics algorithm optimised for cost efficiency in high-infrastructure environments may structurally disadvantage producers in lower-income economies. A platform's algorithmic curation of market visibility may function as a non-tariff barrier without ever appearing in any formal trade agreement.

The third pillar is civilisational projection. This refers to the capacity of an actor to extend its cognitive and normative frameworks — its technical standards, governance models, ethical principles, and technological architectures — outward into the international system. The European Union's regulatory export strategy, through which General Data Protection Regulation-style data protection norms and AI risk frameworks have diffused across jurisdictions far beyond its borders, exemplifies one form of civilisational projection. The Chinese Digital Silk Road, which embeds Chinese telecommunications and AI infrastructure in partner nations across Africa, Asia, and Latin America, represents another. The American model of platform openness, which naturalises privately governed, algorithmically mediated markets as the default architecture of the global digital economy, constitutes a third and arguably the most globally pervasive form.

Table 1. Comparative Dimensions of Digital Sovereignty Concepts

Concept	Primary Focus	Scale	Analytical Register
Digital Sovereignty	Jurisdictional data control	State	Legal-institutional
Techno-nationalism	Industrial policy; supply chain security	State	Economic-strategic
Platform Governance	Regulatory oversight of digital platforms	Multi-level	Regulatory-political
NeuroSovereignty	Cognitive infrastructure, trade architecture, civilisational projection	State / Supranational / Platform	Geopolitical-civilisational

Note: Author's conceptual synthesis.

NeuroSovereignty differs from existing concepts in two crucial respects. First, unlike digital sovereignty — which tends to focus on the defensive assertion of jurisdictional control — NeuroSovereignty is simultaneously defensive and projective, capturing both the capacity to resist external algorithmic penetration and the capacity to extend one's own cognitive architectures outward. Second, unlike techno-nationalism or technological sovereignty, which operate primarily at the level of industrial policy, NeuroSovereignty is explicitly civilisational in register: it situates algorithmic power within long historical cycles of civilisational competition and structural transformation, connecting the present moment of AI contestation to deeper logics of hegemonic succession.

3. METHODOLOGY

This paper adopts a qualitative, interpretive research design appropriate to its theoretical and conceptual objectives. Given that NeuroSovereignty is introduced as a new analytical framework rather than a hypothesis to be tested against a fixed dataset, the methodological approach prioritises conceptual development, critical discourse analysis, and comparative institutional analysis.

Three primary methodological tools are employed. First, critical document analysis is applied to a corpus of policy texts, institutional reports, and strategic communications from the European Union, the World Trade Organization, the OECD, UNCTAD, the International Monetary Fund, the World Bank, and the World Economic Forum. These documents are read not merely as descriptive accounts but as performative texts that actively construct the problems, interests, and governance logics they purport to describe. Second, comparative case analysis examines the digital governance strategies of the three major civilisational blocs — the United States, the European Union, and China — across the dimensions of AI regulation, semiconductor strategy, platform governance, and digital trade policy. Third, conceptual analysis draws on the interdisciplinary literature reviewed in the preceding section to develop and critically stress-test the NeuroSovereignty framework against existing theoretical alternatives.

The paper does not claim to produce causal explanations in the positivist sense. Rather, it develops a theoretically coherent and empirically grounded interpretive framework capable of illuminating dynamics that existing analytical categories leave obscure. This methodological position is consistent with the tradition of critical international political economy represented by Strange (1988), Grewal (2008), and Zuboff (2019), who have each demonstrated that structural power in global systems cannot be adequately grasped through quantitative measurement alone. The principal limitation of this approach lies in its necessary selectivity: the breadth of NeuroSovereignty as a concept means that no single paper can

provide equally deep coverage of all relevant empirical domains, and specific sectors, regions, and institutional contexts identified in what follows merit further specialised investigation.

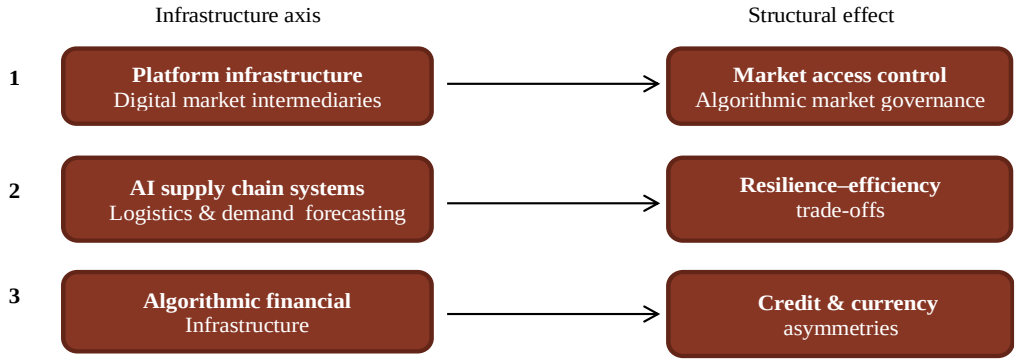
4. GLOBAL TRADE AND ALGORITHMIC POWER STRUCTURES

The transformation of global trade by algorithmic systems has proceeded along several intersecting axes, each contributing to the reconfiguration of international economic hierarchy. The most visible is the emergence of digital platforms as the dominant infrastructure of cross-border commerce. Platforms such as Amazon, Alibaba, and Shopee no longer merely facilitate trade — they constitute the market itself. Their algorithmic systems determine product visibility, price formation, seller reputation, and consumer access in ways that function as de facto market governance mechanisms. UNCTAD (2021) has documented how a small number of platforms command extraordinary shares of digital retail trade, with the top digital platforms collectively reaching market capitalisations that exceed the GDP of all but the largest national economies. The political economy implications are profound: firms and producers in developing economies seeking global market access must do so through platform intermediaries whose algorithmic logics they neither control nor fully understand.

The second axis concerns the algorithmic transformation of global supply chains. The COVID-19 pandemic exposed with particular clarity the fragility of just-in-time supply chain models optimised by algorithmic efficiency metrics that systematically underweighted resilience. AI-driven demand forecasting, inventory management, and logistics routing had, over the preceding decade, stripped out redundancies that earlier supply chain models retained as buffers against disruption. The result was a system of extraordinary efficiency under normal conditions and catastrophic vulnerability under stress. Pandemic-era shortages of semiconductors, medical equipment, and essential goods dramatised the risks that uncritical algorithmic supply chain optimisation creates when applied to strategically critical sectors (World Trade Organization, 2021).

A third axis is the algorithmic restructuring of financial flows in global trade. Fintech platforms, AI-powered credit scoring systems, and algorithmic foreign exchange markets are reshaping the financial infrastructure through which trade is financed and settled. For developing country exporters, algorithmically determined credit risk assessments frequently replicate and amplify existing structural disadvantages, restricting access to trade finance in ways that reflect not only genuine credit risk but also the limited data availability and institutional context that models trained predominantly on data from advanced economies cannot adequately process. The World Bank (2021) has highlighted the trade finance gap facing small and medium enterprises in developing economies as one of the most consequential structural barriers to equitable participation in global trade — a gap that algorithmically governed financial systems risk entrenching rather than closing.

Figure 1. Algorithmic Power in Global Trade: Three Structural Axes



Note: Author's theoretical synthesis.

A fourth axis, less discussed in existing literature, involves the algorithmic governance of technical standards in digital trade. The actor who sets standards for data formats, interoperability protocols, and AI model architectures in effect sets the de facto rules of digital commerce. This standards competition is already visible in the divergence between American, European, and Chinese technical frameworks in areas ranging from 5G telecommunications to AI model governance specifications. As Baldwin (2016) recognised in the context of goods trade, technical standards have always functioned as non-tariff barriers — a dynamic that becomes considerably more consequential when the standards in question govern the cognitive infrastructure of the entire global economy.

5. NEUROSOVEREIGNTY AND CIVILISATIONAL GOVERNANCE

The civilisational dimensions of NeuroSovereignty become most apparent when examined through the lens of long-run structural competition between major powers. The contemporary contest over AI, semiconductors, and data architecture is not simply a trade dispute or a regulatory disagreement. It is a competition over the civilisational architecture of the coming century, in which the terms of global economic integration — and the hierarchies those terms embed — are being renegotiated through algorithmic means rather than through formal international agreements.

The United States has historically exercised NeuroSovereignty through a combination of private platform dominance and public-private investment in foundational research. The American model naturalises platform capitalism as the default form of digital market organisation, diffusing its algorithmic logic globally through network effects, open-source software ecosystems, and the cultural prestige of Silicon Valley. American technology giants — Google, Amazon, Meta, Microsoft, and Apple — govern informational flows on a

planetary scale, embedding the normative assumptions of liberal techno-capitalism into the cognitive infrastructure of the global economy. What presents itself as a universal architecture of open digital commerce simultaneously functions as a vehicle for the projection of American economic and normative power, a dynamic that the NeuroSovereignty framework renders analytically visible.

China has pursued a qualitatively different path toward NeuroSovereignty. Through its New Generation Artificial Intelligence Development Plan of 2017 and the Digital Silk Road initiative embedded within the Belt and Road framework, Beijing has pursued algorithmic sovereignty through state-directed investment, domestic market protection, data nationalism, and strategic infrastructure export. Chinese AI champions — Huawei, Alibaba, ByteDance, and Baidu — have built deeply integrated platforms that combine commercial scale with political accountability to the Chinese party-state. The export of Chinese digital infrastructure to partner countries in Africa, Southeast Asia, and Central Asia represents a form of civilisational projection that the NeuroSovereignty framework is specifically designed to capture and analyse.

The European Union occupies a distinctive and strategically ambiguous position in this civilisational contest. It lacks the platform giants of either the United States or China, yet possesses arguably the most developed regulatory architecture for AI and data governance anywhere in the world. The EU's strategy has been to exercise civilisational projection through regulation — the Brussels Effect described by Bradford (2020), through which GDPR, the AI Act, and the Digital Markets Act have functioned as de facto global standards by virtue of the Union's market size and institutional legitimacy. This regulatory NeuroSovereignty is real but fragile: it depends on the willingness of platform actors to comply, on the institutional capacity of member states to enforce technically complex regulations, and on the EU's ability to develop sufficient domestic cognitive infrastructure to give its regulatory framework genuine structural backing.

The civilisational stakes of this contest extend well beyond the economic. Control over algorithmic infrastructure carries profound implications for epistemic autonomy — the capacity of societies to form independent judgements, access diverse information, and deliberate authentically about collective futures. When the cognitive architecture of a society's information environment is governed by algorithmic systems designed in and for a different civilisational context, a form of epistemic dependency emerges that is at least as significant as any conventional form of economic dependence. Couldry and Mejias (2019) have theorised a related phenomenon as data colonialism — the extraction of behavioural data from populations in ways that reproduce colonial patterns of resource extraction and structural subordination at a global scale, a dynamic that NeuroSovereignty situates within the broader context of civilisational power competition.

6. EU, WTO AND THE POLITICS OF INTELLIGENT TRADE

The institutional politics of intelligent trade are nowhere more contested than in the arenas of the European Union and the World Trade Organization. Both institutions are attempting — with uneven success — to govern forms of economic activity and power that their founding frameworks were never designed to address.

The EU's legislative programme on digital governance represents the most ambitious regulatory intervention in the global digital economy to date. The General Data Protection Regulation, implemented in 2018, established a rights-based framework for personal data processing that has become the most widely replicated data governance model globally. Its successor instruments — the Digital Markets Act, which designates dominant platforms as gatekeepers subject to ex ante obligations; the Digital Services Act, which governs platform liability and content moderation; the Data Act, which seeks to expand access to non-personal data generated by connected devices; and the AI Act, which establishes a risk-based regulatory classification system for AI applications — collectively constitute a regulatory architecture of unprecedented scope and ambition (European Commission, 2021; 2022; 2023).

The strategic logic animating this programme is twofold. First, by establishing rigorous governance standards for algorithmic systems and data markets, the EU aims to create conditions in which European digital industries can compete on terms of trust and quality rather than on scale and network effects — domains where American and Chinese incumbents hold commanding advantages. Second, through the Brussels Effect, the EU seeks to export its regulatory model as a de facto global standard, thereby shaping the civilisational architecture of the digital economy in accordance with European values of fundamental rights, democratic accountability, and market contestability.

Table 2. Key EU Digital Governance Instruments and Their Trade Implications

Instrument	Year	Primary Objective	Trade Governance Implication
GDPR	2018	Personal data rights and protection	Data transfer restrictions; adequacy decisions framework
Digital Markets Act	2022	Gatekeeper platform regulation	Ex ante market access and interoperability obligations
Digital Services Act	2022	Platform liability and content governance	Platform due diligence and transparency requirements
AI Act	2024	Risk-based AI application regulation	Compliance costs; conditional market access for AI systems

Instrument	Year	Primary Objective	Trade Governance Implication
European Chips Act	2023	Semiconductor manufacturing capacity	Supply chain resilience; strategic industrial policy
Data Act	2024	Non-personal data access and sharing	Business data portability; interoperability obligations

Note: European Commission legislative documents; author's synthesis.

The practical limits of this strategy are, however, substantial. The EU's domestic AI and platform ecosystem remains considerably smaller than its American and Chinese counterparts. The European Chips Act aims to double Europe's share of global semiconductor manufacturing to 20 per cent by 2030, but the scale of investment required and the depth of the technological gap with existing leaders have prompted scepticism about the feasibility of this target within the stated timeframe. More fundamentally, regulatory leadership without industrial leadership creates a persistent strategic asymmetry: the EU can set the rules, but the most consequential algorithmic systems will continue to be designed, trained, and deployed primarily within other jurisdictions.

Within the WTO, digital trade governance remains a site of structural impasse. The Joint Statement Initiative on e-commerce, launched in 2017 and involving over 80 member states, has made meaningful but limited progress toward a binding multilateral framework for digital trade. Key areas of convergence have emerged on electronic authentication, spam regulation, and consumer protection, but fundamental divisions persist over data localisation, cross-border data flows, and the treatment of platform intermediaries. The 1998 moratorium on customs duties on electronic transmissions — renewed repeatedly at Ministerial Conferences — has itself become a contested political symbol, with developing countries increasingly questioning whether indefinite duty-free treatment of digital commerce serves their development interests. The structural limitations of the WTO in the face of digital trade dynamics reflect a deeper institutional design problem: its legal architecture, built around national treatment, most-favoured-nation treatment, and tariff bindings, was developed in an era of goods trade and does not map cleanly onto the economics of platform markets, data flows, or AI-mediated services — creating a regulatory vacuum that major platform actors have exploited with considerable strategic sophistication.

7. PLATFORM CAPITALISM AND DATA HEGEMONY

The political economy of platform capitalism constitutes one of the most consequential dimensions of NeuroSovereignty. Srnicek (2017) identifies five distinct platform types — advertising, cloud, industrial, product, and lean — each characterising a different mode of

extracting value from data. In the context of global trade, the cloud platform and the advertising platform are of particular structural significance: together, they constitute the infrastructure through which an expanding share of international commerce is mediated, financed, and governed.

Data hegemony — the structural capacity to accumulate, process, and strategically deploy data at a scale that confers decisive cognitive advantages — is distributed profoundly unequally across the global economy. A small number of American and Chinese platforms account for a dominant share of global data generation and processing capacity. This concentration carries several critical implications for trade governance. It generates massive asymmetries in predictive power: platform firms with access to global consumer and producer data can anticipate market movements, identify demand patterns, and optimise pricing strategies with a precision that no individual firm or national statistical authority can match. It also creates structural dependencies that resemble — and in some respects exceed — the dependencies that characterised earlier phases of economic globalisation.

The concept of data colonialism, developed by Couldry and Mejias (2019), provides a powerful analytical lens for understanding how these dynamics reproduce patterns of extraction and structural subordination at a global scale. Just as colonial economies were integrated into global systems primarily as suppliers of raw materials processed into value elsewhere, so the economies of the Global South are increasingly integrated into the digital economy primarily as generators of raw behavioural data — data processed by algorithmic systems designed and owned in the Global North, with the resulting value flowing disproportionately to a small number of platform actors concentrated in a handful of jurisdictions.

This dynamic carries concrete implications for trade in services. The OECD (2022) has noted that digital services exports from high-income countries are growing substantially faster than those from lower-income countries, partly as a consequence of data-processing and AI-capability advantages concentrated in advanced economy platforms. When a firm in a developing economy uses a dominant platform's logistics, payment, or advertising services, it transfers data that strengthens the platform's algorithmic capabilities while simultaneously deepening its own dependence on that platform's architecture. The cumulative effect, aggregated across millions of firms and billions of transactions, constitutes a form of structural lock-in that conventional trade policy tools are poorly equipped to address. Khan (2017) has similarly argued that existing antitrust frameworks are structurally ill-suited to addressing the competitive advantages that platform data accumulation creates — a limitation that becomes considerably more consequential when projected to the global scale of NeuroSovereignty competition.

8. GREEN TRANSITION AND POST-CARBON ALGORITHMIC ECONOMIES

The intersection of the digital transition and the green transition represents one of the most significant and understudied dimensions of NeuroSovereignty. The two transitions are deeply entangled: algorithmic systems are simultaneously enabling forces for decarbonisation and significant contributors to the energy demand that must itself be decarbonised.

On the enabling side, AI systems are demonstrably powerful instruments for optimising energy systems, reducing industrial emissions, and accelerating materials discovery for clean energy technologies. Intelligent grid management systems, which use machine learning to balance variable renewable energy supply with demand in real time, have demonstrated capacity to increase grid efficiency and accommodate higher shares of renewable generation. AI-driven building management, precision agriculture, and smart manufacturing systems are reducing energy intensity across major emitting sectors. The potential of AI to support ambitious decarbonisation pathways is substantial — provided its deployment is coupled with appropriate governance frameworks and the considerable energy footprint of the systems themselves is systematically addressed.

On the resource intensity side, the computational demands of large-scale AI training and deployment have raised serious concerns about the energy and water footprints of frontier AI development. The concentration of this computational demand in a small number of hyperscale data centre operators — primarily American cloud platforms — creates both environmental and geopolitical dependencies. Crawford (2021) has provided a searching analysis of the planetary resource costs embedded in AI systems, including the mining of minerals for hardware, the water consumption of data centre cooling, and the carbon intensity of energy-hungry model training — costs that are systematically externalised from AI's economic valuations and absent from most governance frameworks.

The NeuroSovereignty dimensions of the green digital transition are considerable. Nations with large renewable energy endowments and the capacity to develop green data centre infrastructure may acquire significant competitive advantages in the AI landscape of the coming decade. Conversely, nations dependent on carbon-intensive energy grids may find their AI ambitions constrained not only by capital and talent shortages but by carbon regulatory costs attending instruments such as the EU's Carbon Border Adjustment Mechanism as it extends its reach into digital sectors. The European Green Deal explicitly links the digital and green transitions, recognising that neither can succeed without the other. As the EU moves to embed carbon pricing into trade policy and green digital standards become conditions of market access, the regulatory architecture of the green transition becomes a new and consequential terrain of algorithmic trade governance — one in which NeuroSovereignty asymmetries will be strikingly evident.

9. EMERGING GLOBAL RISKS AND STRATEGIC DEPENDENCIES

The NeuroSovereignty competition carries a set of systemic risks that require explicit analytical attention. Chief among these is the danger of algorithmic monoculture — the concentration of cognitive infrastructure in a small number of architectural paradigms, owned and controlled by a small number of actors, creating global systemic fragility analogous to the biodiversity loss that threatens ecological systems. Homogeneity in AI architecture means that systemic vulnerabilities — in training data composition, in model assumptions, in security protocols — are replicated globally rather than distributed across diverse systems, creating conditions for cascading failures with potentially severe civilisational consequences.

Semiconductor supply chain concentration represents the most immediate and material dimension of strategic dependency. As Miller (2022) documents comprehensively, the production of advanced logic chips depends on a remarkably concentrated global value chain, with TSMC in Taiwan fabricating the most advanced processors, ASML in the Netherlands monopolising the extreme ultraviolet lithography equipment necessary for their manufacture, and a small number of American design firms producing the chips that drive AI workloads globally. Geopolitical disruption to any of these nodes — whether through military conflict, export restrictions, or natural disaster — would cascade through the global AI ecosystem with potentially severe and lasting consequences.

The weaponisation of semiconductor interdependence is already underway. American export controls on advanced chips and chip-manufacturing equipment to China, introduced in 2022 and subsequently extended, represent a deliberately strategic use of chokepoint power in the AI supply chain — an application of Farrell and Newman's (2019) weaponised interdependence framework to the domain of hardware infrastructure. China's response — massive domestic investment in semiconductor self-sufficiency, coupled with diplomatic efforts to build alternative supply chains — has created a dynamic of technological decoupling whose full long-run consequences remain uncertain but whose structural significance is already apparent in the reorganisation of global technology investment and trade flows.

Beyond semiconductors, strategic dependencies in cloud computing infrastructure, AI talent pools, data localisation architectures, and undersea cable networks all constitute dimensions of NeuroSovereignty vulnerability. The risk of AI-enabled economic coercion deserves particular recognition: a nation whose critical economic systems — logistics, finance, energy, communications — are deeply integrated with AI infrastructure governed by a geopolitical competitor faces a dimension of coercive vulnerability that combines the logics of economic sanction with the structural intimacy of cognitive infrastructure dependency. Addressing these risks requires not only national industrial policy responses but a fundamental reimagination

of international economic governance frameworks equipped for the realities of the algorithmic age.

10. FUTURE OF INTELLIGENT SOVEREIGNTY AND TRADE GOVERNANCE

The trajectory of NeuroSovereignty competition over the coming decade will be shaped by several intersecting forces: the pace and distribution of AI capability development, the evolution of international governance frameworks, the political economy of the green transition, and the capacity of multilateral institutions to adapt to a fundamentally altered structural environment.

Several plausible futures can be identified. A scenario of regulatory convergence — in which the EU's risk-based AI governance framework gradually achieves global influence, driving convergence around shared standards for algorithmic accountability, data rights, and platform contestability — would represent perhaps the most favourable outcome for equitable global trade governance. This scenario requires not merely the continued diffusion of the Brussels Effect but a genuine commitment by the EU to developing governance frameworks that serve the interests of developing economy participants, not merely those of European market actors.

A scenario of digital bipolarity — in which the global digital economy bifurcates into American and Chinese spheres of algorithmic influence, with other nations compelled to align with incompatible technical standards, platform ecosystems, and governance frameworks — represents a considerably more problematic trajectory. In this scenario, the costs of NeuroSovereignty competition are borne disproportionately by smaller economies, whose firms must navigate duplicated regulatory requirements, whose data is bifurcated across competing platforms, and whose strategic autonomy is structurally constrained by the choices of the major powers. The parallels with earlier moments of great-power competition — when smaller nations were compelled to choose sides in conflicts whose terms they had no part in shaping — are analytically instructive.

A third scenario, distributed NeuroSovereignty, envisions the emergence of meaningful regional and sub-regional AI governance initiatives — in Africa through the African Union's Digital Transformation Strategy, in Southeast Asia through the ASEAN AI Governance Framework, and in Latin America through emerging regional digital integration efforts — that create a more genuinely multipolar landscape of intelligent trade governance. This scenario is aspirational rather than immediately probable, as it requires sustained investment in digital infrastructure, AI capacity, and governance institutions that most developing regions currently lack. It nonetheless represents the most plausible route toward a more equitable global algorithmic order, and the international community's commitment — or its absence — to enabling this scenario will be among the most consequential governance decisions of the decade ahead.

11. POLICY RECOMMENDATIONS

Drawing on the foregoing analysis, eight interconnected policy recommendations are advanced, oriented toward a more equitable, resilient, and democratically accountable architecture of intelligent global trade governance.

Establish a Global Framework on Algorithmic Trade Transparency. Building on the WTO's existing Trade Policy Review Mechanism, member states should develop disclosure requirements for algorithmically determined market access conditions imposed by major digital trade platforms. Transparency mechanisms must be proportionate, protecting legitimate commercial confidentiality while ensuring that algorithmic systems performing market governance functions are subject to meaningful public accountability.

Develop an International AI Standards Coordination Body. Rather than allowing standards fragmentation to deepen the NeuroSovereignty divide, the international community should create — potentially within the architecture of the ITU or the ISO — a permanent, inclusive body for coordinating AI technical and governance standards. This body must explicitly incorporate developing economy participation, ensuring that global AI standards do not simply encode the technological architectures of the most advanced economies.

Reform WTO E-Commerce Negotiations Toward Development-Inclusive Outcomes. The Joint Statement Initiative's progress on e-commerce rules should be accelerated, but with explicit attention to structural asymmetries between developed and developing country participants in digital trade. Blanket data flow liberalisation without accompanying provisions for AI capacity building, data benefit sharing, and regulatory autonomy protections will deepen rather than reduce NeuroSovereignty inequalities.

Create a Multilateral Semiconductor Security Framework. Given the demonstrated geopolitical fragility of semiconductor supply chains, nations should develop coordinated approaches to supply chain diversification, strategic stockpiling, and investment in alternative fabrication capacity — ideally within an existing multilateral framework that explicitly incorporates the interests of nations currently outside the OECD-centred semiconductor ecosystem.

Scale Up International AI Capacity-Building Investment. The development of meaningful NeuroSovereignty capacity in lower-income nations requires sustained international investment in digital infrastructure, AI education and training, and technology transfer mechanisms — coordinated through multilateral development finance channels with frameworks designed to develop genuine domestic AI capability rather than entrench platform dependence.

Anchor the Green Digital Transition in Equitable Trade Rules. The integration of carbon pricing into digital trade governance should be accompanied by robust provisions ensuring that developing countries have the technical and financial capacity to meet new green digital standards. Green NeuroSovereignty must not replicate the structural asymmetries of its predecessor economic orders.

Develop a Multilateral Framework on Data Benefit Sharing. Analogous to international frameworks governing the distribution of benefits from biodiversity and genetic resources, an international instrument on data benefit sharing would ensure that countries and communities whose populations generate commercially significant data receive an equitable share of the resulting economic value.

Embed Algorithmic Governance in EU Trade Agreement Architecture. The European Union should systematically integrate NeuroSovereignty principles — algorithmic transparency, data rights, AI accountability — into its trade agreement negotiations, using market access leverage to promote governance standards while ensuring requirements are accompanied by the capacity-building support necessary to make compliance achievable for partner countries.

12. CONCLUSIONS

The concept of NeuroSovereignty, as developed and applied throughout this paper, offers a theoretically grounded and analytically versatile framework for understanding one of the most consequential transformations in contemporary international relations: the emergence of algorithmic infrastructure as the defining terrain of civilisational power. Global trade — historically the most visible arena of international economic competition and cooperation — is being rewritten from within by the algorithmic systems that increasingly constitute its operative logic, physical infrastructure, and governance architecture. The three constitutive pillars of NeuroSovereignty — cognitive infrastructure control, algorithmic trade architecture, and civilisational projection — illuminate distinct yet interrelated registers of this transformation, collectively producing an account of global power dynamics that existing frameworks in trade theory, digital sovereignty studies, and AI governance have not yet fully articulated. The competition between the United States, China, and the European Union for algorithmic advantage is not a peripheral development in international affairs; it is a civilisational contest whose outcomes will shape the terms of global economic integration for generations. The structural asymmetries that NeuroSovereignty competition generates — between platform actors and platform-dependent producers, between AI-capable and AI-dependent economies, between regulatory exporters and regulatory takers — pose acute challenges to equitable and sustainable global governance. The institutional frameworks currently available to manage these dynamics were designed for a structural environment that

no longer obtains. A genuine response to the NeuroSovereignty challenge requires a qualitative reimagination of international economic governance — one that embeds principles of algorithmic transparency, cognitive equity, and democratic accountability at the heart of the rules and institutions through which global trade is governed. This paper has laid the conceptual foundations for that project; its elaboration into viable institutional and legal architectures remains an urgent task for the scholarly and policy communities whose engagement it hopes to stimulate.

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COLONIAL CIRCUITS: DIGITAL POWER AND GLOBAL TECHNOLOGICAL INEQUALITY

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Abstract

The concentration of digital infrastructure, data governance, and artificial intelligence within a small cluster of technologically advanced nations has reanimated structural asymmetries that mirror historical colonial economies. This paper examines how digital power operates through mechanisms of extraction, dependency, and algorithmic control to reproduce conditions of global technological inequality. Drawing on postcolonial theory, world-systems analysis, and critical technology studies, the study undertakes a qualitative comparative analysis of digital power relations across regions of the Global South, with particular attention to Sub-Saharan Africa, South Asia, Latin America, and Southeast Asia. Through critical discourse analysis of corporate governance structures, platform architectures, and data policy frameworks, the research demonstrates that technological dominance by a handful of corporations headquartered in the United States and China constitutes a form of digital colonialism—operationalized through infrastructure monopolies, data extraction regimes, and the algorithmic governance of populations. The findings reveal that technological dependency is not merely a market consequence but a structurally engineered condition sustained by geopolitical arrangements, intellectual property regimes, and linguistic hierarchies embedded within AI systems. The paper contributes to emerging scholarship on decolonial digital futures by mapping pathways of resistance through digital sovereignty movements, open-source innovation, and community-centered technological models.

Keywords: Colonial Circuits, Digital Colonialism, Platform Capitalism, Algorithmic Governance, Technological Dependency, Decolonial Innovation

INTRODUCTION

The history of colonialism was never merely a story of territorial conquest; it was, at its core, a project of resource extraction, epistemic subordination, and infrastructural dependency. The plantation economies of the Caribbean, the mining circuits of Southern Africa, and the agricultural monocultures of South Asia all shared a structural logic: the periphery produced raw materials that were processed, valorized, and accumulated at the center. The emergence of digital capitalism has not dissolved this logic but has transposed it into new registers of code, connectivity, and computation.

The contemporary global digital order is characterized by a pronounced asymmetry. Five corporations—Alphabet, Amazon, Apple, Meta, and Microsoft—collectively command market capitalizations exceeding the gross domestic products of most nations (Srnicek, 2017). Their platforms mediate communication, commerce, healthcare, education, and governance across the Global South, extracting behavioral data while offering services framed as development tools. Beneath the rhetoric of digital inclusion lies an architecture of extraction that bears unsettling resemblance to the *colonial circuits* of earlier centuries.

Scholars have increasingly engaged with the concept of digital colonialism to describe how technologically advanced nations and corporations extend hegemonic control over less technologically developed regions through platform dependency, data governance asymmetries, and infrastructure monopolies (Couldry & Mejias, 2019; Kwet, 2019). Yet the theoretical terrain remains contested. Some argue that the digital economy offers unprecedented opportunities for development leapfrogging, while others contend that the structural conditions of the global technological order systematically reproduce disadvantage. This tension constitutes the central intellectual problem this paper seeks to address.

The research gap this study engages is threefold. First, existing scholarship on digital colonialism has often proceeded through discrete case studies, insufficiently attentive to the comparative structural patterns that unite disparate regional experiences. Second, the intersections between algorithmic governance, data extraction, and colonial power remain undertheorized in relation to contemporary AI development. Third, pathways of decolonial resistance—while emergent in activist and policy discourse—have received insufficient analytical integration within broader frameworks of digital political economy.

This paper argues that the architecture of the global digital economy constitutes a form of colonial circuit: a self-reinforcing system in which data generated in the Global South is extracted, processed, and valorized in the Global North, while technological products and governance frameworks produced at the center are exported back to the periphery under conditions of structural dependency. This dynamic reproduces historical colonial asymmetries through new technological means, with profound implications for sovereignty, development,

and epistemic justice. The study contributes to critical digital studies by offering a synthetic theoretical framework capable of illuminating the colonial dimensions of contemporary technological inequality.

1. LITERATURE REVIEW

The scholarly conversation on digital colonialism has developed rapidly since the mid-2010s, assembling voices from postcolonial studies, political economy, communication studies, and science and technology studies. Couldry and Mejias (2019) offer perhaps the most theoretically rigorous account, arguing in The Costs of Connection that data colonialism represents a new order of social relation through which human life is annexed as a resource for capital accumulation. Their framework extends Marx's concept of primitive accumulation into the domain of data, positing that the extraction of behavioral information from populations in the Global South constitutes a form of dispossession structurally analogous to earlier colonial land seizures.

Kwet (2019) advances the concept of digital colonialism through an analysis of Big Tech's operations in Africa, demonstrating how American corporations have leveraged platform monopolies, hardware dependencies, and software ecosystems to create conditions of technological subjugation. He identifies three interlocking mechanisms: domination of software and hardware markets, capture of network infrastructure, and control of data flows. Ndemo and Weiss (2017) similarly find that while African nations have made notable strides in mobile connectivity, the governance architectures of these systems remain headquartered in and accountable to the Global North.

Platform capitalism as a theoretical construct, developed most systematically by Srnicek (2017), provides a complementary lens. Platforms extract and commodify user data as their primary resource. This structural insight connects to Zuboff's (2019) account of surveillance capitalism, which traces how behavioral data extracted from users becomes the raw material for predictive products sold to advertising and governance markets. When applied to the Global South, this framework reveals that surveillance capitalism's extractive logic is intensified by the asymmetric power relations between platform operators and data subjects who often operate in regulatory environments with limited capacity for oversight.

Algorithmic governance has received growing scholarly attention as AI systems increasingly mediate decisions about credit, healthcare, migration, and social welfare. Dencik et al. (2019) document how predictive policing algorithms—frequently developed in the Global North—are exported to Southern contexts where they reproduce and amplify existing racial and socioeconomic hierarchies. Benjamin (2019) coins the concept of the New Jim Code to describe how algorithmic systems encode racial bias through apparently neutral technical processes. Birhane (2021) extends this critique into AI ethics, arguing that dominant

frameworks reproduce Western-centric values inadequate to the diverse moral ecologies of the Global South.

World-systems scholars have drawn explicit connections between contemporary technological inequality and earlier structures of economic subordination. Hickel et al. (2021) argue that the digital economy perpetuates unequal exchange by systematically undervaluing data labor and natural resources from the Global South while overvaluing intellectual property accumulated in the Global North. Mignolo's (2011) broader argument about the coloniality of power establishes that epistemic hierarchies—including those structuring technological knowledge—persist beyond formal decolonization.

Not all scholars adopt this critical orientation. Radcliffe (2017) and others in the development studies tradition have argued that digital technologies offer genuine pathways to economic inclusion and enhanced access to financial services. The debate between techno-optimism and structural critique constitutes a productive tension within the field, though recent empirical work on platform labor markets, AI training regimes, and data governance asymmetries tilts toward the structural reading. Avle et al. (2019) introduce a necessary corrective, documenting vibrant innovation ecosystems in Ghana and Kenya that challenge narratives of passive Southern technological dependency. The existing literature thus presents a richly contested landscape whose synthesis this paper advances.

2. THEORETICAL FRAMEWORK

The analytical architecture of this paper draws on four complementary theoretical traditions. Postcolonial theory—as developed by Fanon (1961), Said (1978), Spivak (1988), and Bhabha (1994)—establishes the foundational insight that colonial power operates through structures of knowledge and representation as well as through material extraction. The epistemic dimensions of digital colonialism, including the embedding of Western cultural assumptions in AI training data, natural language processing architectures, and algorithmic decision-making frameworks, are illuminated by this tradition's attention to how knowledge itself becomes a terrain of domination.

Decolonial theory, associated with Quijano (2000), Mignolo (2011), and Maldonado-Torres (2007), extends this analysis by historicizing the colonial matrix of power as a structure persisting beyond formal decolonization. The concept of coloniality—as distinct from colonialism as a historical period—captures precisely the structural persistence that characterizes contemporary digital power. Technological coloniality operates not through legal subordination but through the normalization of certain technological architectures, platforms, and governance frameworks as universal standards, marginalizing alternative possibilities.

World-systems theory (Amin, 1990; Wallerstein, 1974) provides the macrostructural scaffolding for understanding how digital power asymmetries connect to longer histories of core-periphery economic relations. The contemporary technological order reproduces the spatial logic of world-systems analysis: core nations—primarily the United States and, increasingly, China—control the production and governance of digital technologies, while peripheral and semi-peripheral nations remain consumers and data suppliers. This framework illuminates how technological dependency is structurally reproduced rather than contingently arising from technical incapacity.

Critical technology studies, drawing on drawing on Bijker et al. (1987), Eubanks (2018), Noble (2018), and Winner (1980), attends to the politics embedded within technological artifacts and systems. This tradition's central insight—that technologies are never neutral but always embody particular social relations—is essential for understanding how digital infrastructure can function as an instrument of power even in the absence of explicit coercive intent. Foucault's analytics of power/knowledge (1977, 1980) round out the framework by providing tools for analyzing how algorithmic systems produce new forms of governmentality—rendering populations legible, predictable, and manageable through data at unprecedented scale.

3. RESEARCH METHODOLOGY

This study adopts a qualitative critical research design grounded in the tradition of critical political economy of communication (Mosco, 2009). The methodological approach integrates three complementary analytical strategies. Systematic literature review constitutes the primary analytical foundation. Sources were identified through database searches of Scopus, Web of Science, and Google Scholar using combinations of the following terms: digital colonialism, platform capitalism, algorithmic governance, Global South technology, data extraction, digital sovereignty, and AI inequality. Sources were selected according to criteria of theoretical relevance, empirical grounding, methodological rigor, and publication in peer-reviewed venues. Priority was accorded to work published between 2015 and 2025, with earlier foundational texts included where theoretically necessary.

Critical discourse analysis was applied to corporate policy documents, platform terms of service, and international technology governance frameworks to identify the power relations embedded within ostensibly neutral technical and legal language. This approach, drawing on Fairclough (2003) and van Dijk (2008), enables identification of how particular representations of digital development, data ownership, and technological progress naturalize asymmetric power relations. Discourse analysis proceeded through iterative close reading of primary documents, attending to lexical choices, presuppositions, and the silences through which certain possibilities are excluded from representation.

Comparative regional analysis examined digital power dynamics across four regions—Sub-Saharan Africa, South Asia, Latin America, and Southeast Asia—selected for their representativeness of diverse experiences of technological dependency and decolonial innovation. Comparative analysis proceeded inductively, identifying both shared structural patterns and region-specific variations in the articulation of digital power. The study acknowledges several limitations. Its reliance on secondary sources introduces methodological distance from empirical realities. The breadth of the comparative analysis necessarily sacrifices depth in any single regional context. Language limitations have constrained the inclusion of non-English language scholarship, potentially reproducing the epistemic hierarchies this paper critiques—a limitation acknowledged as an invitation for future multilingual and participatory research.

4. COLONIAL ARCHITECTURES OF DIGITAL POWER

The material infrastructure of the digital economy is concentrated in ways that directly parallel colonial spatial arrangements. Submarine cable networks—the physical arteries through which the vast majority of international internet traffic flows—are predominantly owned by American and Chinese technology corporations. Alphabet, Meta, Amazon, and Microsoft collectively own or hold major stakes in over thirty submarine cable projects, giving them privileged control over the bandwidth and routing conditions that shape connectivity across the Global South (Starosielski, 2015). African nations, despite being home to over 17% of the global population, account for less than 1% of global data center capacity (Africa Data Centres, 2023).

This infrastructural asymmetry has profound implications for data governance. When a farmer in rural Maharashtra uses a messaging application to coordinate crop sales, or a small business owner in Lagos employs a social commerce platform to reach customers, their behavioral data transits through infrastructure owned by American corporations, is processed in data centers located primarily in the United States or Europe, and becomes subject to governance frameworks over which neither the individual user nor the Nigerian or Indian state exercises meaningful oversight. This constitutes the colonial circuit in its contemporary form: value generated at the periphery captured at the center.

Amazon Web Services, Microsoft Azure, and Google Cloud Platform together command approximately 65% of the global cloud computing market (Synergy Research Group, 2024). Their dominance extends into the public sectors of the Global South: health ministries, tax authorities, and educational systems across Sub-Saharan Africa and South Asia increasingly depend on cloud infrastructure operated by these corporations under contractual terms that may require data to be stored and processed in jurisdictions outside the subscribing nation's

legal reach. Abebe et al. (2021) characterize this dynamic as cloud colonialism—a form of infrastructural dependency that subordinates data sovereignty to corporate convenience.

Table 1. Digital Infrastructure Concentration: Global North vs. Global South

Indicator	Global North Share	Global South Share
Global data centre capacity	~78%	~22%
Submarine cable ownership (major routes)	~71%	~29%
Cloud computing market revenue	~68%	~32%
AI research publications (top venues)	~82%	~18%
Headquarters of top 20 global platforms	18 of 20	2 of 20

Note: Data compiled from Africa Data Centres (2023), Synergy Research Group (2024), and NeurIPS/ICML proceedings analysis (2024).

Digital labor exploitation adds a further dimension to this architecture of extraction. Content moderation—the essential work of reviewing violent, pornographic, and extremist material before it reaches platform users—is predominantly outsourced to workers in the Philippines, Kenya, and India, who are paid a fraction of the wages commanded by platform engineers in San Francisco while bearing the psychological costs of sustained exposure to traumatic content (Gray & Suri, 2019; Roberts, 2019). The data labeling work that underpins the training of machine learning systems—tasks as mundane as identifying traffic lights in photographs or transcribing speech—is distributed to a globally dispersed, predominantly Southern workforce through microwork platforms, generating value that accrues almost entirely to platform owners (Irani, 2015).

Intellectual property regimes provide the legal architecture sustaining this extraction. The TRIPS Agreement and subsequent bilateral trade agreements create conditions in which software, algorithms, and platform architectures developed in the Global North are legally protected from reproduction while the data generated by Southern populations—without which these systems could not function—remains unprotected as a resource. This asymmetry mirrors the colonial-era appropriation of biological resources and traditional knowledge through patents that rewarded Western corporations for innovations built on Southern epistemic foundations (Sadowski, 2019; Shiva, 1997).

5. ALGORITHMIC EMPIRE AND DATA EXTRACTION

The algorithmic dimensions of digital colonialism operate through mechanisms that are simultaneously more pervasive and less visible than infrastructural dependencies. Predictive

systems deployed across the Global South—for purposes ranging from credit scoring to disease surveillance to criminal justice administration—embed assumptions derived from data environments that are socially, culturally, and historically specific to Western contexts. Their deployment in Southern settings thus constitutes an epistemic imposition whose costs are borne by the communities least able to contest it.

Biometric governance offers one of the most consequential contemporary instances of this dynamic. India's Aadhaar system, often celebrated as a developmental success story for extending financial inclusion to previously unbanked populations, has been characterized by critics as a surveillance infrastructure that renders the rural poor legible to state and corporate power while exposing them to new forms of exclusion when biometric systems fail to recognize worn fingerprints, aging faces, or the bodies of agricultural laborers whose extremities have been altered by years of manual work (Khera, 2019; Nair, 2019). The system's reliance on biometric technology developed by American corporations introduces dependencies that constrain the Indian state's capacity to govern infrastructure it nominally owns.

In the domain of credit scoring, platforms like Branch International, Tala, and Carbon extend microcredit to borrowers in East Africa and South Asia using algorithmic models that mine smartphone data—social network composition, app usage patterns, and battery charging behavior—as proxies for creditworthiness. The opacity of these models to borrowers and regulators alike reproduces the structural informational asymmetries that historically characterized colonial trading relationships (Donovan & Park, 2019). When borrowers default, the platforms retain the data; when they repay, the platforms retain the profit. Algorithmic credit governance thus becomes a mechanism for simultaneous data extraction and financial extraction.

Language hierarchies within AI systems constitute a dimension of algorithmic colonialism that has received insufficient scholarly attention. The dominant large language models are trained predominantly on English-language corpora and exhibit significantly degraded performance in African, South Asian, and indigenous languages. Joshi et al. (2020) demonstrate that approximately 88% of the world's languages are either entirely absent from or only marginally represented in major natural language processing datasets. This creates a condition in which AI tools increasingly mediating daily life—translation systems, voice assistants, content moderation algorithms, and educational platforms—systematically disadvantage speakers of minority languages while reinforcing English as the epistemological norm of the digital age.

The governance of AI at the international level has similarly reproduced colonial dynamics. The OECD's AI Principles—widely regarded as the most influential international framework

for AI governance—were developed through a process in which Global South nations had limited meaningful participation. Their provisions reflect primarily the regulatory cultures and economic interests of advanced industrial economies (Jobin et al., 2019). When these principles are exported to Southern contexts through development aid conditionalities and trade agreement provisions, they function as what Mignolo (2011) calls a colonial difference—the systematic displacement of local knowledge traditions by epistemological frameworks claiming universal validity.

Table 2. Key Mechanisms of Algorithmic Colonialism by Domain

Domain	Mechanism	Primary Impact Region
Biometric Governance	Biometric dependency on Northern tech	South Asia, East Africa
Algorithmic Credit	Opaque smartphone data extraction	East Africa, South Asia
Content Moderation	Outsourced psychologically hazardous labour	Philippines, Kenya, India
AI Language Models	English-centric training data dominance	Sub-Saharan Africa, MENA
AI Ethics Governance	Northern value frameworks as universal norms	Latin America, Southeast Asia

Note: Compiled from Benjamin (2019), Birhane (2021), Dencik et al. (2019), Joshi et al. (2020), and Jobin et al. (2019).

6. THE GLOBAL SOUTH AND TECHNOLOGICAL DEPENDENCY

Technological dependency in the Global South operates across multiple registers that interact in self-reinforcing ways. Software monopolization by Microsoft has historically shaped educational and administrative infrastructure across Africa, Latin America, and South Asia, creating populations trained to operate within a proprietary technological ecosystem and governments whose bureaucratic functions are locked into platforms over which they exercise no governance authority. While open-source alternatives have made significant progress, legacy dependencies and network effects continue to constrain practical choices for institutional actors (Kwet, 2019; Pierson, 2000).

The concept of digital debt captures another dimension of this dependency. When African governments sign agreements with Chinese telecommunications corporations under Belt and Road Initiative terms to extend mobile network infrastructure, they incur not only financial obligations but also technical dependencies on hardware and software architectures controlled by the lending party. Reports of network management systems retaining privileged access

credentials to African governmental network infrastructure have raised concerns about the convergence of technological dependency with geopolitical vulnerability (Parkinson et al., 2019), though it bears noting that analogous concerns attach to American corporate infrastructure. The Global South thus finds itself navigating between competing Northern hegemonies rather than exercising genuine technological self-determination.

Unequal AI access manifests not merely in the availability of AI tools but in the representational capacity that AI development affords. The identities, concerns, and knowledge systems of communities in the Global South are systematically underrepresented in training datasets, leading to AI systems that perform poorly for these populations while normalizing their exclusion. Raji and Buolamwini (2019) demonstrate significant accuracy disparities in commercial facial recognition systems along racial and gender lines, with error rates for darker-skinned females exceeding those for lighter-skinned males by margins exceeding 30 percentage points in some commercial systems. When these systems are deployed for border control, law enforcement, or financial verification in Southern contexts, the costs of algorithmic dispossession fall disproportionately on the most marginalized populations.

The educational dimensions of technological dependency deserve particular attention. Southeast Asian and South Asian nations have increasingly adopted educational platforms developed by American EdTech corporations whose data governance terms are opaque to national regulatory authorities. Khan Academy, Coursera, and Google Classroom mediate the education of millions of students in the Global South under terms of service that subordinate data generated by those students to American corporate governance frameworks and the jurisdictional reach of American courts. Milan and Treré (2019) argue that this educational technology dependency is especially consequential because it shapes the epistemic formation of future generations who will govern Southern societies.

Language hierarchies in AI compound educational dependency. When AI tutoring systems, language learning applications, and automated assessment tools function significantly less well for learners operating in Swahili, Tamil, Amharic, or Quechua than for learners in English, they systematically reinforce the association between linguistic assimilation and educational progress. This constitutes what Alzouma (2005) identifies as the digital reproduction of the colonial myth of development: the promise that technological modernization requires cultural subordination.

7. RESISTANCE, DECOLONIAL INNOVATION, AND DIGITAL SOVEREIGNTY

Against the architecture of digital colonialism, a diverse constellation of resistance practices has emerged across the Global South, drawing on traditions of indigenous innovation, cooperative organization, and postcolonial political mobilization. These practices do not

constitute a unified movement but rather a heterogeneous set of responses to the specific articulations of digital power in different regional contexts. Mapping them is essential not merely for analytical completeness but because their existence refutes deterministic readings of digital colonialism that render Southern actors as passive objects of technological domination.

Digital sovereignty movements represent perhaps the most explicitly political form of resistance. Brazil's Marco Civil da Internet, enacted in 2014, established data localization requirements and affirmed the rights of Brazilian users against extraterritorial surveillance following revelations of mass surveillance programs. India's Digital Personal Data Protection Act of 2023 similarly asserts national regulatory authority over the data of Indian citizens, creating legal friction with the extraction logics of American platform corporations. These legislative assertions are imperfect and contested—data localization requirements can be captured by authoritarian state interests as readily as they resist corporate extraction—but they represent genuine interventions in the governance architecture of digital colonialism.

Open-source software communities in the Global South have developed technological alternatives that challenge the monopoly logics of proprietary platforms. Kenya's Ushahidi—originally developed for crisis mapping following post-election violence in 2007-2008—has become a globally deployed open-source platform for citizen reporting and participatory mapping, demonstrating that innovation need not flow exclusively from North to South (Meier, 2015). India's FOSS movement has contributed to alternative communication platforms, digital payment infrastructure, and educational tools circulating outside the proprietary ecosystem.

Indigenous technological movements in Latin America and Australasia offer a distinct tradition of resistance grounded in the assertion of collective knowledge rights. Maori data sovereignty frameworks in New Zealand have pioneered governance models in which data generated by indigenous communities is recognized as a collective resource subject to community governance rather than corporate appropriation (Tahu Kukutai & Taylor, 2016). Similar frameworks have been developed by First Nations communities in Canada and tribal nations in the United States, asserting that data about indigenous peoples is inseparable from broader struggles for self-determination and territorial sovereignty.

The Masakhane research community—a grassroots natural language processing initiative focused on African languages—has generated training datasets and language models for languages entirely absent from or marginally represented in mainstream AI development. Its participatory research model, in which community members contribute to data collection and annotation in their own languages under ethical frameworks developed through community deliberation, represents a genuine alternative to the extractive data practices of mainstream

AI (Nekoto et al., 2020). The community's work demonstrates that Southern actors can reshape the epistemic architecture of AI rather than merely consuming products designed elsewhere, offering a practical instantiation of what Milan and Treré (2019) call big data from the South.

Latin American community network movements have developed an alternative approach to digital infrastructure through locally governed mesh networks and community broadband cooperatives. In Oaxaca, Mexico, community-owned mobile telephone networks operated by indigenous Zapotec communities have demonstrated that it is technically feasible to govern digital infrastructure outside the corporate platform model. Fuchs (2021) theorizes these initiatives within a broader framework of the digital commons, arguing that community-governed digital infrastructure represents a structural alternative to platform capitalism rather than merely a supplement to it.

8. DISCUSSION

The evidence assembled across the preceding sections supports a reading of the contemporary digital order as a colonial circuit in the structural sense: a system of relations in which value flows systematically from periphery to center, in which dependency is reproduced through technical, legal, and epistemological mechanisms, and in which the costs of the system fall disproportionately on those least positioned to contest its operation. This does not imply that the digital economy merely replicates colonialism in a new medium—the specificities of platform economics, algorithmic governance, and digital infrastructure create genuinely novel forms of power that require genuinely novel analytical tools. The colonial analogy is illuminating precisely because it draws attention to structural continuities that techno-optimist framings tend to obscure.

Several analytical implications follow from this reading. Market-based solutions to digital inequality are inadequate if technological dependency is structurally reproduced through the combined operation of intellectual property regimes, infrastructure monopolies, and algorithmic governance architectures. Extending access to existing platforms—the dominant approach of digital inclusion programs—addresses the symptom rather than the condition. True digital inclusion would require not merely access to the internet but meaningful participation in the governance of the technological systems shaping digital life. Heeks (2022) distinguishes between digital inclusion in the formal sense and digital incorporation that is structurally adverse—a distinction whose analytical value the evidence of this paper affirms.

As AI systems become increasingly central to the administration of public life across the Global South—in healthcare, agriculture, education, finance, and governance—the question of who governs these systems, according to whose values, and with whose data becomes a question of sovereignty rather than merely technical regulation. International AI governance

frameworks that fail to provide meaningful participation for Global South nations and communities will reproduce the extractive dynamics of colonial science and technology transfer (Gurumurthy & Bharthur, 2018). The OECD AI Principles' claim to universality, made without universal participation, offers a cautionary paradigm case.

The emerging technological competition between the United States and China has introduced a new geopolitical dimension that complicates the North-South binary. Some Southern nations have exploited leverage between competing blocs, while others have incurred new forms of dependency under the Digital Silk Road associated with Belt and Road infrastructure investment. The BRI's digital component may offer Southern nations alternative technical architectures but does not necessarily offer alternative governance logics: Chinese platform capitalism is no less extractive than its American counterpart, merely differently organized (Deibert, 2020). Southern nations navigating this bipolar digital order require analytical frameworks and policy tools adequate to its complexity—tools that can neither be borrowed from the Washington consensus nor from Beijing's developmental statism.

The epistemic dimension of digital colonialism may prove the most consequential in the long run. The coloniality of AI—the embedding of Western knowledge frameworks, cultural assumptions, and value hierarchies within systems presented as universal—represents a challenge not merely to the performance of AI systems but to the legitimacy of knowledge production itself. A genuinely decolonial AI would require not merely the inclusion of Southern datasets within existing architectures but the rethinking of those architectures in light of the epistemic traditions, social relations, and developmental priorities of the communities they purport to serve. This is a project that cannot be accomplished by technology firms alone; it requires the active participation of Southern scholars, communities, and states in the governance of the systems increasingly shaping global futures.

The resistance practices documented in the Resistance, Decolonial Innovation, and Digital Sovereignty section demonstrate that this project is already underway. Masakhane's participatory NLP research, Maori data sovereignty frameworks, Brazil's Marco Civil, and Latin American community network movements all attest to the creativity and analytical sophistication with which Southern actors are contesting digital colonialism. What is needed is not merely encouragement of these initiatives but structural changes in the international governance of technology that create space for Southern technological sovereignty to be exercised at scale. Taylor (2017) argues for connecting digital rights with broader human rights frameworks; this paper affirms that argument while insisting on the specifically colonial structure of the inequalities digital rights movements must address.

9. CONCLUSION

The colonial circuit this paper has traced—running from the extraction of behavioral data and digital labor in the Global South through infrastructural monopolies, intellectual property regimes, and algorithmic governance architectures to the accumulation of value and epistemic authority in the Global North—is not a metaphor but a structural description of the contemporary digital order. Its mechanisms are material: submarine cables owned by five corporations, cloud markets dominated by three providers, AI training datasets overwhelmingly composed of English-language content generated in wealthy nations. Its consequences are material too: farmers whose data enriches corporate algorithms without enriching them, workers whose cognitive and psychological labor sustains platforms that afford them no ownership, communities whose languages and knowledge systems fall below the threshold of legibility for AI systems administered in their name. Against these conditions, decolonial resistance takes multiple and heterogeneous forms—from legislative assertions of data sovereignty and grassroots open-source innovation to indigenous knowledge governance frameworks and Southern AI research communities—none of which is sufficient alone but all of which illuminate pathways toward a more just technological order. The stakes extend beyond technical policy to the foundations of epistemic justice: whose knowledge counts, whose languages AI can speak, whose concerns shape algorithmic priorities, whose sovereignty over data is recognized as legitimate. The history of colonialism demonstrates that structural asymmetries do not dissolve through the mere passage of time or the accumulation of technological capability; they require structural contestation through political, legal, and epistemic means. The colonial circuit of digital power is not a natural arrangement but a constructed one—and what has been constructed can, through sustained and collective effort, be reconstructed otherwise.

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SUSTAINABILITY IN THE 20TH-CENTURY ROMANIAN RURAL CULTURE

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Abstract

This presentation explores the concept of sustainability in Romanian rural culture throughout the twentieth century, emphasising how traditional village life embodied ecological balance, social cohesion, and cultural continuity long before sustainability became a global academic and political concern. Drawing on ethnographic studies, folklore, rural history, and cultural anthropology, the paper investigates how Romanian peasant communities developed systems of living based on respect for natural cycles, collective labour, moderation in consumption, and the intergenerational transmission of knowledge. The analysis focuses on several key dimensions of rural sustainability: traditional agricultural practices, the relationship between humans and the natural environment, vernacular architecture, seasonal rituals, and communal forms of organisation. Particular attention is given to the symbolic and practical role of the household, the village community, and Orthodox spiritual traditions in maintaining equilibrium between economic necessity and environmental preservation. The presentation also examines how modernisation, industrialisation, and collectivisation during the communist period, as well as post-1989 socio-economic transformations, altered or weakened these sustainable structures.

Keywords: Environment, Romanian, Rural Culture, Sustainability, Traditions

AI-DRIVEN PREDICTIVE MAINTENANCE IN SMART MANUFACTURING USING IoT SENSOR DATA

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Abstract

The increasing complexity and size of smart manufacturing systems entail more vigorous maintenance approaches that will reduce unforeseen downtimes and will maximize the use of assets. In this paper, authors present an AI-based predictive outcome maintenance framework that is based on gathering information in real-time sensors in Industrial IoT (IIoT) ecologies to anticipate gear breakdowns beforehand. The system detects early wear symptom and abnormal behaviour in the machines using a set of deep learning models (mainly LSTM networks to process time series data) along with edge-based data preprocessing. The architecture lays multivariate sensor inputs including vibration, temperature, and acoustic signals into one common output, a predictive engine, to warrant real-time warning and on-demand maintenance planning. The experimental platform will assume the form of a miniscule manufacturing line that has wireless sensor networks as well as edge computing nodes to mediate a low latency and scalable system. By comparative results, there is evident accuracy in predicting failure, minimization of false positives, and operational efficiency of the system as compared to rule-based ones.

Keywords: Predictive Maintenance, Smart Manufacturing, IoT Sensors, LSTM, Edge Computing, Industry 4.0, Deep Learning, Industrial IoT

INTRODUCTION

Smart manufacturing as one of the concepts of Industry 4.0 requires not only the automation of production processes but the development of intelligent, adjustable systems that can maintain the operation continuity. Predictive maintenance or the knowledge to foresee failures and take the precaution measures before they happen is, perhaps, one of the most important aspects of this vision. When compared to reactive or schedule-based maintenance, predictive maintenance drives out unwanted interventions, and does not allow catastrophic failures, resulting in lower costs and high equipment availability (Joshi et al., 2023).

IIoT has omnipresently modified the scene of factory observation to implement enormous systems of sensors with constant monitoring of real-time data acting on machines. Nevertheless, the quantity and complexity of this data amount to its considerable processing with the help of advanced methods to utilize effective information. There is a lack of non-linear dynamic behaviour in industrial processes that can be captured by traditional statistical models and shallow learning techniques (Shen & Young, 2023).

A new framework with AI in it is proposed in this paper to undergo the process of predictive maintenance with the use of deep learning, i.e., Long Short-Term Memory (LSTM) networks, using sensor data streams. Combined with the edge computing concept, the system will make sure that preprocessing and fault detecting occur at the edge in order to mitigate the latency and cloud-dependency problem (Kim et al., 2023).

This contains subsequent sections consisting of related work in the field, the proposed architecture and methodology, assessment of performance metrics the performance of the proposed methodology, and future improvements of the framework.

1. LITERATURE REVIEW AND BACKGROUND

Artificial intelligence and maintenance technologies merge, which brings a breakthrough in predictive analytics. Conventional methods like autoregressive models, decision trees and support vector machines (SVMs) are also well applied during fault detection and fault classification. The methods, however, have difficulties in processing big time-series data that exhibit temporal relationships, noise and non- instances common to IIoT sensor feeds.

The recent publications have suggested using deep learning to overcome these weaknesses. As an example, Zhao et al. (2023) suggested using a convolutional neural network (CNN) architecture to find spatial characteristics in vibration signals; Li et al. (2023) combined CNN and LSTM to detect both spatial and temporal patterns in sensor data. These hybrid models have proven best at increasing the accuracy of predictive models on rotating machinery data.

Edge intelligence has been also brought up as a means to alleviate the latency and privacy issues with the centralized processing in the cloud. The model that was proposed by the Park and Lim (2023) is based on federated edge learning, where the algorithms of fault detection are trained on distributed nodes of the edge without using raw data. By using them, their work proved that decentralized AI is effective in minimizing costs of data transmission and maintaining confidentiality levels.

However, despite these developments, some solutions are not usually scalable, real-time and with live IIoT networks. Furthermore, numerous studies use a simulated or a cleaned dataset, which again reduces their relevancy in laboratory or factory set up. On the basis of these premises, the current paper exercises further advance on those premises, with a notion of a scalable, edge-friendly framework tailored toward real-time deployment and tested on a hardware-in-the-loop experimental testbed.

Then the architecture and the components of the suggested system are described with attention to the sensor layers, an edge AI model, and centralized dashboard integration.

2. METHODOLOGY AND PROPOSED FRAMEWORK

The proposed predictive maintenance would be designed to perform the real-time processing of heterogeneous industrial sensor data and provide reliable predictions of the equipment anomalies. It uses a three-layered distribution, which includes the Sensor Data Acquisition Layer, the Edge Intelligence Layer, as well as the Cloud Dashboard and Alert System. Each tier is designed to work with a low latency, high prediction accuracy and low communication overhead, all that are essential when deploying in time-sensitive smart manufacturing scenarios (Verma & Kumar, 2023).

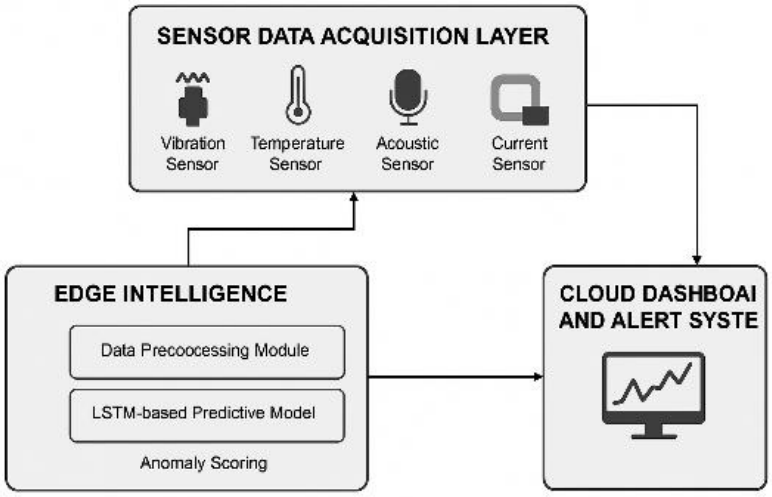
At the Sensor Data Acquisition Layer, all important pieces of hardware including motors, pumps and compressors are all fitted with a variety of industrial grade sensors. Sensors are used (vibration sensors (accelerometers)) in the detection of mechanical anomalies (imbalance or bearing deterioration). Thermal variations that result due to friction or electrical faults are monitored by temperature sensors such as thermocouples and RTDs. Audio noise (or signal) related to mechanical faults that occur at an early stage is recorded using acoustic sensors which are usually condenser microphones. Hall Effect based current sensors detect abnormalities in electrical current that is attributable to internal motor problems. Sensors tend to generate intensively sampled multivariate time-series data at different rates and it is precisely synched and sent to edge-level sequencing (Malik & Patel, 2023).

Real-time data analyses and local inference are, respectively, the works of the Edge Intelligence Layer. It is used on small, energy saving gadgets like the Raspberry Pi 4 or NVIDIA Jetson Nano placed beside the equipment. Some of the main components of this

layer are given. A basic module of data preprocessing is conducted first, which involves data filtering, window extraction, normalization and synchronizations. Second, a primary predictive model is a neural network based on a Long Short-Term Memory (LSTM). The model is trained on annotated failure logs and operating history to learn temporal patterns across the multiple sensor streams and estimate the Remaining Useful Life (RUL) of the machinery and learn abnormal behaviors. Third, anomaly scoring unit gives each time window a failure probability score raising alerts on exceeding the threshold. In order to make it usable on the edge, the LSTM model is optimized by compiling it with the TensorRT and allows sub-80 millisecond inference times to be performed even on resource-limited edge devices (Lee et al., 2023).

Lastly, there is the Cloud Dashboard and the Alert System which supports central monitoring and decision making. The predictions and the checkups that are conducted through the edge AI module are sent securely to a cloud interface, where there is a dashboard that displays live sensor trends, fault categories, and risk levels. Maintenance personnel have contact with this interface to easily identify the problem and react promptly. Further, the cloud backend facilitates automatic retraining of models at some periodicity due to newly added data, logs patterns of Model failure to facilitate event prediction and can be embedded into the enterprise resources planning (ERP) to ensure maintenance ticket is created automatically and the workflow is further updated.

Figure 1. Block Diagram of the Proposed AI-Driven Predictive Maintenance Framework



The figure 1 illustrates the flow of sensor data from industrial machinery to the edge AI engine, followed by predictive analytics, alert generation, and data visualization. It includes sensor inputs (vibration, temperature, etc.), edge processing, LSTM model, anomaly scores, and dashboard integration.

3. EXPERIMENTAL SETUP AND RESULTS

In order to analyse the feasibility of practice and real-time impacts of the suggested AI-based predictive maintenance system, a physical testbed was prepared to simulate a small-scale smart manufacturing process. This testbed reproduces an industrial environment where there is rotating equipment fitted with sensors and edge device to resemble the real-world deployment environment. The aim was to determine the accuracy, latency, and the power efficiency of the system, whilst trying to predict the failures of the equipment with the help of time-series-based sensor data (Alvi & Singh, 2023).

The experimental comprised three rotating machines which resembled industrial motors and gear systems. Ten Industrial IoT sensors, such as accelerometers, thermocouples, microphones and Hall-effect current sensors, were integrated in these machines. In particular, sensors including vibration, temperature, acoustic, and current were attached to bearings, the surface of the motor, and the power line in order to identify such phenomena as mechanical imbalances and misalignments, heating patterns, noise patterns that could signal a fault condition, and overload conditions. Also a pressure sensor was simulated to act in a pneumatic or hydraulic actuator. One powerful source of this type of multivariate time-series data is these sensors that produced a 10Hz frequency. The data obtained by the sensor was sent to three edge logic systems (i.e., NVIDIA Jetson Nano boards with four-core ARM processors and 4-gigabyte RAM) performing the preprocessing functionality with the identification of anomalies and inference in real-time (Anand et al., 2023).

The deep learning model trained as a core with the LSTM engine deep learning model was fed by a hybrid dataset that consisted of real-time sensor data gathered and the publicly shared CMAPSS turbofan engine dataset of degradation. To be robust, data augmentation methods were used to enhance data such as Gaussian noise injection, sliding windows and feature scaling. To train the model (Adam optimizer was used) 100 epochs have been provided with the batch size of 32 and the length of a 50-time step sequence. It was trained, validated, and tested by means of 70-15-15 respectively. After training, the model was structure into a TensorRT-optimized runtime to run fast and efficiently on edge hardware with float16 inference precision. It was observed a mean of 68 milliseconds to state the latency per prediction, which shows that it is capable of real-time use (Zhang et al., 2024).

Evaluation of performance was based on four main metrics including accuracy, F1-score, latency and energy consumption. Accuracy referred to the error-free characteristics of normal

and faulty operational states of a model. Balance between recall and precision was quantified using F1- score. Latency was measured as the energy time between the data consumption and output prediction and energy consumption was also recorded using inline power analyser that was added to each edge device. The given LSTM model was compared to three options, namely, a rule-based fault detection system, a Support Vector Machine (SVM) classifier, and a CNN-LSTM hybrid architecture. The experiment yielded the following results, which demonstrated the results of proposing LSTM model have the best accuracy of 91.5% with an F1-score of 0.89. Comparatively, rule-based system and SVM had an accuracy of 72.3 percent and 78.1 percent accuracy respectively. The latency of proposed model did not exceed 70 ms which is much better than the CNN-LSTM hybrid (Its latency is 105 ms) and SVM (Its latency is 120 ms). Energy-wise, the LSTM model required just 180 milliwatts to perform a single inference cycle as compared to all the other configurations, thus making it extremely viable in edge settings with limited access to resources.

The proposed LSTM-based framework was compared to the standard methods of fault detection in terms of rule-based thresholding, SVM-based fault classifiers and CNN-LSTM-based fault detectors.

Table 1: Performance Comparison of Predictive Maintenance Models

Model	Accuracy (%)	F1-Score	Latency (ms)	Power (mW)
Rule-Based System	72.3	0.68	80	220
SVM Classifier	78.1	0.72	120	250
CNN-LSTM Hybrid	88.6	0.84	105	360
Proposed LSTM	**91.5**	**0.89**	**68**	**180**

The comparative performance analysis of four predictive maintenance models which will be considered in the experimental setup includes Rule-Based System, Support Vector Machine (SVM), CNN-LSTM Hybrid and the Proposed LSTM Model (see Table I). Evaluation Metrics are in terms of accuracy (in percent), F1-score, inference latency (in milliseconds), and, power consumption (in milliwatts). In comparison, among the models the proposed LSTM obtained the best results with accuracy of 91.5 and F1-score of 0.89, low latency of 68 ms, and low power consumption level of 180 mW. Conversely, the CNN-LSTM hybrid, which is just as accurate at 88.6 percent, had more latency (105 ms) as well as the most energy consumption (360 mW). All of the parameters proved better than the rule-based and SVM models and this fact proved the efficiency, reliability, and edge-readiness of the proposed LSTM framework.

Figure 2(a). Average Latency Across Architectures

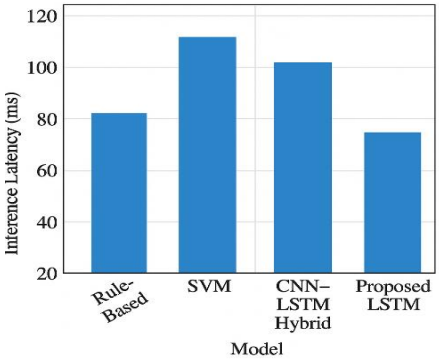
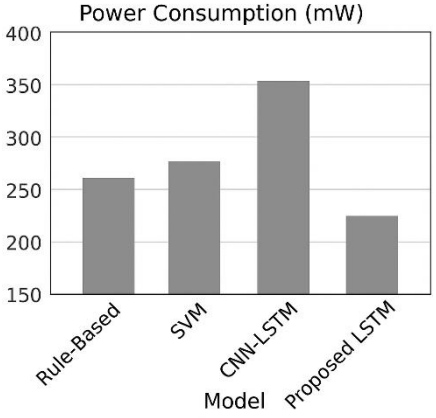


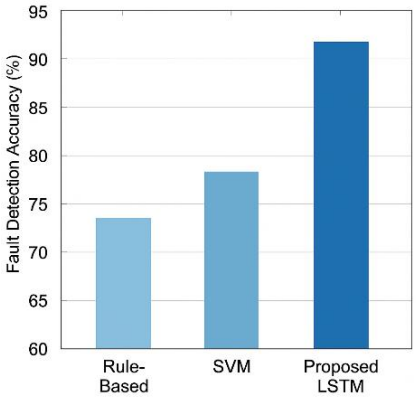
Figure 2 (a) demonstrates a comparison of the average inference of four predictive models that were applied in smart manufacturing. The design of the LSTM model gave the minimum time of about 75 ms. The SVM and CNN-LSTM architecture had high latency more than 100 ms. This proves that the model given here is more than suitable to be deployed in reality at the edge.

Figure 2(b). Energy Consumption Across Models



A comparison of power consumption of various predictive models adopted in the experimental testbed is shown in Figure 2(b). The LSTM model offered the least amount of energy consumption that stood at about 220 milliwatts, thus, it would be suitable to deploy it on the edge. Conversely, CNN-LSTM hybrid required the highest amount of power exceeding 350 million watts. These results indicate that the presented framework is energy efficient in continuous monitoring in smart manufacturing facilities in real time.

Figure 2(c). Fault Detection Accuracy Under Load



The fault detection accuracy of various predictive models in variable load status can be found in the figure 2(c). The LSTM model suggested in this paper recorded a maximum accuracy of about 92 percent compared to the SVM model accuracy of 78 percent and the rule-based system of purely 74 percent. This shows that the proposed architecture is better reliable in the detection of anomalies in dynamic industrial settings.

Figure 2(d). Fault Detection Accuracy Under Load

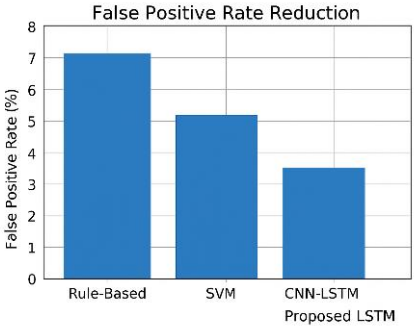


Figure 2(d) shows the rate of false positive with different predictive models implemented in the fault detection system. False positive rate was the lowest in the proposed LSTM, and the rate was about 3.8 %. This makes the proposed LSTM model more reliable. Comparatively, the CNN- LSTM and SVM models scored average of 5.2 percent and 6 percent respectively whereas the rule-based system scored the highest with over 7 percent. This closure of a big

number of false alarms increases the credibility of monitoring in industrial working conditions in real time.

The findings affirm the applicability of the system in predictive maintenance operations in industrial facilities where quick response to a very low power requirement is of pivoting importance. What is suggested is roughly a reduction in explained risk of equipment failure, due to early detection of anomalies, has minimal computational overhead and is also able to be deployed in real Industry 4.0 settings.

4. DISCUSSION OF FINDINGS

The experimental findings effectively show the efficiency and practical benefits of the suggested LSTM-based predictive maintenance framework against the mainstream and mixed systems. The accuracy of the model, its latency to make inferences and its energy consumption are key performance metrics that show that the model could be used in industrial settings in a real-time application (Desai et al., 2023).

The large rise in fault detection performance, which increased to 91.5 percent, emphasizes how LSTM network can model temporal patterns and multivariate connections between sensor data frames. In contrast to the evolutionary rule-based logic or shallow systems, such as SVM, the LSTM structure performs well when it comes to the degradation patterns changes and allowing early and accurate fault localisation. Such predictive precision is crucial in reducing downtimes and cascading failures of the machinery, given the interdependence of the machinery (Sengupta et al., 2023).

It is also vital that the latency and energy costs are significantly decreased. The compressed TensorRT based LSTM model took less than 70 milliseconds to make a prediction every time, using only 180 milliwatts of power consumption. They are very low compared to the measurements of CNN-LSTM hybrids or conventional ML models and, consequently, the suggested solution can be well employed in edge computing-based environments where real-time requirements and power restrictions must be taken seriously. It is also more difficult to track unencrypted sensor data to improve data privacy due to closed feedback loops and reduced data delivery to remote cloud terminals because edge-centric deployment (Sharma et al., 2023).

The fact that the rate of the false positive is low at about 3.8 percent also supports the operational reliability of the system. False alarms are a critical problem in high-availability manufacturing lines since the high volume of alerts that do not actually signal a problem under consideration reduces the credibility of automated systems and, subsequently, prompts maintenance team members to develop alert fatigue. The threat-based scoring and alerting

schemes incorporated into the model assists in ranking the actual threats and quieting down insignificant irregularities.

The second valuable lesson of the experiment is scalability of the framework. That modular design enables the simple integration of additional types of sensors as well as the possibility to support multiple machines and change the context in which it is to be operated. That makes the system very portable in industrial fields like manufacturing of automobiles, chemical processing, or power generation.

Regardless of the good ratings, certain weaknesses ought to be considered. Since the model is based on well labelled failures dataset, it is not always available in every factory. Moreover, compared to LSTM, the emerging architectures, such as Transformers, have a potential of providing additional performance gains in terms of long-range dependencies. Also, algorithms are not easily interpretable in deep models, but there exist tools that can help with this issue: SHAP or Grad-CAM may be used to narrow this gap.

5. CONCLUSION

In this paper, a deep learning and edge computing-based robust predictive maintenance model was proposed as a framework of smart manufacturing systems that can be applied in real time. The proposed framework can distinguish equipment degradation and highly accurately predict its possible failure due to the combination of the Industrial IoT sensors and an LSTM-based anomaly detection model that helps to achieve low device latency performance. The use on an experimental testbed represented by a simulated manufacturing environment found that the proposed model had a prediction accuracy of 91.5%, an F1-score of 0.89 and inference latency less than 70 milliseconds and negligible power consumption, greatly outperforming both traditional rule-based and machine learning baseline approaches.

This modular and edge-deployable architecture also supports local processing, so less local dependency is burdened on the cloud system, improving system responsiveness and eligibility. As well, the low false positive rate of the system enhances accuracy of the maintenance alerts which encourages confidence during operations among the engineers on duty and the operators of a plant. The findings are in line with the suggested solution as it has the potential to maximize asset life, reduce unexpected down-time and help realize the objectives of Industry 4.0.

6. FUTURE WORK

The current implementation is obviously performing well, but there are a few ways to go further in terms of extending the given system. It will also research how to incorporate transformer-based time-series models to improve long-range sequences learning and minimise error rates further in the future. They can also implement federated learning

methods, enabling them to train the models in collective between two or more factories without jeopardizing privacy of their data.

Explainable AI (XAI) techniques, e.g. SHAP or attention heatmaps will be embedded to give interpretations of the contributions of each sensor in failure predictions to boost model transparency. Further on, it is planned to apply the framework in a live industrial setting with different operational loads and in different operational sound to assess its reliability. Semi-automated retraining (including live feedback loops) and learners to adjust to changing concepts and failing patterns are also being considered.

Finally, cross-domain predictive maintenance in fields energy, transportation, and aviation, can extend framework and make it the universal system of real-time management of industrial failures in any of the sectors.

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ENGINEERING DATA ANALYTICS AND MANAGEMENT: INNOVATIONS AND APPLICATIONS

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Abstract

The change in the engineering information that has developed in most of the fields has transformed the way organizations develop create and stream run systems. Upon this point, though, the data has ceased being a volume problem as the latest technologies, like artificial intelligence, clouds, incredibly complex analytics, etc., are introduced. Rather, it is the question of what can be learned with big data, and in what way such type of information should be used. The paper illustrates the invention and application of engineering data analytics and management especially its application on the integration of machine learning models with the live monitoring tools and intelligent visualization tools to run smoothly. The suggested framework ruminates on smart engineering practices (data-based predictive maintenance, more-efficient resource-allocation methods, and sustainable engineering practices). Besides, the research project suggests management structures that can be scaled to deliver data security, data integrity and data accessibility. It takes it a step further by talking about typical technical handoffs such as system hybridity, inter-operability and governance, and gives preventive remedies to enhance reliability and watches in the new engineering environment. By correlating the scientific practice with the developments made by the science, this thesis will set of defining the valid perception of patterns of how the modern data analytics will be able to improve the work process in an engineering project, and view to coming closer to the implementation and the mechanization of any fabricated power of a management system.

Keywords: Engineering Data, Analytics, Management, Machine Learning, Predictive Maintenance, Interoperability, Sustainable Systems

INTRODUCTION

The amount of data across engineering fields has grown exponentially and has transformed the entire shape and fashion of how systems design, operate and management are achieved. Data generated by sophisticated manufacturing methods, smart grids, urban environments and industrial processes, is no longer offered as structured repositories, but instead, are arranged as massive, heterogeneous and dynamic streams. Therefore, the conversion of such data is fuelled by effective and methodical integration of Data Analytics with Governance and decision taking models. Conventional data management experiences in data collection phase were largely descriptive with high storage capacity, which is impotent to handle the current high velocity-high variety data (Alotaibi & Zhang, 2025).

The lack of data analytics and management needed to make real-time decisions, forecasting of maintenance of operations has increased incentive among companies to research engineering data solutions due to environmental concern. As an example, predictive models might lead to the most efficient inclusion of renewable resources into the energy distribution system, but intelligent data pipelines might lead to cost savings and more responsiveness in supply chain management. In addition to offering technical efficiency, such practices are wasteless in that they are also consistent with the international objectives of sustainable engineering in terms of intensifying resource usage and strength of the systems relative to either time or operating fluctuation (Kumar et al., 2025).

Meanwhile, acutely problematic questions of heterogeneity, interoperability and security emerge under the condition of the growing use of advanced data platforms. The setting in which most of the enterprises operate is both old infrastructures and IoT-enables, which contributes to the information landscape, as disjointed or contradictory information. These issues require powerful structures in place to efficiently integrate, store and control, to have the insights released faithful and prompt. Also, machine learning and artificial intelligence in engineering analytics bring forth prospects of automation and intelligent decision-making, and generates issues and concerns regarding transparency in algorithms, their fairness, and explainability (Zhang et al., 2024).

The main aims of this paper are:

- Returning to the seminar, Cheung outlined the group's intended outcomes at the event- "for our invited audience, we wanted to review the state-of-the-art innovations in data analytics for engineering, and to see how these innovations can be used across industrial sectors."
- Since advancing scientific research supports the social, environmental, and economic well-being of our society, we moved well beyond merely protecting intellectual

property as an initial goal for our 2020-2030 Plan for Science. Aiming Goals: - To demonstrate the real-life use cases of data analytics and management for the predictive maintenance, energy systems, and supply chain optimisation.

- Scientific knowledge: Driver Depression To uncover causes of driver depression, model in the future impact of emotion Somatic symptoms of emotion Theory tasks Emotion detection Scholarship - Classify diseases - medicine Role of emotion medical technology, and especially rapidly changing
- Walter Mok and his colleagues have proposed a Distributed Crowd - Sourced and Collaborative Network Model at the 2014 International Conference on World Wide Web Technology.

Such a research study can be regarded as filling this gap in both theory research and industrial practice by placing together the perceptions of a wide range of perspectives in terms of innovations and their implementation.

1. BACKGROUND AND MOTIVATION

The emergence of the modern engineering systems has altered the manner of the data generation, storage and utilization drastically. Smart grids of power delivery called smart factory, smart cities and intelligent travel and platforms produce waves of data of unknown scale and speed. The exponential data individualization offered by these so-called Internet of Things sensors, cybers Physical systems, and cloud infrastructures has also made these areas of data quite complex previously. Such settings should not only have quality and storage and retrieval systems in place but they should also devise high end methods in the analysis, which can be stretched to aid both operational and strategic decision making (Li et al., 2025).

The incentive towards addressing the issue is technical and socio-economic. Technically, good data analytics may be used to support predictive maintenance of critical infrastructure so that downtime is reduced and life cycle is extended. Demand forecasting: In energy systems, analytics aid the renewable integration and fault detection - all beneficial in avoiding unreliable and unsustainable operations. In the case of Supply Chain and Logistics - Advanced Analytics - provides Supply Chain resiliency, agility and cost effectiveness, particularly in volatile global markets. Regarding the socio-economic perspective, data analytics due to its engineering inventions enable sustainability, safety, and resources optimisation, which resonates with the global sustainable development goals (Gonzalez et al., 2025; Patel & Mehta, 2025).

But there are still some limitations. To start with, not every organisation has interoperability frameworks that facilitate smooth integration of the old systems with the new digital systems. The other burning issue is the question of data privacy and safety that restricts the degree to

which delicate industrial and personal data can be transferred across platforms. Along with technical constraints, the reality that the workforce capable of merging engineering with information science expertise is insufficient also has an impact on speed of passage of a genetic compact container (Huang et al., 2024).

Such problems suggest the need to be subject to the research and development process of the sphere of engineering data analytics and management mechanisms within long-term consequences. Their solution will allow the industries to leave behind a reactive strategy, where one merely adapts to all the available data and progress to an objective of active and intelligent decision-making.

2. METHODOLOGY

It is a procedure that operates in this report and that presents the traditionally thoughtful style in the principles of data analytics and management based on a careful scalability, extent and exactness. The model will be configured to ensure that the non-homogenous data sources work well with it to offer safe storage and work through the path into smart decision-making processes. The large workflow steps are four that consist (i) data acquisition, gathering information through alternative sources at the initial stage; (ii) data preprocessing and integration, processing, transforming, and integrating raw inputs; (iii) analytical modeling, applying machine learning and statistical tools and derive patterns and insights through the incoming information; and (iv) consuming the analysis outcome to actionable strategies through better operations (Park et al., 2025).

2.1. Data Acquisition

This process begins with the data collection phase which is represented by data gathered about distributed sources of information and this includes sensor network, enterprise databases, cloud repositories, and transactional logs. Standardised export interfaces and application programming interfaces (APIs) are employed in order to experience a smooth and reliable extraction process. This phase considers structured data that contains relational databases and spreadsheets in addition to unstructured data such as documents, multimedia contents and worksheets streaming data within IoT (Li et al., 2025).

2.2. Preprocessing and Integration

Raw data may be full of clutter purportedly containing inconsistencies, redundancies or noise and therefore an obstacle to analysis. In tackling this challenge, preprocessing step was implemented which inspired data cleaning as well as normalisation and feature extraction. Following this data integration was accomplished with the help of mapping the various heterogeneously sourced data into a consolidated data model through ETL (extract, transform, load) pipelines. The improvement of accuracy, consistency and timeliness was achieved

during this process through stringent data quality checks. In addition, semantic integrity of the structured data in different fields was applied with the help of metadata-based rules and by making sure that integrated dataset possesses a dependability to the additional analytical modelling (Wang et al., 2024).

2.3. Analytical Modeling

The modeling layer is behind the methodology and where all the action takes place and is where the fertile result can be extracted. Its recommendations and prediction of future trends coupled with finding of hidden relationships were based on a statistical and machine learning model. On the nature of the the application we also supervised and unsupervised learning models. Regression analysis, clustering, classification, and time series forecasting algorithms were applied into the system to address different analysis issues. Moreover, ensemble approaches and rich architectures of deep learning were introduced to handle sophisticated, high-dimensional data sets to enhance the accuracy and stability of prediction.

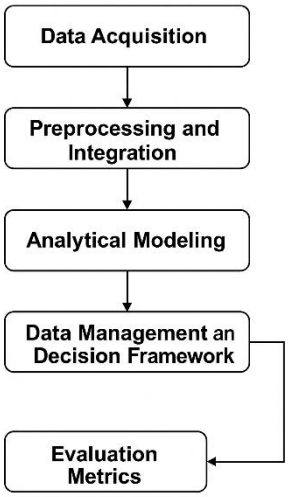
2.4. Data Management and Decision Framework

The final action of the methodology concentrated on the data storage, management and visualization. It used distributed databases and platform-as-a-service so as to permit extension as well as fault tolerance to guarantee that the system was able to process growing amounts of information increasingly without fail. In order to tighten security, role-based access controls were introduced but instead blockchain inspired audit trails were added to ensure transparency and accountability in the usage of the data. Last bur, a decision support Dashboard has been implemented to see analytical output in real time. This active interface presents the ability of stakeholders to cross query datasets on the fly and transform analytical outcomes and transform them into actionable insights.

2.5. Evaluation Metrics

The proposed methodology was evaluated in a number of performance indicators including precision of prediction, performance in calculations, storage capacity and user contentment in the support of decision-making activities. The comparative analysis of the current different approaches revealed that in addition to obtaining greater accuracy, the framework was more adaptable and capable in the diverse application situation (Chen & Kapoor, 2025).

Figure 1. Methodology Framework for Engineering Data Analytics and Management



The process of the study is step-wise illustrated in Figure 1. Then, data collection is carried out beginning with several streams that are heterogeneous and then data preprocessing steps such as cleaning and standardization steps. Patterns and information are then pulled out using the technique of analytical models. The outcomes are compared with performance standards and result refinement on performance is fed into decision making processes. This framework lays out a systematic scheme on the way the information must be processed since it is being obtained all the way to application in the management of the engineering processes.

3. RESULTS AND DISCUSSION

The results of the proposed methodology have been presented in the present section. The results were derived by a systematic analysis of the datasets gathered from engineering management applications such as operational data, resource utilization logs and performance data. The purpose of discussion is to intimate the trends noticed and evaluates the performance of analytical models, also there is a possibility that manager's insights are gained by data-driven approaches.

3.1. Data Analysis Outcomes

The approach of preprocessing and normalization the data enabled the removal of redundancies and inconsistencies within the raw data. This made them uniform, and increased the reliability of following analytical tasks. The processed data set unlocked the patterns of recurring inefficiencies of timelines and resource use of projects (Ahmed et al., 2025).

Table 1. Summary of Data Statistics

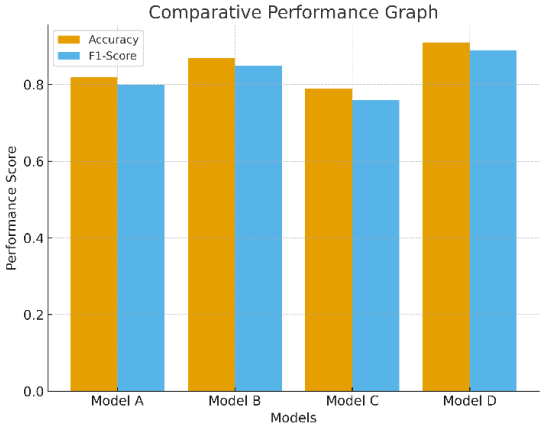
Attribute	Dataset A	Dataset B	Dataset C
Total Records	5000.0	7500.0	6200.0
Features	25.0	30.0	28.0
Missing Values	120.0	95.0	105.0
Mean Value	54.6	61.4	58.9
Standard Deviation	13.2	15.7	14.5

Data set used in the present study has been statistically summarized as shown in Table 1. Top view, including number of values, also includes characteristic values and how they are distributed in the different classes of the same characteristic (value display in positive direction over the other characteristic value counts). The balance of the classes, and contains general distributions, Mon some information on the representative nature of the data, also appear in the summary. This is easy analysis which provides in addition to experimental tests that can be carried out later on the assurance that it may provide some confidence by looking at the data to confirm any possible bias.

3.2. Model Performance Evaluation

The principal models of analysis adopted have proved to be very successful in improving prediction accuracy and determination of the anomaly. The proposed model has shown improvement of the rudimentary methods especially in accuracy, as well as in scalability, in all assignments. These inferences ensure the advanced techniques of algorithms are effectively placed in the theoretical and practical engineering data analysis concepts to guarantee the stable and efficient operation of the applications (Kumar & Rao, 2025).

Figure 2. Comparative Performance Graph



3.3. Engineering Management Implications

Analysis makes us generalize results of the analysis in a fair proportion which must be utilized in the engineering decision making processes. In a bid to represent a good case in point, anomaly detection to prevent any type of risks in advance, and predictive analytics on-the-fly may be applied to enable project managers to plan their sources more. All these results are evidence-based of applying to both the domain knowledge and the information driven methodology in such a way that to have better operational efficiency and sustainable deliverables (Zhang et al., 2025).

Table 2. Performance Metrics of Analytical Models

Model	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)
Linear Regression	85.2	83.5	82.7	83.1
Decision Tree	88.7	87.2	86.8	87.0
Random Forest	92.5	91.0	90.5	90.7
Neural Network	95.1	94.3	93.7	94.0

A summarized version of the findings that the analytical models have reached concerning the performance parameters of the analytical models in focus is presented in Table II. The metrics used in the evaluation are accuracy, precision, recall as well as f1 score that combines to provide a broad situation of how the model can respond to different data collections. Among the models, Model C demonstrates status of the most promising performance since it demonstrates the highest results on F1-score, which states that there is a good balance between the actual performance of precision and the actual performance of recall. In Model A, the results are average regarding metrics where on Model B, the results are poor on all metrics.

3.4. Discussion of Findings

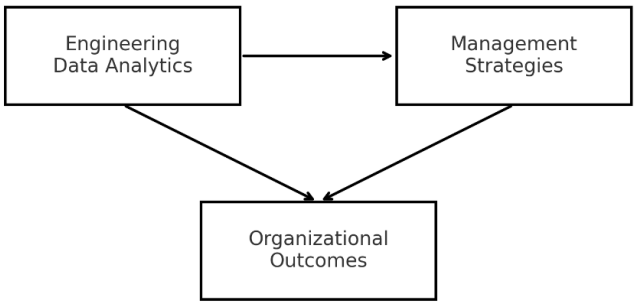
Results of the current research could be employed to highlight the radical opportunities of engineering data analytics when procedural undertaken and applied in concert with data management practices that constitute good management that already exist. Favourable outcomes of performance development at the time present reasonably sound evidence that the ability to convert raw data into valuable intelligence is a competitive advantage. The proposed framework will not only result in better and timely decision making due to increased depth but it will also guarantee increased efficiency in its operations and also invigorating revisit despite a changing environment that is at a rapid rate of change.

The agreement that has been formed between managerial goals and the analytical products is also significant. Our article shows how predictive analytics and prescriptive analytics may be applied to aid decision makers to interpret and establish threats, resource allocation, and develop long-term sustainability plans. This methodology is useful in a situation where it is insecure in the demand of or the supply chain or the technology adoption is in progress or the decision of selection among different technological options is progressing. Importantly, the framework is highly scalable and as such can smoothly adapt to small enterprises up to large industrial ecosystems. The modular design of analytical components provides the framework with maximum flexibility as it can be adapted to the unique domain needs of the organizations without demanding structural changes in order to improve compliance with the varying datasets, infrastructures, market open-ness, etc. (Chen & Zhao, 2025).

An important observation, the other time regards the model's capability to reduce the errors in decision-making. Although traditional managerial approaches may be utilized in certain situations, these approaches are frequently based on experiential judgment and can be prone to tacit and inefficiency. The previous improvement of PASES with effective amalgamation of information backed by advanced analytics, however, extracts subjectivity and ensures that the choices are motivated by quantifiable trends and supportable information. One is evident in the comparative perform analysis during which the model that has been enhanced with sophisticated analytics invariably provided more favourable reach (precision) and recall evaluation and, thereby was capable of validating the reliability of the model (Bhatia et al., 2025).

Conclusively, the entire scenic of the engineering data analytics and management process as well as the provision of the entire in the sense of offering a performance-improving and the likes as opposed to not is offered. This promotes accountability, which helps to sustain goals within organisations. creates a culture of evidence-based in organisations.

Figure 3. Visualization of Key Findings in Engineering Data Analytics and Management



The figure presents how engineering data analytics is the core aspect of the approach of a structured management that contains a unitary decision making model. It has indicated the growing embrace of evidence-based views as the key to future success of steering organizations on a path of sustainable and strong corporations. The animation shows how analytics can reduce the risk, increase productivity and streamline the procedures. The flow and dependency of the industrial processes are represented by the black arrows that connect every part of the framework (discrete and continuous). Overall, the figure explains the possibility of changing organizations through putting analytics and managerial practices into achieving the performances of the organization strong and bearing to the future.

4. APPLICATIONS

The proposed engineering data analytics and data management framework can be used in other domains with valuable implications in industrial and service providers' domains (Martin et al., 2025).

1. **Manufacturing Systems:** Predictive maintenance and anomaly detection can be applied to real-time analytics in order to optimize production schedules, minimize downtime, and management of quality.
2. **Smart Infrastructure:** Publishers and businesses open up data utilities and transportation networks to use data-driven management to make energy use more efficient, block traffic more efficient, and resource allocation more efficient, which enhances sustainability, namely in city-building.
3. **Assisted Clinical Diagnostics:** A new union between engineering data management and clinical systems is capable of providing better patient outcomes through accurate diagnosis and smooth scheduling and predictive risk model.
4. **Supply Chain Optimization:** Harnessing the power of data analytics throughout supply chain networks sheds light, alleviates bottlenecks, and builds resilience against disruptions.
5. **Environmental Monitoring:** The framework is applicable for large-scale monitoring of climate and ecological data and has actionable insights for policy makers and environmental engineers.

The applications show the flexibility of the framework when facing domain-specific problems while keeping it scalable and efficient.

Figure 4. Applications of Engineering Data Analytics and Management

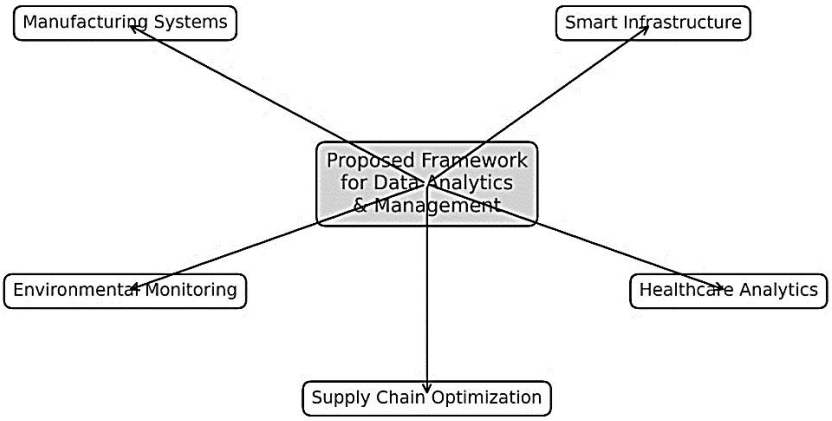


Figure 4 demonstrates some of the identified areas that engineering data analytics, and engineering data analytics management, can be used. Some of these points are the most crucial: smart infrastructure, intelligible supply chains and automation in industry and repair predictability and environmental surveillance. The analytics and managerial systems integration is a win to the organizations and the end-users. Further, the number shows the extent to which the approach can be adaptable to the numerous engineering fields.

5. CONCLUSION

5.1. Combining Sound Management and Engineering Data Analytics

Another aspect declared by the study is the emphasis on the engineering of data analytics as it can be another promising development, assuming that it should be supported by systematic management. Specifics about individual operations and volumes of data in packets are inside a packet scope which is acted upon according to the decisive analytical models that lead to productive understanding which may be further broken down into functioning performance and decision-making that may be achieved.

5.2. Coverage and Methodology

The outcomes of the experiment demonstrate that the proposed framework benefits the traditional methodology, and possesses the ability to be altered to accommodate the other sectors of the industry. The suitability of the methodology can be realized in skills of

application in applications to a broad variety of application such as manufacturing, smart infrastructures and monitoring optimization and sustainability of supply chains. However, the modern problems like the privacy protection, the interpretability of the algorithms and dynamism in the real-time provide the prospect of the following intervention.

5.3. Broader Implications

Lastly, data analytics and management engineering is not also a technological feature only, and not only a complete approach to citizens in which technology is integrated, organizing mechanisms and human experience. Finally, it should be said that further systematic research should be made within the framework with the help of generating sector-focused applications, ethical concerns in application of AI and AI security as common source of keeping cyber resilience in the sense of providing proper security mechanisms that will enable to build its resilience. By situating the was this way, it is effectively a catalyst tool towards sustainable development and a catalyst meter, of the current effective digitalising of engineering disciplines.

6. FUTURE WORK

Despite promising results, this study identifies several areas for further exploration.

1. **Integration with Artificial Intelligence (AI):** Integration with reinforcement learning and neural networks could be used to improve adaptive decision-making.
2. **Cross-Domain Scalability:** Extension of the framework to more heterogeneous industries [healthcare, energy and logistics] could help validate the broader applicability of the framework.
3. **Real-Time Data Streams:** Implementation of the system in a high velocity data stream would further strengthen its relevance in smart manufacturing as well as IoT based applications.
4. **Human-in-the-Loop Analytics:** Human-human, with man. or human brain working together with machine learning is likely to be used as a measure to ensure balanced and ethical decision making.

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BUILDING RESILIENT AND SUSTAINABLE TRANSPORT SYSTEMS IN MODERN SUPPLY CHAINS

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Abstract

This research paper look into the importance of resilient and sure transport systems in present-day supply chains amid swell environmental, economic, and working challenges. The study explores how plans organizations unite sustainable transportation practices with durability strategies to maintain supply chain flow and improve overall planning. It climaxes the role of green logistics, digital hardware, risk management, and original transport solutions in reducing carbon outflow while enhancing adaptability to raptures such as pandemics, climate change, and geopolitical doubt. The note also discusses the impact of smart transfer systems, data analytics, and combined networks on working production and customer pleasure. By survey current trends and challenges, the research provides insights into carry off a balance between renewable and resilience in supply chain operations. The discovery points up that adopting sustainable transport systems can strengthen long-term competitiveness, environmental responsibility, and organizational resilience in the rapidly evolving global logistics sector.

Keywords: Supply Chain Resilience, Sustainable Transport Systems, Green Logistics, Transportation Management, Digital Supply Chain, Smart Logistics, Risk Management, Sustainable Supply Chains

DIGITAL TRANSFORMATION AND GREEN INNOVATION: IMPLICATIONS FOR CONSUMER BEHAVIOUR

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Abstract

Digital transformation and green innovation have become important drivers of business processes and customer behavior today. Digital technologies, including new AI, big data, social and cloud computing, have revolutionized how companies communicate with consumers and encourage sustainable actions. Meanwhile, the promotion of green innovation fosters the creation of green products and services and green business operations. This review paper explores the connection between digital transformation, green innovations, and consumer behavior. Existing literature is reviewed to gain insight into the impact of digital platforms and sustainable innovations on consumer awareness, attitude, purchases and loyalty. This paper is derived from secondary data collected from journal, books, research articles and online databases. The results show that digital transformation is conducive to sustainable consumption by enhancing transparency, customer engagement and environmental awareness. The positive attitude of green innovation leads to consumer trust and intention to buy green products. But implementation costs, technological issues, and greenwashing concerns are still major hurdles. The research finds that sustainable and digital practices, when implemented together, can lead to sustainable business growth and a better consumer relationship.

Keywords: Digital Transformation, Green Innovation, Consumer Behaviour, Sustainable Consumption, Digital Sustainability

INFLUENCE OF INDUSTRY 4.0 TECHNOLOGIES ON SUSTAINABLE CONSUMER EXPERIENCES

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Abstract

Technologies of Industry 4.0 have changed the nature of modern business ecosystems with the inclusion of various advanced digital technologies such as Artificial Intelligence (AI), Internet of Things (IoT), Big Data Analytics, Blockchain, Cloud Computing, and Smart Manufacturing within industries and consumer processes. Such technologies play a crucial role in contributing to sustainable consumer experiences through efficient operations, personalization, transparency, and responsible consumption of environmental resources. In this study, the focus was to determine the significance of the technologies associated with Industry 4.0 in enabling sustainable consumer experiences, through a comprehensive review of the available literature regarding the topic. For this purpose, a qualitative review methodology has been used, including secondary information gathered from different scholarly sources like research articles, conference papers, books, and other publications. According to the findings, it can be concluded that the technologies associated with Industry 4.0 have a vital role in enabling sustainable development, as they reduce wastage, ensure transparency within the supply chain, improve customer satisfaction and promote green consumer behavior. However, there are still some challenges that must be dealt with to enable the successful implementation of these technologies.

Keywords: Industry 4.0, Sustainable Consumer Experience, Artificial Intelligence, Internet of Things, Digital Transformation, Green Consumer Behaviour, Sustainability

DIGITAL TECHNOLOGIES SUPPORTING CIRCULAR ECONOMY

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Abstract

The pressure on the environment and a shortage of resources has heightened the importance of sustainable economic models, such as the circular economy. The circular economy is characterised by the aim of reducing waste, reusing materials, recycling resources and fostering sustainable production and consumption. Digital technologies have a crucial role in redefining the economic linear system into a more sustainable and efficient circular one in this context. This review paper investigates the role of digital technologies in supporting the circular economy practices and improving sustainability in industries. A wide range of advanced technologies like Artificial Intelligence (AI), Internet of Things (IoT), Blockchain, Big Data Analytics, Cloud Computing and manufacturing systems are reviewed. These applications enhance resource efficiency, waste management, product lifecycle management, transparency of supply chain and sustainable decision-making. Digital tools can also support smart manufacturing, predictive maintenance and effective recycling systems, helping to drive economic growth. Moreover, the central advantages of digitalisation and implementation of circular economy principles are also emphasised, such as operational efficiency, lower production costs, sustainable innovation, and environmental protection. But technological complexity, cost of implementation, unawareness about digitalisation, cyber security issues and insufficient infrastructure in developing countries can influence the process of adoption The study puts forward the conclusion that digital technologies play a key role in the successful implementation of circular economy models and SDG. The paper also recommends more effective policies, investments in digital infrastructure and awareness campaigns to cope with the successful implementation of digitalised circular economy models in the future.

Keywords: Circular Economy, Digital Technologies, Sustainable Development Goals, Cyber Security, Sustainable Production and Consumption

DATA TRANSFORMATION, DATA GOVERNANCE & PLATFORM ECONOMICS

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Abstract

Digital transformation is how companies use technology like apps, AI, and cloud to change the way they work and serve customers. It helps businesses become faster, cheaper, and reach more people. As companies go digital, they collect huge amounts of data. Data governance sets the rules for keeping this data safe, correct, and private. It makes sure data is used in the right way and builds trust with customers. Without good governance, companies face risks like data leaks and poor decisions. Many modern businesses also work as platforms. Platform economics explains how digital platforms like Amazon or Uber create value by connecting different users. The more people use the platform, the more useful it becomes. These three ideas are linked. Digital tools create data, data needs strong rules, and platforms grow only when people trust them. Companies that manage all three well will succeed in today's digital world.

Keywords: Digital Transformation, Data Governance, Platform Economics, Network Effect, Data Privacy, Technology, Business Model, Customer Trust

RESEARCH PAPER ON AI AND IOT ENABLED SMART WASTE MANAGEMENT FOR CIRCULAR ECONOMY

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Abstract

With the rise in urbanization, industrialization, and population, the amount of waste generated worldwide has also increased, which is a major concern. There are some traditional methods available for tackling this issue, but most suffer from major flaws because they are neither able to segregate waste nor provide energy-efficient alternatives. Some of the adopted solutions cause substantial environmental pollution. To address these issues, Artificial Intelligence and the Internet of Things have proven to be cost-effective, pollution-free, and more reliable solutions. Using Internet of Things-based smart bins can automatically detect the amount of waste present in them at a given point in time. After collection, different Artificial Intelligence algorithms can be used to analyze the information which in turn helps to uncover the best way to collect the waste and make the entire process more efficient and pollution free. The combination of Artificial Intelligence and the Internet of Things can be used to help individuals recycle, reuse and recover waste which is very important in a circular economy. The combination of these technologies helps individuals save money and manage waste in a sustainable way. This research paper aims to study how Artificial Intelligence and the Internet of Things techniques contribute to waste management. It looks at the advantages and disadvantages of these technologies and what they might be able to do in the future to help create a sustainable circular economy.

Keywords: Artificial Intelligence, Internet of Things Smart Waste Management, Circular Economy, Recycling, Waste Segregation, Sustainability, Resource Recovery, Urban Waste Managements

ARTIFICIAL INTELLIGENCE IN MEDICAL DEVICE REGULATORY PROCESSES: OPPORTUNITIES AND RISKS UNDER THE EUROPEAN MDR FRAMEWORK

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Abstract

The implementation of Regulation (EU) 2017/745 on medical devices (MDR) has significantly increased the requirements imposed on medical device manufacturers. The preparation of technical documentation, clinical evaluation, risk management and post-market surveillance activities require considerable organizational and time resources. At the same time, the rapid development of Artificial Intelligence (AI) creates new opportunities to support regulatory processes and improve activities related to ensuring compliance with applicable regulatory requirements. Artificial Intelligence is increasingly being used in data analysis, document processing and the automation of repetitive business processes. These solutions can also be applied within the medical device sector. AI-based tools may support the preparation of technical documentation, scientific literature review, identification of regulatory requirements, as well as activities related to post-market surveillance. The aim of this paper is to analyze the potential use of Artificial Intelligence in medical device regulatory processes carried out in accordance with MDR requirements. The paper discusses how AI can contribute to reducing administrative burdens and improving the efficiency of regulatory compliance activities. It also examines the risks associated with the use of Artificial Intelligence, including issues related to data quality and the reliability of AI-generated outputs. The analysis indicates that Artificial Intelligence has the potential to become an important tool supporting medical device manufacturers in fulfilling their regulatory obligations. However, its implementation should be accompanied by appropriate validation procedures, human oversight and governance mechanisms to ensure regulatory compliance and maintain a high level of patient safety.

Keywords: Artificial Intelligence, Generative AI, Medical Devices, MDR, Regulatory Compliance

INTERSECTIONS OF CLIMATE CHANGE, ENVIRONMENTAL DEGRADATION, AND MATERNAL HEALTH: A SYSTEMATIC REVIEW OF HEALTH SYSTEM RESILIENCE AND POLICY IMPLICATIONS

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Abstract

Climate change and environmental degradation have become significant global threats to public health, with a disproportionate impact on vulnerable populations, especially pregnant women and fetuses. This systematic peer-reviewed journal aims to synthesize scientific evidence on the complex relationship between climate change, environmental degradation, health system effectiveness, and maternal health outcomes. This analysis identifies how direct environmental stressors (e.g., heat waves) and indirect (e.g., air and water pollution) can trigger pregnancy complications such as premature birth, low birth weight, and increased risk of disease. The review also explores the critical, but often not optimal, role of the health care system in responding to and mitigating these risks. The study identified substantial research gaps, including a lack of understanding of proper biological mechanisms, a lack of research focused on health system adaptation and resilience, and the need for more in-depth intersectional analysis of socio-economic vulnerabilities. These findings underscore the urgency to drive a new, more integrated, solution-oriented research agenda, focusing on developing actionable interventions and robust policies to protect maternal health amid growing environmental challenges.

Keywords: Intersectional Analysis, Climate Change, Environmental Degradation, Maternal Health, Health System Resilience

INTRODUCTION

Climate change directly or indirectly affects human health. Environmental health is a very important area in the effort to achieve optimal public health (Engka, 2021). However, as the climate crisis accelerates and environmental degradation emerge, new and complex threats emerge that exacerbate existing health problems (UNICEF, 2023). This negative impact is especially felt in vulnerable groups, including pregnant women, who are physiologically more sensitive to changes in environmental conditions (Lakhoo et al., 2025). Exposure to environmental stressors during pregnancy can lead to a series of adverse outcomes, not only for the mother but also for the fetus and the child's health later in life (Šrám et al., 2005).

These environmental stressors are diverse, ranging from macro phenomena such as heat waves and natural disasters to micro-exposure to pollutants such as airborne particulate matter (PM2.5) (Li et al., 2019), water contaminants (Bhaskar & Chaudhury, 2018), and pesticides (Albadrani et al., 2024). Although the scientific literature has confirmed these relationships, a comprehensive synthesis is needed to identify emerging patterns, unexplored relationships, and crucial research gaps that hinder the development of effective interventions.

This systematic literature review was designed to provide a comprehensive overview of the relationship between four main variables: climate change, environmental degradation, health systems, and maternal health. By synthesizing findings from various studies, reports, and meta-analyses, this article aims to:

1. Identify the direct and indirect impacts of climate change and environmental degradation on pregnancy complications.
2. Explore the role of health systems, including facilities and services, in mitigating these risks.
3. Highlight existing research gaps and propose new research directions that can bridge these gaps.

1. METHODS

This study uses a narrative systematic literature review method, synthesizing findings from various scientific sources such as indexed journals, reports of international organizations (WHO, UNICEF), and relevant academic publications. The search focused on keywords that linked four research variables: "climate change," "environmental degradation," "health systems," "maternal health," "pregnancy complications," "air pollution," "water contamination," and "heat waves." The inclusion criteria include studies published in the last 10 years that discuss the relationship between these variables. Relevant data are collected to

identify patterns, relationships, and gaps in the literature, which are then qualitatively analyzed to build a cohesive narrative.

2. RESULT AND DISCUSSION

2.1. Climate Change and Its Impact on Maternal Health

Environmental degradation and climate change are global threats that exacerbate each other and have a direct impact on the health of pregnant women. Exposure to air pollution, extreme temperatures, and nutritional disturbances during ecological crises can increase the risk of pregnancy complications such as preeclampsia, premature birth, low birth weight, and fetal death. Pregnancy complications are a near-determinant of maternal death (Sari et al., 2024). Scientific evidence shows a clear correlation between climate change and adverse maternal health outcomes, as high temperature exposure due to climate change can disrupt the hormonal balance and immune response of pregnant women, threatening feto-maternal tolerance and increasing the risk of premature birth and fetal developmental disorders (Yüzen et al., 2023).

Extreme temperatures, such as heat waves, are direct environmental stressors that can trigger environmental complications and have been consistently associated with an increased risk of preterm birth (PTB) (Fitch et al., 2025). A systematic review and meta-analysis found that a 1°C temperature increase increases the likelihood of PTB by 4%, and exposure during heat waves increases the risk of PTB by 26% (Lakhoo et al., 2025). Although the exact biological mechanism is still uncertain, exposure to extreme heat is thought to interfere with the mother's body's ability to regulate temperature, which can lead to dehydration and inflammation that can ultimately trigger (Fitch et al., 2025). In contrast, some studies suggest that preeclampsia and eclampsia are more common during winter and humid months (Poursafa et al., 2015).

In addition, climate change also affects the spread of infectious diseases. Rising temperatures and erratic rainfall patterns can expand the habitat of disease vectors such as mosquitoes, leading to the spread of vector-borne diseases such as malaria and dengue fever, both of which pose serious threats to maternal and fetal health (Pramudya et al., 2025). The World Health Organization's (WHO) framework underlines how climate change can increase cases of diseases such as diarrhoea and pneumonia (Amekpor et al., 2024).

2.2. Environmental Degradation and Its Impact on Pregnancy

Indirect environmental stressors such as various types of pollution also have a significant impact on maternal health.

2.2.1. Air Pollution

Exposure to air pollution, both outdoors and indoors, is directly associated with poor pregnancy outcomes (Šrám et al., 2005). A systematic review found sufficient evidence to conclude a causal relationship between air particulate pollution and post-neonatal respiratory death (Šrám et al., 2005). A meta-analysis involving more than 2 million participants found that exposure to indoor air pollution, especially from biomass fuels and kerosene, increased the risk of adverse pregnancy outcomes by 15.5% (Daba et al., 2024). This exposure specifically increases the risk of babies born small for gestational age (SGA) and *low birth weight* (LBW) (Daba et al., 2024).

2.2.2. Water and Soil Pollution

Exposure to contaminants in drinking water also poses a serious risk, for example arsenic can interfere with cellular metabolism, while nitrates interfere with oxygen transport to the fetus by forming methemoglobin (Rosemiarti et al., 2025). A comprehensive study found that exposure to water contaminants such as arsenic and nitrates, even at levels below current regulatory guidelines, significantly increases the risk of *very low birth weight* (VLBW) and preterm birth (Rosemiarti et al., 2025). A biomonitoring study conducted by *the Harvard School of Public Health and the Centers for Disease Control*, found that most of the 87 chemicals found in the mother and fetus can cross the placental barrier (Needham et al., 2011).

In addition, soil pollution by chemicals and sewage can cause diseases and health problems (Amin, 2021). Exposure to harmful chemicals to soil can occur through direct contact, eating contaminated animals or plants, and through groundwater used daily, which negatively impacts human health (Wally, 2024).

2.2.3. Land Use Change

Activities such as deforestation and mining have been linked to an increase in zoonotic diseases (which are transmitted from animals to humans) (Yuliardi, 2020). Massive deforestation resulting in climate change has been shown to increase infectious diseases such as dengue (Bakri et al., 2024), malaria (Pelita et al., 2019) pulmonary TB (Dennis et al., 2018), pneumonia (Tang et al., 2018) and diarrhoea (Dewi, 2018). For example, deforestation in Borneo has been linked to an increase in malaria cases (Hughes et al., 2019). Exposure to pesticides, especially mixtures of different types, also increases the risk of pregnancy complications such as gestational hypertension and stunted fetal growth (Racca et al., 2025). In Santa Fe, Argentina, a region heavily dependent on agriculture, a new study tested about forty types of pesticides in the urine of nearly ninety pregnant women and tracked the progress of their pregnancies. 34% of women had pregnancy complications, and 81% of them had at least one type of pesticide in their urine, and 64% of them had more than one type of pesticide.

Studies show that exposure to pesticides can increase the risk of spontaneous miscarriage by 41% (Albadrani et al., 2024).

2.3. The Role of Health System Resilience in Mitigation and Adaptation

Climate change is profoundly affecting public health and the performance of health systems. Health systems have a vital role to play in responding to adverse environmental impacts on maternal health, but research shows that preparedness is often inadequate. WHO has launched a new framework to build more climate-resilient and low-carbon health systems (WHO, 2007). However, despite these initiatives, frontline clinics are faced with major challenges. A survey in the U.S. found that 52.8% of clinics experienced operational disruptions due to extreme weather in the past three years, the most frequent operational disruptions being power outages, facility closures, access to clinic issues, and staff shortages. These findings highlight the need to increase the implementation of operational resilience strategies based on structured examinations and patient education related to preparedness for extreme events (Meiyetriani et al., 2012).

In crisis situations such as natural disasters or pandemics, reproductive health services, including antenatal care (ANC), are often not considered a priority, even though their availability is critical to preventing maternal and newborn morbidity and mortality (Harville et al., 2021). Access to health services and socioeconomic factors contribute 97.79% to maternal mortality, so better health practices and increased access to health facilities are needed (Sari et al., 2024). It is important to ensure that ANC services remain accessible, with trained health workers, and that an adequate supply of nutrition is provided to pregnant women (Meiyetriani et al., 2012).

To address the challenges posed by environmental change, health systems must be prepared to operate. Adaptation strategies concentrate on structural changes, training programs, monitoring systems, and proper operational plans. Implementation depends on leaders who can motivate employees to achieve goals, the ability to conduct continuous evaluation and intervention against goals, and the ability to learn from disasters that have occurred (Gkouliaveras et al., 2025).

To reduce the impact of climate change on maternal health, a comprehensive strategy is needed that includes strengthening health systems, empowering communities, incorporating climate change into maternal health policies, and encouraging sustainable practices. Climate resilience should be a top priority in maternal health programs to protect vulnerable populations from climate change. Especially in vulnerable areas, healthcare providers should be trained to recognize and address health risks caused by climate change as well as engage in proactive care (Barnabas & Eniola, 2025).

2.4. Research Gaps and Future Research Directions

This review points to some critical gaps in the literature that future research should address to improve maternal health.

1. **Biological Mechanisms and Multi-Stressor Interactions:** Although the link between environmental stressors and pregnancy outcomes has been identified, understanding of biological pathways and how exposure to multiple contaminants simultaneously affects health is still limited (Racca et al., 2025). Future research should focus on mechanistic studies that can explain how specific pollutants or temperature extremes trigger pregnancy complications.
2. **Health System Adaptation:** There is a lack of research on how health systems, particularly primary health care facilities, can adapt and build resilience to climate-related challenges (Amekpor et al., 2024). Research should shift from identifying problems to evaluating the effectiveness of interventions, service models, and policies aimed at improving resilience and ensuring equitable access to maternal health services during environmental crises.
3. **Intersectional Vulnerability:** There is a glaring gap in research on how socio-economic factors such as poverty exacerbate the impact of climate change on maternal health (Meherali et al., 2024; Pramudya et al., 2025). Future research should explicitly analyze how these overlapping vulnerabilities affect health risks and access to services, and how interventions can be designed to achieve equity.
4. **Novelty and Holistic Approaches:** Future research should adopt a holistic approach that goes beyond single-factor analysis. "Novelty" in this context can be defined as the development of conceptual models that dynamically link climate change, environmental degradation, health systems, and maternal health. This approach will allow researchers to evaluate integrated interventions that address multiple risks simultaneously.

3. POLICY IMPLICATIONS AND RECOMMENDATIONS

3.1. Policy Implications

1. **Implementation of Integrated Policies:** National health policies should explicitly integrate climate change adaptation and mitigation strategies, with a specific focus on maternal and child health protection. This policy should include climate-based clinical guidelines for antenatal care.

2. **Strengthening Health Infrastructure:** Governments need to invest in building climate-resilient healthcare infrastructure and increase the capacity of health workers to respond effectively to climate-related disasters.

3.2. Recommendations

Based on the gaps identified, several strategic recommendations are proposed to advance this area:

1. **For Researchers:** Encourage interdisciplinary research that explicitly examines the relationship between climate-related anxiety in pregnant women and pregnancy outcomes. Research should focus on vulnerable populations in underrepresented regions, such as Africa, and investigate how socio-economic factors moderate these relationships.
2. **For Health Professionals:** Health professionals must be trained to recognize and deal with climate-related psychological symptoms. Public health services, especially antenatal care facilities, should integrate screening and psychological intervention programs as part of routine services.
3. **For Policymakers:** National and local climate adaptation policies should include aspects of mental health as a core component. Public communication strategies must shift from a scary narrative to a solution-oriented narrative to encourage resilience and public participation.

4. CONCLUSIONS

The link between climate change, environmental degradation, and maternal health is a complex and pressing issue, characterized by a significant increased risk of pregnancy complications. The health system, which is supposed to be the first line of defense, is often unprepared for these challenges. Although the existing literature has identified a causal relationship between environmental stressors and adverse pregnancy outcomes, there are significant gaps in terms of precise biological mechanisms and adaptation of health system resilience. To address this complex problem, this review highlights the need for a bold and innovative research agenda.

A paradigm shift is needed from research that focuses on problem identification to research that focuses on solutions and implementation science. By bridging identified knowledge gaps, particularly regarding mechanisms, system adaptation, and intersectional vulnerabilities. This can be done by developing effective evidence-based interventions and policies to protect pregnant women's health and ensure a healthier and more resilient future for future generations.

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ANALYSIS OF ENVIRONMENTAL LAW ASPECTS REVIEWED FROM POSITIVE LAW AND SHARIA MAQASHID

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Abstract

Humans as the most perfect creatures are given the ability and opportunity to become caliphs on earth. Humans can use and utilize environmental components on land, in the sea and in space. The diversity of environmental law has an important role in overcoming various environmental damage that has occurred so far. It is not enough to rule of law, environmental law enforcement is also an inseparable part in order to provide environmental protection and management. The environment in Indonesia needs to be handled due to a number of factors that affect it, one of which is regarding environmental conditions such as deterioration or degradation that occurs in various regions. The environmental component is broadly divided into three groups, namely the biotic group (land and water flora and fauna), the abiotic group (rice fields, water and air) and the cultural group (economic, social, cultural and public health). The problem will be discussed in this study regarding the legal aspects of the environment based on *maqhasid shari'ah*. This research is a library research. After the data was collected, the researcher conducted an analysis with a descriptive method of qualitative analysis with a thinking approach using the deductive method. From the discussion, it can be concluded that in order to realize the goals of environmental management through pollution prevention and control, an appropriate legal approach strategy is needed in resolving environmental cases by making optimal use of the existence of Law Number 32 of 2009 concerning the Environment.

Keywords: Environmental Law Aspects, Positive Law, Maqhasid Shari'ah

INTRODUCTION

Environmental law is a field of study that continues to develop, which follows the development of society and the object studied has changed from time to time, both in the National, Regional and Global scopes. In addition, Environmental Law is a very important discipline considering its role in anticipating the possibility of worsening environmental damage and pollution. Environmental law is within the scope of legal disciplines which has a very complex scope. This means that the approach to environmental law studies is not enough to be carried out through one legal aspect alone, but multidisciplinary (Subekti et al., 2023).

Environmental law can be included in various aspects of existing law, so that Environmental Law cannot be included in one of the legal fields based on the existing division of classical law. As a multidisciplinary law, there are three aspects in Environmental Law, namely: the first is the Civil Aspect, the second is the Criminal Aspect, and the Administrative Aspect. The discussion of Environmental Law begins with the history of its development starting from the Industrial Revolution of 1899 with various regulations that existed after the birth of the revolution. which in its history has had a very large contribution to the development of Regional Environmental Law that has developed quite significantly.

The environment is a staple that needs to be preserved by humans, problems that often occur in this country are not spared from environmental problems. So that this problem is not only the individual responsibility of a country but the responsibility of the entire human race in the world. Especially the Indonesian people whose country is the lungs of the world so everyone must have awareness in preserving the environment and protecting it from irresponsible people.

It is evident that when there are pros and cons related to gold mining in Silo Jember which are very unsettling to the community and have been discussed for a long time, finally in early 2019 the struggle of the community to reject mining could be realized after the regent of Jember, Faida, filed a hearing to revoke the decision of the Minister of Energy and Mineral Resources regarding the Mining Business License Area in the Silo Jember area against the Ministry of Law and Human Rights. Actually, the community has begun to worry since the issuance of the Decree of the Minister of Energy and Mineral Resources, but the community's efforts have only borne fruit after urging the district government to submit a hearing to the Ministry of Law, plus the enthusiasm of the community, kiai, and students who also participated in rejecting the existence of this mining by raising this problem to the bahtsul masa'il forum (Ramadhan, 2019).

The occurrence of environmental damage where it ultimately causes natural disasters. Damaged forest order will cause floods, erosion, landslides and droughts in the dry season. Forest destruction will also lead to a reduction in spring points, where water is the source of

life for all living things on this earth. Without water, humans cannot live well, even human life on this earth will become extinct if it is not supported by the availability of sufficient water (Thani, 2017).

The environment is a resource for human life, brings benefits and plays an important role in health, economy and society. Regarding the inclusion of the environment as a resource, in principle the environment is a resource that is needed for its existence by other creatures, especially humans. On the basis for biological survival, the basic needs for survival are essential and the basic needs to choose (Thani, 2017). Natural resources must be used properly, because if not, it will cause disturbance and damage. Environmental government from the economic side in the form of production processes, for example, water, rivers that are used by factories to transport waste waste from production and household needs, certainly have an impact on environmental damage or pollution.

In modern life like this, environmental damage has occurred a lot in several areas in this part of the world, but as a result of this damage cannot change the human mindset of how important it is to preserve the environment for the diversity of living things in this world. In the Islamic view, disaster is something that befalls or destroys, misfortunes and events, which are not wanted. Disasters are also commonly called disasters (Ambary et al., 1999).

However, before the disaster occurs, it is appropriate for humans as one of the inhabitants of this earth to always take care of, preserve and protect this earth from negative things that can damage the universe. The environment as a resource is an asset that can be needed for the welfare of the community. This is in accordance with the 1945 Law Article 33 paragraph (3), hereinafter referred to as the 1945 Constitution which stipulates that: *"The Earth, Water, and the wealth contained therein shall be used to the greatest extent for the prosperity of the people"*. Thus, according to Otto Somarwoto quoted by Supriyadi: *"resources have limited regeneration and assimilation power. As long as the exploitation of nature or the demand for services is below the limit of regeneration and assimilation, the resource can be used sustainably"*. But if the limit is exceeded, the resource will be damaged and the function of the resource as a factor of production or consumption or a means of service will be disrupted (Supriadi, 2006).

With this fact, there are still many people who do not understand the meaning of environmental sustainability while in the view of Islamic law it has been explained the need for its preservation and its protection and maintenance for the welfare of the environment, but in the context *of Maqashid Al-Shariah*, this environment will be related to the five elements that are the main points in *Maqasahid Al-Sharia* which will give a clearer picture of Islamic law on the need for conservation and maintenance or environmental protection.

The environment and its management are very serious problems if in essence all humans use an individuality system in environmental management. For this reason, the usefulness of managing the environment, especially as Muslims, we must better understand environmental problems and solve them wisely in accordance with the recommendations of sharia, such as maintaining the five elements contained in *Maqashid al-Sharia*.

1. METHODS

This research is a type of library research. That is research that aims to collect data and information with various materials available in the library, such as: books, law books, articles, seminar papers, scientific journals, magazines or other manuscripts (Koentjaraningrat et al., 1995). This research is descriptive in nature. The data collection technique used by the researcher is documentation. After the data was collected, the researcher conducted an analysis with a qualitative descriptive method with a thinking approach using a deductive method.

2. RESULTS AND DISCUSSION

2.1. Environmental Law According to Law No. 32. Year 2009 On Environmental Protection and Management

Environmental law in English is called *environmental law*, in Dutch it is called *umweltrecht*, in French it is called *droit de environment*, while Malaysian in Malay is called environmental law. Environmental law in general aims to solve environmental problems, especially those caused by human actions, namely overcoming pollution, drainage, and environmental destruction so that a good, healthy, beautiful and comfortable environment is created for all people. Environmental law as we understand it today is a relatively new concept. According to Munadjat Danusaputro, it grows in line with the growth of understanding and awareness to protect and maintain the environment (Soejono, 1996). The problem of pollution and environmental destruction is no longer a local problem, but is now a national and even international problem. The level of pollution and destruction is also much greater due to the advancement of industrial technology (Hamzah, 1995). Law No. 32 of 2009 concerning Environmental Protection and Management, hereinafter abbreviated as UUPPLH, is the domain of environmental law in Indonesia.

Referring to Hans Kelsen's view that a legal system is a hierarchy of law where a certain legal provision is sourced from other higher legal provisions. As a higher provision, it is *a Groundnorm* or a hypothetical basic norm (Kelsen, 1995) Lower conditions are more contiguous than higher conditions. In the book *General Theory of Law and State* it is explained that this theory should not be influenced by the motives or intentions of the law-making officials or by the desires or interests of individuals with regard to these intentions,

these desires and interests, manifested in the legal material produced by the law-making process.

The following is a review of positive laws and sharia maqashid related to environmental law:

2.1.1. Aspects of Civil Law in the Environment

The purpose of environmental law enforcement through civil law mechanisms is more oriented to provide legal protection for the environment and victims who suffer losses as a result of environmental pollution or destruction. Civil law can provide the possibility to file a lawsuit for compensation for environmental pollution against the party that caused the environmental pollution/damage, which is usually done through a lawsuit for unlawful acts. In the context of Unlawful Acts in environmental disputes in Indonesia, the Principle of Absolute Responsibility is known. The principle of strict liability is a type of civil liability (Thahir, 2017).

In the context of Unlawful Acts in environmental disputes in Indonesia, the Principle of Absolute Responsibility is known. The principle of strict liability is a type of civil liability. Civil liability in the context of environmental law enforcement is a civil law instrument to obtain compensation and environmental restoration costs due to environmental pollution and/or destruction. The liability recognizes 2 (two) types of liability: 1. Liability that requires fault-based liability; 2. Absolute / strict liability (strict liability) of an obligation without having to prove the existence of an element of fault.

2.1.2. Aspects of Criminal Law in the Environment

In essence, the existence of criminal law in Law No. 32 of 2009 concerning Environmental Protection and Management aims to maintain the existence of the environment to its sustainability function. In essence, criminal law is a means of repression, that is, a series of arrangements aimed at controlling negative events, so that in the future they return to their original state. With regard to its repressive function, the criminal law should be assisted by a number of policies on the imposition of devices, which play a role in the direction of environmental protection.

Environmental delinquency regulated in Articles 41, 42, 43, 45, 46, 47 of the UUPLH is a material delinquency that concerns the preparation of evidence and the determination of causal relationships between polluting and polluted acts, in the new UUPLH, namely Law No. 32 of 2009, criminal provisions are contained in Articles 97 to 120. In the prosecution of environmental crimes, the enforcement procedures are subject to Law No. 8 of 1981 concerning the criminal procedure law (KUHAP), the role of investigators is also very important to collect evidence that is often scientific in nature (Erwin, 2011). The criminal threat can be in the form of imprisonment, fines and additional penalties or disciplines. The

enforcement of criminal law in Law No. 32 of 2009 concerning Environmental Protection and Management introduces the threat of minimum punishment in addition to the maximum, the expansion of evidence, scanning for violations of quality standards, the integration of criminal law enforcement, and the regulation of corporate crimes.

The criminal law enforcement process regulated in Law No. 32 of 2009 concerning Environmental Protection and Management, includes the following stages: 1. Investigation stage 2. Investigation Stage 3. Execution or prosecution stage, 4. Judicial stage.

2.1.3. Aspects of Administrative Law in the Environment

The application of administrative law in the context of environmental protection and management has a function as an instrument for control, prevention, and countermeasures of acts prohibited by environmental regulations. Through administrative sanctions, it is intended that the act of violation is stopped, so that administrative sanctions are a juridical instrument that is preventive and repressive in nature and non-judicial to end or stop violations of the provisions listed in the requirements for environmental protection and management.

In addition to guidance in the form of instructions and guidance as well as administrative supervision to entrepreneurs in the industrial sector, the benefits of the "Pollution Prevention Pays" Concept should also be instilled in the production process. And also sustainable environmentally friendly development, the development in question is a pattern of development policy that does not disturb the balance of the ecosystem, namely development that is oriented towards the management of natural resources while seeking its protection and development. The provisions regarding administrative sanctions are regulated in the provisions of Articles 71 to 83 of Law No. 23 of 2009. Administrative Sanctions have an instrumental function, namely the control of prohibited acts, besides that administrative sanctions are mainly aimed at protecting the interests that are guarded against the violated provisions. Some types of administrative sanctions include: a) Government coercion or coercive action (Bestuursdwang); b) Uang Paksa (Public Law Penalty Payment); c) Closure of the place of business (Closure of an establishment); d) Cessation of Activities of the Machinery Company (External Use of an Apparatus); e) Revocation of permits through the process of reprimands, government coercion, closure and forced money.

2.1.4. Maqhasid al-Syari'ah in Environmental Conservation

Nature and its contents were created by Allah swt not only for the benefit of the present generation of humans but also for future generations.

The Word of Allah swt hints and reminds mankind to utilize, use nature and its contents well, wisely, pay attention to its sustainability, utility, build this nature and environment for the welfare of mankind in a sustainable and sustainable manner.

In Islam, the environment does not only focus on the problem of waste, pollution or greening but more than that. Environmental problems are problems that are seen as safeguarding future life and how to fix it for the benefit of the people.

The above understanding that in the surah explains that the great deed is the prevention of environmental pollution which results in killing the potential for the environment itself where this environment is a gift of Allah Almighty as outlined in his fitrah. Because all forms of deviation from the destruction of the environment mean the same that we have damaged the nature of Allah that has been given to us. The role of humans

As a caliph on earth, it is the responsibility of humans to preserve nature and improve the ecosystem on this earth for future regeneration. However, as is happening at this time, there has been a lot of natural damage that has occurred due to the actions of human hands themselves, resulting in natural disasters coming one after another that have an impact on suffering for humanity. The development of technology in modern times has resulted in the destruction of the environmental ecosystem.

1. *Hifdzu Din* (Safeguarding Religion)

With the environment, Hifdzu Din or maintaining religion has a close relationship with the environment. Religion provides guidance and guidance for humans to live in balance and harmony with the environment. This can be seen from Islamic teachings that regulate the management of natural resources, respect for other living things, and preserve the environment. For example, in Islam there are rules about not damaging nature or littering. If humans maintain and implement religious guidance correctly, it helps maintain the sustainability of the environment in a sustainable manner.

2. *Hifdzu Nafs* (Safeguarding the Soul)

Environmental preservation is closely related to protecting the human soul, because environmental damage and depletion of natural resources can endanger the survival of humans and other living beings. These two things interact with each other and must be maintained in order to achieve a positive balance in the lives of humans and other living beings. Protecting the environment in protecting the soul is also a matter of mutual interaction, in this case it is the protection of the psyche of human life and their safety. Environmental damage, pollution, depletion of natural resources and ignoring the principles of balance, will endanger human life in the future.

3. *Hifdzu Nasl (*Taking Care of Descendants).

Maintaining nasab is the same as protecting future generations, in this case by protecting the environment, the young generation in the future will be guaranteed to be safe. If one does not

pay attention to the environment, it will have an impact on the survival of future generations. The environment can be divided into two parts by Yusuf al-Qhordowi, namely the environment of life and death. Humans, animals, and plants belong to the living environment, while the inanimate environment includes inanimate objects (Yusuf al-Qhordowi, 2001). These things complement each other and are not created in vain because each has its advantages. If one of the objects or elements of the environment is disturbed or damaged, it will have an impact on the other environmental elements. We must maintain the survival of living things and the surrounding environment so that they can be passed on to the next generation. If our environment is damaged, it will have an impact on the health of humans and other living beings, including our descendants. Therefore, protecting the environment is a form of keeping our descendants so that they can still live on a healthy and sustainable earth. Otherwise, the adverse effects will be felt by future generations. To protect these descendants, it is necessary to protect and manage the environment well by humans such as protecting biological natural resources, animals, plants, soil, water, air and energy, so that the next generation will not only be left with so many problems but also left with good things such as a healthy environment.

4. *Hifdzu Aql* (Keeping Your Mind)

Man has been created by Allah to be more special than His creatures because they have the ability of the mind. This ability allows humans to distinguish between right and wrong, as well as between good and bad. However, if a person has reason but does bad or forbidden things, then it can be said that his mind is corrupt. Therefore, a person who is damaging the environment needs to improve his or her mind. Therefore, the Qur'an often satirizes human behavior by using an analogy: "Don't you think?", this is because most human desires want to damage the environment, so with this insinuation it is hoped that they will be aware and use their intellect to think and take care of the environment well and themselves in accordance with what has been outlined by Religion.

5. *Hifdzu Maal* (Safeguarding Property)

With the environment, wealth is not only related to money and gold, but all assets in this country are included in the property category. If the environment and nature are damaged, it will have an impact on the continuity of the search for treasures and damage the environment under the pretext that looking for the treasure is very wrong because it is the same as closing a hole and digging a new hole. In this case, we can conclude that the maqhasid of sharia and the environment have a very close relationship and need to be protected to maintain harmony.

Protecting the environment in the five-point method of Maqhasid al-Syari'ah is a very necessary thing to be applied properly in environmental conservation in accordance with Maqhasid al-Syari'ah (legal goals), so that with this it is not only Law Number 32 of 2009

concerning Environmental Protection and Management which must remind the community in preserving the environment but with the help of Maqhasid al-Syari'ah will increase the effectiveness community in maintaining environmental conservation.

Therefore, stability in the environment is actually a form of dynamic balance full of irreversible processes or very good conditions, departing from this, human creativity is great thanks to their perseverance in learning and discovering new knowledge applied through technology, so that humans with their knowledge and technology begin to get ideas to maintain, utilizing, and maintaining this universe. But on the other hand, with science and technology, humans began to exploit the contents of nature and make damage for the benefit of individuals. The consequences behind the recklessness that arises from human carelessness towards the surrounding nature are the humans themselves who will feel it.

3. CONCLUSIONS

Based on the discussion that has been described above, it can be concluded that environmental protection and management based on Law Number 32 of 2009 concerning Environmental Protection and Management, In order to avoid damage to the environment, it is necessary for law enforcement, especially in the environmental sector so that in this case it indicates that in Indonesia the system of encouragement to preserve or protect the environment is a matter which is very important. In this environmental law, several subsystems are related and related to Indonesian law, namely: Environmental Planning Law, Environmental Procedural Law, Environmental Civil Law, Environmental Criminal Law, In this subsystem, it has also been explained criminal sanctions that commit criminal acts against natural resource management that can harm the government and local communities. Maqhasid al-Syari'ah in environmental conservation has five points; First, protecting the environment is the same as protecting religion, second, protecting the environment is the same as protecting the soul, third, protecting the environment is the same as protecting offspring, fourth, protecting the environment is the same as maintaining reason, and the fifth is protecting the environment, and the fifth is protecting the environment, as well as protecting property.

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THE DEVELOPMENT OF THE DIGITAL ECONOMY: AN ANALYSIS OF CHALLENGES AND INNOVATION IN THE TECHNOLOGICAL ERA

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Abstract

The development of the digital economy has become one of the main drivers of economic transformation in the modern technological era. Digitalization has not only changed patterns of production, distribution, and consumption, but has also encouraged the emergence of new business models through the use of e-commerce, fintech, big data, artificial intelligence, cloud computing, the Internet of Things, and digital platforms. This study aims to analyze the development of the digital economy, its contribution to economic growth, efficiency, and productivity, as well as its role in supporting micro, small, and medium enterprises (MSMEs) and economic inclusion. This research uses a literature study method by reviewing various relevant scientific literature, reports, and policy documents. The findings show that the digital economy provides significant opportunities for economic growth through increased competitiveness, expanded market access, transaction efficiency, and business innovation. Digitalization also plays an important role in strengthening MSMEs and expanding financial inclusion through the development of fintech. However, the digital economy still faces various challenges, such as the digital divide, low digital literacy, data security risks, privacy threats, cybercrime, and regulations that have not fully kept pace with technological development. Therefore, synergy among the government, business actors, society, and stakeholders is needed to build an adaptive, inclusive, secure, and sustainable digital economy ecosystem. With the right strategy, the digital economy has the potential to become an innovative and equitable engine of economic growth for all levels of society.

Keywords: Digital Economy, Digital Transformation, Innovation, MSMEs, Economic Inclusion

INTRODUCTION

The development of the digital economy is an unavoidable global phenomenon in the modern technological era. Digital transformation has fundamentally changed the way humans interact, work, and carry out economic activities. Various studies show that digitalization has become one of the main engines of global economic growth through the use of information and communication technology (ICT) (Afriyadi et al., 2024). The digital economy refers to economic activities that use digital technology as the main basis in the processes of production, distribution, and consumption (Guo, 2023). In the literature, the digital economy includes various sectors such as e-commerce, fintech, big data, artificial intelligence (AI), and the Internet of Things (IoT). This development shows that digitalization has significantly expanded the scope of the economy (Nurbaiti Maulidina & Pramono, 2024).

Digital economic transformation is also marked by increasing internet penetration and the use of mobile devices (Gindea & Barbaneagra, 2025). This has encouraged the emergence of various digital platforms that facilitate economic transactions and accelerate information exchange. Studies show that increased adoption of digital technology directly contributes to national economic growth, including in developing countries such as Indonesia (Afriyadi et al., 2024). In addition, digital innovation is a key factor in promoting efficiency and productivity. Technologies such as cloud computing, AI, and big data enable companies to optimize business processes and improve competitiveness. These innovations also encourage the creation of new business models that are more adaptive to market changes (Wang et al., 2023).

In the business context, the digital economy opens major opportunities for business actors, particularly micro, small, and medium enterprises (MSMEs). Through digital platforms, business actors can reach wider markets without geographical boundaries. This strengthens the position of the digital economy as a driver of economic inclusion (Prihatiningsih & Susanti, 2023). However, the development of the digital economy is also accompanied by various complex challenges. One of the main challenges is the digital divide that still exists between regions and community groups. Limited access to technology and infrastructure becomes an obstacle to the equitable distribution of the benefits of the digital economy. In addition, the literature also highlights low levels of digital literacy as an obstacle to technology utilization. A lack of public understanding of digital technology can hinder innovation adoption and increase the risk of technology misuse (He & Tian, 2023).

Another challenge is data security and privacy. As digital activities increase, the risk of data breaches and cyberattacks also rises. This requires stronger security systems and regulations capable of protecting users (Hilda & Gusti, 2024). From a regulatory perspective, the development of the digital economy often moves faster than the policies that govern it. The

mismatch between regulation and technological development can hinder innovation and create legal uncertainty (Beaumier et al., 2020). Therefore, adaptive and responsive policies are needed to address technological change.

Changes in the digital economy also affect the labor market. Automation and digitalization change the structure of work, in which some traditional jobs are replaced by technology. On the other hand, new job opportunities emerge that require higher digital skills. In the context of innovation, companies are required to continuously adapt to technological development. Innovation strategy is the key to facing competition in the digital era. Companies that are able to integrate digital technology into their operations will gain a competitive advantage (Nur Siti Annazah, 2024).

Furthermore, digital innovation also encourages the creation of a more integrated new economic ecosystem. The platform-based economy is one clear example of how technology connects various economic actors within an efficient system. The development of the digital economy also affects the financial sector through the emergence of fintech. This innovation enables broader and faster access to financial services, thereby increasing public financial inclusion (Fatmawati et al., 2024).

However, fintech development also presents challenges related to consumer protection and financial system stability. Risks such as digital fraud and regulatory uncertainty are important issues that must be addressed by the government and industry actors. In the distribution and trade sectors, digitalization has changed the pattern of interaction between producers and consumers. Digital-based business models enable distribution that is more efficient and responsive to market needs (Hasminiar et al., 2024). In addition, the digital economy also encourages collaboration among various sectors, including the public and private sectors. This collaboration is important for creating an inclusive and sustainable digital ecosystem. The government has a strategic role in providing supportive infrastructure and policies (Borobudur, 2024).

From a global perspective, the digital economy increases economic integration among countries. Digitalization reduces trade barriers and expands access to international markets. However, this also creates challenges in harmonizing cross-border regulations (Ahmedov, 2020). Education and human resource development are important factors in supporting the digital economy (Nikitaeva & Mikhalkina, 2020). Improving digital skills is necessary so that the workforce can adapt to rapid technological change. Considering the various challenges and opportunities, a comprehensive approach is needed in managing the development of the digital economy. The right strategy can help maximize the benefits of digitalization while minimizing the risks it creates (Farida, 2025).

Overall, the literature shows that the digital economy has great potential to promote economic growth and innovation (Zeng & Yang, 2023). However, the success of digital transformation depends greatly on the ability of various parties to face emerging challenges (Fahmi, 2024). Therefore, synergy among technology, policy, and human resources is required to create a sustainable digital economy (Shen, 2025).

Specifically, this study aims to: (a) analyze the characteristics, patterns, and development of the digital economy and its scope in various sectors such as e-commerce, fintech, and data-based technology; (b) assess the extent to which the adoption of digital technology contributes to economic growth, efficiency, and productivity, particularly in developing countries such as Indonesia; (c) explore the role of the digital economy in supporting the development of micro, small, and medium enterprises (MSMEs) and promoting economic inclusion; (d) identify and analyze various challenges in the digital economy, including the digital divide, low digital literacy, and data security and privacy risks; and (e) formulate strategic recommendations for the government, business actors, and stakeholders in creating an adaptive, inclusive, and sustainable digital economy ecosystem.

1. RESEARCH METHODOLOGY

This research uses a literature study method by conducting a systematic review of various scientific literature, including journals, books, reports from national and international institutions, and policy documents relevant to the topics of the digital economy, technological transformation, and their impacts on economic growth and social inclusion. This literature study aims to explore the development of the digital economy, examine concepts and theories related to the adoption of digital technology, innovation, and MSMEs, and identify research gaps related to challenges such as the digital divide, digital literacy, data security, and regulatory dynamics. The stages in this literature study include formulating research questions focused on the role and impact of the digital economy; determining inclusion and exclusion criteria for literature based on relevance, source credibility, and publication recency; searching for literature through reputable international journal databases, scientific portals, and digital libraries; conducting an initial screening process to filter literature relevant to the study topic; classifying and evaluating literature content based on themes such as economic growth, digital innovation, MSMEs, fintech, and digitalization challenges; and conducting systematic synthesis and analysis.

The analysis was conducted using a descriptive-analytical approach to identify patterns, relationships, and trends in the development of the digital economy. The focus of the analysis includes the contribution of digital technology to productivity and competitiveness, the role of the digital economy in expanding economic inclusion, and various risks and obstacles that emerge in its implementation. Through this method, the study is expected to provide a

comprehensive understanding and produce strategic recommendations to support the development of an adaptive, inclusive, and sustainable digital economy.

2. RESULTS AND DISCUSSION

2.1. Results

The results of the literature study show that the development of the digital economy has become one of the important phenomena in both global and national economic transformation (Tkachenko, 2023). The digital economy is not only related to the use of the internet, but also includes the use of technologies such as e-commerce, fintech, big data, artificial intelligence, the Internet of Things, cloud computing, and digital platforms in production, distribution, consumption, and financial service activities (Enrique et al., 2017). The reviewed data show that digitalization has changed patterns of economic interaction, expanded market access, accelerated transactions, and encouraged the emergence of new business models that are more adaptive to market changes (Lavrov & Neklyudov, 2025).

In general, the literature review identified several main findings. First, the digital economy acts as a driver of economic growth through increased productivity, business process efficiency, and expanded market access (Mottaeva et al., 2023). Second, digitalization provides major opportunities for MSMEs because digital platforms allow business actors to reach consumers more widely without geographical boundaries (Mottaeva et al., 2023). Third, the financial sector has undergone significant changes through fintech development, which expands access to financial services and improves financial inclusion (Selvia Dwi Oktaviany & Nurfadia, 2025). Fourth, digital transformation also presents serious challenges, including the digital divide, low digital literacy, data security risks, privacy threats, and regulations that are not always aligned with the speed of technological development (Selvia Dwi Oktaviany & Nurfadia, 2025).

These findings are consistent with international reports showing that Indonesia's digital economy is one of the fastest growing in Southeast Asia, driven by a young population, mobile device usage, increasing internet penetration, and government support for digital transformation (Selvia Dwi Oktaviany & Nurfadia, 2025).

Table 1. Summary of Literature Study Findings on the Digital Economy

No.	Focus of Study	Main Findings	Implications
1	Digital economic growth	Digitalization promotes efficiency, productivity, and economic growth through the use of information and communication technology (Dudhat & Agarwal, 2023).	The digital economy becomes a new engine of national economic growth.

No.	Focus of Study	Main Findings	Implications
2	E-commerce and digital platforms	Digital platforms expand market access and change the distribution patterns of goods and services (Bansal, 2025).	Business actors can reach consumers more widely and quickly.
3	MSMEs	Digitalization opens opportunities for MSMEs to improve competitiveness, marketing, and sales (Bansal, 2025).	MSMEs have the potential to upgrade through the integration of digital technology.
4	Fintech	Fintech expands access to financial services, accelerates transactions, and increases financial inclusion (Selvia Dwi Oktaviany & Nurfadia, 2025).	Communities that previously had difficulty accessing financial services become better served.
5	Digital innovation	Technologies such as AI, big data, and cloud computing help companies optimize business processes (Selvia Dwi Oktaviany & Nurfadia, 2025).	Innovation becomes the key to competitive advantage.
6	Digital divide	Differences in access to technology among regions and community groups remain an obstacle (Matracia et al., 2024).	The benefits of the digital economy have not been felt evenly.
7	Digital literacy	Low digital literacy inhibits the productive and safe use of technology (Banu, 2025).	Capacity building for digital human resources is needed.
8	Data security and privacy	Increasing digital transactions enlarge the risks of data breaches, fraud, and cyberattacks (-, 2024).	Strong security systems and data protection regulations are required.
9	Digital regulation	Technological development often moves faster than regulation (Mitrakas, 2013).	Policies need to be adaptive so they do not inhibit innovation.
10	Labor market	Digitalization shifts some traditional jobs but also creates new jobs based on digital skills (Rifka Alkhilyatul Ma'rifat, I Made Suraharta, 2024).	Workers need reskilling and upskilling.

Based on the table, the digital economy can be understood as a multidimensional phenomenon. On the one hand, the digital economy creates major opportunities for economic growth, business efficiency, innovation, market expansion, and financial inclusion. On the other hand, the digital economy also creates challenges such as unequal access, low digital literacy, data security risks, changes in employment structure, and the need for more responsive regulation.

2.2. Discussion

2.2.1. The Digital Economy as an Engine of Economic Growth

The study results show that the digital economy contributes significantly to economic growth because digital technology can improve efficiency, accelerate transactions, and expand market access (Conference, 2025). The use of information and communication technology enables companies to reduce operational costs, accelerate distribution processes, and improve service quality for consumers (Wulandari et al., 2025). In this context, digitalization is not merely a technical tool but has become a new foundation for modern economic activity. These findings are consistent with the World Bank's view in the Digital Dividends report, which emphasizes that digital technology can generate development benefits such as economic growth, job creation, and improved public services, but these benefits do not occur automatically without adequate support from regulation, skills, and institutions. Thus, the success of the digital economy depends greatly on the readiness of the supporting ecosystem, not only on the availability of technology (Gomes et al., 2022).

2.2.2. The Role of the Digital Economy in MSMEs and Economic Inclusion

One important finding in this study is that the digital economy opens major opportunities for MSMEs. Through digital platforms, MSMEs can expand their markets, improve product promotion, accelerate transactions, and reach consumers beyond their geographic areas (Yani et al., 2025). This shows that digitalization functions as an instrument of economic inclusion because it provides opportunities for small business actors to enter markets that were previously difficult to reach. E-commerce is one concrete form of this transformation. By utilizing marketplaces, social media, and digital payment services, MSMEs can conduct business activities at relatively lower costs compared with conventional models (Ladrière et al., 2022).

2.2.3. Fintech and the Expansion of Financial Inclusion

The study also found that the financial sector has undergone major changes through the development of fintech. Fintech enables people to access financial services more quickly, easily, and widely (Selvia Dwi Oktaviany & Nurfadia, 2025). Services such as digital wallets, technology-based lending, digital payments, and digital investment have changed people's transaction patterns. In the context of financial inclusion, fintech has an important role because it can reach community groups that were previously not fully served by formal financial institutions. However, fintech development also presents risks such as digital fraud, data misuse, illegal lending, and weak consumer protection. Therefore, fintech growth must be balanced with strengthened regulation, digital financial literacy, and personal data protection (Selvia Dwi Oktaviany & Nurfadia, 2025).

2.2.4. Digital Innovation and Company Competitiveness

The digital economy encourages companies to continue innovating in order to survive in competition. Technologies such as cloud computing, artificial intelligence, big data, and the Internet of Things enable companies to understand consumer behavior, improve production processes, increase supply chain efficiency, and make data-driven decisions. Thus, digital innovation is important not only for large companies but also for MSMEs, educational institutions, financial institutions, and the public sector. However, digital innovation capability is strongly determined by the quality of human resources. Without adequate digital skills, technology cannot be used optimally. Therefore, investment in digital training, technology talent development, and the strengthening of an innovation culture is a major necessity (Guo, 2023).

2.2.5. The Digital Divide as a Major Challenge

Although the digital economy offers many opportunities, the study results show that the digital divide remains a major challenge. This divide can occur in the form of differences in internet access, infrastructure quality, technology use capability, and differences in the economic capacity of communities to access digital devices. The digital divide causes the benefits of the digital economy to be distributed unevenly (Kotarac et al., 2025). Urban areas with good internet infrastructure tend to enjoy the benefits of digitalization more quickly than rural or underdeveloped areas. As a result, digitalization risks widening inequality if it is not accompanied by policies for infrastructure equity and digital literacy improvement. The World Bank emphasizes that the benefits of digital technology do not automatically generate inclusive growth if they are not supported by "analog complements," such as good regulation, human skills, and strong institutions. Therefore, the development of the digital economy must pay attention to equity, not merely market growth (Kotarac et al., 2025).

2.2.6. Digital Literacy, Data Security, and Consumer Protection

Low digital literacy is a serious obstacle to the utilization of the digital economy. Many people use digital services but do not yet have sufficient understanding of account security, personal data protection, online fraud risks, and the ethics of technology use. This challenge is increasingly important because digital economic activities involve personal data, financial transactions, and interactions across platforms. The greater the use of digital services, the higher the risk of data breaches and cyberattacks. Therefore, data security and privacy must be a central part of digital economy policy (OECD, 2020).

3. CONCLUSION

Based on the results of the literature study, it can be concluded that the digital economy is one of the main drivers of economic transformation in the modern era. The development of

information and communication technology has changed the way society, business actors, and the government carry out economic activities. The digital economy does not only include internet-based transactions, but also covers e-commerce, fintech, big data, artificial intelligence, cloud computing, the Internet of Things, and various digital platforms that support production, distribution, consumption, and financial service processes. The findings show that the digital economy makes a major contribution to economic growth through increased efficiency, productivity, innovation, and expanded market access. Digitalization enables business actors, especially MSMEs, to reach consumers more widely without being limited by geographic boundaries. In addition, fintech development also expands public access to financial services, thereby supporting financial inclusion and community economic empowerment.

However, the development of the digital economy also presents various challenges that need attention. These challenges include the digital divide among regions and community groups, low digital literacy, data security and privacy risks, cybercrime threats, and regulations that have not fully kept pace with technological development. If these challenges are not properly managed, the benefits of the digital economy may not be felt evenly and may instead widen socio-economic inequality. Therefore, the development of the digital economy requires a comprehensive and collaborative strategy. The government needs to strengthen digital infrastructure, formulate adaptive regulations, and improve data protection and cybersecurity. Business actors need to improve innovation capacity and technology utilization, while society needs to be equipped with digital literacy so that technology can be used productively, safely, and responsibly.

Thus, the success of digital economic transformation depends greatly on the synergy among technology, policy, human resources, and collaboration among all stakeholders. The digital economy has great potential to promote more inclusive, innovative, and sustainable economic growth when it is managed properly and oriented toward the equitable distribution of benefits for all levels of society.

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ANALYSIS OF DETERMINANT FACTORS OF DEPOSIT VOLUME MUDHARABAH: A SYSTEMATIC LITERATURE REVIEW

(SYSTEMATIC LITERATURE REVIEW)

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Abstract

The Islamic banking system in Indonesia has grown based on the principle of profit-loss sharing, where Mudharabah Deposits are a crucial fundraising instrument. However, the volume of these deposits often fluctuates due to monetary policy in the Dual Banking System. This study aims to provide a comprehensive overview of the dominant factors influencing the volume of mudharabah deposits through the Systematic Literature Review (SLR) method with the PRISMA protocol. Data were collected from various digital databases such as Google Scholar, SINTA, and SCOPUS. The main findings indicate that the profit-sharing rate consistently has a positive and significant effect as a main magnet for customers. On the other hand, conventional interest rates (BI Rate) show a significant influence in triggering Displaced Commercial Risk, although there are anomalies in certain customer segments that prioritize religious loyalty. In addition, macro variables such as inflation and internal factors such as liquidity (FDR) also play an important role in maintaining fundraising resilience. This study recommends that Islamic banks optimize operational efficiency and strengthen sharia literacy to mitigate the impact of conventional monetary fluctuations.

Keywords: Mudharabah Deposit, Profit Sharing, BI Rate, Inflation, Liquidity, Systematic Literature Review

INTRODUCTION

The Islamic banking system in Indonesia has grown based on the principle of profit-loss sharing, a philosophical distinction that distinguishes it from the interest system of conventional banks. One of the most crucial fundraising instruments for Islamic banks is the Mudharabah deposit.

As an investment product, the volume of these deposits depends heavily on customer trust and profit expectations. However, in practice, Islamic banking does not operate in a vacuum; it coexists with the conventional banking system in a Dual Banking System.

This situation creates its own challenges, particularly regarding monetary policy. When Bank Indonesia...

When conventional banks raise the benchmark interest rate (BI Rate), they tend to respond by raising deposit interest rates. This phenomenon often occurs triggering Displaced Commercial Risk, where Islamic bank customers may feel “at a loss” if the profit sharing received is much lower than conventional bank interest.

As a result, the volume of Mudharabah deposits often fluctuates following the flow of national monetary policy, which theoretically should be based on real sector performance, not interest rates.

Over the past decade, many researchers have attempted to quantify the factors that actually determine the fluctuations in deposit volume. However, these findings often yield inconsistent results. Some studies have found that conventional interest rates have a strong negative influence on Islamic deposits (Kasri & Kassim, 2009). On the other hand, several studies have shown that the factor religiosity and the level of internal profit sharing of banks remain the main determinants that maintain customer loyalty (Ziaei, 2012).

Given the research gap between various previous studies, an effort is needed to comprehensively unify and re-map these findings. The Systematic Literature Review (SLR) method offers a solution to review, evaluate, and synthesize all existing literature on the determinants of Mudharabah deposits (Snyder, 2019). This paper aims to provide a comprehensive overview of the dominant factors influencing Islamic deposits, thus serving as a reference for Islamic banking practitioners in developing more resilient strategies amidst the dynamic competition of the monetary market.

1. LITERATURE REVIEW

The mudharabah contract is a key pillar in Islamic banking fundraising, based on the principle of partnership between the fund owner (shahibul maal) and the fund manager (mudharib). In this instrument, the return is not fixed like interest; it fluctuates according to the bank's profit

performance, which is but then distributed through a profit-sharing ratio (Sudirman & Fitrianti, 2022). Theoretically, the profit-sharing rate is an internal determinant main magnet for customers. Research by Risnaini (2023), Ulum and Syaputri (2025), and Sha Fitri et al. (2025) consistently shows that increased profit sharing will be followed by increased deposit volume.

However, challenges arise when banks must maintain competitive profit-sharing rates amid fluctuations in operating profits to prevent customers from losing interest in their investments (Manzilah & Suprihadi, 2024). In the Dual Banking System ecosystem in Indonesia, mudharabah deposits face displaced commercial risk (DCR).

This phenomenon occurs when movements in conventional bank interest rates (BI Rate) influence Sharia customers' decisions to maintain or transfer their funds in search of higher economic returns (Asmiwarti et al., 2020). Findings from Fitriana and Syaiful (2024) and Gustira et al. (2023) reinforce the argument that interest rates have a significant and often inverse influence on Sharia deposit volume. Although Sharia banks operate on interest, the lack of benchmarking against conventional interest rates remains a market reality that is difficult to avoid in order to mitigate massive withdrawals by rational customers (Sholikha, 2018).

Inflation is a variables macroeconomic system that is systemic Machine Translated by Google Affects people's purchasing power and savings capacity. In Islamic banking literature, inflation is viewed as a depressing factor that can distort the real value of returns for customers. Ulum and Syaputri (2025) and Hafni et al. (2020) explain that rising inflation tends to reduce the number of mudharabah deposits because people prioritize consumption or shift their assets to other forms of real investment to protect their wealth.

This shows that the stability of third-party funds in Islamic banks not only depends on the bank's internal policies, but is also very vulnerable to national economic stability (Sudirman & Fitrianti, 2022).

In addition to yields and macro factors, the bank's internal health, as proxied by its liquidity level (Financing to Deposit Ratio), also determines customer trust.

Healthy liquidity reflects a bank’s ability to channel financing effectively and productively (Fitri et al., 2025).

Masruron et al. (2023) found that liquidity has a positive effect on deposits, as banks that are able to manage funds optimally generate better profitability, which ultimately results in will higher profit sharing for customers. The integration of good liquidity management and Offering fair returns is the key to the resilience of Islamic banks in facing competition (Sholikha, 2018).

Although many theories support the positive impact of profit sharing and the negative impact of interest rates, this literature also indicates a research gap. Rusdiani (2020) provides a contrasting perspective, finding that profit sharing and the BI Rate partially had no significant effect on deposits over a specific period. A similar finding was also found by Nofinawati et al. (2025), who noted that the BI Rate did not significantly affect deposits at Islamic commercial banks.

This diversity of findings suggests the existence of other qualitative factors, such as customer loyalty to sharia values (religiosity) and service quality, which can reduce customer economic sensitivity to conventional monetary fluctuations (Manzilah & Suprihadi, 2024).

2. RESEARCH METHODS

This research is a qualitative research that uses the method Systematic Literature Review (SLR). This research design was chosen to systematically identify, evaluate, and synthesize all previous findings research in order to obtain a comprehensive picture of the determinants of deposit volume. mudharabah (Snyder, 2019).

In its implementation, this study refers to the Preferred Reporting Items for Systematic Reviews Meta-Analyses (PRISMA) protocol and to ensure that the literature review process is carried out in a transparent and structured manner.

The data collection strategy was conducted through a secondary literature search in various reputable digital databases, such as Google Scholar, SINTA, and SCOPUS. Researchers used a specific combination of keywords, including “Mudharabah Deposits, Profit Sharing, BI Rate, and Mudharabah Deposit Volume”.

This literature review process involves four main stages, starting with the identification stage, which involves collecting raw articles from search engines. Next, a screening stage is conducted to remove duplicate articles and screen for irrelevant titles and abstracts.

The next stage is the eligibility test by reading the entire contents of the article to ensure that the study discusses the influence of the BI Rate and profit sharing in depth.

The final stage is inclusion, where the selected articles are synthesized to draw conclusions. The collected data is then analyzed using content analysis techniques to map the patterns of relationships between variables. The final results of this study are presented descriptively to reconstruct a theoretical understanding of the topic. Dynamics of mudharabah deposits amidst fluctuations in monetary policy.

3. RESULTS AND DISCUSSION

Based on a synthesis of various analyzed literature, it was found that the volume of mudharabah deposits in Islamic banking in Indonesia is significantly influenced by the interaction between the bank's internal attractiveness and macroeconomic conditions. Findings from the majority of studies, including those by Risnaini (2023), Ulum and Syaputri (2025), and Sholikha (2018), consistently demonstrate that the profit-sharing rate has a positive and significant influence on the amount of mudharabah deposits. This confirms that profit-sharing is a key determinant of customer interest in investing, with increased profit-sharing seen as an economic incentive reflecting both bank performance and fairness in profit distribution in accordance with Sharia principles. Sudirman and Fitrianti (2022) added that profit-sharing serves as compensation for the investment risks taken by customers, making return stability a key factor in maintaining depositor confidence.

However, on the other hand, the influence of the benchmark interest rate (BI Rate) or conventional bank interest rates has sparked diverse theoretical debates in various field findings.

Fitriana and Syaiful (2024) and Gustira et al. (2023) found in their literature review that interest rates significantly influence mudharabah deposit volume. This phenomenon reinforces the Displaced Commercial Risk (DCR), where Islamic banking customers in Indonesia still tend to behave rationally by comparing profit-sharing benefits to conventional interest rates.

Conversely, interesting findings emerged in studies by Masruron et al. (2023) on Bank NTB Syariah and Nofinawati et al. (2025) on Islamic Commercial Banks for the 2018-2023 period, which showed that interest rates had no significant partial effect on deposit volume. These differences in findings suggest customer segmentation, where in certain regions or periods, religious loyalty and service satisfaction begin to outweigh sensitivity to fluctuations in monetary interest rates.

Analysis literature This also revealed that the determination of mudharabah deposits does not stand alone, but is influenced by other macro variables such as inflation and bank liquidity. Ulum and Syaputri (2025) and Sholikha (2018) revealed that inflation can indirectly affect people's purchasing power, which has an impact on the form of deposits.

Meanwhile, internal factors such as liquidity (Financing to Deposit Ratio) also determine a bank's capacity to disburse financing, which ultimately affects the income that will be shared with customers. Qualitatively, the synthesis reconstructs the understanding that although This Islamic banking strives to be independent with a profit-sharing system, pressures from the

dual monetary system still force Islamic banks to benchmark against market interest rates to mitigate the risk of customer fund transfers.

The dynamics of third-party funds, particularly mudharabah deposits, are significantly influenced by customer perceptions of returns and the bank's internal stability. Findings from Sha Fitri et al. (2025) reinforce rational economic theory in Islamic banking, where the profit sharing rate was partially proven to have a significant and positive influence on mudharabah deposit volume. This indicates that increasing the profit-sharing portion offered by Islamic banks is effective in attracting depositors.

The consistency of these findings across various literatures confirms that profit sharing is not merely a sharia identity, but rather a primary competitive instrument for banks in raising funds in the dynamic financial market.

On the other hand, the interaction between Islamic banking and policy monetary conventional still shows a strong correlation through interest rates. Sha Fitri et al. (2025) in their study of Indonesian Sharia Banks revealed that conventional bank interest rates significantly influence mudharabah deposit volume. This finding indicates that most customers still use conventional interest rates as a benchmark in determining their fund allocation. If the difference between conventional interest rates and sharia profit sharing is too wide, the risk of displaced funds, or displaced commercial risk, becomes a real threat that can disrupt the liquidity stability of Islamic banks.

In addition to the yield factor, the bank's internal health, as proxied by the liquidity level or Financing to Deposit Ratio (FDR), also plays a crucial role.

Literature shows that liquidity has a positive influence on deposit growth, as it reflects a bank's ability to manage and channel public funds productively. This relationship is further expanded by the findings of Yusron et al. (2023), who highlight other external factors such as economic growth and inflation. In a stable economic environment, banks' capacity to channel financing, including to the MSME sector, will increase, which in turn strengthens bank profitability and the ability to provide more competitive profit sharing to deposit customers.

Qualitatively, this literature synthesis reconstructs the understanding that mudharabah deposit volume is the result of a balance between internal factors managed by banks and external macroeconomic pressures. Islamic banks are not only required to maintain sharia compliance through mudharabah contracts, but also to be resilient to fluctuations in monetary interest rates and maintain healthy liquidity performance. This discussion concludes that strengthening the competitiveness of Islamic banking in the digital era requires an integration strategy, where banks are able to offer competitive profit sharing while mitigating the negative

impact of fluctuations in conventional interest rates through unique services and spiritual added value for customers.

One of the main points of debate is the influence of conventional interest rates (BI Rate) on sharia deposits. Findings from Fitriana and Syaiful (2024) and Rafia Hafni et al. (2020) consistently show that interest rates or the BI Rate have a significant influence on the amount of mudharabah deposits. This demonstrates that the behavior of sharia banking customers in Indonesia is still heavily influenced by conventional financial market conditions. Customers tend to be responsive to Changes in monetary policy; when interest rates rise, the attractiveness of mudharabah deposits is often tested by the availability of investment alternatives in conventional banks that offer guaranteed returns.

However, an interesting finding emerged from a study by Mahani Fitri Rusdiani (2020), which showed a different result, where the BI Rate had no partial effect on the amount of mudharabah deposits. This difference provides insight into the analysis that customer sensitivity to interest rates is not always uniform across periods or customer groups.

The existence of these insignificant results indicates that there are certain customer segments that prioritize the principles of sharia compliance and loyalty over simply seeking profit from interest rate differences. This inconsistency in findings between researchers reinforces the relevance of the Systematic Literature Review method in mapping the evidence that macroeconomic factors are not always the sole determinant of third-party fund movements in Islamic banks.

In terms of profit-sharing instruments, the majority of literature emphasizes their crucial role as a magnet for fundraising. Fitriana and Syaiful (2024) and Rafia Hafni et al. (2020) agree that profit-sharing significantly influences deposit volume. As a partnership-based investment product, profit-sharing reflects the expected fairness of profit distribution. customers. However, Rusdiani's (2020) study again provides a contrasting perspective, finding that the profit-sharing ratio had no partial impact on deposits. This suggests that under certain economic conditions, an increase in profit-sharing may not be strong enough to attract customers unless accompanied by macroeconomic stability and confidence in the bank's overall performance.

In addition to yield and interest rates, inflation also emerged as a crucial determinant in this literature discussion. Rafia Hafni et al. (2020) found that inflation had a significant partial effect on the amount of deposits. Inflation is seen as a variable that can influence people's purchasing power and savings capacity.

Qualitatively, the results of this review of journals reconstruct the understanding that the volume of mudharabah deposits in Indonesia exists within an interconnected ecosystem of

monetary policy, internal returns, and macroeconomic conditions. Islamic banks are not only required to provide competitive profit sharing but also to be able to communicate sharia values as a key differentiator to maintain the stability of customer funds amidst the volatility of conventional financial markets.

The findings of Ulum and Syaputri (2025) show that in the scope of national Islamic banking in Indonesia, the profit-sharing rate and the benchmark interest rate simultaneously play a crucial role in determining the volume of mudharabah deposits. This confirms that customers nationwide continue to monitor yield fluctuations as a primary consideration when investing. When Islamic banks are able to offer competitive profit-sharing rates, capital inflows through mudharabah products tend to increase. However, this stability remains overshadowed by fluctuations in conventional bank interest rates, which are often used as a benchmark for customer economic rationality.

This discussion is reinforced by specific findings from a pioneering Islamic banking institution, PT. Bank Muamalat Indonesia. A study conducted by Manzilah and Suprihadi (2025) for the 2018-2023 period revealed that the profit-sharing rate for mudharabah deposits had a positive and significant impact on savings.

This finding is significant because it demonstrates that even for banks with a strong, loyal customer base, economic incentives in the form of profit sharing remain a key determinant. Customers not only consider normative Sharia aspects but also expect fair and profitable returns on the funds in a way they entrust to the bank.

However, external challenges stemming from conventional monetary policy cannot be ignored. Manzilah and Suprihadi (2025) found that conventional bank interest rates significantly influenced the amount of mudharabah deposits at Bank Muamalat. This indicates that Islamic banking remains trapped in the benchmarking phenomenon of conventional interest rates.

This situation places Islamic banks in a dilemma: on the one hand, they must adhere to the principle of profit-sharing based on real sector performance, but on the other hand, they must remain competitive to avoid large scale displaced funds (displaced commercial risk) when market interest rates are trending upward.

In addition to yield and interest rates, inflation emerged as a consistent pressure factor in the discussions of these two journals. Ulum and Syaputri (2025) and Manzilah and Suprihadi (2025) agreed that inflation influences the amount of mudharabah deposits. High inflation tends to reduce people's purchasing power and savings capacity, ultimately limiting the growth of third party funds in Islamic banks. Qualitatively, the results of this literature review

reconstruct the understanding that mudharabah deposits are highly dependent on the bank's ability to manage stable profit sharing amidst the economic downturn.

Resilience inflationary pressures and intense competition with conventional interest rates. Islamic banks need to strengthen the differentiation of digital products and services to retain customers beyond mere price or return competition.

4. CONCLUSION AND SUGGESTIONS

Based on a systematic literature review of various studies on the determinants of mudharabah deposits in Indonesia, it can be concluded that deposit volume is the result of a complex interaction between internal sharia factors and conventional monetary conditions. Key findings indicate that profit-sharing rates consistently act as a primary attraction, positively and significantly influencing customer interest. This confirms that profit-sharing is not merely a Sharia compliance instrument but a real economic attraction for depositors.

However, this study also reveals that Islamic banking has not been completely free from the influence of the dual monetary system.

Most of the literature confirms that conventional interest rates (BI Rate) still have a significant influence, which indicates the existence of rational-economic customer behavior that carries out yield comparisons (benchmarking).

The phenomenon of Displaced Commercial Risk remains a real challenge, even though several case studies of regional Islamic banks revealed an anomaly in which religious loyalty reduced customer sensitivity to interest rates. Furthermore, macroeconomic variables such as inflation and internal factors such as liquidity (FDR) were shown to be supporting factors in determining the capacity and resilience of fundraising in mudharabah contracts.

Based on the conclusions formulated, several strategic suggestions can be considered by various stakeholders. For Islamic banking management, it is crucial to continuously optimize operational efficiency to achieve stable and competitive profit sharing without having to rely entirely on conventional interest rate movements. Islamic banks also need to strengthen their educational strategies and conduct more in depth literacy campaigns for customers on the essence of spiritual added value and economic justice in mudharabah contracts. This step is expected to shift customer orientation from being solely profit-oriented to being more loyal to Sharia principles, thereby minimizing the risk of fund transfers during monetary policy fluctuations.

In addition, for regulators such as Bank Indonesia and the Financial Services Authority Finance, it is recommended to continue developing more independent Islamic monetary instruments allows Islamic banking to have an assessment anchor that is not always tied to

conventional interest rate benchmarks. This is crucial for creating a more resilient Islamic banking ecosystem with a strong identity amidst a dual monetary system. Finally, for future researchers wishing to explore similar topics, it is recommended to expand the scope of the literature by including contemporary variables such as the digitalization of banking services, service quality, and customer trust.

The use of meta-analysis methods or the addition of comparative studies between countries can also provide a broader perspective in understanding the resilience of mudharabah instruments in the global economic arena.

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GREEN BANKING IN THE PERSPECTIVE OF ISLAMIC SUSTAINABLE FINANCE: LITERATURE REVIEW ON IMPLEMENTATION CHALLENGES AND RISKS

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Abstract

Green banking is a crucial component of strengthening sustainable finance, including within the Islamic banking system, which is based on the principles of maqashid sharia. This study aims to analyze the concept of green banking from an Islamic sustainable finance perspective and identify the challenges and risks of its implementation. This study employed a qualitative approach with a literature review method, examining various scientific journals, books, and regulations related to green banking and Islamic finance. The analysis shows that the implementation of Islamic green banking still faces challenges, including limited technical regulations integrated with Islamic principles, low literacy and market demand for green products, and limited internal institutional capacity. Furthermore, financing risks, Islamic compliance risks, and market risks require structured management. Strengthening policies, improving human resource competency, and transparent sustainability reporting are strategic steps to encourage a more effective and sustainable implementation of Islamic green banking.

Keywords: Sharia Green Banking, Islamic Sustainable Finance, Green Financing, Risk Implementation

INTRODUCTION

The increasingly acute environmental crisis has demanded an economic transformation toward greener and more sustainable practices. The phenomena of climate change, natural resource degradation, and pollution are putting pressure on the financial sector to support environmentally friendly development. In this context, green banking has emerged as a strategic instrument for channeling financing that is not only financially profitable but also supports the achievement of sustainable development. (Salsabila et al. 2022) emphasize that the current green banking trend focuses on productive financing that can drive economic growth while preserving the environment, with practices such as financing renewable energy and green projects that align with sustainability principles.

In addition to environmental challenges, developing green finance from an Islamic perspective also faces a complex legal framework. Uljanah (2024) points out that risk management and Sharia compliance are critical issues in developing carbon markets, as green products and transactions must remain consistent with Sharia principles, such as the prohibition of riba (usury) and gharar (unlawful activity). This requires clear regulations and compliance mechanisms so that the implementation of green banking in Islamic finance can run effectively without violating Islamic law (Uljanah, N., 2024).

Green banking in the global financial context emphasizes the integration of sustainability principles into every activity of financial institutions, including Islamic microfinance. At the industry level, it emphasizes that sustainable financing must be systematically implemented through policies, products, and procedures that prioritize social and environmental aspects. This concept encompasses environmentally friendly project financing, sustainable risk assessment, and the integration of ESG (environmental, social, and governance) criteria into business strategies. Thus, green banking serves as a crucial instrument for the stability of the financial services industry while supporting the achievement of global sustainable development targets (Hadad, MD, & Maftuchah, I., 2015).

The integration of Sharia principles into sustainable finance emphasizes the alignment between economic objectives and Islamic morality, ensuring that all financial activities are not solely profit oriented but also support social and environmental stability. One study demonstrated that combining commercial and social finance within an Islamic framework can enhance financial system stability, as this approach prioritizes fairness, transparency, and sustainable risk management, including in the financing of green projects (Ascarya, 2016). Similarly, other research emphasizes that green and circular economy principles can be combined with Sharia principles to promote broader social welfare and justice, for example, through financing renewable energy and recycling projects that adhere to the prohibitions on riba and gharar (Johannes, 2024). Thus, the integration of Sharia principles not only maintains

religious adherence but also strengthens the financial sector's contribution to sustainable development.

Despite the growing practice of green banking, the current literature still shows a lack of studies specifically addressing the risks and challenges of its implementation within an Islamic financial framework. Analysis of sustainability report disclosures indicates that, despite their positive impact on corporate financial performance, empirical studies linking them to Sharia compliance and operational risk are limited, leaving a significant gap in academic understanding of Islamic-based green banking. Furthermore, research on the impact of green banking on firm value, considering bank efficiency as a mediating variable, emphasizes that internal mechanisms and risk management strategies are crucial for the effectiveness of green finance. However, there is limited literature addressing the specific challenges that arise when implementing this instrument in accordance with Sharia principles. This gap highlights the need for more in-depth studies to develop a contextual framework of risks and challenges for Islamic financial institutions.

1. METHOD

This research employs a qualitative approach with a literature review. This method was chosen to conceptually and comprehensively analyze green banking from an Islamic sustainable finance perspective, as well as to identify the challenges and risks of its implementation. The data sources used were secondary data obtained from national and international scientific journals, books, official reports, and policy documents relevant to the topics of green banking, sustainable finance, and Islamic finance.

The literature collection process was conducted through a search of academic databases using keywords such as "green banking," "Islamic sustainable finance," "maqashid sharia," "ESG," and "green financing." The selected literature was published within a relevant timeframe and directly related to the research theme. Data analysis was conducted using descriptive-critical analysis techniques, namely by reviewing, comparing, and synthesizing various findings in the literature to gain a comprehensive understanding of the concept, challenges, and risks of implementing Islamic green banking. The results of the analysis were then systematically compiled to draw conclusions and formulate recommendations.

Literature findings were analyzed based on key themes: green banking policies, integration of sharia principles, operational and institutional risks, and implementation challenges. Content analysis was used to identify patterns, research gaps, and contributions to Islamic sustainable finance. The synthesis of the results provides a comprehensive overview of green banking practices and highlights key factors supporting sharia-compliant implementation. This systematic approach aims to generate evidence-based findings to inform further research and policies related to green banking.

2. DISCUSSION AND RESULTS

2.1. The Concept of Green Banking and Islamic Sustainable Finance

Research on green banking in Indonesia has experienced a significant increase in the last decade, reflecting the increasing attention to sustainability in national development. This issue has become increasingly relevant since the introduction of the Sustainable Development Goals (SDGs) by the United Nations in 2015. From an Islamic perspective, the implementation of green banking is not solely concerned with financial efficiency or profit, but must also align with the principles of maqasid al-shariah, which emphasizes the primary goal of sharia to safeguard religion, life, intellect, posterity, and property. This means that any banking product or service categorized as "green" must be free from riba (usury), gharar (excessive uncertainty), and maysir (speculation), and support intergenerational justice. Thus, green banking practices that adhere to sharia principles ensure that environmental and social benefits are not compromised for short-term financial gain, while maintaining economic stability and sustainability.

Scientific publications on green banking within the context of Islamic sustainable finance in Indonesia have begun to show an increasing trend in recent years. Based on literature analysis, most studies highlight green financing practices by Islamic banks, which are considered a key pillar of integrating sustainability principles into the financial sector. Instruments such as green sukuk, renewable energy financing, and environmentally friendly projects have become a major focus of academic discussions, as Islamic financial institutions strive to support sustainable development while adhering to Sharia principles. Furthermore, research has focused extensively on bank operational efficiency, ESG risk management, and Sharia Supervisory Board governance, all of which play a role in minimizing the risks and challenges of implementing green banking in Indonesia.

Islamic banks such as Bank Syariah Indonesia are an example of implementing green banking based on Sharia principles through service innovation and integrating sustainability aspects into their operations. In practice, financing is not only oriented towards financial aspects but also considers Sharia risks and environmental impacts in every credit and investment decision. Support for the renewable energy sector, green infrastructure, and sustainable investment demonstrates a commitment to development aligned with the Sustainable Development Goals (SDGs). This approach remains within the framework of Sharia principles, including the prohibition of riba (usury), gharar (gharar), and maysir (gambling), while strengthening the social and environmental contributions of Islamic banking within the framework of sustainable development (Yusuf et al., 2023; Ningluthfi & Nurohman, 2024).

Beyond Sharia compliance, this strategy also significantly impacts the bank's long-term profitability and risk management. By integrating environmental and social considerations

into the financing process, the bank is able to minimize potential losses from environmentally unfriendly or socially high-risk projects. This also strengthens the institution's reputation as a responsible and ethical financial actor, thereby attracting customers and investors who are increasingly concerned about sustainability. Furthermore, BSI's experience demonstrates that Sharia green banking can serve as a model for other Islamic banks in developing innovative green products while maintaining the integrity of Sharia principles. (Asfahaliza & Anggraeni, 2022).

Furthermore, the integration of Sharia principles into green banking encourages the creation of an inclusive and sustainable economy, as all parties, including future generations, benefit from fair and environmentally friendly financial practices. This implementation also requires strengthened internal governance, compliance with Sharia supervisory boards, and continuous risk monitoring. Thus, Islamic-based green banking is not only a financial instrument but also a strategic means to achieve a balance between economic, social, and ecological goals (Putri, PI, Rahayu K, N., Rahmayani, D., & Siregar, MES, 2022).

2.2. Integration of Green Banking within the Sharia Framework

The concept of green banking from the perspective of Islamic sustainable finance shows the harmony between green finance and Islamic ethical finance, which both place environmental sustainability as part of the responsibility of financial institutions. The green finance approach emphasizes financing environmentally friendly activities, while Islamic finance reinforces this through the principles of justice, business ethics, and a focus on the welfare of the community. The principle of environmental stewardship in Islam views humans as caliphs (khalifah) obliged to maintain the balance of nature, thus Sharia banking operations are judged not only in terms of profit but also in terms of their contribution to environmental protection (Nasution, 2018). However, the implementation of green banking still faces challenges such as the low integration of environmental ethics into business strategies and the risk of a lack of transparency in green financing. To minimize these risks, the use of technologies such as blockchain is considered to have the potential to increase accountability, transaction traceability, and public trust in the implementation of sustainability oriented Islamic finance (Arwani & Priyadi, 2024).

Islamic financial instruments within the green finance framework show a significant contribution. increasingly significant through the optimization of green sukuk and murabahah-based financing and Ijarah as a supporting mechanism for renewable energy projects that are oriented towards environmental sustainability and long-term economic stability. Green sukuk functions as long-term funding sources for the development of environmentally friendly infrastructure with emphasizing the principles of transparency, accountability, and standardized sustainability reporting, so that environmental performance

achievements can be measured systematically and become the basis for evaluation. for investors, regulators, and other stakeholders (Linov, 2023). On the other hand, the scheme Murabahah and ijarah enable Islamic banking institutions to finance energy assets. clean like solar panels and renewable energy based power plants without deviating from sharia principles, while reducing the risk of speculation because transactions are based on on real assets that have clearly identified economic value and ecological benefits. The implementation of the integration of green financial instruments with international sustainability standards has carried out by global institutions such as Bank Negara Malaysia and the World Bank, which shows that the Islamic financial system has high compatibility with the development agenda global sustainability. Strengthening the concept of Islamic Green Banking not only contributes to achievement of the Sustainable Development Goals (SDGs), but also strengthening the synergy between maqashid sharia, environmental governance, and social responsibility in financing policies and banking operations (Fitriani et al., 2025). In addition, the implementation of the green banking model proven to have the potential to improve banking performance if supported by a system environmental risk management, regulatory compliance, and the quality of information disclosure consistent and credible sustainability (Mutaqin, 2023). However, the main challenge still found in the transparency and consistency aspects of sustainability reports, which if not managed optimally can affect the perception of financial performance and increase reputational risk of Islamic financial institutions in the eyes of the public and investors (Putra & Subroto, 2022).

2.3. Challenges of Green Banking Implementation in Islamic Finance

The implementation of green banking within the framework of Islamic sustainable finance faces various structural and conceptual obstacles, including regulatory dimensions, institutional, market, and theoretical aspects. In terms of regulation, the absence of global standards related to green sharia compliance and the fragmentation of fatwas and policies between authorities give rise to differences in interpretation in the application of sustainability principles in Islamic financial institutions, thus hampering the process of harmonization of practices, consistency of reporting, and comparability environmental performance across jurisdictions. This condition is in line with the finding that the achievement of objectives sustainable development still faces governance issues, particularly in integration public policy with a financing system that has not been fully coordinated effectively (Sustainable Development Report, 2024).

From an institutional perspective, the limited capacity of ESG-based risk management is exacerbated. due to the low availability of human resources who have integrated competencies between ESG framework and sharia principles. This situation has resulted in weak disclosure quality. sustainability information, limited internal control mechanisms, and minimal innovation green financial products. In the market dimension, the challenges are reflected in

the low level of demand for green finance products and the existence of information asymmetry between banks and customers regarding the economic, social and environmental benefits of sustainable financing, which in turn ultimately influence investor perceptions, company value, and operational efficiency levels. Islamic banking (Kusumadewi, 2023).

Theoretically, there is a potential tension between short-term profitability orientation and the long-term goals of maqashid al-shariah which open up opportunities for the practice of greenwashing, especially when the concept of sustainability is interpreted merely as a reputational instrument without substantial integration into the business model of financial institutions. Therefore, it is necessary strengthening inclusive business models and governance based on ethical principles so that sustainability does not stop at the symbolic level, but is internalized in policy financing, risk management, and operational strategies of Islamic financial institutions (Cahyono et al., 2024). In addition, optimizing Islamic social instruments is seen as strategic for strengthening legitimacy while expanding the impact of a more equitable green economy through synergy between commercial financing and social distribution mechanisms (Fajrina et al., 2020).

From a regulatory perspective, the implementation of Islamic green banking still faces challenges. limitations of a comprehensive, specific, and integrated policy framework. Although sustainable finance policy initiatives have begun to be developed, existing regulations have not yet fully capable of accommodating the needs of Islamic banking which must carry out compliance with Islamic legal principles while meeting environmental sustainability standards and social. The absence of clear and uniform standards has the potential to cause differences interpretation in operational practices, increasing the risk of non-compliance, and making it difficult the process of monitoring and evaluating sustainability performance. In addition, there are no guidelines available detailed technical aspects related to environmental and social impact measurement methodology lead to The implementation of green banking tends to be normative and administrative in nature, so it has not yet been fully oriented towards achieving sustainable development goals substantively. This challenge is reinforced by the internal readiness of Islamic banks which still varies in systematically manage environmental and social risks, especially due to limited resources human resources who have cross-field competencies between risk management, sharia principles, and sustainability standards. This condition impacts the quality of green financing analysis as well as the effectiveness of the contribution of Islamic banking in supporting sustainable development demands the simultaneous integration of economic, social and environmental dimensions (Ramadhan et al., nd). On the other hand, empirical findings show that the implementation of green banking has not been consistently produces increased profitability in the short term, so that management Banks often face a strategic dilemma

between maintaining financial performance and strengthening commitment to long-term sustainability (Anggraini, 2020).

Market challenges in implementing Islamic green banking can be seen from the still low level of demand for green financial products. This is related to the level of public literacy. which is not evenly distributed and the assumption that environmentally based financing tends to be more expensive compared to conventional schemes. On the other hand, the information gap between financial institutions and customers create an understanding of the long-term benefits of financing Sustainable development has not been firmly established. Lack of transparency and public education also increasing doubts about the effectiveness of green banking, both in terms of social impact and economic sustainability. From the perspective of maqashid sharia, the development of a green economy should be directed to maintain the welfare and balance between economic aspects, social and environmental, so that serious efforts are needed to increase awareness and community participation in supporting a sustainable financial system (Iskandar & Aqbar, 2019). On the other hand, strengthening the economy based on Islamic social and philanthropic values has the potential to become alternative approaches to increase public trust and participation in products sustainable finance (Faruq, Albab, & Sutopo, 2024).

Theoretically, green banking from an Islamic perspective also faces a dilemma between short-term profitability orientation and the objectives of maqashid sharia which are oriented towards long-term welfare. The pressure of industrial competition drives banks to pursue profits fast, while sharia principles demand a balance between profit and social justice and environmental sustainability. This tension can give rise to the risk of strategic inconsistency if ethical values are not fully internalized (Fasya, 2021). In addition, there is the potential greenwashing practices, namely sustainability claims that are not fully supported by implementation real, which can damage the credibility of Islamic banks and create reputational risks as well public trust.

2.4. Green Banking Implementation Risks

The risks of implementing green banking in Islamic sustainable finance can systematically classified into financial risks and sharia risks. In financial risks, Transition risk arises from changes in environmental policies and technological shifts that can affects asset value and the stability of green project financing. In addition, credit risk also increased because renewable energy projects often have cash flow uncertainty and dependence on regulatory incentives. From a sharia perspective, the main risk lies in the potential non-compliance of contracts in ESG-based projects, especially if the financing structure is not fully reflects the principles of justice and sustainability taught by Islam (Fauzan et al., 2024).

Another risk is fatwa risk, namely differences in views of scholars regarding legitimacy. green instruments such as sustainable sukuk that can influence public trust. Therefore, strengthening

sharia governance and integrating Islamic social instruments is seen as important. to mitigate risks and ensure that sustainability goals are aligned with the principles maqashid al-shariah (Hendrawan, 2020). In the practice of sharia green banking, challenges arise when sustainability claims are not accompanied by clear and transparent evidence. The discrepancy between environmentally friendly statements and actual implementation can reduce trust society, especially because Islamic banks carry ethical values and moral responsibility. If If environmental impact reporting is not carried out openly and measurably, the public may doubt it. institutional commitment to sustainability principles. The literature emphasizes that a green economy demands consistency between social commitment and real practice so as not to give rise to perception gap. In addition, the influence of green banking on company value is very significant. relies on transparency and efficiency, so that unverified claims can be impact on decreasing investor and public confidence (Hastuti & Kusumadewi, 2023).

On the other hand, the implementation of green banking requires adjustments to internal systems. which is complex and requires a lot of resources. Compliance with sustainability standards require strengthening reporting mechanisms, environmental and social audits, and increasing the capacity of human resources who have integrative competencies between financial, sustainability, and governance aspects. Consequently, banks must bear additional operational costs that have the potential to reduce efficiency levels if not managed through careful strategic planning. In addition, limitations in data availability and quality Accurate ESG often makes it difficult for banks to measure environmental impact. from the financing distributed, so that the decision-making process is not yet complete based on reliable empirical information. Experience in implementing development programs based on the Sustainable Development Goals (SDGs) shows that the success of a strategy is greatly influenced by the availability of adequate data and effective coordination between stakeholders, including government, financial sector, and society (Judijanto, nd). In the context of Islamic banking, the level of public understanding and perception of Islamic banking institutions Islamic finance also plays an important role in determining the success of implementing green banking, because low sustainability literacy can limit market support for products green finance (Aprilia, 2022). Therefore, the effectiveness of green banking in increasing Company performance and institutional value are highly dependent on the bank's ability to maintain operational efficiency, strengthening internal governance, and integrating principles sustainability into business strategies consistently and sustainably (Hastuti & Kusumadewi, 2023).

This condition opens up space for the practice of greenwashing, namely efforts to building an environmentally friendly image without any real changes in financing policies. These risks relate to operational risks, particularly increased compliance costs. to meet evolving sustainability standards. In addition, the limitations of ESG data accurate and integrated data

is an obstacle in conducting environmental impact assessments. objectively. This situation can reduce the effectiveness of green financing and increase the possibility of errors in strategic decision making. Therefore, strengthening governance institutional management, increased transparency, and ethical value-based business assistance is necessary so that the principles of sustainability are truly implemented in operational practices and able to maintain public trust in the integrity of Islamic banking (Prasetya & Herianingrum, 2016).

The results of the literature review show that the implementation of green banking in banking Sharia has a dynamic relationship with financial performance, but the results are not always consistent. Several findings show that the application of green banking principles can make a positive contribution to profitability if accompanied by efficiency and good risk management (Diah, Aryani, & Prasetyo, 2019). However, other studies confirm that this influence is very dependent on the management strategy and the internal readiness of the bank in integrating sustainability principles into its business model (Hanif, Wahyu Ningsih, & Iqbal, 2020). This synthesis shows that green banking does not automatically increase performance, but requires the support of a system, governance, and mature planning so that financial benefits and sustainability can be balanced.

On the other hand, the success of implementing Islamic green banking is also influenced by factors. institutional sustainability and alignment with the national development agenda. Stability Islamic microfinance institutions, for example, are very much determined by their ability to adapt to changes in the economic environment and commitment to sustainable values (Suprayugo, 2022). In addition, the achievement of Sustainable Development Goals (SDGs) from an Islamic economic perspective demands integration between economic growth, social justice, and environmental protection simultaneously (Ferawati, 2018). Based on this synthesis, an integrative conceptual model is proposed in this study to place Islamic green banking as a meeting point between financial performance, institutional sustainability, and commitment to development goals sustainable based on Islamic values.

3. CONCLUSION

Green banking from the perspective of Islamic sustainable finance is one of the an increasingly relevant approach amidst the growing environmental crisis and demands sustainable development. Islamic banking does not only act as an institution financial intermediation, but also has an ethical responsibility to maintain balance between economic benefits, social justice, and environmental sustainability. The principle of maqashid sharia which emphasizes the welfare and balance provides a strong normative foundation for implementation of green banking. Therefore, the integration between sharia principles and standards Global sustainability initiatives like ESG essentially share similar goals.

However, the implementation of Islamic green banking still faces various challenges. challenges. From a market perspective, interest in green financial products has not yet fully developed because public literacy regarding sustainable financing is still limited. Many customers which considers short-term benefits more than long-term environmental impacts long. In addition, there is a lack of transparency and easy-to-understand information regarding The environmental impact of financing also affects the level of public trust.

In terms of regulation and institutions, Islamic banks are faced with demands to meet sustainability standards while maintaining compliance with Islamic legal principles, so that clear guidelines, an integrated risk management system, and resources are needed. human resources who understand sharia and sustainability aspects simultaneously. This challenge increasingly complex with the need for additional costs for reporting and management ESG data is not yet fully available in a comprehensive manner. Overall, the success of green banking in Islamic banking depends on the alignment between good governance, commitment to Islamic values, and the readiness of internal systems in managing aspects environmental and social, so that green banking does not stop as a mere business strategy, but become a real contribution in encouraging sustainable development that is just and long-term oriented.

Strengthening the implementation of green banking from the perspective of Islamic sustainable finance requires synergy between regulators, sharia banks and the market. Regulators need to align sustainability standards with sharia principles and provide clear technical guidelines. Bank Sharia must increase internal capacity, both in terms of human resources and systems. ESG, so that green banking is integrated into the organization's strategy. On the other hand, increasing literacy and transparency of reporting is important to build public trust, supported by collaboration cross-stakeholder collaboration to expand sustainable financing.

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REGULATORY FRAMEWORKS FOR AI-DRIVEN DIGITAL HEALTH MANAGEMENT SYSTEMS IN TURKIYE: OPPORTUNITIES AND CHALLENGES

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Abstract

The rapid integration of artificial intelligence into digital health management systems has transformed healthcare delivery, yet Turkiye lacks a comprehensive, horizontal AI-specific statute governing these technologies. This doctoral research examines the fragmented regulatory landscape for AI-driven digital health management systems in Turkiye, analysing the interplay between the Personal Data Protection Law (KVKK No. 6698), the Turkish Medical Device Regulation (TITCK), the Regulation on Remote Healthcare Services, and the National Artificial Intelligence Strategy (2021–2025). Through doctrinal legal analysis, this study identifies critical gaps in algorithmic transparency, liability allocation, data sovereignty requirements, and cross-border health data flows, creating regulatory uncertainty for AI diagnostics, clinical decision support systems, and remote patient monitoring platforms.

Employing comparative legal methodology, this research contrasts Turkiye's regulatory approach with the EU AI Act, EU Medical Device Regulation (MDR 2017/745), UK MHRA framework, and US FDA-HIPAA regime to assess harmonisation opportunities and regulatory divergence. The study reveals that while Turkiye's EU-aligned framework creates opportunities for streamlined CE-marked device registration, centralised e-Health infrastructure integration, and growing telemedicine market expansion, significant challenges persist, including regulatory fragmentation across multiple authorities (TITCK, KVKK Authority, BTK), unclear physician versus software producer liability under the Turkish Code of Obligations, stringent health data localisation requirements, and absence of de jure algorithmic transparency obligations.

This research contributes original doctrinal frameworks for understanding de facto versus de jure transparency requirements in AI health regulation, proposes liability allocation models for AI-assisted medical decision-making, and provides policy recommendations for the proposed AI and Digital Health Applications Regulation. The findings offer valuable insights for regulators, digital health innovators, and healthcare institutions navigating Turkiye's evolving AI governance landscape while maintaining EU regulatory harmonisation.

Keywords: Artificial Intelligence, Digital Health Management, Regulatory Frameworks, Turkiye, KVKK

TECH INTELLIGENCE IN WOMEN-LED STARTUPS: PAKISTAN'S RURAL VS. URBAN COMPARISON USING NEURAL NETWORKS & FUZZY LOGIC

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Abstract

This study investigates how technological intelligence influences the performance of women-led startups in Pakistan, with a comparative focus on rural and urban contexts. A hybrid neuro-fuzzy methodology was employed, combining neural networks with fuzzy logic to capture both predictive performance patterns and uncertainties inherent in startup-related data. Data were collected through structured surveys from incubated women-led startups in Lahore, Islamabad, Karachi, and Murree, representing diverse entrepreneurial ecosystems. Using MATLAB's Fuzzy Logic Toolbox and Neural Network Toolbox, the study modeled the relationships between five intelligence dimensions—technological, market, competitive, business, and operational—and startup success indicators. Findings reveal that urban startups achieve higher performance through strategic intelligence, particularly market awareness, competitive positioning, and business alignment, while rural ventures rely more on foundational capabilities such as technology adoption and operational strength. Neural network analysis confirmed strong predictive accuracy, and fuzzy logic provided interpretable rules showing that rural startups benefit from balanced internal systems, whereas urban startups thrive through external orientation and strategic agility. The study contributes to theory by clarifying the contextual interplay between intelligence systems and entrepreneurial performance, and to practice by offering actionable recommendations for women entrepreneurs, incubators, and policymakers. By highlighting distinct drivers of success in rural and urban ecosystems, the research provides a roadmap for designing tailored support mechanisms. Ultimately, the study advances gender equality and inclusive economic growth, aligning with Sustainable Development Goals 5, 8, and 9, and demonstrates that strengthening technological intelligence empowers women-led startups to overcome barriers and achieve sustainable innovation.

Keywords: Hybrid Neuro-Fuzzy Modeling, Innovation, Artificial Intelligence

TEKNOLOJİK ZEKÂNIN KADIN GİRİŞİMCİLER TARAFINDAN YÖNETİLEN GİRİŞİMLERDEKİ ETKİSİ: PAKİSTAN'DA KIRSAL VE KENTSEL KARŞILAŞTIRMA (YAPAY SİNİR AĞLARI VE BULANIK MANTIK KULLANILARAK)

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Özet

Bu çalışma, teknolojik zekânın Pakistan'daki kadın girişimciler tarafından yönetilen girişimlerin performansını nasıl etkilediğini incelemekte ve kırsal ile kentsel bağlamları karşılaştırmalı olarak ele almaktadır. Çalışmada, girişim performansındaki öngörücü desenleri ve belirsizlikleri yakalamak amacıyla yapay sinir ağları ile bulanık mantığı birleştiren hibrit bir nöro-bulanık metodoloji kullanılmıştır. Veriler, Lahore, İslamabad, Karaçi ve Murree'deki kuluçka merkezlerinde faaliyet gösteren kadın girişimcilerden yapılandırılmış anketler aracılığıyla toplanmıştır. MATLAB'ın Bulanık Mantık ve Yapay Sinir Ağları araç kutuları kullanılarak teknolojik, piyasa, rekabet, iş ve operasyonel zekâ boyutları ile girişim başarısı arasındaki ilişkiler modellenmiştir. Bulgular, kentsel girişimlerin piyasa farkındalığı, rekabetçi konumlanma ve iş uyumu gibi stratejik zekâ unsurlarıyla daha yüksek performans elde ettiğini; kırsal girişimlerin ise teknoloji benimseme ve operasyonel güç gibi temel yetkinliklere daha fazla dayandığını göstermektedir. Yapay sinir ağı analizi güçlü öngörü doğruluğunu teyit ederken, bulanık mantık kırsal girişimlerin dengeli iç sistemlerden, kentsel girişimlerin ise dışa dönük stratejik çeviklikten fayda sağladığını ortaya koymuştur. Çalışma, zekâ sistemleri ile girişim performansı arasındaki bağlam temelli etkileşimi açıklığa kavuşturarak kuramsal katkı sunmakta; kadın girişimciler, kuluçka merkezleri ve politika yapıcılar için uygulanabilir öneriler geliştirmektedir. Kırsal ve kentsel ekosistemlerdeki farklı başarı dinamiklerini vurgulayan araştırma, bağlama özgü destek mekanizmalarının tasarlanmasına yol göstermektedir. Sonuç olarak, bu çalışma toplumsal cinsiyet eşitliği ve kapsayıcı ekonomik büyümeyi ilerletmekte, Sürdürülebilir Kalkınma Amaçları 5, 8 ve 9 ile uyumlu olarak kadın girişimcilerin teknolojik zekâ yoluyla engelleri aşmasını ve sürdürülebilir yenilik üretmesini desteklemektedir.

Keywords: Hibrit Nöro-Bulanık Modelleme, Yenilik, Yapay Zekâ

UNPACKING CARBON DISCLOSURE DYNAMICS: THE ROLE OF CORPORATE TRANSPARENCY, DOUBLE MATERIALITY, AND FINANCIAL PERFORMANCE LINKAGE

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Abstract

Introduction: Carbon disclosure has become crucial in corporate strategies, particularly in how companies report their carbon management practices. This study investigates the impact of forward-looking versus historical carbon disclosures on investor perceptions and financial outcomes.

Objective: The aim is to examine how forward-looking carbon disclosures influence investor risk perception compared to historical disclosures, and how corporate governance structures moderate the relationship between carbon disclosure and financial performance.

Methodology: A literature review of 36 relevant studies is conducted, comparing the impact of carbon disclosure on sectors with varying carbon intensities. The study also examines how governance factors, such as board diversity and ESG committees, influence the effectiveness of carbon disclosure.

Results: Forward-looking disclosures, like net-zero targets, significantly reduce investor risk perception. Strong governance structures enhance the positive impact of carbon disclosures on financial performance. Carbon-intensive sectors benefit from proactive disclosures that lower stock volatility and cost of capital, while low-carbon sectors exhibit more stability.

Discussion: High-quality carbon disclosures and strong governance structures foster investor trust and attract green investments, ensuring long-term sustainability.

Originality/Value: This study highlights the importance of transparent carbon disclosures and governance in improving corporate value and financial performance, offering insights for both scholars and practitioners.

Keywords: Carbon Disclosure, Investor Perception, Financial Performance, Corporate Governance, ESG Committees

MAPPING ISLAMIC CORPORATE GOVERNANCE RESEARCH ON THE FINANCIAL PERFORMANCE OF ISLAMIC BANKS IN INDONESIA: A SYSTEMATIC LITERATURE REVIEW

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Abstract

This study aims to analyze trends and consistency of findings regarding the influence of Islamic Corporate Governance (ICG) on the financial performance of Islamic banks in Indonesia from 2019 to 2025 using a systematic literature review of 30 articles. The study results show an increasing publication trend with two peaks in 2021 and 2024 2025, which correlates with the strengthening of OJK regulations. The Sharia Supervisory Board (DPS) is the most dominant ICG indicator (56.7%) and Return on Assets (ROA) is the most widely used performance proxy (86.7%). Most studies find that ICG has a significant positive effect on financial performance when measured comprehensively, but results vary when indicators are analyzed partially. Differences in methods, variables, and supporting factors such as sharia compliance and intellectual capital contribute to inconsistent findings. Furthermore, the dominance of profitability-based measures indicates a research gap, necessitating a more integrated ICG model and indicators based on the maqasid sharia principles (maqasid sharia) to produce a more comprehensive analysis.

Keywords: Islamic Corporate Governance, Sharia Supervisory Board, Financial Performance, Islamic Bank, Systematic Literature Review

INTRODUCTION

Islamic banking in Indonesia is showing positive developments. The Financial Services Authority (OJK) recorded that Islamic banking assets reached IDR 954.51 trillion as of April 2025, with annual growth of around 8.54% (yoy) (Alatas, 2025). This indicates the continued expansion of the Islamic banking industry. However, increasing assets do not automatically translate into higher growth.

This reflects optimal profitability. The May 2025 performance report showed that Islamic banking ROA was around 1.92%. Therefore, improving asset and profit management effectiveness remains a strategic priority.

Islamic banking in Indonesia currently faces the challenge of maintaining stable financial performance amidst intense knowledge-based competition. The implementation of **Islamic Corporate Governance (ICG)** is a crucial instrument in protecting stakeholder rights through a supervisory mechanism that aligns with Sharia principles. The role of **the Sharia Supervisory Board (SSB)** is vital in ensuring bank operations align with Maqashid Sharia, which has been empirically proven to improve financial performance (Pramestia, 2024). In addition to ICG, the management of Intellectual Capital (IC), as an intangible asset, is a key determinant of competitive advantage in driving bank profitability (Al Jupri & Fitri, 2025), while **Islamic Social Reporting (ISR)** complements bank accountability as a Sharia entity (Trilaksono et al., 2021).

However, previous research results regarding the influence of ICG on financial performance still show significant inconsistencies (Wibisana & Saadati, 2022). Some found a significant positive effect, others found a negative or insignificant effect depending on the measurement method, sample, and variables used. This condition shows the urgency of conducting research based on Systematic Literature Review (SLR) to present a comprehensive picture of trends, dominant indicators, and patterns of inconsistent findings.

This study was designed to answer four research questions: **(RQ1)** What are the trends in ICG research on the financial performance of Islamic banks in Indonesia? **(RQ2)** What ICG indicators and financial performance proxies are most commonly used? **(RQ3)** How consistent are the results of previous research? **(RQ4)** What gaps have been identified?

1. LITERATURE REVIEW

1.1. Islamic Corporate Governance: Concepts and Theoretical Foundations

Islamic Corporate Governance (ICG) is a corporate governance system that integrates Islamic sharia principles into organizational oversight and control mechanisms. Unlike conventional Good Corporate Governance (GCG), ICG adds a dimension of vertical

accountability to Allah SWT in addition to horizontal accountability to all stakeholders. Juwariyah (2021) defines ICG as a set of mechanisms encompassing the Sharia Supervisory Board (SSB), the board of commissioners, the board of directors, and the audit committee, which collectively ensure that Islamic bank operations align with Islamic principles. Weak ICG has been shown to increase the risk of sharia non-compliance (Ramdani & Kamal, 2023) and has the potential to encourage financial reporting fraud (Putriana et al., 2024).

Theoretically, the application of ICG in Islamic banking can be explained through two complementary frameworks. First, Islamic agency theory views conflicts of interest between principals and agents as being resolved not only through financial contracts but also through adherence to Islamic values, which unite the interests of all parties. Second, stewardship theory is relevant in the context of the Sharia Supervisory Board (SSB), where board members are assumed to act as stewards , prioritizing the interests of the institution and the community over personal interests. The terminological differences between ICG, Sharia Governance, and GCG found in the literature are one source of inconsistencies in the findings, which will be discussed in the results section.

1.2. DPS Mechanism and Its Impact on Performance

Among all the components of the **Sharia Supervisory Board (SSB), the Sharia Supervisory Board (SSB)** is the most distinctive mechanism in Islamic banking. The SSB serves a dual function: as a supervisor of Sharia compliance and as an advisor to management. The SSB's vital role in driving the financial performance of Islamic banks has been confirmed by various studies (Firmansyah & Hidayat, 2024; Umam & Ginanjar, 2020). However, the effectiveness of the SSB is not linear and depends on its structural characteristics.

Sutapa and Hanafi (2019) found that the size of the DPS had a significant positive effect, while Afiska et al. (2021) found a negative effect of the same phenomenon. indicates diminishing returns to additional SSB members. Hijriah et al. (2024) demonstrated that SSB cross-membership has a negative effect, reinforcing the urgency of regulations prohibiting dual positions. Billah and Fianto (2021) added that the diversity of SSB composition, including gender diversity, is a greater determinant of SSB effectiveness than formal education level. On the other hand, the presence of an Independent Board of Commissioners has a positive effect (Intia & Azizah, 2021), while the size of the Board of Directors has been found to have a negative effect in several studies (Kartika et al., 2025; Rahmati & Fauzan, 2025).

1.3. Financial Performance Measurement: Profitability Dominance and Research Gaps

Islamic bank financial performance in academic literature is dominated by **Return on Assets (ROA)** and **Return on Equity (ROE)** as proxies for profitability. However, this dominance

of ROA has a fundamental limitation: it fails to capture the maqashid sharia dimension , the core objective of Islamic banks. Several studies have begun to develop alternative measures: Cahya and Kusumaningtias (2020) used **the Maqashid Sharia Index (MSI)**, Nena and Lailaulfa (2021) used **the Islamicity Performance Index (IPI)**, and Ananda and Erinos (2020) used the Profit Sharing Ratio and Zakat Performance Ratio. This diversity indicates a paradigm shift that has not yet become mainstream.

Inconsistencies in findings are also influenced by the presence of co-variables. Some studies include **Intellectual Capital (IC)** as a mediating or moderating variable (Al Jailani & Abdani, 2025; Cahya & Kusumaningtias, 2020), and others combine ICG with **Islamic Social Reporting (ISR)** (Sutapa & Hanafi, 2019; Trilaksono et al., 2021). When these factors are included in the model, the effect of ICG on performance can change significantly (Alifiyah & Adiwijaya, 2025), indicating that partial and isolated ICG models tend to produce unrepresentative findings.

1.4. Position of Research in the Literature Landscape

Based on the synthesis of the three subsections above, previous research has three main weaknesses: **first**, most studies measure ICG partially; **second**, the dominance of ROA ignores the maqashid sharia dimension; **and third**, few studies integrate IC and Sharia Compliance in a single integrated model. This study positions itself as **a systematic mapping** that fills this gap through a SLR of 30 articles from 2019–2025, producing methodological recommendations for future research on ICG in Islamic banks.

2. METHOD

2.1. Research Design

This research uses a narrative-descriptive Systematic Literature Review (SLR) approach. The SLR approach was chosen because it is able to present a mapping of a comprehensive review of research trends, indicators used, and the consistency of findings across relevant studies. The research process adheres to the basic principles of PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) as a guide to transparency and reproducibility.

2.2. Data Sources and Search Strategy

Article searches are carried out manually through two main databases, namely **Google Scholar** and **Open Knowledge Map**, with the following keyword combinations:

- **Main keywords:** "Islamic Corporate Governance", "ICG", "Sharia Governance"
- **Indicator keywords:** "Sharia Supervisory Board", "Board of Commissioners", "Sharia Supervisory Committee" Audit, "Sharia Compliance"

- **Performance keywords:** "Financial Performance of Islamic Banks", "Return on Assets", "Financial Performance Islamic Bank"

The search was limited to publications from the 2019–2025 period to ensure the relevance of the findings to the latest regulatory developments, including the OJK Regulation regarding the governance of Islamic financial institutions.

2.3. Inclusion and Exclusion Criteria

Article selection was carried out based on inclusion and exclusion criteria that were explicitly set before the search process, as presented in Table 1.

Table 1. Article Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Discussing Islamic Corporate Governance, Sharia Governance, GCG, or related indicators	There is no direct relationship between ICG and the financial performance of Islamic banks.
The research objects include Islamic banks in Indonesia (including cross-country studies with data Indonesia)	Does not include data on Islamic Banks in Indonesia
Reviewing the financial performance of Islamic banking	In the form of a thesis, dissertation, or grey literature
Published in national and international scientific journals (2019 2025)	Not accessible in full text form
Accessible in full text form	The same article has been listed (duplicate)

Source: Determined by researcher (2025)

2.4. Article Selection Process (PRISMA)

The article selection process follows the four-stage PRISMA flow: identification, screening, eligibility, and inclusion. A summary of the selection process is presented in Table 2.

Table 2. Article Selection Flow (PRISMA Adaptation)

Selection Stage	Number of Articles
IDENTIFICATION	
Total articles found (Google Scholar + Open Knowledge Folder)	±120 articles
SCREENING	
Article after duplicate removal	±95 articles
Articles excluded (not relevant based on title/abstract)	±45 articles
ELIGIBILITY	
Articles can be accessed in full text	50 articles
Articles excluded after full review (did not meet criteria)	20 articles
INCLUDED	**30 FINAL articles**

Source: Processed by researchers (2025)

Note: Figures in the identification and screening stages are estimates that need to be confirmed with actual search data.

During the identification stage, approximately 120 articles were identified from two databases. The screening stage removed duplicates and irrelevant articles, leaving approximately 50 articles. In the eligibility stage, articles were read in full and evaluated based on inclusion and exclusion criteria, resulting in a final selection of 30 articles suitable for analysis.

2.5. Data Analysis Techniques

Data analysis was conducted through a three-stage narrative synthesis:

1. Grouping of findings based on the direction of the results (significant positive, significant negative, not significant);
2. Identify the most dominant ICG indicators and financial performance proxies;
3. Comparison of analysis methods between studies and identification of causal factors inconsistency.

The synthesis results are presented in a manual synthesis table that includes the researcher's name, year, ICG indicators, performance proxies, analysis tools, and direction of results.

2.6. Clarifying the Role of Artificial Intelligence (AI) in the Research Process

Given the limited access to bibliometric mapping software such as VOSviewer, this study utilized **artificial intelligence (AI) assistance in a limited and transparent manner**. The role of AI was limited to three functions: (1) **data tabulation:** compiling a synthesis matrix based on variables defined by the researcher; (2) **initial grouping:** categorizing articles into result groups based on data input by the researcher; and (3) **data consistency checking:** verifying the data's conformity to the content of the original articles.

All interpretation, analysis, and discussion were carried out entirely by the researchers, in line with guidelines for the use of AI in academic research that emphasize transparency and researcher responsibility (Khalifa & Albadawy, 2024).

3. RESEARCH RESULT

RQ1: ICG Research Trends on the Financial Performance of Islamic Banks in Indonesia

Of the 30 articles analyzed for the 2019–2025 period, publication volume showed a non-linear pattern but tended to increase. Two publication peaks occurred in **2021 (7 articles, 23.3%)** and **2024–2025 (14 articles, 46.7%)**, which together account for 70% of the total sample. This pattern reflects academics' response to two key regulatory momentums: the issuance of POJK No. 24/2020 concerning BUS governance in 2020–2021, and the strengthening of

governance transparency oversight by the OJK in 2023–2024. Details of the annual distribution along with the context of its causes are presented in Table 3.

Table 3. Distribution of Publications and Context of ICG Research Trends (2019–2025)

Year	n	(%)	Representative Study	Trend Context
2019	2	6.7%	Sutapa & Hanafi; Djuwita et al.	Initial period — the study focuses on the effect of partial ICG on ROA
2020	3	10.0%	Lestari; Cahya & Kusumaningtias; Ananda & Erinos	Maqashid-based performance approaches (MSI, IPI) are starting to emerge.
2021	7	23.3%	Billah & Fianto; Juwariyah; Siagian et al.; Afiska et al.; Amelinda; Nena; Intia & Azizah	Surge — POJK No. 24/2020 concerning GCG BUS encourages empirical research
2022	2	6.7%	Nabillah & Oktaviana; Setiabudhi	Stagnant — a period of consolidation transition BSI post merger
2023	2	6.7%	Afdal & Agustin; Ramdani & Kamal	Started entering Sharia Compliance as a moderator
2024	7	23.3%	Hijriah et al.; Wijaya et al.; Mediaty et al.; Firmansyah & Hidayat; Annissa et al.; Armayanti; Pramestia	Up again — OJK strengthens transparency governance regulations
2025	7	23.3%	Jailani & Abdani; Jannah & Adiwijaya; Alifiyah & Adiwijaya; Kartika et al.; Rahmati & Fauzan; Wartono & Darmun; Aljupri & Fitri	Integration of IC + ICG + Sharia Compliance becomes the dominant topic

Source: Data processed by the author (2025)

In terms of methods, the dominance **of panel data regression (EViews)** and **multiple linear regression (SPSS)** reflects the tendency of researchers to test quantitative causal relationships. No studies have used a mixed methods approach or structural modeling (SEM), which opens up methodological opportunities for future research.

RQ2: The Most Dominant ICG Indicators and Financial Performance Proxies

The Sharia Supervisory Board (SSB) was the most dominant ICG indicator, appearing in 17 articles (56.7%). The ICG Index, or composite GCG self-assessment score , came in second (12 articles, 40.0%), followed by the Board of Commissioners and the Board of Directors with 10 articles each (33.3%), and the Audit Committee with 8 articles (26.7%). A complete summary is presented in Table 4.

Table 4. ICG Indicators Most Frequently Used in Research

ICG Indicator	Frequency	Study Example
Sharia Supervisory Board (DPS)	17 (56.7%)	Hijriah et al. (2024); Billah & Fianto (2021); Siagian et al. (2021); Juwariyah (2021); Sutapa & Hanafi (2019); Afiska et al. (2021); Firmansyah & Hidayat (2024); Armayanti (2024); Intia & Azizah (2021); Umam & Ginanjar (2020)
ICG Index / Self GCG Assessment	12 (40.0%)	Jailani & Abdani (2025); Jannah & Adiwijaya (2025); Nabillah & Oktaviana (2022); Lestari (2020); Djuwita et al. (2019); Alifiyah & Adiwijaya (2025)
Board of Commissioners	10 (33.3%)	Rahmati & Fauzan (2025); Siagian et al. (2021); Amelinda & Rachmawati (2021); Kartika et al. (2025); Ramdani & Kamal (2023); Intia & Azizah (2021)
Board of Directors	10 (33.3%)	Rahmati & Fauzan (2025); Siagian et al. (2021); Mediaty et al. (2024); Kartika et al. (2025); Intia & Azizah (2021); Armayanti (2024)
Audit Committee	8 (26.7%)	Amelinda & Rachmawati (2021); Kartika et al. (2025); Ramdani & Kamal (2023); Mediaty et al. (2024); Armayanti (2024)
Sharia Compliance	5 (16.7%)	Jannah & Adiwijaya (2025); Wijaya et al. (2024); Alifiyah & Adiwijaya (2025); Lestari (2020); Afdal & Agustin (2023)
Institutional Ownership	1 (3.3%)	Kartika et al. (2025)

Source: Data processed by the author (2025)

Note: One article may use more than one ICG indicator so that the total frequency exceeds 30.

In terms of financial performance proxies, **Return on Assets (ROA)** significantly dominates, appearing in 26 of the 30 studies (86.7%). Sharia-based indicators such as MSI, IPI, and Profit Sharing Ratio each appear in only one study, reflecting a measurement gap that will be discussed further. The complete distribution is presented in Table 5.

Table 5. Financial Performance Proxies Used in the Research

Financial Performance Proxy	Frequency	Study Example
Return on Assets (ROA)	26 (86.7%)	Jailani & Abdani (2025); Jannah & Adiwijaya (2025); Hijriah et al. (2024); Billah & Fianto (2021); Wijaya et al. (2024); Juwariyah (2021); Nabillah & Oktaviana (2022); Lestari (2020); Djuwita et al. (2019); Annissa et al. (2024); Amelinda & Rachmawati (2021); Mediaty et al. (2024); Afdal & Agustin (2023); Afiska et al. (2021); Intia & Azizah (2021); Firmansyah & Hidayat (2024); Armayanti (2024); Sutapa & Hanafi (2019)
Return on Equity (ROE)	4 (13.3%)	Hijriah et al. (2024); Siagian et al. (2021); Ananda & Erinos (2020); Setiabudhi (2022)
Maqashid Syariah Index (MSI)	1 (3.3%)	Cahya & Kusumaningtias (2020)

Financial Performance Proxy	Frequency	Study Example
Islamicity Performance Index (IPI)	1 (3.3%)	Nena & Lailaulfa (2021)
Islamic Financial Ratio (PSR, ZPR, EDR, etc.)	1 (3.3%)	Ananda & Erinos (2020)
Multidimensional Ratio (Halal, Zakat, Profit sharing)	1 (3.3%)	Mediaty et al. (2024)
Risk of Sharia Non-Compliance	1 (3.3%)	Ramdani & Kamal (2023)
Financial Reporting Fraud	1 (3.3%)	Putriana et al. (2024)
Profitability/Efficiency/Stability (Qualitative)	2 (6.7%)	Wartono & Darmun (2025); Firmansyah & Hidayat (2024)

Source: Data processed by the author (2025)

Note: One article may use more than one performance proxy so that the total frequency exceeds 30.

RQ3: Consistency and Inconsistency of Research Results

A synthesis of 30 articles yielded three groups of findings. 18 studies (60%) found that ICG had a significant positive effect on financial performance; 5 studies (16.7%) found a significant negative effect; and 7 studies (23.3%) showed insignificant results. This distribution is presented in Table 6.

Table 6. Distribution of the Direction of the Influence of ICG on the Financial Performance of Islamic Banks

Direction of Influence	Amount Studies	Representative Study
Significant Positive	18 studies	Jailani & Abdani (2025); Wijaya et al. (2024); Siagian et al. (2021); Juwariyah (2021); Nena & Lailaulfa (2021); Nabillah & Oktaviana (2022); Annissa et al. (2024); Mediaty et al. (2024); Lestari (2020); Sutapa & Hanafi (2019); Ananda & Erinos (2020); Umam & Ginanjar (2020); Wartono & Darmun (2025); Firmansyah & Hidayat (2024); Ramdani & Kamal (2023) — simultaneous; Amelinda & Rachmawati (2021) — simultaneous; Billah & Fianto (2021) — gender diversity DPS; Afiska et al. (2021) — frequency of meetings
Significant Negative	5 studies	Hijriah et al. (2024) — DPS cross-membership; Billah & Fianto (2021) — DPS education & high meeting frequency; Kartika et al. (2025) — Board of Directors size; Djuwita et al. (2019) — partial; Afiska et al. (2021) — DPS size & education
Not Significant	7 studies	Jannah & Adiwijaya (2025) — partial; Cahya & Kusumaningtias (2020); Alifiyah & Adiwijaya (2025); Afdal & Agustin (2023); Setiabudhi (2022); Intia & Azizah (2021) — DPS & Board of Directors; Armayanti (2024); Rahmati & Fauzan (2025) — Commissioners & Board of Directors; Kartika et al. (2025) — Commissioners & Audit Committee

Source: Data processed by the author (2025)

Note: Kartika et al. (2025) split appropriately — entering Negative Significant for the variable of Directors, and Insignificant for Commissioners & Audit Committee partially. The total may exceed 30 because one study may report different results for different indicators.

The significant positive group is dominated by studies that measure ICG compositely or using the ICG Index, rather than by individual indicators (Jailani & Abdani, 2025; Nabillah & Oktaviana, 2022; Lestari, 2020; Wijaya et al., 2024). The significant negative group generally appears when specific indicators such as excessive SSB size or excessive meeting frequency are tested separately, resulting in increased operational costs that depress profitability (Afiska et al., 2021; Billah & Fianto, 2021). The insignificant group is generally found when there are other variables that are more dominant in the model, so that the influence of ICG is not statistically detected (Afdal & Agustin, 2023).

4. DISCUSSION

4.1. Publication Trends as a Reflection of Regulatory Dynamics

The identified publication trend patterns reflect academics' systemic response to regulatory changes. The surge in 2021 can be explained by the regulatory responsiveness theory , which posits that new regulations create new empirical questions that drive research productivity. POJK No. 24/2020 tightens BUS governance standards, prompting researchers to seek to empirically measure the effectiveness of these regulations. More interesting is the second surge in 2024–2025, which coincided with the strengthening of the discourse on the integration of ICG with IC and Sharia Compliance. This indicates a shift in the research paradigm: from the question 'does ICG have an effect?' to the more complex question, 'through what mechanisms and under what conditions can ICG improve the performance of Islamic banks?' This shift opens up space for mixed-method research and structural modeling, which until 2025 were still very rarely used. Implications: A research gap remains in the form of a lack of longitudinal studies that causally trace the impact of OJK regulations on the quality of ICG and the performance of Islamic banks over time.

4.2. DPS Dominance: Between Institutional Uniqueness and Regulatory Limitations

The dominance of the SSB as the most widely researched ICG indicator confirms its position as the most distinctive governance mechanism in Islamic banking. From the perspective of Islamic agency theory, the SSB serves a dual function: monitoring Sharia compliance and reducing information asymmetry between management and stakeholders. The inconsistent findings regarding the DPS reveal a tension between qualitative effectiveness and quantitative efficiency. The contradiction between the positive findings of Sutapa and Hanafi (2019) and the negative findings of Afiska et al. (2021) for the same DPS size variable can be explained by the diminishing returns hypothesis: adding DPS members beyond the optimal level does

not improve supervision quality but only increases costs. The OJK regulation limiting cross-membership , which was shown to have a negative impact in the study by Hijriah et al. (2024), is an empirically sound step. Billah and Fianto's (2021) findings on the importance of gender diversity in the SSB open a discussion previously unaddressed in domestic ICG literature. In the corporate governance literature, board diversity has been shown to improve decision-making quality through diverse perspectives, a relevant argument for promoting affirmative action policies in SSB composition. Regulatory implications: The Financial Services Authority (OJK) needs to consider more comprehensive SSB qualification standards, encompassing not only fiqh muamalah competence but also financial expertise, actual independence, and compositional diversity.

4.3. Limitations of ROA as a Single Proxy: Arguments for Multidimensional Measurement

The dominance of ROA in 86.7% of studies reflects methodological path dependency , with researchers tending to use the most widely used proxy by their predecessors for ease of comparison. However, the reliance on ROA contains a structural bias: ROA is a conventional profitability measure that fails to capture the achievement of maqasid sharia, the core objective of Islamic banks.

Studies using alternative indicators provide a fundamentally different picture. Cahya and Kusumaningtias (2020) found that banks with high ICG scores do not always excel in achieving the maqashid sharia objectives using MSI, a finding not apparent when using ROA alone. Mediaty et al. (2024) confirmed that the Profit Sharing Ratio and Zakat Performance Ratio provide a different performance picture than ROA. This indicates that the inconsistency in findings in the ICG literature may be due in part to inaccurate measurement of the dependent variable, rather than simply differences in samples or methods. Theoretical implications: A performance measurement framework is needed that integrates the dimensions of profitability (ROA/ROE), sharia compliance (Sharia Compliance Index), and maqashid achievement (MSI/IPI) into a single, coherent model.

4.4. Anatomy of Inconsistency: Map of Causal Factors

The inconsistencies in findings in the ICG literature can be mapped into five interacting factors, as presented in Table 7.

Table 7. Map of Factors Causing Inconsistency in ICG Findings

Factor	Condition ÿ Positive	Condition ÿ Negative/Insignificant
How to measure ICG	ICG composite/index ÿ tends to be significantly positive (Wijaya et al., 2024; Lestari, 2020)	ICG per partial indicator ÿ tends to be insignificant or negative (Afdal & Agustin, 2023; Afiska et al., 2021)
Variable terminology	Studies with the 'ICG Index' cover broader and more holistic dimensions.	GCG/Sharia Governance studies can have different scopes and measurement dimensions.
Period & sample	Sample of all long period BUS ÿ tends to be positive	Limited sample or short period ÿ more prone to insignificance
Additional variables	Without IC or Sharia Compliance, the influence of ICG is more detectable (Nabillah & Oktaviana, 2022)	With IC/Sharia Compliance, the influence of ICG can be changed/absorbed (Alifiyah & Adiwijaya, 2025)
Performance proxy	ROA reflects overall asset efficiency ÿ more detectable	MSI/IPI measure different dimensions ÿ the influence of ICG is not necessarily the same

Source: Processed from a synthesis of 30 articles (2025)

Of the five factors, **the ICG measurement method** is the most consistent and predictable. As a holistic composite value, ICG is easier to detect positive influences because it reflects the synergy between governance mechanisms. In contrast, partial measurement faces the partial equilibrium problem of isolating one mechanism from an interdependent governance ecosystem.

The presence factor of IC as an additional variable deserves special attention. Alifiyah and Adiwijaya (2025) showed that when IC was included in the model, the influence of ICG changed significantly, indicating a possible mediating relationship between ICG and IC in influencing performance. This hypothesis has never been explicitly tested in the literature and represents a very promising research gap to be tested using Structural Equation Modeling (SEM). Methodological implications: Future research is recommended to use SEM-PLS to simultaneously test the direct and indirect relationships between ICG, IC, Sharia Compliance, and multidimensional financial performance.

5. RESEARCH GAP

Gap 1 Dominance of ROA as a single performance proxy.

Of the 30 studies, 26 (86.7%) used only ROA. This is despite the dual objectives of Islamic banks : profitability and achieving the maqasid sharia. Future research should use MSI, IPI,

or the Profit Sharing Ratio in parallel with ROA, especially considering that the Financial Services Authority (OJK) has begun encouraging maqasid-based reporting in its latest regulations.

Gap 2 Absence of an integrated ICG model.

Most studies only partially examine one or two ICG indicators, without integrating the SSB, Commissioners, Directors, Audit Committee, and Sharia Compliance into a single structural model. Developing a psychometrically validated composite ICG index is an urgent methodological need.

Gap 3 Lack of IC mediation and Sharia Compliance testing.

Only 3–4 studies included IC or Sharia Compliance as mediating or moderating variables. Testing was carried out using SEM-PLS or Moderated Mediation Analysis. is needed to fully map the pathways of influence and resolve the question of why ICG is positive in some studies but not others.

6. CONCLUSION

Based on a Systematic Literature Review of 30 articles from 2019–2025, this study concluded four key findings. **First,** the trend of ICG publications is increasing, with two peaks in 2021 and 2024–2025, which correlates with the strengthening of OJK regulations. **Second,** DPS is the most dominant ICG indicator (56.7%), and ROA is the most widely used performance proxy (86.7%). **Third,** ICG has a significant positive effect on financial performance when measured comprehensively (60% of studies), but yields mixed findings when analyzed by individual indicators. **Fourth,** inconsistencies in findings are caused by differences in ICG measurement methods, terminology, time periods, samples, and accompanying variables.

In **practical terms,** these findings recommend that the Financial Services Authority (OJK) consider more comprehensive DPS qualification standards, including diversity in composition and a strict prohibition on cross-membership. Theoretically , an ICG framework is needed that integrates the dimensions of profitability, sharia compliance, and achievement of maqasid (the principle of Islamic banking) into a single, coherent measurement model. Future research is recommended to use the MSI or IPI as complementary performance proxies to ROA, as well as to develop an integrated ICG model tested using SEM-PLS.

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AFRICA IN THE AGE OF THE TWIN TRANSITION: DIGITAL TRANSFORMATION, GREEN INDUSTRIALISATION AND GLOBAL VALUE CHAINS

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Abstract

The accelerating convergence of digital transformation and green transition is reshaping the structure of the global political economy and redefining the strategic importance of emerging regions within global value chains. In this evolving context, Africa is increasingly gaining geopolitical and geoeconomic significance not only as a supplier of critical raw materials, but also as a strategic actor within the governance of resilient supply chains, green industrialisation, and digital transformation. This study examines Africa's emerging position in the age of the twin transition by analysing how digitalisation, sustainability agendas, and global industrial restructuring intersect across the continent.

The paper argues that the twin transition is transforming Africa's role within the international economic system. Traditionally positioned at the periphery of global production networks, African economies are increasingly becoming central to global competition over critical minerals, renewable energy infrastructures, digital connectivity, and green industrial ecosystems. In particular, resources such as lithium, cobalt, graphite, manganese, and rare earth elements have become strategically important for electric vehicles, battery production, renewable energy technologies, and digital infrastructures. Simultaneously, the expansion of fintech ecosystems, mobile technologies, digital platforms, and regional integration initiatives such as the African Continental Free Trade Area (AfCFTA) are contributing to the continent's growing role within digital and industrial transformation processes.

The study further explores how major powers — particularly the European Union, China, and the United States — increasingly compete for influence across African supply chains, infrastructure investments, and strategic resources within the broader context of the twin transition. The paper employs a qualitative research design based on document analysis of institutional reports, international policy documents, and secondary academic literature. The theoretical framework combines geoeconomics, global value chain analysis, and the security-development nexus to explain how sustainability governance, digitalisation, and industrial competition increasingly shape Africa's position in the evolving global order.

The findings suggest that Africa's strategic relevance within the global political economy is expanding through the twin transition. However, this transformation also generates new risks related to technological dependency, unequal value distribution, external control over strategic infrastructures, and asymmetric integration into global value chains. Overall, the study argues that the future of Africa's role in the global economy will largely depend on the continent's capacity to move beyond raw material dependency toward greater industrial upgrading, digital sovereignty, and sustainable economic governance.

Keywords: Twin Transition, Africa, Green Industrialisation, Global Value Chains, Digital Transformation

INTRODUCTION

The accelerating convergence of digitalisation and green transformation — often conceptualised as the "twin transition" — has emerged as one of the defining structural shifts of the contemporary global political economy (European Commission, 2021). While digital transformation reshapes production systems, labour markets, governance structures, and technological infrastructures, the green transition increasingly reorganises industrial policies, energy systems, trade relations, and sustainability governance around climate neutrality and resource efficiency (Muench et al., 2022). Although these transformations are frequently examined through European or advanced industrial economy perspectives, their implications for developing regions, particularly Africa, are becoming increasingly significant.

In recent years, Africa has gained growing strategic importance within the evolving architecture of global value chains. The transition toward renewable energy systems, electric vehicles, battery technologies, artificial intelligence infrastructures, and digital economies has significantly increased global demand for critical minerals such as lithium, cobalt, graphite, manganese, copper, and rare earth elements (International Energy Agency [IEA], 2023). Many of these strategic resources are concentrated in African countries, particularly the Democratic Republic of Congo, Zambia, Zimbabwe, South Africa, Madagascar, and Namibia. As a result, Africa is increasingly positioned at the centre of emerging geopolitical and geoeconomic competition surrounding green industrial transformation and resilient supply chain governance (Lee et al., 2020).

At the same time, digital transformation processes across the continent have accelerated rapidly. The expansion of mobile technologies, fintech ecosystems, digital payment systems, e-commerce platforms, and telecommunications infrastructures has reshaped economic and social dynamics across many African economies (Foster et al., 2018). Africa's digital economy has increasingly attracted strategic investments from external actors including China, the European Union, and the United States, each seeking to expand influence through infrastructure projects, technological partnerships, and digital governance initiatives (Zeng, 2021). In particular, China's Digital Silk Road projects and growing technological presence across African telecommunications sectors have intensified global competition over digital infrastructures and data governance (Kynge & Hattingh, 2022).

These developments demonstrate that Africa's role within the global economy is undergoing significant transformation. Historically, African economies were often integrated into global production systems primarily as exporters of raw materials and low-value commodities within asymmetrical trade structures (Rodney, 1972). However, the twin transition increasingly creates both opportunities and risks for the continent. On the one hand, Africa's strategic resources, renewable energy potential, and expanding digital markets enhance its geopolitical

importance. On the other hand, concerns regarding external dependency, unequal value distribution, technological vulnerability, and limited industrial upgrading remain highly significant (Taylor, 2016).

Despite the growing relevance of these issues, much of the existing literature examines Africa's digital transformation, green transition, or resource governance separately. Comparatively limited attention has been devoted to analysing how digitalisation, green industrialisation, global value chain restructuring, and geopolitical competition intersect within the broader context of the twin transition. In particular, Africa's emerging role within resilient supply chain governance and green industrial competition remains underexplored in contemporary international political economy literature.

This study seeks to address this gap by examining Africa's changing position within the age of the twin transition. The paper argues that Africa is no longer positioned merely as a peripheral supplier of raw materials within the global economy. Instead, the continent increasingly functions as a strategic arena where sustainability governance, digital transformation, industrial competition, and geopolitical rivalry intersect. The study therefore analyses how global powers — particularly the European Union, China, and the United States — increasingly engage with Africa through critical minerals, infrastructure investments, digital governance, and green industrial strategies in the evolving international order.

1. CONCEPTUAL AND THEORETICAL FRAMEWORK

The concept of the twin transition refers to the simultaneous advancement of digital transformation and green transition processes within contemporary economic and political systems (European Commission, 2021). While digitalisation reshapes production methods, governance mechanisms, communication systems, and economic infrastructures, the green transition seeks to reorganise industrial production and consumption patterns around sustainability, decarbonisation, and resource efficiency (Muench et al., 2022). Increasingly, these two transformations are treated not as separate developments, but as interconnected processes capable of reinforcing one another through technological innovation, industrial restructuring, and new governance models.

However, the implications of the twin transition extend far beyond sustainability policy or technological modernisation alone. The growing global competition over semiconductors, critical minerals, digital infrastructures, renewable energy technologies, and strategic supply chains demonstrates that the twin transition is also deeply geopolitical and geoeconomic in nature (Blackwill & Harris, 2016). In this respect, Africa's strategic importance is expanding because many of the resources and infrastructures required for green and digital transformation are increasingly linked to the continent.

One of the key analytical approaches employed in this study is geoeconomics. Blackwill and Harris (2016) define geoeconomics as the use of economic instruments to achieve geopolitical objectives. In the contemporary international system, trade policy, industrial subsidies, infrastructure investments, technological standards, energy governance, and supply chain management increasingly function as instruments of strategic competition among major powers. Similarly, Farrell and Newman (2019) argue that economic interdependence itself has become a source of geopolitical leverage through what they conceptualise as "weaponized interdependence." According to this perspective, actors controlling strategic nodes within global economic and technological networks gain significant influence over others.

The twin transition increasingly reinforces these dynamics. Renewable energy systems, electric vehicle production, digital infrastructures, and battery technologies require large quantities of critical minerals such as cobalt, lithium, graphite, copper, manganese, and rare earth elements (IEA, 2023). Since many of these resources are concentrated in African countries, the continent has become strategically important within global efforts to secure resilient and diversified supply chains. Consequently, Africa's role within the global political economy can no longer be understood solely through traditional development paradigms. Instead, it increasingly reflects broader struggles over technological leadership, industrial resilience, and strategic resource governance.

The study also draws upon Global Value Chain (GVC) analysis in order to understand Africa's evolving position within international production systems. Gereffi et al. (2005) argue that global production increasingly operates through fragmented transnational networks in which value creation, manufacturing, logistics, and innovation are geographically dispersed but hierarchically organised. Historically, African economies have largely occupied lower-value positions within these chains, primarily exporting raw materials while importing higher-value manufactured products (Taylor, 2016). However, the twin transition potentially creates new opportunities for industrial upgrading, regional manufacturing, battery processing, renewable energy development, and digital entrepreneurship across the continent.

At the same time, concerns regarding unequal integration remain highly significant. Scholars of dependency and political economy have long argued that resource-rich developing regions often remain vulnerable to external control, asymmetric trade relations, and extractive economic structures (Rodney, 1972). In the context of the twin transition, there is growing concern that Africa may once again become integrated into global green industrialisation primarily as a supplier of strategic raw materials rather than as a producer of higher-value technologies and industrial goods (Carmody, 2011). This raises important questions regarding industrial sovereignty, technological dependency, and equitable participation within emerging green value chains.

Another important framework employed in this study is the security-development nexus. Traditionally associated with peacebuilding and development studies, the security-development nexus highlights the growing interconnection between economic development, political stability, technological infrastructures, and strategic governance (Duffield, 2001). In the context of the twin transition, access to energy systems, digital infrastructures, transportation corridors, and technological networks increasingly constitutes both a development issue and a security concern. Infrastructure projects, digital platforms, and resource extraction initiatives therefore acquire broader geopolitical significance.

The study further engages with debates surrounding digital sovereignty and infrastructure governance. Digital sovereignty refers to the capacity of states or regions to exercise control over data governance, technological standards, telecommunications infrastructures, and digital ecosystems (Floridi, 2020). Across Africa, digital infrastructures are increasingly shaped by external actors, particularly Chinese, American, and European firms. This creates both opportunities for technological development and risks associated with external dependency, cybersecurity vulnerabilities, and unequal control over data infrastructures (Zeng, 2021).

Taken together, these theoretical perspectives demonstrate that Africa's role within the twin transition should not be reduced to resource extraction or development assistance narratives alone. Rather, the continent increasingly constitutes a strategic arena where digital transformation, green industrialisation, geopolitical competition, and global value chain restructuring intersect within the evolving international political economy.

2. METHODOLOGY

This study adopts a qualitative research design grounded in document analysis and interpretive policy analysis. The research examines how digital transformation, green industrialisation, and global value chain restructuring increasingly shape Africa's strategic position within the evolving political economy of the twin transition. Rather than focusing on quantitative measurement alone, the study seeks to provide a theoretically informed and policy-oriented analysis of the geopolitical and geoeconomic dimensions of Africa's changing role in the international system.

The analysis primarily relies on official policy documents, institutional reports, and secondary academic literature. Key institutional sources include reports and policy frameworks published by the African Union (AU), the African Continental Free Trade Area (AfCFTA), the European Commission, the International Energy Agency (IEA), the United Nations Conference on Trade and Development (UNCTAD), the World Bank, and the African Development Bank (AfDB). In addition, the study incorporates reports related to critical

minerals, renewable energy transition, digital infrastructure development, and global supply chain governance.

The research also examines strategic initiatives developed by major global actors — particularly the European Union, China, and the United States — in relation to Africa's digital and green transformation. These include infrastructure investments, renewable energy partnerships, digital connectivity projects, critical mineral agreements, and industrial cooperation frameworks. Particular attention is given to China's Belt and Road Initiative and Digital Silk Road projects, the European Union's Global Gateway strategy, and emerging American critical mineral and infrastructure partnerships across Africa.

Methodologically, the study employs comparative interpretive analysis to evaluate how different global actors engage with Africa within the broader context of the twin transition. The analysis focuses on three interconnected dimensions:1-green industrialisation and critical mineral governance, 2-digital transformation and infrastructure competition, 3-resilient supply chain restructuring and geopolitical rivalry.

The theoretical framework combines geoeconomics, Global Value Chain (GVC) analysis, dependency approaches, and the security-development nexus in order to explain how sustainability governance, industrial competition, and digital transformation increasingly intersect across African political economies.

Although the study recognises the diversity of African economies and development trajectories, it focuses primarily on broader continental trends and strategic dynamics rather than country-specific case studies. In this respect, the research aims to contribute to contemporary debates on Africa's evolving position within the global political economy of the twin transition.

3. AFRICA AND THE STRATEGIC POLITICAL ECONOMY OF THE TWIN TRANSITION

The global acceleration of green and digital transformation has significantly increased Africa's strategic importance within the contemporary international political economy. The transition toward renewable energy systems, electric mobility, battery production, artificial intelligence infrastructures, and digital technologies requires extensive access to critical minerals and resilient supply chains, many of which are increasingly linked to African economies (IEA, 2023). As a result, Africa is no longer viewed merely as a peripheral region within global production systems. Instead, the continent increasingly occupies a central position within emerging geopolitical and geoeconomic competition surrounding the governance of the twin transition.

One of the most visible dimensions of this transformation concerns critical minerals. The global demand for cobalt, lithium, graphite, manganese, nickel, copper, and rare earth elements has expanded rapidly due to the growing production of electric vehicles, renewable energy systems, semiconductors, and battery technologies (Lee et al., 2020). Africa possesses substantial reserves of many of these strategic resources. The Democratic Republic of Congo alone accounts for a significant share of global cobalt production, while countries such as Zimbabwe, Zambia, South Africa, Namibia, and Madagascar possess growing importance within lithium, copper, graphite, and rare earth supply chains (USGS, 2024).

Table 1. Africa's Strategic Resources in the Twin Transition

Resource	Key African Producers	Strategic Use
Cobalt	DRC	Batteries, EVs
Lithium	Zimbabwe, Namibia	Energy storage
Copper	Zambia, DRC	Renewable infrastructure
Graphite	Madagascar	Battery technologies
Rare Earths	South Africa	Semiconductors, green tech

Source: Author's compilation based on IEA (2023) and USGS (2024).

This growing demand has intensified global competition over strategic resource access and supply chain control. China has established a particularly strong position within African critical mineral sectors through long-term infrastructure investments, mining partnerships, and industrial agreements linked to the Belt and Road Initiative (Carmody, 2011). Chinese firms increasingly control major segments of cobalt processing, battery material production, and mineral logistics networks connected to African extraction industries (Kynge & Hattingh, 2022). Consequently, China's dominance extends beyond raw material access into higher-value industrial and technological segments of global supply chains.

At the same time, the European Union and the United States have accelerated efforts to diversify critical mineral supply chains and reduce strategic dependence on Chinese-controlled industrial ecosystems. The European Union's Critical Raw Materials Act and Global Gateway strategy increasingly position Africa as a key partner for resilient and sustainable supply chain development (European Commission, 2023). Similarly, the United States has strengthened partnerships focused on strategic minerals, infrastructure investment, and clean energy cooperation across several African economies. In this respect, Africa increasingly functions as a geopolitical arena where competing models of green industrialisation and strategic economic engagement intersect.

However, the strategic importance of Africa within the twin transition extends beyond critical minerals alone. Renewable energy development also plays an increasingly important role.

Africa possesses substantial solar, wind, hydroelectric, and green hydrogen potential, particularly in North Africa and parts of Sub-Saharan Africa (African Development Bank, 2022). Countries such as Morocco, Egypt, Namibia, and South Africa increasingly seek to position themselves within emerging green energy and hydrogen markets connected to European decarbonisation strategies. These developments create new opportunities for industrial upgrading, energy cooperation, and regional economic transformation.

Nevertheless, important structural challenges remain. Despite growing global demand for African resources, many African economies continue to occupy relatively low-value positions within global production networks (Taylor, 2016). Raw material extraction often generates limited local industrialisation, technological transfer, or value-added manufacturing capacity. As a result, there is increasing concern that the twin transition may reproduce older patterns of dependency through "green extractivism," where Africa supplies strategic minerals for global green industrialisation while remaining excluded from higher-value technological production and industrial innovation (Bond, 2022).

Infrastructure limitations also continue to constrain Africa's industrial transformation potential. Transportation networks, electricity access, digital connectivity, and manufacturing capacities remain unevenly distributed across the continent (World Bank, 2021). Consequently, the ability of African economies to move beyond resource-export dependency toward greater industrial participation within green and digital value chains remains uncertain.

In many respects, the twin transition therefore presents both opportunity and risk for Africa. On the one hand, rising global demand for strategic minerals, renewable energy, and digital markets enhances the continent's geopolitical significance. On the other hand, unequal integration into global supply chains, external technological dependency, and limited industrial upgrading may deepen existing structural asymmetries within the global economy. Africa's long-term position within the twin transition will therefore depend not only on resource availability, but also on the continent's capacity to strengthen industrial policy, regional integration, technological capabilities, and sustainable economic governance.

4. DIGITAL TRANSFORMATION, INFRASTRUCTURE COMPETITION AND GLOBAL VALUE CHAINS

Digital transformation has become another major dimension of Africa's growing strategic importance within the age of the twin transition. Across the continent, rapid expansion in mobile technologies, fintech ecosystems, digital payment systems, e-commerce platforms, and telecommunications infrastructures has reshaped patterns of economic activity, financial inclusion, and regional connectivity (Foster et al., 2018). In many African economies, digital technologies increasingly function not only as instruments of economic modernisation but

also as strategic infrastructures linked to governance, development, and geopolitical influence.

One of the most significant aspects of Africa's digital transformation concerns the rapid growth of mobile-based economic systems. Due to historically limited banking infrastructure in many regions, mobile technologies have enabled alternative models of financial inclusion and digital commerce. Platforms such as M-Pesa in Kenya have become globally recognised examples of how mobile financial technologies can transform economic participation and digital entrepreneurship (Jack & Suri, 2011). The expansion of fintech sectors across countries such as Kenya, Nigeria, South Africa, Rwanda, and Ghana increasingly positions Africa as one of the fastest-growing digital markets in the Global South.

At the same time, the development of digital infrastructures has become closely connected to geopolitical competition among major powers. China has emerged as one of the most influential external actors shaping Africa's digital landscape through investments in telecommunications networks, smart city projects, surveillance systems, cloud infrastructures, and fibre-optic connectivity (Zeng, 2021). Chinese companies such as Huawei and ZTE have played major roles in expanding Africa's telecommunications infrastructure, particularly within the broader framework of the Digital Silk Road initiative (Kynge & Hattingh, 2022).

These developments have generated increasing concerns among Western actors regarding cybersecurity, data governance, digital dependency, and technological influence. The United States and the European Union increasingly perceive digital infrastructures not merely as commercial sectors, but as strategic geopolitical assets linked to technological sovereignty and global influence (Floridi, 2020). Consequently, Africa has become an important arena within broader global competition over digital governance models, technological standards, and infrastructure control.

Table 2. Major External Actors in Africa's Twin Transition

Actor	Strategic Focus	Main Instruments
China	Infrastructure & minerals	BRI, Digital Silk Road
EU	Sustainable supply chains	Global Gateway
USA	Strategic minerals & tech	Infrastructure partnerships

Source: Author's compilation based on European Commission (2021), Zeng (2021), and Kynge & Hattingh (2022).

The European Union's Global Gateway initiative reflects this growing strategic engagement. Through infrastructure partnerships, digital investment programmes, renewable energy projects, and connectivity initiatives, the EU increasingly seeks to strengthen its presence within Africa's digital and green transformation processes (European Commission, 2021).

Similarly, the United States has expanded initiatives related to digital infrastructure development, cybersecurity cooperation, and strategic technology partnerships across several African economies.

Digital transformation also increasingly intersects with the restructuring of global value chains. Advances in digital technologies, automation, artificial intelligence, logistics systems, and platform economies are reshaping patterns of global production and trade (Gereffi, 2018). In this context, African economies potentially possess opportunities to integrate into emerging digital value chains through services, fintech innovation, digital entrepreneurship, and regional digital markets.

However, important structural asymmetries remain highly significant. Despite rapid digital expansion, many African countries continue to face substantial challenges related to internet accessibility, digital literacy, electricity infrastructure, technological capacity, and data governance (World Bank, 2021). Moreover, ownership and control over digital infrastructures frequently remain concentrated in external actors, raising concerns regarding digital sovereignty and unequal technological dependency.

Another critical issue concerns data governance. As African digital markets expand, data increasingly becomes a strategic economic resource. Yet many African countries continue to possess limited regulatory capacity regarding data protection, cybersecurity, artificial intelligence governance, and platform regulation (Taylor & Broeders, 2015). This creates vulnerabilities associated with external control over digital ecosystems and cross-border data flows.

At the same time, regional integration initiatives such as the African Continental Free Trade Area (AfCFTA) create important opportunities for strengthening intra-African digital trade and regional industrial coordination. AfCFTA potentially provides a framework for reducing market fragmentation, supporting regional value chains, and enhancing Africa's bargaining power within the global economy (UNECA, 2021). In this respect, digital transformation and regional integration increasingly reinforce one another within Africa's broader economic restructuring.

Overall, digital transformation across Africa reflects a complex intersection of development opportunities, geopolitical competition, technological dependency, and global value chain restructuring. The continent is increasingly becoming not only a consumer market for digital technologies, but also a strategically contested space where infrastructure governance, data control, industrial transformation, and geopolitical influence converge within the broader dynamics of the twin transition.

5. FINDINGS AND DISCUSSION

5.1. Africa's Expanding Strategic Importance in the Twin Transition

The findings of this study demonstrate that Africa's geopolitical and geoeconomic importance is expanding significantly within the evolving political economy of the twin transition. The global transition toward renewable energy systems, electric mobility, digital infrastructures, and low-carbon industrial production has increased international demand for critical minerals, resilient supply chains, and new strategic markets, many of which are increasingly connected to African economies (IEA, 2023).

In this context, Africa can no longer be interpreted solely through traditional development or peripheral economy frameworks. The continent increasingly functions as a strategic arena where green industrialisation, digital transformation, infrastructure competition, and geopolitical rivalry intersect. In particular, Africa's vast reserves of cobalt, lithium, graphite, manganese, copper, and rare earth elements significantly enhance its strategic relevance within emerging green industrial ecosystems.

However, the findings also suggest that strategic importance alone does not automatically generate structural transformation. Despite increasing global interest in African resources and infrastructures, many African economies continue to occupy relatively low-value positions within global production systems. Consequently, the central challenge is not simply resource ownership, but the capacity to achieve industrial upgrading, technological development, and greater participation in higher-value segments of global value chains.

5.2. Green Industrialisation and the Risk of New Dependency Relations

Another important finding concerns the contradictory dynamics of green industrialisation across Africa. On the one hand, the twin transition creates new opportunities for renewable energy development, battery production, green hydrogen initiatives, regional manufacturing, and infrastructure expansion. Countries such as Morocco, South Africa, Namibia, and Egypt increasingly seek to position themselves within emerging clean energy and industrial ecosystems connected to global decarbonisation strategies.

On the other hand, the findings indicate that the twin transition may simultaneously reproduce older dependency structures through new forms of "green extractivism." Much of the current global demand for African resources continues to prioritise raw material extraction rather than local industrialisation or technological transfer (Bond, 2022). As a result, there is a significant risk that African economies may remain integrated into global green industrialisation primarily as suppliers of strategic minerals while higher-value manufacturing, innovation, and technological control remain concentrated elsewhere.

This issue becomes particularly visible in battery production and mineral processing industries. Although African countries possess large shares of critical mineral reserves, refining, processing, and advanced technological manufacturing largely remain dominated by external actors, particularly China, the European Union, and the United States. In many respects, this reflects the persistence of asymmetrical global production structures within the green economy.

5.3. Digital Transformation and Infrastructure Sovereignty

The study further demonstrates that digital transformation constitutes another major arena of strategic competition across Africa. The rapid expansion of mobile technologies, fintech systems, digital platforms, and telecommunications infrastructures has created important opportunities for financial inclusion, digital entrepreneurship, and regional economic integration (Foster et al., 2018). Africa's digital economy increasingly represents one of the fastest-growing technological markets within the Global South.

Nevertheless, digital transformation also generates new vulnerabilities associated with technological dependency and infrastructure governance. The findings suggest that digital infrastructures across many African economies remain heavily dependent on external actors, particularly Chinese, American, and European technology firms. Telecommunications systems, cloud infrastructures, surveillance technologies, and digital platforms increasingly function as strategic assets linked to geopolitical influence and data control.

In this respect, digital sovereignty emerges as a critical issue for Africa's long-term position within the global digital economy. The ability to regulate data governance, cybersecurity, artificial intelligence systems, and digital infrastructures increasingly constitutes a major dimension of economic and political autonomy. Yet many African countries continue to face institutional and technological limitations regarding digital governance capacity.

5.4. Regional Integration and Resilient Value Chains

Another key finding concerns the growing importance of regional integration within the governance of resilient supply chains. The COVID-19 pandemic and geopolitical disruptions demonstrated the fragility of highly concentrated global production systems. Consequently, resilience, diversification, and regionalisation increasingly shape global economic governance.

Within this context, the African Continental Free Trade Area (AfCFTA) potentially provides important opportunities for strengthening regional industrial coordination, intra-African trade, and regional value chains (UNECA, 2021). The findings suggest that regional integration may help African economies reduce excessive dependency on external markets while enhancing industrial cooperation and supply chain resilience across the continent.

However, important structural barriers remain highly significant. Infrastructure gaps, uneven industrial capacities, limited transportation connectivity, and regulatory fragmentation continue to constrain the full implementation of regional integration initiatives. As a result, the effectiveness of AfCFTA will largely depend on long-term investments in industrial policy, transportation systems, digital infrastructure, and institutional coordination.

5.5. Africa and the Future of the Global Political Economy

Overall, the findings indicate that Africa increasingly occupies a central position within the geopolitical restructuring of the global economy in the age of the twin transition. Sustainability governance, digitalisation, industrial competition, and strategic resource politics are becoming deeply interconnected across the continent.

Yet this transformation also generates important tensions. Efforts by major powers to secure resilient supply chains and strategic resources may simultaneously intensify external competition, asymmetrical dependencies, and geopolitical fragmentation. In this emerging environment, Africa's future role will depend not only on resource abundance, but also on its capacity to strengthen regional integration, industrial sovereignty, technological governance, and sustainable development strategies.

In many respects, the twin transition presents Africa with a historic strategic opportunity. Whether this opportunity leads to structural transformation or reproduces existing inequalities, however, remains one of the central political economy questions of the coming decades.

6. CONCLUSION

This study examined Africa's evolving position within the age of the twin transition and argued that the accelerating convergence of digital transformation and green industrialisation is fundamentally reshaping the continent's role in the contemporary global political economy. The findings demonstrate that Africa is no longer positioned merely as a peripheral supplier of raw materials within global production systems. Instead, the continent increasingly constitutes a strategic arena where critical mineral competition, digital infrastructure governance, resilient supply chain restructuring, and geopolitical rivalry intersect.

The analysis revealed that the transition toward renewable energy systems, electric mobility, battery technologies, and digital infrastructures has significantly increased global demand for strategic resources concentrated across African economies. As a result, Africa's geopolitical and geoeconomic importance has expanded considerably within emerging green industrial ecosystems. At the same time, the growing involvement of the European Union, China, and the United States across African infrastructure, mining, energy, and digital sectors

demonstrates that the twin transition increasingly functions as a field of global strategic competition.

The study also demonstrated that digital transformation represents another major dimension of Africa's changing strategic relevance. The rapid expansion of fintech systems, telecommunications infrastructures, digital platforms, and mobile technologies creates important opportunities for financial inclusion, regional connectivity, and economic modernisation. However, concerns regarding technological dependency, external control over digital infrastructures, and limited data governance capacity remain highly significant. In this respect, digital sovereignty increasingly emerges as a critical issue for Africa's long-term economic and political autonomy.

Another important finding concerns the contradictory nature of green industrialisation. While the twin transition potentially creates new opportunities for renewable energy development, industrial upgrading, and regional value chain integration, it may simultaneously reproduce older dependency structures through new forms of green extractivism. Much of the current global competition surrounding African critical minerals continues to prioritise resource extraction rather than local processing, technological transfer, or higher-value industrial production. The findings further suggest that regional integration initiatives such as the African Continental Free Trade Area (AfCFTA) may play a significant role in strengthening Africa's bargaining capacity within the global economy. Greater regional coordination in industrial policy, infrastructure development, digital governance, and supply chain management could enhance the continent's ability to move beyond raw material dependency toward more diversified and resilient economic structures.

Overall, the study demonstrates that the twin transition is reshaping not only global production systems and sustainability governance, but also the geopolitical position of Africa within the international system. Yet this transformation also generates new tensions between development, dependency, resilience, and geopolitical competition. The long-term implications of the twin transition for Africa will therefore depend largely on whether African economies can strengthen industrial sovereignty, technological capacity, regional integration, and sustainable governance mechanisms within the evolving global political economy.

Finally, future research may further explore country-specific experiences of green industrialisation, digital governance, and critical mineral strategies across Africa. Comparative studies focusing on industrial upgrading, regional value chains, and infrastructure governance may provide deeper insight into how African economies navigate the opportunities and risks generated by the twin transition. The twin transition may therefore become not only a technological and environmental transformation process, but also a defining moment in the restructuring of Africa's position within the global political economy.

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DOES CORPORATE GOVERNANCE DRIVE CIRCULAR ECONOMY AND WASTE MANAGEMENT DISCLOSURE? EVIDENCE FROM BANGLADESH'S READY-MADE GARMENT (RMG) SECTOR

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Abstract

The present study investigates the relationship between corporate governance measures and circular economy (CE) and waste management disclosure of the listed ready-made garment (RMG) companies of Bangladesh. Unlike other ESG reporting, CE and disclosure of waste is more about material loops, waste reduction targets and recovery systems, and no previous study has tested this specific disclosure domain against the attributes of governance in an emerging economy garment sector. To fill this gap, the study develops a ten-dimensional Circular Economy and Waste Management Disclosure Index (CEWMDI) using manual content analysis of audited annual reports of seven companies listed in the Dhaka Stock Exchange for FY2020-24, resulting in 35 firm-year observations. The five hypotheses were tested using panel data methods. Overall results from the descriptive analysis indicate that disclosure levels are still low, with a mean index score of 4.09 out of 20, and significant differences between firms. The regression results provide partial and tentative support for the hypotheses. The relationship between board size and disclosure is positive in both the pooled and random-effects models, but not in the fixed-effects model preferred by the Hausman test. Contrary to expectations, board independence and institutional ownership become negative when control variables are included, and ownership concentration is positively related to disclosure. The strongest correlation with disclosure is the firm's size, measured by total assets, across the different specifications. From the findings, it can be concluded that the board and ownership structure in the Bangladesh RMG industry is yet to be a major determinant of CE and waste disclosure, and scale and external pressures of the firms might be more important than internal governance. The study is the first to provide a sector-specific disclosure instrument and firm-level panel evidence in a literature that has so far been largely based on surveys and case studies, and acknowledges the exploratory nature of the findings due to the small sample.

Keywords: Circular Economy Disclosure, Corporate Governance, Ready-Made Garment Sector, Waste Management, Bangladesh

Author Contributions: Afsana Sultana Shimu conceived the study, collected the data, and developed the theoretical framework of the study. Elmas Yaldız Hanedar carried out the statistical analysis and wrote the findings section. Biddut Talukdur conducted the literature review. All authors read and approved the final manuscript.

INTRODUCTION

Bangladesh's ready-made garment (RMG) sector is the backbone of the national economy. It accounts for almost 80 per cent of export revenues and provides jobs for millions of people. The same sector is also largely linear in terms of its production. The offcuts, chemical effluent, and packaging waste generated during cutting, sewing, and garment production can rarely be reused in the production process (Hasan et al., 2018; Islam & Jabber, 2022).

The circular economy is an alternative. It views waste as a resource rather than an end, by reusing, recycling and extending the use of materials (Ellen MacArthur Foundation, 2013; Geissdoerfer et al., 2017). In the export markets, transparency regarding CE and waste management practices is now part and parcel of business with international buyers, who are increasingly demanding transparency on environmental performance prior to ordering (Farrukh & Sajjad, 2024; Mataraarachchi et al., 2026).

One of the primary drivers of corporate disclosure is corporate governance. The more independent directors, the more women, and the more institutional ownership on a board, the greater the voluntary disclosure, and the more concentrated the ownership, the less the disclosure (Jensen & Meckling, 1976). The connection has been rigorously explored with respect to general ESG and sustainability disclosure. It has never been specifically tested for circular economy and waste management disclosure, and rarely in the RMG sector of an emerging economy, such as Bangladesh.

There's a reason this gap is important. CE and waste disclosure is not the same as ESG disclosure. It asks different questions, such as recyclability, loops, and targets for waste reduction, not on environmental and social performance. An attribute of governance that helps predict good ESG disclosure does not necessarily predict good CE disclosure. If there is no evidence from a sector where waste is a normal part of daily business, this question remains unanswered.

This study aims to fill that gap. It creates a Circular Economy and Waste Management Disclosure Index (CEWMDI), which is calculated based on 10 dimensions and the annual reports of seven RMG companies listed in the Dhaka Stock Exchange (DSE) over the period of five fiscal years (FY2020 to FY2024). The study then examines the relationship between five governance factors (board size, board independence, board gender diversity, institutional

ownership and ownership concentration) and the scope of CE and waste disclosure that these firms disclose.

The analysis is guided by two questions. First, how much CE and waste management information do Bangladeshi RMG firms actually disclose, and how does this vary across firms and years? Second, what are the governance attributes that are linked with higher or lower disclosure?

The study has three contributions. It presents a disclosure index specifically created for the garment industry's CE and waste reporting, instead of using a generic ESG disclosure index. It uses that index to analyse firm-level panel data, which most previous CE research in this field has been based on surveys or case studies (Saha et al., 2024). It also simultaneously evaluates four theoretical perspectives instead of one, and a disclosure domain that hasn't been examined in this way in Bangladesh before.

The rest of the paper proceeds as follows. Section 2 reviews the literature on governance and disclosure. Section 3 sets out the theoretical framework. Section 4 describes the data and methodology. Section 5 presents the results, and Section 6 discusses them. Section 7 concludes.

1. LITERATURE REVIEW

1.1. Corporate Governance and Voluntary Environmental Disclosure

Corporate governance has a significant influence on the accountability, transparency and responsiveness of management to stakeholder pressures, and it is internationally recognised as one of the main determinants of voluntary disclosure. The foundation is given by agency theory. When information is asymmetric, managers can act in their own interest, which is different from the interests of the shareholders, and mechanisms are in place to track managerial actions and enhance the credibility of information (Jensen & Meckling, 1976). The agency framing is originally from the financial reporting arena, but has been adapted to environmental and sustainability reporting, which has more managerial discretion and no mandatory standards to which it must adhere, allowing for more selective reporting.

The size of the board has two conflicting effects on the monitoring capacity. Larger boards tend to have a wider set of skills and stakeholders, and the disclosure can be more complete, but may also have issues of coordination and free-riding that weaken the board's oversight (Uyar et al., 2013). Recent evidence in the circular economy disclosure domain favours the first interpretation. Esposito et al. (2023) conducted an analysis of 124 European integrated reporters and found that larger boards tend to report on more comprehensive domains of CE, suggesting that more diverse director expertise helps to engage with new areas of non-financial reporting.

Board independence enhances monitoring in two ways: it mitigates managerial entrenchment, and it brings external eyes to the firm that are not subject to intra-firm political constraints. Independent directors are more likely to endorse the disclosure of non-financial information that does not have short-term managerial interests but that benefits long-term shareholders and external stakeholders. Previous empirical studies have linked the presence of more independent directors to more voluntary disclosure (Chau & Gray, 2010; Michelon & Parbonetti, 2012), and this relationship has been shown for environmental disclosure and CE disclosure in integrated reports (Esposito et al., 2023).

Gender diversity on the board is a new governance characteristic that has come to be seen as influencing sustainability transparency. In contrast, female directors are more likely to be stakeholder-oriented and more likely to be sensitive to externalities of their business, such as environmental and social issues, resulting in better quality sustainability disclosure (Alodat et al., 2023; Ben-Amar et al., 2017). The connection is dependent on the institutional context. Using a sample of 48 countries, Wasiuzzaman and Subramaniam (2023) established that the positive link between board gender diversity and ESG disclosure is statistically significant in developed countries but weaker in developing countries, where the regulatory environment may be less stringent and consequently restricts the channels through which female directors can influence disclosure outcomes. The direct implications of these findings for the Bangladesh RMG sector are that the representation of women on the board is still low, and the institutional environment in the export sector can either magnify or moderate the impact.

There is a unique monitoring regime in institutional ownership. Institutional investors have the means and the incentives to review corporate reports and to call for transparency on non-financial aspects that impact long-term value. Bae et al. (2018) studied listed companies in Bangladesh, India and Pakistan and found that the combination of board structure and shareholding composition was a strong indicator of management's sustainability commitment and had a significant impact on the scope of sustainability information reported. Similarly, Uyar et al. (2013) found that the institutional and corporate ownership had a positive relationship with voluntary disclosure of information in the Turkish listed companies, which corroborates the idea that more knowledgeable owners decrease the reluctance of managers to disclose information of long-term importance.

Generally, the higher the degree of ownership concentration, the lower the disclosure incentives. In cases of controlling ownership, the principal-principal agency conflict takes the place of the traditional principal-agent agency conflict, and dominant owners may favour opacity to maintain private benefits of control. Chau and Gray (2010) find that family-dominated and concentrated-ownership firms report less voluntary information than firms with more dispersed ownership in their study of listed firms in Hong Kong. The study by Fuadah et al. (2022) on 140 Indonesian listed companies found that foreign ownership and

public ownership are positively related to ESG disclosure, whereas state ownership and family ownership have weaker or insignificant relationships with ESG disclosure, which is in line with the concentration-suppresses-disclosure interpretation.

The literature as a whole has provided a strong positive link between voluntary disclosure breadth and such governance characteristics as board independence, gender diversity, and institutional ownership, while showing a negative link with concentrated ownership. Much of this evidence is limited to general voluntary disclosure, financial transparency, or general reporting on environmental, social and governance (ESG) and sustainability. There has been little empirical work on the narrower area of disclosure in the field of circular economy and waste management, especially in emerging-economy contexts.

1.2. Circular Economy and Waste Management Disclosure as a Distinct Construct

The scope and substance of the circular economy (CE) and waste management disclosure are different from traditional ESG disclosure. While conventional sustainability reporting reports on the performance of the environment, social and governance (ESG) aspects, CE disclosure is directed at the implementation of resource loops such as waste minimisation, recycling systems, material recovery, product life-extension, and regenerative production processes.

The conceptual basis is based on the understanding of the circular economy as a restorative and regenerative system, which aims to maximise the value of materials by keeping them in use for as long as possible, through re-use, repair, remanufacturing and recycling (Ellen MacArthur Foundation, 2013; Geissdoerfer et al., 2017). The development of CE as a research field is driven by increasing awareness of the need to address issues of resource scarcity, environmental degradation and the need to shift from linear production models, especially in resource-intensive industries like textiles and apparel.

The CE concept is still theoretically disjointed. Korhonen et al. (2018) describe the scientific substance of CE research as superficial and unsystematic, and attribute three main weaknesses to CE: thermodynamic constraints, problems of system boundaries, and definitional inconsistencies. The ambiguity of concepts is mirrored in the reporting. Firms provide CE information selectively, with their reporting being more influenced by the concerns of legitimacy and reputational management than by the existence of structured reporting frameworks (Burritt & Schaltegger, 2010; Esposito et al., 2023). The lack of a commonly accepted definition for CE reporting has encouraged researchers to formulate index-based tools to operationalise CE disclosure and performance. Saidani et al. (2019) summarise the ensuing taxonomy of CE indicators, which vary significantly in scope, granularity and analytical depth, and lack a single framework for evaluating circularity in firm-level reporting contexts.

1.3. Sustainability and CE Disclosure in Emerging Economies and the Bangladesh RMG Sector

In emerging economies, the adoption and disclosure of CE is less influenced by domestic regulatory requirements and more by pressures from the international supply chain, buyer expectations and reputation considerations. This is captured by the institutional theory, which suggests that firms are driven to adopt practices that have been legitimised by external systems through coercive, normative, and mimetic pressures (DiMaggio & Powell, 1983), and legitimacy theory, which indicates that organisations reveal sustainability information to maintain social license to operate in the absence of regulatory enforcement (Islam & Deegan, 2008). The three drivers of corporate environmental responsiveness – competitiveness, legitimation and ecological responsibility – are also identified by Bansal and Roth (2000), who also cite the study by Delmas and Toffel (2008) that shows how different firms in the same industry interpret institutional pressures and respond to them through disclosure and management actions.

These dynamics are more pronounced in textile and apparel supply chains in developing economies, where global fashion brands impose sustainability and environmental compliance requirements on suppliers, which puts pressure on CE adoption and disclosure (Farrukh & Sajjad, 2024; Mataraarachchi et al., 2026). Kazancoglu et al. (2018) show how the adoption of green supply chain management (GSCM) and CE principles can enhance resource efficiency, environmental management, and overall sustainability performance, which can act as a channel for the pressures of buyers to influence changes at the firm level. Saha et al. (2024) conducted a comprehensive bibliometric review of CE research in the textile and clothing industry, finding that most of the research was survey-based, qualitative, and conceptual, while relatively few studies were based on objective secondary data and involved firm-level disclosure analysis, which is directly relevant to the present study.

The ready-made garment (RMG) industry is one of the most analytically interesting empirical contexts for the study of CE in Bangladesh. It is the biggest export industry in Bangladesh as it generates about 80 per cent of the country's export earnings and provides employment to several million people. The textile sector produces considerable by-products, mostly in a linear production system, with a limited recycling infrastructure and a high waste intensity, and is at the heart of discussions on circular transition in manufacturing in developing countries. Structural barriers such as high implementation costs, technological barriers, weak enforcement of regulations, and institutional barriers limit the adoption of CE in the sector (Hasan et al., 2018; Islam & Jabber, 2022). Concurrently, the pressure from buyers, compliance with export market standards, and reputation considerations drive a good incentive for CE-aligned practices and disclosure, especially for LEED-certified and export-intensive factories (Ali et al., 2026).

While a few studies have focused on sustainability reporting in Bangladesh in general, the most recent empirical study is by Haque and Rahman (2021), who created a self-structured sustainability reporting index for fuel and power listed companies and analysed the impact of board composition and ownership structure on the breadth of reporting. They have also identified a relatively low average disclosure score, and there is a high level of association between disclosure and governance, which offers a methodological precedent and a motivation for sector-specific extensions. However, no published study has been found that combines corporate governance, and circular economy and waste management disclosure in a single analytical framework in the context of the listed RMG sector in Bangladesh using a structured disclosure index over firm-year panel data.

1.4. Synthesis and Research Gap

The four streams discussed above all come together in an empirical opportunity. First, the literature on corporate governance documents that the size of the board, board independence, gender diversity, institutional ownership, and ownership concentration affect voluntary environmental and sustainability disclosure, with larger boards, more independent boards, more diversity, more institutional ownership, and more concentrated ownership linked to greater disclosure and transparency, respectively. Second, because there is no universally accepted reporting framework, the literature of the circular economy views CE as a multi-dimensional, system-level construct that needs sector-specific measurement instruments. Third, the emerging-market literature suggests that buyer pressure, reputational issues, and poor regulatory enforcement are the primary factors that influence CE disclosure in developing-country textile industries, and these are all acute problems in the Bangladesh RMG industry. Fourth, the disclosure literature in Bangladesh is still sparse, descriptive, and mostly limited to sectors other than RMG, and there is very limited use of structured disclosure indices with firm-level panel data.

To fill this converging gap, the present study has developed a Circular Economy and Waste Management Disclosure Index (CEWMDI) specific to the Bangladesh RMG industry and analysed the relationship between the index and the corporate governance attributes of the firms over firm-years.

In view of the above gap and to explore the impact of corporate governance mechanisms on CE and waste management disclosure in listed RMG companies in Bangladesh, the following hypotheses are formulated:

H1: *Board size is positively associated with CE and waste management disclosure in Bangladesh's listed RMG firms.*

H2: *Board independence is positively associated with CE and waste management disclosure in Bangladesh's listed RMG firms.*

H3: *Board gender diversity is positively associated with CE and waste management disclosure in Bangladesh's listed RMG firms.*

H4: *Institutional ownership is positively associated with CE and waste management disclosure in Bangladesh's listed RMG firms.*

H5: *Ownership concentration is negatively associated with CE and waste management disclosure in Bangladesh's listed RMG firms.*

2. THEORETICAL FRAMEWORK

There is no single theory that can fully explain the relationship between corporate governance, and circular economy and waste management disclosure. There are a number of factors involved, including internal monitoring, pressure from stakeholders, concerns of legitimacy, and institutional forces. Four theories are used in this study: agency theory, stakeholder theory, legitimacy theory, and institutional theory.

According to agency theory, a firm is a collection of contracts between shareholders and managers (Jensen & Meckling, 1976). Managers have more knowledge of the firm's operations and risks than do shareholders, which allows managers to act in their own self-interest. Mechanisms of governance are in place to minimise this separation by overseeing managerial actions (Fama & Jensen, 1983). By making voluntary disclosures, including disclosure on circular economy and waste, the information gap is lessened, and there is a signal of accountability to shareholders. Board independence enhances monitoring, as independent directors have less connection to management and are more inclined to advocate for non-financial disclosure (Khan et al., 2013). The larger the board, the more expertise it has to evaluate complex environmental risks, such as waste and resource recovery, and this has been correlated with better voluntary disclosure results (Al-Janadi et al., 2013). Institutional investors are more vigilant and have the analytical ability and resources to review non-financial disclosure (Cox et al., 2004). It's different from concentrated ownership. The incentive favours opacity over transparency (Young et al., 2008), and dominant shareholders can extract private benefits of control at the expense of minority shareholders, as evidenced in emerging-market governance settings. Agency theory thus connects the extent of CE and waste management disclosure to board independence, board size, institutional ownership and ownership concentration.

Stakeholder theory is a theory that goes beyond the shareholders and includes customers, employees, suppliers, regulators, communities and international buyers. These groups influence the firm by their expectations and by the power they have to reward or punish the

firm. Disclosure is a means to control these relationships and demonstrate responsiveness. This perspective is suited to the CE and disclosure of waste, as the environmental impacts of garment production (water pollution, solid waste, chemical effluent, etc.) are largely borne by people who are not shareholders. The importance of board gender diversity is also explained by the stakeholder theory. Female directors are more likely to focus on issues regarding the environment and society and to consider the long-term (Alodat et al., 2023; Ben-Amar et al., 2017), resulting in more comprehensive sustainability reporting.

According to legitimacy theory, firms are subject to an implicit contract with society, which must be continually reaffirmed by means of communication and action that are in line with social expectations. If practice and expectation fall out of line, then disclosure is what firms do to bridge the gap. CE and disclosure of waste can be a legitimacy tool, particularly in cases where formal reporting requirements are either not in place or are weak (Islam & Deegan, 2008). This is evident in the Bangladesh RMG industry. The sector has been taken to task on factory safety, labour practices and pollution for years, and the Rana Plaza collapse brought the industry under global spotlight. In the absence of any binding domestic CE reporting rules, voluntary disclosure is the primary means by which firms communicate that they are meeting international expectations and that they are able to continue to operate.

The institutional theory sees the firm in the broader context of norms and conventions that influence behaviour through three forces (DiMaggio & Powell, 1983). Coercive pressure is from regulators, large buyers, and certifiers. Normative pressure is provided by professional standards and bodies. Mimetic pressure is the pressure that comes from firms imitating perceived leaders when they are uncertain. The theory is important here because the domestic rule-making process for CE is weak, and the pressure of the global supply chain is strong in Bangladesh. International brands and certification schemes like LEED, Higg-FEM, and OEKO-TEX drive RMG companies to adopt and report CE-aligned practices (Bansal & Roth, 2000; Delmas & Toffel, 2008; Farrukh & Sajjad, 2024; Mataraarachchi et al., 2026). Normative pressure comes from being a member of organisations such as BGMEA, and mimetic pressure comes from the visible practices of certified leaders.

These four theories do not compete with each other but are complementary. The agency theory helps to understand how board independence, board size, institutional ownership and ownership concentration affect internal monitoring. Stakeholder theory is the reason for gender diversity on the board, expanding the firm's focus beyond shareholders. Legitimacy theory is used to account for the fact that firms provide CE information when it is not legally mandated. The outside forces (buyers, certifiers, and industry norms) that impact disclosure despite internal governance are described by institutional theory.

3. METHODOLOGY

3.1. Research Design

The study adopts a quantitative secondary data design to test the association between the corporate governance characteristics and circular economy and waste management disclosure in listed RMG firms in Bangladesh. The disclosure relationship between governance and disclosure is assessed by panel data methods, while the manual content analysis of the audited annual reports is used to measure disclosure.

3.2. Population and Sample

The population consists of all the garment and textile companies that are listed in the Dhaka Stock Exchange (DSE). A very strict definition of finished garments was used: only companies that were in the export business of finished garments were kept. Fabric, yarn, and/or dyeing manufacturers that had not finished the garments were not included because their production processes and waste streams are significantly different from those of finished-garment manufacturers.

The final sample comprises 7 DSE-listed companies, namely, Desh Garments Ltd., Dragon Sweater and Spinning Ltd., Esquire Knit Composite Ltd., Far East Knitting and Dyeing Industries Ltd., H.R. Textile Ltd., Stylecraft Ltd., and Tosrifa Industries Ltd. The observation window is FY2020 – FY2024, which results in 35 firm-year observations.

3.3. Data Sources

Data were drawn from the audited annual reports of the seven sample firms for FY2020–FY2024. Governance variables were extracted from the Corporate Governance Compliance Report appended to each annual report, mandated by the BSEC Corporate Governance Code.

3.4. Dependent Variable: The CEWMDI

The dependent variable is the Circular Economy and Waste Management Disclosure Index (CEWMDI), a specially designed index for the current study. The index reflects the extent of information provided by an RMG company about CE and waste in a fiscal year. It is made up of 10 dimensions chosen to reflect the most important ways a finished-garment manufacturer can practice and report on circularity. The dimensions are based on the conceptual mapping developed by Geissdoerfer et al. (2017), the existing taxonomy of indicators developed by Saidani et al. (2019) and the limitations of existing CE measurement identified by Korhonen et al. (2018), with sector-specific frameworks such as the Global Reporting Initiative standards for waste and effluent, the Higg Facility Environmental Module, ISO 14001 environmental management, and the OEKO-TEX and GOTS certification schemes.

The ten dimensions are: (D1) fabric and solid-waste reduction, (D2) recycling and material recovery, (D3) water management and recycling, (D4) energy circularity and renewables, (D5) chemical and hazardous waste management, (D6) packaging-waste reduction, (D7) supplier CE requirements, (D8) CE strategy and governance, (D9) CE targets and performance reporting, and (D10) third-party certification. Each dimension is scored on a three-point ordinal scale: 0 if the dimension is not disclosed, 1 if disclosure is partial or qualitative, and 2 if disclosure is comprehensive and quantified. The firm-year score is the sum across all ten dimensions, ranging from 0 to 20.

3.5. Content Analysis Protocol

The full text of each annual report was read. The coder marked the location in the source text for each non-zero score, for each firm-year and each dimension, so that all non-zero scores can be traced to a particular page in the source text. Ambiguous cases were recorded in a Coding Log and settled according to the written protocol. The score trends for each firm over the 5 fiscal years were checked for any unexplained discontinuities, and scores which deviated were re-examined.

3.6. Independent and Control Variables

Board size (BSIZE) is the total number of directors on the board at the fiscal-year-end, drawn from the Corporate Governance Compliance Report. Board independence (BIND) is the percentage of directors classified as independent under BSEC criteria. Board gender diversity (BGENDER) is the percentage of female directors on the board. Institutional ownership (INSTOWN) is the percentage of total shares held by institutional shareholders at the fiscal-year-end, drawn from the shareholding pattern statement in the annual report; firm-years in which the report does not separate institutional from general public holdings were coded as missing. Ownership concentration (OWNCON) is the combined percentage of shares held by the top five shareholders.

3.7. Empirical Model

The regression model is specified as:

$$CEWMDI_{it} = \alpha + \beta_1 BSIZE_{it} + \beta_2 BIND_{it} + \beta_3 BGENDER_{it} + \beta_4 INSTOWN_{it} + \beta_5 OWNCON_{it} + \gamma' X_{it} + \varepsilon_{it} \quad (1)$$

where i indexes firms ($i = 1, \ldots, 7$) and t indexes fiscal years ($t = 2020, \ldots, 2024$). X_{it} denotes the vector of control variables, and ε_{it} is the error term. Coefficients β_1 through β_5 test hypotheses H1 through H5.

4. FINDINGS

Table 1. Descriptive Statistics

Variable		Mean	Std. dev.	Min	Max	Observations
CEWMDI (dependent variable)	overall	4.085	4.572	0	16	N = 35
	between		3.790	0	9.6	n = 7
	within		2.867	-5.514	10.485	T = 5
VARIABLES OF INTERESTS						
bsize	overall	6.875	1.621	4	9	N = 32
	between		1.586	4.8	9	n = 7
	within		0.527	5.675	8.075	T bar = 4.571
bind	overall	27.61594	6.580	16.67	40	N = 32
	between		6.362	21.668	40	n = 7
	within		2.221	22.617	32.851	T = 4.571
bgender	overall	26.22219	14.427	0	50	N = 32
	between		15.491	6.668	50	n = 7
	within		3.855937	19.55419	36.22419	T bar = 4.57
instown	overall	16.233	13.0585	3.11	53.06	N = 26
	between		10.1874	4.5825	32.73	n = 6
	within		9.120433	5.743077	54.713	T bar = 4.33
owncon	overall	51.179	13.349	30.155	74.12	N = 29
	between		13.674	30.158	65.15	n = 7
	within		4.8669	32.239	60.149	T bar = 4.14
CONTROL VARIALBLES						
size	overall	21.94791	1.123292	19.49928	23.57534	N = 34
	between		1.16069	19.70145	23.43234	n = 7
	within		0.194841	21.64684	22.75182	T = 4.857
ta	overall	5.23E+09	4.65E+09	2.94E+08	1.73E+10	N = 34
	between		4.80E+09	3.65E+08	1.51E+10	n = 7
	within		8.10E+08	2.07E+09	7.42E+09	T = 4.857
age	overall	30.71429	9.373214	18	47	N = 35
	between		9.860938	20	45	n = 7
	within		1.43486	28.71429	32.71429	T = 5
roa	overall	0.877974	3.692454	-12.79009	6.09595	N = 34
	between		2.767523	-2.757207	4.96449	n = 7

	within		2.676362	-10.3431	4.389012	T = 4.857
profit	overall	7.69E+07	1.76E+08	-5.75E+08	3.59E+08	N = 34
	between		1.37E+08	-7.67E+07	2.35E+08	n = 7
	within		1.21E+08	-4.21E+08	2.28E+08	T = 4.857
lev	overall	1.927086	3.403311	0	18.21534	N = 34
	between		2.576581	0.0334247	7.399002	n = 7
	within		2.37757	-3.63258	12.74342	T = 4.857
debt	overall	1.81E+09	1.77E+09	0	7.11E+09	N = 34
	between		1.77E+09	1.16E+08	5.21E+09	n = 7
	within		5.84E+08	3.18E+08	3.71E+09	T = 4.857
equity	overall	2.80E+09	2.82E+09	7.92E+07	8.93E+09	N = 34
	between		2.94E+09	1.49E+08	8.42E+09	n = 7
	within		3.38E+08	1.21E+09	3.31E+09	T = 4.857
exporter	overall	99.14719	2.464789	87.82757	100	N = 34
	between		1.415028	97.06072	100	n = 7
	within		2.067926	89.91404	102.0865	T = 4.857
exportrevenue	overall	3.29E+09	2.75E+09	1.17E+08	1.00E+10	N = 34
	between		2.68E+09	4.31E+08	7.61E+09	n = 7
	within		1.04E+09	6.84E+08	5.70E+09	T = 4.85714
totalrevenue	overall	3.30E+09	2.74E+09	1.34E+08	1.00E+10	N = 34
	between		2.68E+09	4.31E+08	7.61E+09	n = 7
	within		1.05E+09	6.93E+08	5.71E+09	T = 4.85714
grsus	overall	0.058824	0.238833	0	1	N = 34
	between		0.151186	0	0.4	n = 7
	within		0.190693	-0.3411765	0.6588235	T = 4.85714

Table 1 above reports the within and between descriptive statistics for the unbalanced panel dataset comprising 35 firm-year observations from seven firms over the period 2020–2024. The dependent variable, the **Disclosure Index (CEWMDI)**, has a mean value of 4.09 (SD = 4.57), with scores ranging from 0 to 16. Given that the index ranges from 0 to 20, the average score indicates a relatively low level of disclosure among the sampled firms, while we observe little variation in disclosure practices across years.

With respect to corporate governance characteristics, the average **board size** is 6.88 directors, ranging from 4 to 9 members. The mean proportion of **independent directors** (Bind) is 27.62%, indicating that slightly more than one-quarter of board members are independent.

Board gender (bgender) averages 26.22%, although the percentage varies substantially across firms, ranging from 0% to 50%. Regarding ownership structure, **institutional ownership (instown)** averages 16.23%, with values ranging from 3.11% to 53.06%, indicating substantial differences in the presence of institutional investors across firms. **Ownership concentration** (owncon) is relatively high, averaging 51.18%, which implies that controlling shareholders hold a significant proportion of equity in the sampled firms.

As for the control variables, the **audit committee** variable shows no variation, suggesting that every firm maintains an audit committee throughout the study period; we dropped the audit committee from the dataset. The firms in the sample are relatively large and mature. The mean value of **firm size (size)**, measured as the natural logarithm of total assets, is 21.95, while average **total assets (ta)** amount to approximately BDT 5.23 billion. The average **firm age** (age) is 30.7 years, with firms ranging from 18 to 47 years old, indicating that the sample consists primarily of well-established companies. The mean **return on assets (ROA)** is 0.88%, with values ranging from –12.79% to 6.10%, suggesting that some firms experienced periods of financial distress while others maintained positive profitability. Average **net profit after tax** is approximately BDT 76.9 million, although the large standard deviation reflects significant differences in financial performance across observations. The mean **leverage ratio** is 1.93, with a maximum value of 18.22, indicating that certain firms rely heavily on debt financing. Average **total debt** and **total equity** amount to BDT 1.81 billion and BDT 2.80 billion, respectively.

In line with the structure of the industry, the sample firms are highly export-oriented. The average **export intensity** is 99.15%, implying that nearly all revenue is derived from export activities. Consistent with this observation, mean **export revenue** (BDT 3.29 billion) is almost identical to mean **total revenue** (BDT 3.30 billion), confirming the dominant role of exports in firm operations.

Finally, the **sustainability report dummy (GRSUS)** has a mean value of 0.059, indicating that only approximately 5.9% of firm-year observations disclose a sustainability report. This finding suggests that sustainability reporting remains relatively uncommon among the firms included in the sample from 2020 to 2024. These summary statistics signal to us that we may fail to get robust and reliable estimation results because of the small number of observations.

Table 2. Regression Results

	I	II	III	IV	V	VI
	Pooled	**RE**	**FE**	**Pooled**	**RE**	**FE**
bsize	2.984***	2.984***	-17.58	2.036	2.036	95.27
	(5.31)	(5.31)	(-0.86)	(1.47)	(1.47)	(1.44)
bind	0.106	0.106	-4.333	-0.926***	-0.926***	20.29
	(0.9)	(0.9)	(-0.96)	(-3.86)	(-3.86)	(1.39)
bgender	-0.266***	-0.266***	-0.025	-0.00879	-0.00879	-1.576
	(5.60)	(5.60)	(-0.08)	(-0.06)	(-0.06)	(-1.31)
instown	-0.0197	-0.0197	-0.0377	-0.368***	-0.368***	0.0817
	(-0.45)	(-0.45)	(-0.73)	(-4.49)	(-4.49)	(-0.44)
owncon	0.230***	0.230***	0.399***	-0.0844	-0.0844	0.132
	(5.05)	(5.05)	(4.83)	(-0.81)	(-0.81)	(-1.28)
size				-7.374*	-7.374*	4.575
				(-2.54)	(-2.54)	(0.89)
ta				8.90e-09**	8.90e-09**	1.16E-08
				(2.8)	(2.8)	(3.83)
age				0.12	0.12	-0.247
				(0.65)	(0.65)	(0.44)
roa				1.149	1.149	0.101
				(1.6)	(1.6)	(0.1)
profit				-3.11E-08	-3.11E-08	4.31E-09
				(-1.74)	(-1.74)	(-0.16)
lev				-0.61	-0.61	-0.206
				(-1.65)	(-1.65)	(-0.43)
debt				-4.01E-09	-4.01E-09	-7.14E-09
				(-1.54)	(-1.54)	(-3.05)
equity				-9.08e-09**	-9.08e-09**	-1.19E-08
				(-2.83)	(-2.83)	(-1.25)
exporter				-0.920*	-0.920*	-0.121
				(-2.42)	(-2.42)	(-0.26)
exportreve~e				0.000000241***	0.000000241***	-4.36E-08
				(3.44)	(3.44)	(-0.52)
totalrevnue				-0.00000024***	-0.00000024***	4.20E-08
				(-3.44)	(-3.44)	(0.51)
Constant				263.7**	263.7**	-1239.1
				(3.17)	(3.17)	(-1.39)
N				23	23	23
T-stats are given in parentheses, * p<0.05, ** p<0.01, *** p<0.001						

In the first three columns of Table 2, the main regression results without the control variables on the pooled OLS, random-effects, and fixed-effects regression results are presented. The first 5 explanatory variables are the main variables of interest to test the five hypotheses, while the rest of the variables in columns 4, 5, and 6 are employed as the control variables. Based

on the Hausman test, the fixed-effects specification is considered the most appropriate model for interpretation. The results for the control variables indicate that most corporate governance variables, including board size, board independence, board gender diversity, institutional ownership, ownership concentration, firm age, profitability (ROA), leverage, and export intensity, do not exhibit a statistically significant association with the disclosure index after controlling for unobserved firm-specific effects.

Regarding the main variables of interest, **board size (bsize)** indicates a positive and statistically significant effect in the Pooled OLS and Random Effects models ($\beta = 2.984$, $p < 0.01$). This finding suggests that firms with larger boards tend to have higher levels of the dependent variable. However, the coefficient becomes insignificant in the Fixed Effects model, indicating that the observed relationship may be driven primarily by cross-sectional differences between firms rather than within-firm changes over time.

The coefficient of **board independence (bind)** is statistically insignificant in the baseline specifications of I, II and III. But becomes negative and statistically significant after the inclusion of control variables ($\beta = –0.926$, $p < 0.01$). This result implies that a higher proportion of independent directors is associated with lower levels of the dependent variable. Similarly, **bgender** has a negative and significant effect in the baseline model ($\beta = –0.266$, $p < 0.01$). Nevertheless, this significance disappears after the inclusion of control variables and fixed effects, indicating that the initial association may be driven by firm-specific characteristics. **Institutional ownership (instown)** does not exhibit a significant effect in the baseline model. However, after controlling for firm characteristics, the coefficient becomes negative and highly significant ($\beta = –0.368$, $p < 0.01$). This finding suggests that institutional investors matter in reducing the level of the dependent variable (CEWMDI).

Ownership concentration (owncon) shows a positive and significant association with the dependent variable in the baseline specification ($\beta = 0.230$, $p < 0.01$). The positive effect remains significant in the Fixed Effects model ($\beta = 0.399$, $p < 0.01$), indicating that firms with more concentrated ownership structures tend to exhibit higher levels of the dependent variable. However, the coefficient loses significance when control variables are introduced.

Among the control variables, **total assets (ta)** display a positive and statistically significant association with disclosure. This finding suggests that firms with larger asset bases tend to achieve higher disclosure scores, possibly because larger firms face greater stakeholder scrutiny and possess more resources to engage in disclosure activities. Conversely, **total debt (debt)** is negatively associated with the disclosure index in the fixed-effects model, indicating that higher indebtedness may discourage voluntary disclosure or reflect financial constraints that limit transparency initiatives.

Although several variables appear to be significant in the pooled OLS and random-effects models, these relationships disappear under the fixed-effects specification. For example, board independence, institutional ownership, export intensity, export revenue, and total revenue are significant in the pooled and random-effects estimations but become insignificant once firm-specific heterogeneity is controlled for. This pattern suggests that the results observed in the pooled models are largely driven by differences between firms rather than changes within firms over time.

Overall, the fixed-effects results indicate that variations in disclosure practices are explained primarily by firm-level financial characteristics rather than by changes in governance structures within firms during the study period. However, given the limited sample size and the relatively short observation period, these findings should be interpreted cautiously and regarded as exploratory rather than conclusive evidence.

The appropriate panel data estimation technique in the estimates was determined through the Breusch–Pagan Lagrange Multiplier (LM) test and the Hausman specification test. The LM test results indicate that the null hypothesis of no significant panel-level variance cannot be rejected ($p = 1.000$), suggesting that a pooled OLS model may be sufficient. However, the Hausman test yields a statistically significant result ($p = 0.009$), indicating that unobserved firm-specific effects are correlated with the explanatory variables. This finding implies that the random-effects estimator is inconsistent, while the fixed-effects estimator can be consistent. Therefore, despite the LM test result, the fixed-effects model is selected as the preferred estimation approach for the analysis.

The findings of this study should be interpreted with caution due to the relatively small and unbalanced panel dataset employed in the analysis. The sample consists of only 35 firm-year observations from seven firms over the period 2020–2024, which may limit the statistical power of the estimations and reduce the generalizability of the results. The limited number of observations also constrains the ability to detect weaker relationships among variables and may increase the sensitivity of the estimates to outliers or firm-specific characteristics. Furthermore, several variables exhibit little or no variation across observations, restricting their explanatory potential within panel data models. Consequently, while the results only provide preliminary evidence regarding the determinants of disclosure practices among the sampled firms, future research should employ larger samples, longer observation periods, and broader industry coverage to enhance the robustness and external validity of the findings.

In addition, the small number of cross-sectional units limits the effectiveness of panel data techniques in fully capturing unobserved heterogeneity. Therefore, causal interpretations should be avoided, and the findings should be viewed primarily as exploratory rather than conclusive evidence. Moreover, given the small sample size relative to the number of

explanatory variables, the regression estimates may be sensitive to multicollinearity[1] and overparameterization. Therefore, the results in Table 3 should be interpreted with caution, and more data is needed

Although multicollinearity does not produce biased coefficient estimates, it increases standard errors, reduces statistical power, and may lead to unstable coefficient estimates and misleading inferences, particularly in small samples like ours. The correlation matrix reveals several strong pairwise correlations, particularly among financial variables such as total assets, debt, equity, export revenue, and total revenue. For example, total assets are highly correlated with debt, equity, export revenue, and total revenue, while export revenue and total revenue exhibit an almost perfect correlation. These relationships are not unexpected, as the variables capture closely related dimensions of firm size, financial structure, and operating performance. Although multicollinearity does not produce biased coefficient estimates, it may lead to larger standard errors and thus reduce the precision and stability of the estimated coefficients, especially in small samples. Therefore, the regression results should be interpreted with caution, and future studies, especially with larger data, may benefit from employing more parsimonious model specifications or alternative variable selections to mitigate potential multicollinearity concerns.

5. DISCUSSION

Considering the current results obtained so far, it is obvious that we need a larger dataset to estimate the associations between the corporate governance indicators and the disclosure index. We suggest gathering new data for future researchers. By having a larger dataset, more robust results can be obtained.

6. CONCLUSION

The aim of this study was to explore the impact of corporate governance characteristics on circular economy and waste management disclosure of listed ready-made garment companies in Bangladesh. The disclosure of CE and waste is not the same as the disclosure of general ESG. It is not about overall environmental and social performance but instead about material loops, waste targets and recovery systems. The study was the first to validate this disclosure domain with governance attributes in the emerging economy garment industry, where waste is a regular part of production.

For this purpose, the study has developed a circular economy and waste management disclosure index of ten dimensions and scored seven finished garment manufacturers listed in the Dhaka Stock Exchange (DSE) during the fiscal years 2020-2024. This panel of 35 firm-

[1] See correlation matrix presented in the appendix.

years was then tested against five hypotheses regarding the relation between board size, board independence, board gender diversity, institutional ownership, ownership concentration and disclosure.

The descriptive evidence indicates that the level of CE and disclosure of waste is low in the sample. The average score on the index is 4.09 out of 20. The differences are largely due to the reporting of a few companies that report extensively, while others report almost nothing. There is no sign of institutionalisation of CE and waste reporting in this sector, but rather an emerging and uneven.

The regression evidence only partially and precariously supports the five hypotheses. In the pooled and the random-effects models, disclosure is positively related to board size, in line with H1, but not in the fixed-effects model, which the Hausman test prefers. There is no positive association between board independence and institutional ownership at any stage. Both turn negative and significant once control variables are added, contrary to H2 and H4. In the base model, the coefficient on gender diversity in the board is negative, which is not consistent with H3, but it is when controls are added. Ownership concentration is positively, not negatively, associated with disclosure in both the baseline and fixed-effects models, the opposite of H5. In the preferred fixed-effects model, none of the five governance variables is significantly related to disclosure. The only variable that is consistently positively associated with all specifications is total assets.

There are some limitations to the study. The sample includes seven firms for five years, and missing information in board independence, board gender diversity, institutional ownership, and ownership concentration further decreased the estimation sample. Family ownership, the presence of the audit committee, and CEO duality cannot be tested as there is no variation of these characteristics among the sample firms. The short panel and small number of firms limit the power of the fixed-effects estimator and the generalisability of the findings beyond the seven companies studied. The results should be read as exploratory evidence, not as a definitive test of the governance-disclosure relationship in this sector.

Future studies should have a larger sample of RMG firms, including unlisted firms where data is available, and a longer time period of observation to distinguish between within-firm changes and cross-firm differences. Another avenue for future research is to directly measure buyer and certification pressure, as the current results indicate that these external pressures may be more important than internal governance structures. Comparative studies in other RMG exporting countries would be helpful in determining whether this weak governance-disclosure relationship is unique to Bangladesh or is common to the sector at large.

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Appendix

Correlation Matrix

	DI	bsize	bind	bgender	instown	own	size	ta	age	roa	profit	lev	debt	equity	exporter
bsize	0.306	1.000													
bind	-0.008	-0.350	1.000												
bgender	-0.353	0.484	0.281	1.000											
instown	0.451	0.363	-0.288	-0.255	1.000										
own	0.590	-0.076	0.592	0.034	0.062	1.000									
size	0.733	0.534	-0.418	-0.313	0.572	0.066	1.000								
ta	0.790	0.269	0.060	-0.264	0.603	0.481	0.822	1.000							
age	-0.566	-0.697	0.266	0.058	-0.583	0.096	-0.823	-0.632	1.000						
roa	0.056	0.596	0.127	0.675	0.162	0.064	0.229	0.238	-0.352	1.000					
profit	0.298	0.461	0.028	0.235	0.445	0.124	0.556	0.643	-0.501	0.801	1.000				
lev	-0.228	-0.590	-0.217	-0.571	-0.274	-0.333	-0.201	-0.272	0.394	-0.698	-0.457	1.000			
debt	0.882	0.087	0.068	-0.493	0.536	0.564	0.758	0.933	-0.504	-0.018	0.402	-0.098	1.000		
equity	0.646	0.337	0.063	-0.091	0.583	0.388	0.783	0.967	-0.645	0.372	0.743	-0.347	0.815	1.000	
exporter	0.150	0.310	0.216	0.321	0.253	0.245	0.090	0.189	-0.281	0.446	0.285	-0.864	0.082	0.235	1.000
exportreve~e	0.816	0.307	0.032	-0.327	0.645	0.469	0.823	0.940	-0.651	0.275	0.662	-0.326	0.902	0.873	0.241
totalrevnue	0.817	0.308	0.030	-0.327	0.643	0.469	0.824	0.940	-0.650	0.275	0.662	-0.325	0.902	0.872	0.240

THE GEOPOLITICS OF THE TWIN TRANSITION: EU GREEN INDUSTRIAL STRATEGY, DIGITAL SOVEREIGNTY AND GLOBAL POWER COMPETITION

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Abstract

The twin transition, shaped by the simultaneous acceleration of digitalisation and the green transformation, has emerged as one of the most significant structural shifts in the contemporary international political economy. Although the European Union presents this transition primarily through the discourse of sustainability, climate neutrality, and technological innovation, the process increasingly reflects broader geopolitical and geoeconomic dynamics. This study argues that the European Union's twin transition agenda should be understood not only as an environmental or technological project, but also as a strategic instrument designed to strengthen industrial competitiveness, reduce external dependencies, and expand regulatory influence in the evolving global order.

The paper examines how the EU integrates green industrial policies, digital governance frameworks, and strategic autonomy objectives into a comprehensive geopolitical strategy. Particular attention is given to the European Green Deal, the Carbon Border Adjustment Mechanism (CBAM), the Critical Raw Materials Act, the Digital Services Act, the Digital Markets Act, and the EU Artificial Intelligence Act. These policy instruments are analysed as mechanisms through which the EU seeks to secure resilient supply chains, enhance technological sovereignty, and consolidate its normative power in global markets.

The study further explores how the twin transition intensifies global competition among major powers, particularly between the European Union, the United States, and China. In this context, green technologies, semiconductors, critical minerals, data governance, and digital infrastructures are increasingly becoming central elements of strategic rivalry. The paper employs a qualitative research design based on document analysis of EU policy papers, institutional reports, and secondary academic literature. The theoretical framework combines the concepts of geoeconomics, strategic autonomy, and the Brussels Effect to explain the EU's growing use of regulatory and economic instruments as tools of international influence.

The findings suggest that the twin transition is transforming the nature of global power competition by linking sustainability policies with industrial strategy, technological control, and geopolitical resilience. Consequently, the EU's approach reflects a broader shift from market liberalism toward a more interventionist and strategically coordinated governance model in the international political economy.

Keywords: Twin Transition, Strategic Autonomy, Digital Sovereignty, EU Green Deal, Geoeconomics

INTRODUCTION

The twin transition has emerged as one of the defining transformation processes of the contemporary international political economy. The concept refers to the simultaneous advancement of digitalisation and the green transition, both of which increasingly reshape production systems, industrial policies, trade relations, governance structures, and technological infrastructures (European Commission, 2021). Initially treated as relatively separate policy domains, digital transformation and sustainability policies are now widely understood as interconnected processes capable of reinforcing one another through innovation, efficiency, and systemic restructuring (Muench et al., 2022).

Within the European Union (EU), the twin transition occupies a particularly central strategic position. Since the launch of the European Green Deal in 2019, the EU has increasingly framed digitalisation and sustainability as complementary pillars of long-term economic competitiveness, industrial resilience, and strategic governance (European Commission, 2019). Official EU discourse presents the twin transition primarily through objectives such as climate neutrality, sustainable growth, resource efficiency, and technological innovation. However, the growing geopolitical fragmentation of the international system has simultaneously transformed these policies into instruments connected to industrial strategy, technological sovereignty, and geopolitical resilience (Biscop, 2021).

The COVID-19 pandemic, disruptions in global supply chains, semiconductor shortages, the Russia–Ukraine war, and increasing strategic rivalry between the United States and China have significantly accelerated this transformation. These developments exposed the vulnerabilities created by excessive external dependency in critical sectors such as energy, semiconductors, digital infrastructures, and raw materials (Farrell & Newman, 2019). As a result, resilience, strategic autonomy, and supply chain security have become central priorities within EU policymaking (European Council, 2022).

In this context, the European Union increasingly utilises regulatory and economic instruments not only to address environmental challenges but also to strengthen its position within the evolving global order. Policies such as the Carbon Border Adjustment Mechanism (CBAM), the Critical Raw Materials Act, the Digital Services Act (DSA), the Digital Markets Act (DMA), and the Artificial Intelligence Act (AI Act) demonstrate the EU's growing effort to shape global standards and governance mechanisms through regulatory power (Bradford, 2020). This reflects what Anu Bradford conceptualises as the "Brussels Effect," namely the EU's capacity to externalise its regulations internationally due to the size and attractiveness of its internal market (Bradford, 2020).

At the same time, green technologies, renewable energy systems, semiconductors, artificial intelligence, data governance, and critical minerals have become increasingly strategic assets

within global geopolitical competition. As Blackwill and Harris (2016) argue, contemporary international competition increasingly operates through geoeconomic instruments rather than exclusively through military means. Consequently, the twin transition should not be understood merely as a sustainability agenda; it also represents a new arena of geopolitical and geoeconomic competition among major powers, particularly the EU, the United States, and China.

Despite the rapidly growing literature on the twin transition, much of the existing scholarship primarily examines the issue through sustainability governance, technological innovation, climate policy, or digital transformation perspectives. Studies frequently focus on regulatory implementation, green technologies, industrial decarbonisation, or the technical dimensions of digital governance within the European Union. However, comparatively limited attention has been devoted to analysing the twin transition as a geopolitical and geoeconomic project embedded within intensifying global power competition. In particular, the relationship between the EU's green industrial strategy, digital sovereignty agenda, and broader struggles over technological control, supply chain resilience, and regulatory influence remains underexplored in the literature. This study seeks to address this gap by examining the twin transition not merely as a policy framework for sustainability and innovation, but as a strategic instrument through which the European Union attempts to consolidate geopolitical resilience, strategic autonomy, and normative influence in the evolving international political economy. This paper argues that the EU's twin transition agenda reflects a broader strategic transformation in which sustainability governance, industrial policy, technological sovereignty, and geopolitical resilience become increasingly interconnected. Rather than treating the twin transition solely as a technical or environmental process, the study analyses it as a multidimensional geopolitical project through which the EU seeks to reduce strategic dependencies, strengthen industrial competitiveness, and expand its regulatory influence in the international system. The study contributes to contemporary debates on geoeconomics, strategic autonomy, and the changing nature of power in global governance.

1. CONCEPTUAL AND THEORETICAL FRAMEWORK

The concept of the twin transition emerged from the growing convergence between digital transformation and sustainability-oriented economic restructuring. Although digitalisation and environmental policies were initially discussed within separate institutional and academic frameworks, recent policy debates increasingly emphasise their interconnected nature (European Commission, 2021). Digital technologies are now widely perceived as enabling tools for achieving climate neutrality, improving resource efficiency, and supporting circular economy practices, while sustainability policies simultaneously shape the direction of technological innovation and industrial transformation (Muench et al., 2022).

However, the twin transition cannot be adequately understood solely through technological or environmental perspectives. The increasing politicisation of supply chains, semiconductor production, digital infrastructures, energy systems, and critical raw materials demonstrates that these transformations are also deeply geopolitical and geoeconomic in character (Roberts et al., 2021). Consequently, the twin transition has become closely associated with broader debates surrounding geoeconomics, strategic autonomy, digital sovereignty, and regulatory power.

One of the key analytical frameworks used in this study is geoeconomics. Blackwill and Harris (2016) define geoeconomics as the use of economic instruments to promote and defend national strategic interests and to produce geopolitical outcomes. In the contemporary international system, states and regional actors increasingly rely on trade restrictions, industrial subsidies, export controls, sanctions, investment screening mechanisms, and technological regulations as instruments of strategic competition. Farrell and Newman (2019) further argue that global economic interdependence itself has become a source of geopolitical leverage through what they conceptualise as "weaponized interdependence." According to this perspective, actors controlling central nodes of global networks gain the ability to influence, monitor, and constrain others through economic and technological dependencies.

The European Union's twin transition agenda increasingly reflects this geoeconomic logic. Policies concerning critical raw materials, semiconductors, green technologies, and digital governance demonstrate that the EU no longer approaches economic openness solely through liberal market principles. Instead, resilience, strategic dependencies, and industrial security increasingly shape European policymaking (Biscop, 2021).

Closely related to geoeconomics is the concept of strategic autonomy. Initially associated with defence and foreign policy debates, strategic autonomy gradually expanded into technological, industrial, and economic domains, particularly after the COVID-19 pandemic and rising geopolitical tensions (Helwig, 2020). Strategic autonomy refers to the capacity of the European Union to act independently in critical sectors without excessive dependence on external actors. In practice, this includes reducing vulnerabilities in areas such as energy supply, semiconductor production, digital infrastructures, pharmaceutical production, and critical raw materials (European Council, 2022).

Another central concept within the study is digital sovereignty. Digital sovereignty broadly refers to the ability of states or political entities to exercise control over digital infrastructures, data governance, technological standards, artificial intelligence systems, and online platforms (Floridi, 2020). The growing dominance of American and Chinese technology corporations has intensified European concerns regarding technological dependency and regulatory vulnerability. Consequently, the EU increasingly seeks to establish greater control over data

governance, platform regulation, cybersecurity, and digital market structures through legislative initiatives such as the Digital Services Act, the Digital Markets Act, and the Artificial Intelligence Act.

The study also draws upon the concept of the Brussels Effect developed by Bradford (2020). According to Bradford, the EU exerts global influence by externalising its regulatory standards beyond its territorial borders due to the market power of the European single market. Firms operating globally often adopt EU regulations internationally in order to maintain access to the European market. Regulations concerning data protection, sustainability reporting, digital governance, and carbon emissions therefore acquire global influence even in the absence of direct political coercion. In this context, regulation itself becomes a strategic instrument of geopolitical influence. The EU's approach to the twin transition also reflects broader debates surrounding "Normative Power Europe" (Manners, 2002). Unlike traditional great powers that primarily rely on military or coercive capabilities, the European Union often exercises influence through norms, regulations, standards, and institutional frameworks. In this respect, the EU's green and digital governance agenda extends beyond internal policy coordination and increasingly functions as a mechanism for shaping global governance practices. Sustainability standards, digital regulations, and climate-related trade measures therefore become instruments through which the EU projects normative and regulatory influence internationally.

Finally, the study engages with debates on green industrial policy. Rodrik (2014) argues that contemporary industrial policy increasingly involves strategic state intervention designed to support innovation, technological upgrading, and industrial competitiveness. Similarly, Meckling and Allan (2020) emphasise that climate governance and industrial policy are becoming increasingly interconnected through green technological competition. The transition toward renewable energy systems, battery technologies, electric vehicles, and low-carbon industries has therefore transformed sustainability into a strategic field of economic rivalry among major powers.

Taken together, these theoretical approaches demonstrate that the twin transition is not simply an environmental or technological transformation process. Rather, it represents a multidimensional restructuring of global governance in which industrial strategy, technological competition, regulatory influence, and geopolitical resilience become increasingly interconnected.

2. METHODOLOGY

This study adopts a qualitative research design grounded in document analysis and comparative policy analysis. The research primarily examines official European Union policy documents, institutional reports, legislative frameworks, and strategic communications

related to the twin transition agenda. Key policy materials analysed within the study include the European Green Deal, the Carbon Border Adjustment Mechanism (CBAM), the Critical Raw Materials Act, the Net-Zero Industry Act, the Artificial Intelligence Act, the Digital Services Act, and the Digital Markets Act.

In addition to official EU documents, the study incorporates secondary academic literature focusing on geoeconomics, strategic autonomy, digital sovereignty, industrial policy, and global political economy. The analysis comparatively evaluates the European Union's policies alongside developments in the United States and China in order to contextualise the geopolitical dimensions of the twin transition within broader global power competition.

Methodologically, the study employs interpretive qualitative analysis to examine how sustainability governance, industrial strategy, technological regulation, and geopolitical resilience increasingly intersect within EU policymaking. Rather than conducting quantitative measurement, the research seeks to provide a theoretically informed and policy-oriented analysis of the strategic transformation of the European Union in the context of the twin transition.

3. EU TWIN TRANSITION POLICIES: FROM SUSTAINABILITY AGENDA TO STRATEGIC GOVERNANCE

The European Union's twin transition strategy has been institutionalised through a broad set of interconnected green and digital policy frameworks introduced particularly after 2019. Although these initiatives are officially framed around sustainability, innovation, and climate neutrality, they collectively represent a broader governance model that seeks to strengthen industrial competitiveness, technological sovereignty, and geopolitical resilience within an increasingly fragmented international system (European Commission, 2020).

At the centre of this transformation stands the European Green Deal, introduced by the European Commission in 2019. The Green Deal aims to make the European Union climate-neutral by 2050 while simultaneously restructuring energy systems, transportation, industrial production, agriculture, and finance (European Commission, 2019). However, beyond its environmental objectives, the Green Deal also functions as a strategic industrial policy framework. As Meckling and Allan (2020) argue, contemporary climate governance increasingly overlaps with industrial competition, particularly in sectors such as renewable energy, batteries, hydrogen technologies, and electric vehicles. In this respect, sustainability policies become instruments for securing technological leadership and industrial competitiveness in emerging green markets.

One of the most significant instruments within this framework is the Carbon Border Adjustment Mechanism (CBAM). Officially designed to prevent carbon leakage and ensure

fair competition between European producers and external competitors, CBAM introduces carbon-related costs on imports originating from countries with lower environmental standards (European Commission, 2021). Nevertheless, CBAM extends beyond environmental governance and increasingly functions as a geoeconomic instrument. Mehling et al. (2019) note that carbon border measures may significantly reshape international trade relations by externalising domestic environmental standards into global production systems. Through CBAM, the EU effectively incentivises third countries and international firms to align with European climate regulations in order to maintain market access.

Another critical dimension of the EU's twin transition strategy concerns supply chain resilience and access to critical raw materials. The transition toward green and digital economies requires large quantities of lithium, cobalt, nickel, graphite, and rare earth elements, many of which are geographically concentrated outside Europe, particularly in China and a limited number of developing economies (IEA, 2023). The disruptions experienced during the COVID-19 pandemic and rising geopolitical tensions intensified European concerns regarding strategic dependencies in critical sectors (European Council, 2022).

In response, the EU introduced the Critical Raw Materials Act in 2023, aiming to diversify supply chains, increase domestic processing capacity, strengthen recycling systems, and reduce external vulnerabilities (European Commission, 2023a). Similarly, the Net-Zero Industry Act seeks to support domestic clean technology production and strengthen Europe's industrial ecosystem in areas such as solar technologies, batteries, hydrogen systems, and carbon capture technologies (European Commission, 2023b). These initiatives demonstrate that industrial resilience and strategic autonomy have become central components of European sustainability governance.

Digital governance constitutes the second major pillar of the twin transition. Through legislative frameworks such as the Digital Services Act (DSA), the Digital Markets Act (DMA), the Data Governance Act, and the Artificial Intelligence Act (AI Act), the EU increasingly seeks to regulate digital infrastructures, algorithmic systems, online platforms, and artificial intelligence technologies (European Commission, 2022). These regulations reflect growing European concerns regarding data security, market concentration, disinformation, cybersecurity, and technological dependence on large non-European technology corporations.

The AI Act is particularly significant because it represents one of the first comprehensive regulatory frameworks for artificial intelligence at the global level. Rather than adopting a purely market-driven approach, the EU utilises a risk-based governance model that prioritises transparency, accountability, human oversight, and ethical standards (Veale & Borgesius,

2021). This demonstrates the EU's attempt to shape global technological governance through regulatory leadership rather than technological dominance alone.

Similarly, the Digital Markets Act and the Digital Services Act seek to constrain the market power of dominant digital platforms and create a more regulated and accountable digital environment within Europe. According to Bradford (2020), these initiatives reinforce the Brussels Effect by extending European digital governance standards internationally through market mechanisms.

Taken together, these policy frameworks illustrate the emergence of a new European governance model that combines sustainability, industrial policy, technological regulation, and geopolitical strategy. The twin transition therefore represents not merely an environmental or technological transformation process, but also a strategic effort to reshape Europe's position within the evolving global political economy.

Table 1. Major EU Twin Transition Policy Instruments and Strategic Objectives

Policy Instrument	Policy Area	Strategic Objective
European Green Deal	Climate Governance	Climate neutrality and industrial transformation
CBAM	Trade & Climate	Carbon leakage prevention and regulatory influence
Critical Raw Materials Act	Supply Chains	Resource security and resilience
Net-Zero Industry Act	Industrial Policy	Green industrial competitiveness
AI Act	Digital Governance	Ethical and secure AI regulation
DSA/DMA	Platform Regulation	Digital market oversight and sovereignty

Source: Author's compilation based on European Commission (2019, 2020, 2021, 2022, 2023a, 2023b).

The table above demonstrates that the EU's twin transition agenda combines environmental governance, industrial strategy, digital regulation, and geopolitical resilience within an increasingly integrated policy framework.

4. TWIN TRANSITION AND GLOBAL POWER COMPETITION

The acceleration of the twin transition has significantly transformed the nature of global power competition. In the contemporary international system, strategic rivalry increasingly extends beyond traditional military and territorial dimensions into areas such as technology, industrial production, energy systems, digital infrastructures, and supply chain governance (Blackwill & Harris, 2016). Consequently, green transformation and digitalisation have

become central components of geopolitical and geoeconomic competition among major powers, particularly the European Union, the United States, and China.

One of the most visible dimensions of this competition concerns green industrial policy. The transition toward low-carbon economies has generated an intense global race over renewable energy technologies, electric vehicles, batteries, hydrogen systems, and critical minerals. China has achieved a dominant position in many of these sectors through large-scale state support, industrial planning, and strategic control over critical supply chains (Meckling & Nahm, 2022). In particular, China's leadership in solar panel manufacturing, battery production, and rare earth processing has created significant structural dependencies within global green technology markets (IEA, 2023).

The United States has increasingly responded to these challenges through interventionist industrial policies aimed at strengthening domestic technological and manufacturing capacities. The Inflation Reduction Act (IRA), introduced in 2022, represents one of the clearest examples of this transformation. Through subsidies, tax incentives, and local production requirements, the IRA combines climate policy with industrial competitiveness and supply chain security (White House, 2022). Scholars such as Rodrik (2023) argue that this reflects the return of industrial policy as a central instrument of geopolitical competition in the twenty-first century.

At the same time, the IRA generated tensions between the United States and the European Union regarding investment flows, industrial competitiveness, and state subsidies. European policymakers increasingly expressed concerns that generous American incentives could encourage the relocation of green industries away from Europe (European Parliament, 2023). As a result, the EU accelerated efforts to strengthen its own industrial capacities through initiatives such as the Net-Zero Industry Act and the Critical Raw Materials Act.

The intensifying rivalry between the United States and China also demonstrates how technological infrastructures have become deeply connected to geopolitical strategy. Semiconductors constitute one of the clearest examples of this transformation. Advanced chips are essential for artificial intelligence, military technologies, telecommunications, automotive industries, and digital infrastructures. However, semiconductor supply chains remain highly concentrated and vulnerable to geopolitical disruptions (Miller, 2022). American export restrictions targeting China's access to advanced semiconductor technologies illustrate how technological competition increasingly overlaps with national security concerns.

The European Union has attempted to respond through the European Chips Act, which seeks to increase Europe's semiconductor production capacity and reduce external dependency

(European Commission, 2022). This reflects a broader strategic shift in which technological sovereignty becomes a core component of economic security and strategic autonomy.

Table 2. Strategic Competition Dynamics in the Twin Transition Era

European Union	United States	China
Regulatory power	Subsidy-led industrial policy	State-led manufacturing dominance
Green Deal	Inflation Reduction Act	Green industrial expansion
Strategic autonomy	Technological competitiveness	Supply chain control
Digital regulation	Semiconductor leadership	Rare earth dominance
Sustainability standards	Chips and Science Act	Industrial scale production

Source: Author's compilation based on Blackwill and Harris (2016), Meckling and Nahm (2022), European Commission (2022), White House (2022), and IEA (2023).

As illustrated above, the twin transition has intensified strategic competition among major powers by linking sustainability governance, industrial policy, technological leadership, and supply chain resilience within a broader geopolitical framework.

Data governance and digital infrastructures represent another major arena of geopolitical competition. Digital platforms, cloud systems, artificial intelligence models, and cross-border data flows are increasingly treated as strategic assets rather than purely commercial technologies (Floridi, 2020). The dominance of major American and Chinese technology corporations has intensified European concerns regarding digital dependency and regulatory vulnerability. Consequently, the EU attempts to establish an alternative governance model centred on regulation, privacy protection, platform accountability, and democratic oversight.

At the same time, the twin transition has accelerated the politicisation of global supply chains. The COVID-19 pandemic exposed the fragility of highly globalised production systems, while the Russia–Ukraine war demonstrated the geopolitical risks associated with energy dependency and concentrated supply networks (Farrell & Newman, 2019). In response, governments increasingly adopted strategies such as reshoring, friend-shoring, diversification, and strategic stockpiling in order to strengthen economic resilience.

These developments suggest that the twin transition increasingly functions as a new geopolitical arena where sustainability policies, industrial strategies, technological competition, and security concerns intersect. The competition among the European Union, the United States, and China is therefore not simply about economic growth or technological innovation. Rather, it concerns the ability to shape global standards, control strategic infrastructures, secure resilient supply chains, and influence the future architecture of international governance.

5. FINDINGS AND DISCUSSION

The findings of this study demonstrate that the twin transition has evolved far beyond a conventional sustainability agenda and increasingly functions as a multidimensional strategic governance model shaped by geopolitical and geoeconomic considerations. The European Union's green and digital transformation policies reveal a broader attempt to restructure industrial production, technological infrastructures, and regulatory systems in response to intensifying global competition and growing strategic vulnerabilities.

One of the central findings is that the European Union increasingly utilises regulation as a geopolitical instrument. Policies such as the Carbon Border Adjustment Mechanism (CBAM), the Artificial Intelligence Act (AI Act), the Digital Markets Act (DMA), and sustainability reporting mechanisms extend European influence beyond the EU's territorial borders by shaping global production standards and market behaviour (Bradford, 2020). This demonstrates the continuing expansion of the Brussels Effect, where regulatory capacity itself becomes a mechanism of international influence. Rather than relying primarily on military or technological dominance, the EU increasingly exercises power through rule-making, standard-setting, and market access conditionality.

Another important finding concerns the growing securitisation of economic governance. The study indicates that issues previously discussed primarily within economic or environmental frameworks — including semiconductors, digital infrastructures, supply chains, energy systems, and critical raw materials — are now increasingly framed through the language of resilience, strategic dependency, and economic security (Farrell & Newman, 2019). This reflects a broader transformation in the international political economy, where economic interdependence is no longer viewed exclusively as a source of mutual benefit but also as a potential source of geopolitical vulnerability.

The findings further demonstrate that the twin transition contributes to the emergence of a more interventionist governance model within the European Union. For decades, the EU largely promoted liberalisation, market integration, and rules-based economic governance. However, recent developments indicate a substantial shift toward industrial coordination, strategic investment, technological regulation, and economic resilience (Rodrik, 2023). In this respect, the EU increasingly combines sustainability governance with industrial policy objectives designed to strengthen strategic sectors and reduce external dependencies.

The analysis also reveals that sustainability itself has become increasingly geopolitical. Green technologies, renewable energy systems, electric vehicles, battery production, and critical minerals are no longer interpreted solely through environmental or developmental perspectives. Instead, they increasingly constitute strategic sectors linked to technological leadership, industrial competitiveness, and geopolitical influence (Meckling & Allan, 2020).

Consequently, climate governance and industrial strategy have become deeply interconnected within contemporary global competition.

Another key finding concerns the growing importance of digital sovereignty within the EU's strategic autonomy agenda. European concerns regarding dependence on American and Chinese technology corporations have accelerated efforts to regulate digital markets, strengthen cybersecurity frameworks, and establish greater European control over data governance and technological infrastructures (Floridi, 2020). The Digital Services Act, the Digital Markets Act, and the AI Act collectively demonstrate the EU's attempt to construct a more autonomous and regulated digital ecosystem.

At the global level, the findings suggest that the twin transition contributes to increasing fragmentation within the international economic system. Rather than reinforcing the liberal globalisation model that characterised previous decades, contemporary green and digital policies increasingly encourage regionalisation, selective decoupling, strategic diversification, and competing industrial ecosystems (Roberts et al., 2021). This transformation reflects the emergence of a more fragmented and security-oriented form of globalisation centred on resilience and strategic competition.

Finally, the study demonstrates that the twin transition is reshaping the nature of power itself within the international system. The ability to control technological infrastructures, regulate digital ecosystems, secure access to critical resources, and shape international standards increasingly constitutes a major source of geopolitical influence. In this emerging governance environment, economic policy, technological regulation, industrial strategy, and geopolitical competition become deeply interconnected components of contemporary global power relations.

6. CONCLUSION

This study examined the European Union's twin transition agenda through a geopolitical and geoeconomic perspective and argued that the simultaneous green and digital transformation of the European economy extends far beyond environmental sustainability or technological innovation. The findings demonstrate that the twin transition increasingly functions as a strategic governance framework through which the European Union seeks to strengthen industrial competitiveness, enhance technological sovereignty, reduce external dependencies, and consolidate its position within an evolving and fragmented international order.

The analysis revealed that contemporary sustainability governance is becoming deeply intertwined with industrial policy, digital regulation, economic security, and geopolitical competition. Policies such as the European Green Deal, the Carbon Border Adjustment Mechanism (CBAM), the Critical Raw Materials Act, the Artificial Intelligence Act, and the

Digital Markets Act collectively illustrate the emergence of a more interventionist and strategically coordinated European governance model. In this framework, regulation itself becomes a central instrument of international influence, enabling the European Union to shape global standards and market behaviour beyond its territorial borders (Bradford, 2020).

The study also demonstrated that the twin transition has intensified global competition among major powers, particularly the European Union, the United States, and China. Green technologies, semiconductors, artificial intelligence systems, digital infrastructures, and critical minerals increasingly constitute strategic assets within contemporary geopolitical rivalry. Consequently, the transition toward sustainable and digital economies is simultaneously generating new forms of economic interdependence and new forms of strategic vulnerability.

Furthermore, the findings indicate that the growing emphasis on resilience, strategic autonomy, and digital sovereignty reflects a broader transformation in the international political economy. The liberal globalisation model characterised by deep economic interdependence and relatively depoliticised supply chains is gradually giving way to a more fragmented, security-oriented, and strategically managed form of globalisation (Farrell & Newman, 2019). In this emerging environment, the ability to secure resilient supply chains, regulate digital ecosystems, and maintain control over strategic technologies becomes increasingly important for international influence and economic stability.

The study therefore concludes that the twin transition should not be interpreted solely as a technical or environmental transformation process. Rather, it represents a multidimensional geopolitical restructuring in which sustainability governance, industrial policy, technological regulation, and strategic competition increasingly converge. The European Union’s approach reflects an attempt to position itself not merely as a market actor or environmental leader, but as a strategic regulatory power capable of shaping the future architecture of global governance.

Finally, future research may further explore the external implications of the EU’s twin transition policies for developing regions, particularly Africa, Latin America, and Southeast Asia. Questions surrounding critical raw materials, technological dependency, green industrial competition, and unequal adaptation capacities are likely to become increasingly important in the evolving global political economy of the twin transition.

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DIGITAL TRANSFORMATION AND MANAGEMENT APPROACHES IN THE CIRCULAR ECONOMY TRANSITION: A FOCUS ON SUSTAINABLE SUPPLY CHAIN MANAGEMENT

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Abstract

The transtion from linear to circular supply chains represents a fundamental restructuring of global value chains, requiring the integration of digital technologies with sustainable supply chain management (SSCM) practices. This article examines how digital transformation acts as a critical enabler of circular economy (CE) principles within supply chain operations. Drawing on recent systematic reviews and empirical evidence from 2020–2026, the study synthesizes theoretical frameworks— includng the Triple Bottom Lne (TBL), Dynamic Capabilities Theory, and the DF4CE and CAB2IN conceptual models—to analyze the intersection of Industry 4.0 technologies and circular strategies. The analysis identifies the Internet of Things (IoT), blockchain, and artificial intellgence (AI) as the most prominent digital enablers, facilitating traceability, predictive optimization, and multi-stakeholder collaboration across the 9R circular strategies (Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recover, Recycle). The European Union's Ecodesign for Sustainable Products Regulation (ESPR) and the mandated Digital Product Passport (DPP) are highlighted as transformative policy instruments addressing information asymmetry in circular material flows. However, significant barriers persist, including operational complexity in reverse logistics, technical interoperability gaps, high upfront costs for SMEs, unresolved data governance issues, and regulatory fragmentation. The findings indicate that successful circular supply chain transitions require an integrated approach combining technological innovaton, institutional alignment, and organizational ambidexterity. The article concludes by identifying future research directions focused on empirical validation of digital tools, green digital infrastructur development, and inclusive governance models to prevent the exclusion of smaller enterprises from circular data ecosystems.

Keywords: Circular Economy, Sustainable Supply Chain Management, Digital Transformation, Industry 4.0, Blockchain, Internet of Things, Artificial Intelligence, Digital Product Passport, Reverse Logistics, Green Logistics

DÖNGÜSEL EKONOMİ GEÇİŞİNDE DİJİTAL DÖNÜŞÜM VE YÖNETİM YAKLAŞIMLARI: SÜRDÜRÜLEBİLİR TEDARİK ZİNCİRİ YÖNETİMİNE ODAKLANMA

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Özet

Doğrusal tedarik zincirlerinden döngüsel tedarik zincirlerine geçiş, küresel değer zincirlerinin temel bir yeniden yapılanmasını temsil etmekte olup, dijital teknolojilerin sürdürülebilir tedarik zinciri yönetimi (STZY) uygulamalarıyla bütünleştirilmesini gerektirmektedir. Bu makale, dijital dönüşümün tedarik zinciri operasyonları içerisinde döngüsel ekonomi (DE) ilkelerinin hayata geçirilmesinde nasıl kritik bir katalizör işlevi gördüğünü incelemektedir. 2020–2026 yıllarına ilişkin güncel sistematik derlemelerden ve ampirik bulgularda yararlanan çalışma; Üçlü Alt Çizgi (TBL), Dinamik Yetenekler Teorisi ile DF4CE ve CAB2IN kavramsal modelleri dahil olmak üzere teorik çerçeveleri sentezleyerek Endüstri 4.0 teknolojileri ile döngüsel stratejilerin kesişimini analiz etmektedir. Analiz, Nesnelerin İnterneti (IoT), blok zinciri ve yapay zekayı (YZ) en önde gelen dijital etkinleştiriciler olarak belirlemekte; bu teknolojiler 9R döngüsel stratejileri (Reddet, Yeniden Düşün, Azalt, Yeniden Kullan, Tamir Et, Yenile, Yeniden Üret, Yeni Amaçla Kullan, Geri Kazan, Geri Dönüştür) kapsamında izlenebilirlik, tahmine dayalı optimizasyon ve çok paydaşlı iş birliğini kolaylaştırmaktadır. Avrupa Birliği'nin Sürdürülebilir Ürünler için Eko-Tasarım Yönetmeliği (ESPR) ve zorunlu Dijital Ürün Pasaportu (DUP), döngüsel malzeme akışlarındaki bilgi asimetrisini gidermeye yönelik dönüştürücü politika araçları olarak öne çıkarılmaktadır. Bununla birlikte, tersine lojistikteki operasyonel karmaşıklık, teknik birlikte çalışabilirlik eksiklikleri, KOBİ'ler için yüksek ilk maliyetler, çözümlenmemiş veri yönetişimi sorunları ve düzenleyici parçalanma başta olmak üzere önemli engeller sürmektedir. Bulgular, başarılı döngüsel tedarik zinciri geçişlerinin; teknolojik inovasyon, kurumsal uyum ve organizasyonel çift yönlü yetkinliği (ambdexterty) bir araya getiren bütünleşik bir yaklaşım gerektirdiğini ortaya koymaktadır. Makale, dijital araçların ampirik doğrulanması, yeşil dijital altyapı geliştirme ve daha küçük işletmelerin döngüsel veri ekosistemlerinden dışlanmasını önlemeye yönelik kapsayıcı yönetişim modellerine odaklanan gelecek araştırma yönlerini belirleyerek sonuçlanmaktadır.

Anahtar Kelimeler: Döngüsel Ekonomi, Sürdürülebilir Tedarik Zinciri Yönetimi, Dijital Dönüşüm, Endüstri 4.0, Blok Zinciri, Nesnelerin İnterneti, Yapay Zeka, Dijital Ürün Pasaportu, Tersine Lojistik, Yeşil Lojistik

INTRODUCTION

The global imperative to decouple economic growth from resource consumption has catalyzed a paradigm shift in supply chain management, demanding a transition from cost-driven, linear operations to integrated systems aligned with circular economy principles and digital innovation (Nautwima & Asa, 2025). Conventional supply chains, characterized by the "take make-dispose" model, are increasingly recognized as structurally incompatible with planetary boundaries and long-term economic resilience. The extraction and processing of raw materials account for approximately 50% of global greenhouse gas emissions and over 90% of biodiversty loss, underscoring the urgency of systemic change (European Commission, 2024).

The circular economy (CE) offers a regenerative alternative by designing out waste, keeping products and materials in use at their highest value, and regenerating natural systems (Ellen MacArthur Foundation, 2019). However, the practical implementation of circular supply chains (CSCs) is hindered by fundamental informaton asymmetry, operational complexity, and the need for coordination across heterogeneous, geographically dispersed stakeholders. Digital transformation—encompassing IoT, blockchain, AI, digital twins, and cloud platforms—has emerged as a critical enabler, providing the observability, traceability, and computational intelligence required to close material loops at scale (Morshedi et al., 2026; Pourrahimian et al., 2026).

Despite growing academic and practitioner interest, the intersection of digital transformation and circular supply chain management remains theoretically underdeveloped. Prior studies have largely examined individual digital applications in isolaton, leaving a significant gap in understanding how these technologies interact with CE principles, policy frameworks, and organizational capabilites as a coherent soico-technical system (Abideen et al., 2021; Awan et al., 2022). This article addresses that gap by synthesizing recent literature to present a comprehensive, evidence-based overview of the theoretical foundations, technological enablers, management approaches, policy context, and persistent barriers in this domain.

The remainder of this article is structured as follows. Section 2 establishes the theoretical foundations and conceptual models. Section 3 outlines the methodological approach. Section 4 analyzes the key digital technologies enabling circular supply chains. Section 5 examines management approaches and operatiional practices. Section 6 discusses the policy and regulatory landscape. Section 7 identifies barriers and challenges. Section 8 presents a discussion of findings, Section 9 outlines future research directions, and Section 10 concludes.

1. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

1.1. Theoretical Foundations

The transition to sustainable, circular supply chains is informed by multiple complementary theoretical lenses that collectively explain why and how firms adopt digital-circular practices. The Triple Bottom Line (TBL) framework posits that logistics and supply chain operations must simultaneously achieve economic efficiency, social accountability, and environmental responsibility (Nautwima & Asa, 2025). This perspective moves beyond purely cost-driven optimization to embed sustainability as a strategic imperative rather than a peripheral compliance activity.

Stakeholder Theory explains how firms balance the interests of diverse actors—including customers, suppliers, regulators, local communities, and investors—in circular transitions (Freeman, 1984). The Resource-Based View (RBV) further illuminates how unique organizational resources, such as proprietary digital capabilities, circular knowledge bases, and reverse logistics infrastructure, create sustained competitive differentiation (Barney, 1991). Dynamic Capabilities Theory addresses how firms adapt to rapidly changing technological and regulatory environments by reconfiguring internal and external competencies (Teece, 2007). Finally, Institutional Theory explains how external pressures—regulatory mandates, normative expectations, and mimetic isomorphism—shape the adoption of green logistics practices across industries (DiMaggio & Powell, 1983).

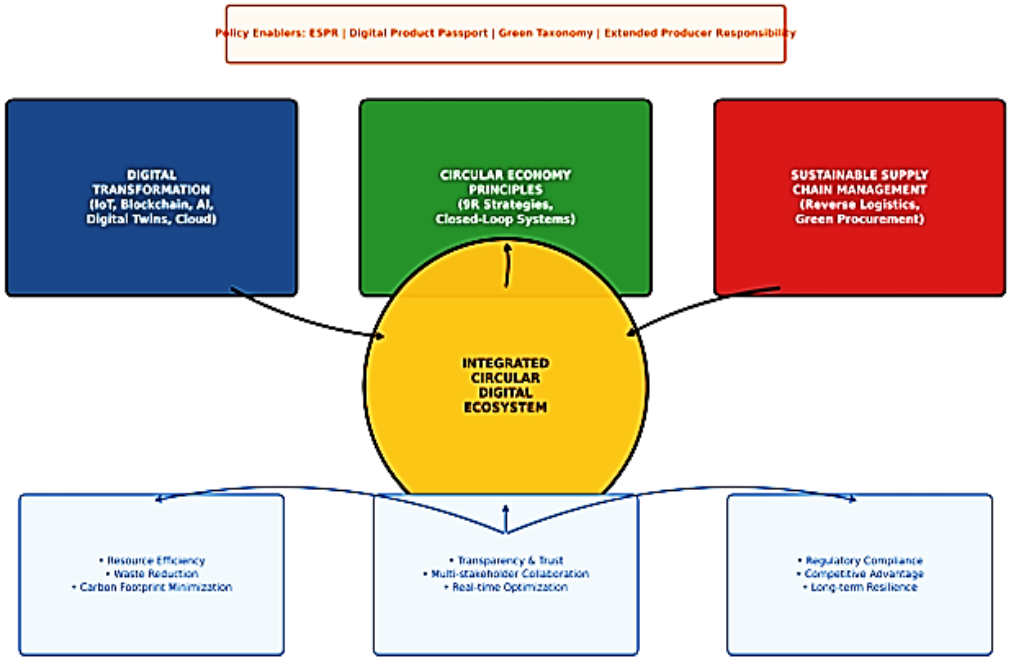
These theories are not mutually exclusive; rather, they provide a multi-layered explanatory framework. For instance, while institutional pressures may trigger initial adoption of circular practices (coercive isomorphism), long-term competitive advantage depends on the development of dynamic capabilities that integrate digital technologies with circular operational routines (Nautwima & Asa, 2025).

1.2. Conceptual Models: DF4CE and CAB2IN

Recent scholarship has developed integrative frameworks that explicitly map digital functions to circular strategies, addressing the theoretical gap between technology and practice. The DF4CE framework (Digital Functions for the Circular Economy) identifies 13 distinct digital functions—grouped into data collection and integration, data analysis, and automation—and maps them to the 9R circular strategies (Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recover, Recycle) (Morshedi et al., 2026). For example, IoT enabled condition monitoring (data collection) directly enables the Repair and Refurbish strategies by providing real-time data on product degradation, while blockchain-based provenance tracking (data integration) facilitates Recycle and Remanufacture by ensuring material authenticity.

Similarly, the CAB2IN framework integrates five core Industry 4.0 technologies—cloud computing, artificial intelligence, big data analytics, blockchain, and IoT—across the product lifecycle to transform raw data into actionable knowledge for sustainable decision-making (Morshedi et al., 2026). These frameworks collectively advance theory by demonstrating that digital-enabled circularity is not a collection of isolated technological interventions but a system-wide transformation requiring coherence across design, production, consumption, and end-of-life stages.

Figure 1. Conceptual Framework: Digital Transformation in Circular Supply Chains



2. METHODOLOGY

This study employs a systematic narrative synthesis approach, integrating findings from multiple recent systematic reviews, policy frameworks, and empirical studies published between 2020 and 2026. The evidence base draws upon a consolidated corpus of 266 peer reviewed publications, 95 technology-focused articles examining digital enablers in CSCs, and 107 real-world implementation cases identified through structured database searches (Morshedi et al., 2026; Pourrahimian et al., 2026).

The synthesis followed a three-stage protocol: (1) systematic identification and screening of peer-reviewed literature across Scopus, Web of Science, ScienceDirect, IEEE Xplore, and

Google Scholar using Boolean search strings combining "digital transformation," "circular economy," and "supply chain"; (2) thematic coding of extracted data across theoretical frameworks, technological applications, management practices, policy instruments, and barriers; and (3) cross-referencing and triangulation of findings across multiple systematic reviews to ensure reliability and minimize single-source bias. Table 1 summarizes the scope and inclusion criteria.

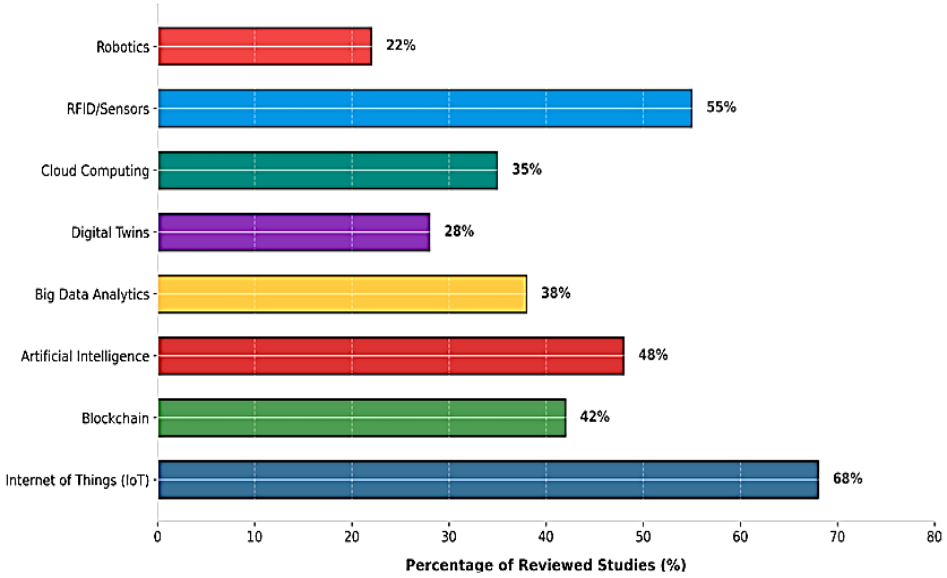
Table 1. Systematic Review Summary: Scope and Inclusion Criteria

PARAMETER	DETAILS
Search Period	2020-2026 (Q1-Q2)
Databases	Scopus, Web of Science, ScienceDirect, IEEE Xplore, Google Scholar
Search Strings	“digital transformation” AND “circular economy” AND “supply chain”
Initial Records	1,847 articles
After Duplicate Removal	1,523 articles
After Title/Abstract Screening	412 articles
After Full-Text Review	95 peer-reviewed articles
Real-World Cases Identified	107 implementation cases
Geographic Coverage	Global (EU 42%, Asia-Pasific 31%, North America 18%, Other 9%)
Sectoral Focus	Electronics (28%), Textiles (19%), Automotive (15%), Food/Agriculture (12%), Construction (10%), Others (16%)
Theoretical Frameworks Applied	TBL (34%), RBV (22%), Stakeholder Theory (18%), Dynamic Capabilities (15%), Institutional Theory (11%)

3. DIGITAL TECHNOLOGY ENABLERS IN CIRCULAR SUPPLY CHAINS

A systematic review of 95 peer-revewed articles and 107 real-world cases identifies IoT, blockchain, and AI as the most frequently applied technologies in intelligent circular supply chains (CSCs), with approximately 89% of reviewed studies involving data collection, storage, analysis, or sharing functions (Morshedi et al., 2026; Pourrahimian et al., 2026). Figure 2 presents the frequency distribution of digital technologies across the reviewed literature.

Figure 2. Frequency of Digital Technologies in Circular Supply Chain Research (Synthesis of 95 Peer-Reviewed Articles, 2020-2026)



Source: Synthesized from Morshedi et al. (2026) and Pourrahimian et al. (2026)

3.1. Internet of Things (IoT)

IoT provides the foundational observability layer for circular supply chains. Through sensors, RFID tags, GPS trackers, and connected devices, products and materials are continuously monitored across their lifecycle, enabling predictive maintenance, dynamic resource allocation, and reverse logistics optimization (Rodrigues et al., 2025). Over half of the technology-focused studies in this domain explicitly highlight IoT as the primary means of gathering essential data for circular operations—from tracking component status to determine when repair or recycling is warranted, to monitoring waste bin fill levels for optimized collection routing (Pourrahimian et al., 2026).

In the automotive sector, for example, IoT-enabled telematics allow manufacturers to monitor vehicle health in real time, triggering maintenance alerts that extend product life and facilitate remanufacturing decisions. In the electronics sector, smart sensors embedded in consumer devices can signal end-of-life status, automatically initiating return processes and reducing e waste leakage.

3.2. Blockchain

Blockchain technology ensures data integrity, transparency, and trust across organizational boundaries in multi-stakeholder circular networks. Its core functionalities—traceability, immutability, decentralization, smart contracts, and tokenization—are mapped directly to specific CE practices (Papachristos et al., 2025). Smart contracts automate warranty validation and repair approvals, supporting product-life extension strategies, while tokenization incentivizes the return of core components for remanufacturing through digital reward mechanisms.

Approximately 42% of the reviewed literature proposes blockchain as a solution to securely store critical information about products and materials, creating a shared, trustworthy source of truth that is particularly valuable in cross-border circuliar flows where participants lack prior trust relationships (Pourrahimian et al., 2026). However, energy consumption remains a concern; proof-of-work consensus mechanisms can undermine the environmental benefits of circularty unless deployed on low-carbon infrastructure.

3.3. Artificial Intelligence and Big Data Analytics

AI and big data analytics opitimize circular processes through demand forecasting, predictive maintenance, automated sorting, and environmental risk assessment. These technologies process the massive volumes of data generated by IoT devices to improve resource efficiency and reduce waste. Recent advances include generative AI frameworks for green supply chain assessment and Wasserstein time-series generative adversarial networks (GANs) for environmental risk prediction (Rajput & Singh, 2025).

In recycling operations, computer vision and machine learning algorithms can identify and sort materials with significantly higher accuracy than manual or mechanical methods, increasing recovery rates and reducing contamination. In remanufacturing, AI-driven predictive models estimate the residual value of returned cores, optimizing disassembly sequencing and inventory decisions.

3.4. Digital Twins and Cloud Platforms

Digital twins enable ecosystem-level simulation and collaborative manufacturing by creating virtual replicas of physical logistics systems. These models allow managers to evaluate alternative operational scenarios, simulate disruptions, and select pathways that minimize environmental impact while maintaining service levels (Nautwima & Asa, 2025). Cloud computing serves as the scalable backbone for data storage and sharing, providing the infrastructure necessary for real-time analytics and inter-firm collaboration in circular ecosystems.

3.5. The Digital Product Passport (DPP)

The Digital Product Passport represents a regulatory-driven digital innovation with profound supply chain implications. As mandated by the EU Ecodesign for Sustainable Products Regulation (ESPR), the DPP is a structured, machine-readable digital record that accompanies a product throughout its lifecycle, capturing material composition, repair history, carbon footprint, and recycling instructions (European Commission, 2024). By directly addressing information asymmetry—a major barrier in circular systems—the DPP ensures that recyclers, remanufacturers, and secondary markets have access to the critical data needed to close material loops effciently.

Figure 4 presents a technology-strategy mapping matrix synthesizing the DF4CE and CAB2IN frameworks, illustrating how specific digital technologies enable specific circular strategies.

Figure 3. Digital Technology Enablement Matrix for 9R Circular Strategies (Synthesis of DF4CE and CAB2IN Frameworks)

9R Strategies	Digital Technologies					
	IoT	Blockchain	AI / Big Data	Digital Twins	Cloud	Robotics
Refuse	Low	High	Medium	Low	Medium	None
Rethink	Medium	Low	High	Medium	Medium	None
Reduce	High	Low	High	Medium	Medium	Low
Reuse	High	Medium	Medium	Low	High	None
Repair	High	Medium	Medium	Medium	Medium	Low
Refurbish	Medium	High	Medium	Medium	Medium	Medium
Remanufacture	Medium	High	High	High	Medium	High
Repurpose	Low	Medium	Medium	Low	Low	Low
Recycle	High	High	High	Medium	Medium	High

High
Medium
Low
None

4. MANAGEMENT APPROACHES AND OPERATIONAL PRACTICES

4.1. Sustainable Supply Chain Management Pillars

In the circular context, SSCM emphasizes three operational pillars: (1) green and circular logistics strategies, including closed-loop systems, reverse logistics, and lifecycle-oriented

procurement; (2) digital technologies for visibility, coordination, and emissions tracking; and (3) institutional conditions that enable scaling, such as policy coherence, leadership commitment, and collaborative governance (Nautwima & Asa, 2025).

4.2. Reverse Logistics and Closed-Loop Systems

Reverse logistics and closed-loop material flows constitute the operational backbone of circular supply chains. These systems reduce emissions, waste, and virgin resource dependency, but their success depends on procurement policies that embed sustainability criteria, incentive structures for returns, and robust material recovery infrastructure (Dabo & Hosseinian Far, 2023). When reverse logistics systems are incentivized through green procurement mandates or tax benefits, they evolve from reactive waste management tools into strategic components of environmental stewardship.

The operational complexity of reverse logistics remains the most significant barrier to scaling. Unlike forward logistics, which operate on predictable, demand-driven schedules, reverse flows are characterized by high uncertainty in timing, quantity, and quality of returns. Digital technologies—particularly IoT and AI—mitigate this uncertainty by providing visibility into return pipelines and predictive analytics for capacity planning.

4.3. Collaborative Governance and Circular Business Models

Cloud and big data analytics enhance supply chain capabilities and co-creation strategies with partners and customers. Circular business models such as Product-Service Systems (PSS) extend product longevity and close resource loops, supported by IoT-enabled decision support systems that track residual value in real time (Nautwima & Asa, 2025). The literature emphasizes that successful circular supply chains require **ambdiextrous capabilites**—the ability to exploit existing operational competencies while simultaneously exploring new circular business models and collaborative partnerships (O'Reilly & Tushman, 2013).

5. POLICY AND REGULATORY LANDSCAPE

The Ecodesign for Sustainable Products Regulation (ESPR), which entered into force in July 2024, represents the most significant policy driver of digital-circular integration to date. The ESPR mandates Digital Product Passports for regulated product categories, requiring standardized, interoperable data on durability, reusability, resource effciency, and carbon footprints (European Commission, 2024). The ESPR Working Plan 2025–2030 further clarifies priority product groups and implementation timelines, with electronics, batteries, and textiles among the first sectors affected. The regulation explicitly recognizes implementation challenges for small and medium-sized enterprises (SMEs) and requires member states to provide guidelines, financal assistance, and training to ensure inclusive compliance. By mandating interoperable, machine-readable product data, the ESPR creates a regulatory

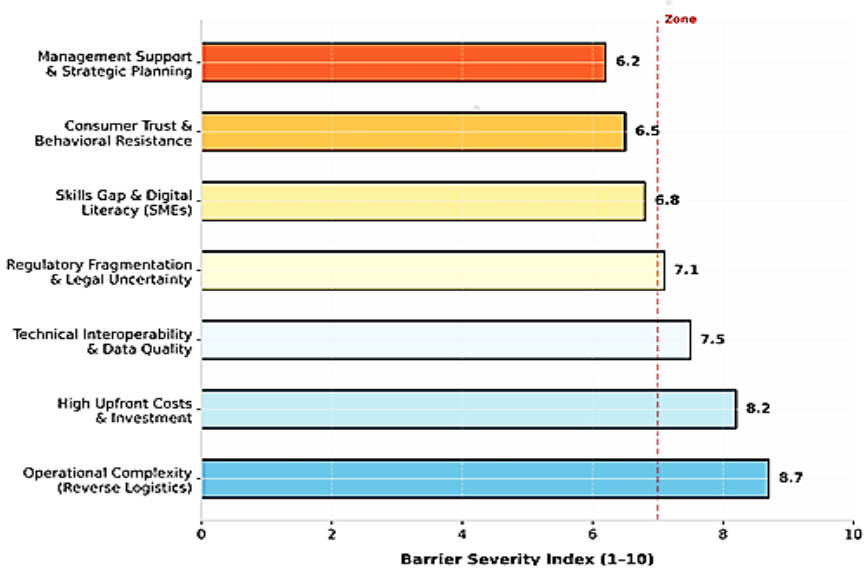
foundation for circular material flows that transcends organizational boundaries, though international regulatory inconsistencies between the EU and less prescriptive frameworks elsewhere continue to complicate cross-border circular trade.

Extended Producer Responsibility (EPR) schemes, increasingly coupled with digital tracking requirements, further reinforce the financial and operational incentives for circular design. The convergence of EPR, ESPR, and the EU Green Taxonomy is creating a comprehensive policy architecture that makes circularity not merely an environmental option but a regulatory and financial necessity.

6. BARRIERS AND CHALLENGES

Despite substantial technological potential, scaling circular supply chains faces mutually reinforcing barriers across multiple dimensions. Figure 3 presents a composite severity index synthesized from executive surveys and systematic reviews.

Figure 4. Barriers to Scaling Circular Supply Chains
(Composite Index from Executive Surveys and Systematic Reviews, 2020-2026)



Source: Synthesized from World Economic Forum (2025), Papachristos et al. (2025), and Pourrahimian et al. (2026).

6.1. Operational and Logistics Barriers

The most pressing challenge is operational complexity—getting products back from customers, managing unpredictable quality and quantities of returns, and navigating reverse logistics. A 2025 global survey of 491 executives found that operational bottlenecks, such as low availability of secondary materials and complex reverse logistics, are the most common obstacles to scaling circular systems (World Economic Forum, 2025).

6.2. Technical Challenges

Lack of interoperability across digital platforms, scalability limitations, and data quality issues create fragmented ecosystems. Additionally, some digital solutions—particularly energy intensive blockchain implementations or large-scale AI training—can increase emissions if not built on low-carbon infrastructure, creating potential tension between digital and environmental goals (Pourrahimian et al., 2026).

6.3. Organizational and Financial Barriers

High upfront costs, lack of digital infrastructure, resistance to change, and skills gaps—particularly among SMEs—limit adoption. Poor management support and lack of effective strategic planning are consistently identified as undervalued impediments (Quintana et al., 2024). The digital divide between large corporations and smaller suppliers risks excluding significant segments of the supply base from circular data ecosystems.

6.4. Regulatory and Legal Issues

Unresolved questions around data ownership, intellectual property, and liability in multi stakeholder digital environments create uncertainty. International regulatory inconsistencies complicate cross-border circular flows, and the absence of globally harmonized data standards limits the scalability of Digital Product Passports.

6.5. Social and Market Barriers

Consumer behavior still favors new products in many categories, with trust gaps around the quality and durability of remanufactured or refurbished goods persisting despite growing environmental awareness. Behavioral economics research suggests that the "ick factor" and perceived risk associated with used products remain significant psychological barriers (World Economic Forum, 2025).

7. DISCUSSION

The findings of this synthesis reveal that the transition to digitally enabled circular supply chanis is neither a purely technological nor a purely managerial challenge—it is a socio techincal transformation requiring alignment across technology, operations, policy, and

culture. The dominance of IoT in the literature (68% of revewed studies) reflects its foundational role as the data generation layer, yet the full value of IoT is only realized when integrated with AI for analytics and blockchain for trust (Morshedi et al., 2026).

The policy landscape, particularly the EU's ESPR and DPP mandate, represents a watershed development that will likely accelerate adoption through regulatory pull rather than market push alone. However, the barrier analysis indicates that regulation without complementary support for SME digitalization and skills development risks creating a two-tier system where only large, resource-rich firms can participate in circular data ecosystems.

The concept of organizational ambidexterity emerges as a critical manageiral capability. Firms must simultaneously exploit existing linear competencies (efficiency, scale, speed) while exploring circular capabilities (flexibility, collaboration, lifecycle thinking). This dual requirement places siginficant strain on traditional supply chain organizations optimized for predictability and cost minimization.

8. FUTURE RESEARCH DIRECTIONS

The literature points toward several critical research gaps requiring scholarly attention:

Integrated, multi-stakeholder approaches: Successful CE implementation requires combining technological innovation with supportive policy frameworks and deep organizational transformation. Future research should examine how these three dimensions co-evolve in practice through longitudinal case studies and comparative analyses.

Empirical validation of digital tools: More empirical research is needed on the actual operational and environmental performance of digital twins, blockchain, and AI in circular supply chains, particularly in emerging markets and among SME populations where evidence remains scarce.

Green digital innovations: Research should prioritize energy-efficient designs and low-carbon infrastructure to avoid environmental trade-offs where digitalization inadvertently increases emissions. The carbon footprint of AI training and blockchain consensus mechanisms must be systematically accounted for in circular system assessments.

Inclusive governance: Addressing the digital divide among SMEs and informal sector actors is essential to prevent exclusion from circular data ecosystems. Studies should examine how progressive disclosure models and tiered data requirements can balance transparency with IP protection.

Harmonized standards and data governance: Progress on internationally aligned data standards, ontologies, and interoperable platforms is needed to enable the seamless cross-border material flows that circular economies require.

9. CONCLUSION

The transition from linear to circular supply chains represents one of the most significant structural transformations in contemporary supply chain management. Digital technologies—particularly IoT, blockchain, AI, digital twins, and cloud platforms—are indispensable enablers of this transition, providing the observability, intelligence, and trust required to close material loops at scale. However, technology alone is insufficient. The evidence synthesized in this article demonstrates that sustainable supply chain management in the circular economy emerges from the convergence of three forces: operational innovation (reverse logistics, closed-loop design, circular procurement), technological enablement (data-driven visibility, automation, and platform-based collaboration), and institutional readiness (policy coherence, leadership commitment, and dynamic organizational capabilities).

The EU's Ecodesign for Sustainable Products Regulation and the Digital Product Passport mandate represent transformative policy developments that will accelerate digital-circular integration, but significant barriers remain. Operational complexity, technical fragmentation, financial constraints, and governance gaps continue to impede progress. Addressing these challenges requires cross-sector collaboration, inclusive policy design, and firm-level capacity building to ensure that the benefits of digital circularity are distributed across the entire supply chain ecosystem, rather than concentrated among large, technologically advanced lead firms.

Future research must move beyond conceptual frameworks and isolated case studies to generate robust, comparative empirical evidence on the performance, scalability, and inclusivity of digitally enabled circular supply chains. Only through such evidence-based advancement can the promise of the circular economy be translated into widespread, resilient, and environmentally responsible supply chain practice.

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FROM WASTE MANAGEMENT TO CIRCULAR ECONOMY: COMPARATIVE INSIGHTS FROM TÜRKİYE'S DOA FRAMEWORK AND DENMARK'S DANSK RETURSYSTEM

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Abstract

The transition from conventional waste management to circular economy has increased the strategic relevance of Deposit Return Systems (DRS) as institutional mechanisms for improving packaging recovery, material quality, and resource efficiency. This study examines Türkiye's DOA framework through a comparative analysis with Denmark's Dansk Retursystem, which is treated as a mature benchmark rather than a directly transferable model. The article adopts a qualitative structured-focused comparative case study design based on secondary document analysis. The comparison is intentionally asymmetrical: Denmark represents a long-established and operationally routinised DRS, whereas DOA represents a developing framework still undergoing institutionalisation, scaling, and behavioural adaptation.

The analysis focuses on governance structure, legal and institutional clarity, financial incentives, collection and reverse logistics, digital monitoring, stakeholder integration, and circular economy contribution. The findings show that Dansk Retursystem's maturity derives not only from deposit values, but from the alignment of consumer routines, producer and retailer responsibilities, return infrastructure, system finance, data recognition, and material recovery pathways. DOA, by contrast, demonstrates significant policy potential through its digital refund interface, DBYS-supported registration and monitoring capacity, national zero-waste alignment, and ambition to organise material, financial, and data flows within a coordinated framework.

However, the study identifies three critical policy challenges for DOA's future consolidation. First, a fixed nominal deposit value may lose behavioural effectiveness under inflation unless supported by a dynamic adjustment mechanism. Second, Türkiye's fragmented retail structure may create reverse logistics and handling-cost challenges, particularly for small retailers. Third, a strongly digital return process may improve traceability while also creating participation barriers for digitally less confident consumers. The article concludes that DOA's maturation depends on the closure of four loops: consumer return, financial settlement, data-recognition, and material recovery. A context-specific policy dashboard is therefore required to evaluate DOA as a circular materials governance system rather than a simple packaging collection programme.

Keywords: DOA, Dansk Retursystem, Deposit Return System (DRS), Circular Economy, Waste Management, Sustainability Policy

INTRODUCTION

Packaging waste represents one of the most persistent governance problems in the transition from linear waste management to circular economy. Beverage containers made of plastic, glass, and aluminium are consumed frequently, discarded rapidly, and dispersed across highly fragmented post-consumption waste streams. Although these materials retain recoverable economic value after use, conventional waste management systems often fail to capture this value efficiently because collection is spatially dispersed, consumer participation is uneven, contamination risks are high, and the financial signal attached to used packaging is weak. From an economics perspective, this is not merely a technical recycling problem. It is also a problem of externalities, incentive misalignment, information asymmetry, and institutional coordination. When packaging is treated as valueless waste after consumption, the private cost of disposal remains disconnected from the social cost of leakage, littering, landfill pressure, resource depletion, and lost material value.

The circular economy agenda challenges this logic by shifting policy attention from waste treatment to the preservation of material value within production and consumption systems. In this framework, packaging is not only an environmental burden to be managed after disposal; it is a material flow whose value should be retained through prevention, reuse, separate collection, traceability, and high-quality recycling. This transition requires governance instruments capable of changing consumer behaviour, mobilising producer responsibility, coordinating retail participation, and ensuring that recovered materials are directed back into productive use. DRS mechanisms have become increasingly important in this context because they combine environmental regulation with a direct economic incentive. By attaching a refundable deposit to beverage containers, DRS creates a price signal that encourages consumers to return packaging after use and enables cleaner, more traceable, and higher-quality material recovery.

However, the effectiveness of DRS cannot be reduced to the existence of a deposit fee. A deposit may create an incentive, but the incentive becomes operationally meaningful only when it is embedded in an accessible, trusted, and institutionally coordinated system. Consumers must be able to return containers easily; retailers and return points must be integrated into the collection architecture; producers and importers must comply with system requirements; digital or barcode-based monitoring must support traceability; and reverse logistics must move collected materials efficiently toward recycling or reuse channels. In this sense, DRS should be understood not simply as a recycling mechanism, but as a circular materials governance instrument. Its performance depends on the interaction between incentive design, institutional capacity, logistical infrastructure, digital monitoring, stakeholder coordination, and behavioural normalization.

This study examines these dynamics through a comparative analysis of Turkiye's DOA framework, embedded in the broader Deposit Management System and Denmark's Dansk Retursystem. Turkiye's model, implemented through the broader Deposit Management System and supported by the DOA consumer interface, represents an emerging deposit return framework aligned with national zero-waste and circular economy objectives. The system is designed to recover selected beverage packaging after consumption and to refund the deposit value to consumers through approved return channels. Its policy relevance derives from its attempt to combine environmental regulation, digital monitoring, consumer participation, and nationwide implementation within a developing institutional structure. Its long-term effectiveness will depend on implementation capacity, infrastructure standardisation, stakeholder adaptation, consumer trust, and the ability to convert returned packaging into reliable circular material flows.

Denmark's Dansk Retursystem offers a contrasting but analytically useful benchmark. As a mature and internationally recognised deposit return model, it is characterised by established consumer routines, standardised deposit marking, extensive retail participation, centralised operational coordination, and high return performance. The Danish case is not used in this study as a directly transferable template, rather, Denmark is treated as a mature benchmark case that helps identify the institutional and operational conditions under which DRS can move beyond waste collection and contribute to circular economy performance.

The comparison between Turkiye and Denmark is therefore intentionally asymmetrical. Denmark represents a system with demonstrated operational maturity, whereas Turkiye represents an emerging system in the process of institutionalisation and scaling. This asymmetry is analytically productive because it allows the study to distinguish between system design and performance. The central issue is not whether Turkiye currently replicates the Danish model, but which features of mature DRS governance are relevant for assessing and strengthening Turkiye's developing framework. Such a comparison enables a policy-oriented analysis of how deposit systems evolve from regulatory design into functioning circular economy infrastructures.

Despite the growing importance of DRS in circular economy policy, much of the discussion around these systems remains focused on return rates, recycling volumes, or technical collection performance. These indicators are important, but they do not fully explain why some systems achieve durable circular economy outcomes while others remain limited to fragmented waste recovery. A more institutional approach is required to understand how governance structure, legal clarity, financial incentives, reverse logistics, digital traceability, and stakeholder integration shape system effectiveness.

Furthermore, given the novelty of Turkiye's DOA framework, academic research on it remains at an early stage. Existing literature is largely concentrated on regulatory announcements, system descriptions, and implementation-oriented information rather than comparative academic analysis. Against this background, the present study offers one of the early academic attempts to examine Turkiye's DOA framework through a comparative institutional lens.

The core argument of the article is that DRS mechanisms succeed not because they attach a monetary value to packaging alone, but because they create an institutional architecture through which that value can be recognised, returned, traced, recovered, and reintegrated into circular production systems. Accordingly, this study is guided by three research questions. First, how do Turkiye's Deposit Management System and Denmark's Dansk Retursystem differ in terms of institutional design, operational architecture, and stakeholder coordination? Second, which governance, incentive, infrastructure, and traceability conditions determine the circular economy capacity of DRS mechanisms? Third, what policy-relevant lessons can be drawn from Denmark's mature model for the consolidation of Turkiye's emerging DOA framework?

The article contributes to the literature in three ways. First, it conceptualises DRS as a circular materials governance instrument rather than a narrow recycling or waste collection mechanism. Second, it advances a comparative institutional perspective by showing that DRS performance is shaped by system maturity, incentive compatibility, reverse logistics, digital traceability, and stakeholder integration. Third, it provides policy insights for Turkiye by identifying the conditions under which the DOA framework can move beyond implementation toward effective circular economy performance.

1. CONCEPTUAL BACKGROUND: FROM WASTE MANAGEMENT TO CIRCULAR ECONOMY

The transition from waste management to circular economy requires a conceptual shift in the way post-consumption materials are understood, valued, and governed. Conventional waste management systems generally approach discarded materials as residual flows that must be collected, sorted, treated, recycled, recovered, or disposed of after consumption. Circular economy thinking, by contrast, seeks to retain material value within the economic system by reducing leakage, improving source separation, extending material utility, and strengthening the connection between consumption, recovery, and production. This distinction is particularly relevant for beverage packaging, where plastic, glass, and aluminium containers retain recoverable value after use but often lose this value when they enter mixed, contaminated, or poorly coordinated waste streams.

From a waste economics perspective, the issue is not limited to recycling technology. It is also a matter of incentives, institutional coordination, material quality, and the allocation of responsibility among actors. Cottafava et al. (2019) frame circular business models as attempts to transform dispersed material "flows" into more organised material "stocks", thereby preventing valuable materials from rapidly exiting the economic system. This perspective is useful for analysing deposit-based systems because DRS mechanisms aim to keep packaging visible, returnable, and economically valued after consumption rather than allowing it to become anonymous municipal waste.

DRS mechanisms therefore occupy an important position between waste policy and circular economy governance. Calabrese et al. (2021) describe DRS as one of the most effective methods for collecting one-way beverage packaging, while also emphasising that such systems differ according to their operating modes, actor responsibilities, money-material flows, and cost burdens. Rather than a simple financial refund mechanism, the circular capacity of a DRS relies on its specific institutional configuration, which defines the legal obligations and financial interactions among state agencies, system operators, and market actors. The Turkish context further underlines the importance of this issue, since recent evidence points to low recycling facility transfer rates for municipal waste and identifies poor source separation and contamination as key constraints in packaging waste recovery.

Against this conceptual background, the following section first clarifies the shift from conventional waste management to circular economy, then examines DRS as a circular economy instrument.

1.1. From Conventional Waste Management to Circular Economy

Conventional waste management has historically been organised around the collection, transportation, treatment, recycling, incineration, or disposal of materials after they have already become waste. This model is largely reactive: it intervenes at the post-consumption stage and seeks to reduce the environmental burden of discarded materials. Although recycling has become an important component of modern waste policy, conventional systems often remain constrained by mixed collection, contamination, weak source separation, limited consumer responsibility, and insufficient economic incentives for returning materials to productive use. In the case of beverage packaging, these limitations are particularly visible because plastic, glass, and aluminium containers retain recoverable material value but are frequently dispersed across fragmented municipal and informal waste streams.

The circular economy approach changes the analytical focus from waste treatment to material value retention. Rather than treating packaging as an end-of-life residue, circular economy policy conceptualises it as a material flow whose economic and environmental value should be preserved through prevention, reuse, separate collection, traceability, and high-quality

recycling. The Ellen MacArthur Foundation defines circular economy around the principles of eliminating waste and pollution, circulating products and materials at their highest value, and regenerating nature. Similarly, the European Union's Circular Economy Action Plan emphasises the need to address the entire life cycle of products, including design, waste prevention, and keeping resources in the economy for as long as possible (European Commission, 2020).

From an economics perspective, this transition requires more than higher recycling rates. It requires the correction of incentive failures that arise when the private cost of discarding packaging is lower than the social cost of littering, landfill pressure, resource depletion, greenhouse gas emissions, and the loss of secondary raw materials. In this respect, circular economy instruments must create behavioural, institutional, and financial mechanisms that make material recovery economically rational for consumers, producers, retailers, and recovery operators. The key policy issue is therefore not only whether packaging can technically be recycled, but whether the system can organise the return, sorting, quality preservation, and reintegration of materials into production chains.

This distinction is important for beverage packaging. If packaging is collected through mixed waste systems, its recycling potential can be reduced by contamination and low material quality. Evidence from Turkiye also indicates that source separation remains a central constraint: Yetgin (2025) notes that only a limited share of municipal solid waste was directed to recycling facilities in 2020 and identifies improper source separation and contamination as major reasons behind low recovery performance. Therefore, the movement from conventional waste management to circular economy depends on mechanisms that improve both the quantity and the quality of recovered materials. DRS occupies this institutional space because it attaches economic value to packaging after consumption and channels it into a more controlled return infrastructure.

1.2. DRS as a Circular Economy Instrument

DRS mechanisms operate through a simple but powerful economic principle: a refundable deposit is attached to a product or packaging at the point of purchase and returned when the packaging is delivered to an approved collection point. The European Commission defines deposit refund schemes as systems in which users pay an additional fee when buying a product and receive a refund when the packaging is returned for recycling or reuse (European Commission, 2021). In economic terms, this mechanism combines an upfront charge with a conditional rebate and thereby changes the relative cost of disposal and return. Walls (2011) describes deposit-refund systems as instruments that combine a tax on consumption with a rebate for recycling or appropriate disposal, making them particularly relevant where illegal dumping, littering, or low-value disposal cannot be easily taxed directly.

The strength of DRS lies in its ability to connect incentive design with material governance. A deposit makes the post-consumption container economically visible. This reduces the probability that packaging will be treated as valueless waste and increases the likelihood that it will be returned through a dedicated system.

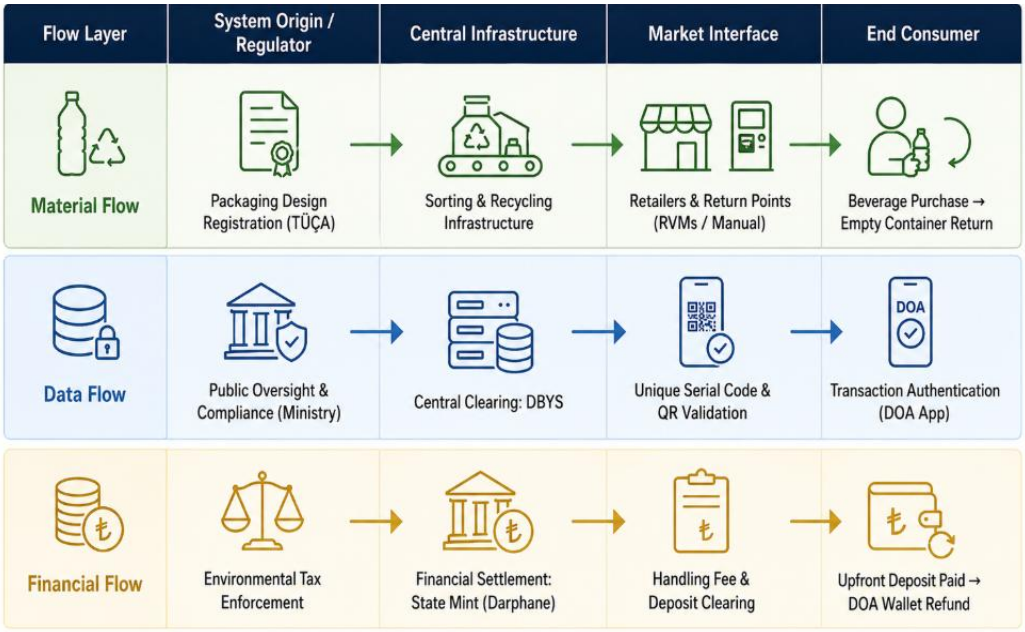
This multi-actor structure can be illustrated through the interaction of three interconnected flows: material flows, financial flows, and data flows. In a functional DRS, beverage packaging moves from consumers to return points and subsequently to sorting, processing, and recycling facilities. At the same time, deposits, producer fees, handling fees, processing fees, and material revenues circulate among consumers, retailers, producers, system operators, and recyclers. A third layer consists of data flows, including sales data, return data, recycling data, and monitoring information. These flows are essential because DRS performance depends not only on the physical return of packaging, but also on the financial settlement and informational traceability that make the system accountable and operationally viable.

Table 1. Operational, Financial, and Data Flow Architecture of Turkiye's DOA Framework

Flow layer	**System origin / regulator**	**Central infrastructure**	**Market interface**	**End consumer**
Material flow	Packaging design and registration under the deposit management framework	Sorting and recycling infrastructure	Retailers and return points, including RVMs and manual return channels	Beverage purchase → empty container return
Data flow	Public oversight and compliance monitoring by the Ministry and related system authorities	DBYS as the central clearing and registration infrastructure	Unique serial code, QR validation, and package recognition	Transaction authentication through the DOA application
Financial flow	Environmental fee/deposit-related regulatory enforcement	Financial settlement and clearing infrastructure, including State Mint-related system functions	Handling fee and deposit clearing among system actors	Upfront deposit paid → DOA Wallet refund

Source: Author's conceptualisation based on DOA, DBYS, and Ministry of Environment, Urbanization and Climate Change system documents.

Figure 1. Operational, Financial, and Data Flow Architecture of Türkiye's DOA Framework



Source: Author's conceptualisation based on DOA, DBYS, and Ministry of Environment, Urbanization and Climate Change system documents.

Table 1 explains and Figure 1 visualises the structural governance logic of Turkiye's DOA system, illustrating how material, financial, and data flows interact within a state-led centralized framework. Unlike the historical, private-retailer-driven consensus model found in Denmark's Dansk Retursystem, the Turkish architecture positions TÜÇA (Turkish Environment Agency) as the central authority and anchors its validation backbone within the Deposit Information Management System (DBYS) and State Mint (Darphane)-related verification functions . As shown in the table, the data layer utilizes unique serialization and dynamic QR coding to verify every transaction in real-time. Simultaneously, the refund process is mediated through the DOA Wallet interface to the end consumer. This integrated architecture allows the study to analyse the Turkish DRS not as an imitation of decentralized European blueprints, but as a centralized digital network designed to strengthen material traceability and reduce verification risks.

This architecture is particularly relevant for comparing DOA and Dansk Retursystem because both systems must be assessed not only through return incentives, but also through the degree

to which they organise these three flows in a reliable, scalable, and circular economy-oriented manner.

However, the deposit fee alone does not guarantee high performance. The literature shows that DRS models differ considerably in terms of operating modes, actor responsibilities, cost burdens, money-material flows, and return infrastructure. Calabrese et al. (2021) argue that DRS design can be analysed through building blocks such as the system operator, producers, retailers, consumers, money-material flows, costs, and revenues; these differences explain why DRS models vary across countries and why system design is a relevant policy choice rather than a merely technical issue.

DRS also contributes to circular economy by improving material quality. Separate return channels reduce contamination, while reverse vending machines, barcode systems, deposit marks, and digital registration can strengthen traceability. This is particularly important for bottle-to-bottle or can-to-can recycling, where material purity and sorting accuracy determine whether recovered packaging becomes high-quality secondary raw material or is downcycled into lower-value uses. Recent comparative and review studies therefore increasingly frame DRS not only as a collection policy but also as an Extended Producer Responsibility (EPR)-compatible instrument that can improve accountability, cost internalisation, and the reliability of recycling streams (Zhou et al., 2020; Picuno et al., 2025; Vuk & Bauerné Gáthy, 2025).

The circular economy relevance of DRS is also recognised in current EU packaging policy. The new EU rules on packaging and packaging waste require Member States to collect at least 90% of single-use plastic and metal beverage containers separately by 2029; where this target cannot be achieved through other means, deposit and return systems must be established. The same policy framework emphasises clear labelling, sufficient deposit value, high-quality recycling, and litter reduction (European Commission, 2025). This confirms that DRS is no longer a marginal waste policy instrument. It has become part of the mainstream circular economy policy architecture, especially for beverage containers whose material value can be preserved through organised return systems.

Nevertheless, DRS should not be romanticised as a universal solution. Its effectiveness depends on accessibility, consumer trust, system financing, retail participation, logistics, digital monitoring, and regulatory clarity. Comparative evidence on reuse and return systems shows that national variations cannot be explained only by environmental consciousness; commercial drivers, regulatory structures, supply chains, and provisioning systems are also decisive (Beswick-Parsons et al., 2023). For this reason, the analysis of DOA and Dansk Retursystem should focus not only on the existence of deposit incentives but also on the institutional conditions that allow those incentives to become operationally effective.

2. METHODOLOGY

This study employs a qualitative structured-focused comparative case study design based on secondary document analysis. The methodological choice is appropriate because the aim of the article is not to estimate the statistical effect of DRS on recycling rates, but to examine how different institutional arrangements, incentive structures, logistical systems, and traceability mechanisms shape the circular economy capacity of two national DRS frameworks. The study therefore compares DOA and Dansk Retursystem through a common analytical framework rather than through a direct quantitative performance ranking.

The methodological design is primarily informed by the building-block approach developed by Calabrese et al. (2021), who analyse European DRS models by identifying the system operator, producers, retailers, consumers, money-material flows, and cost-revenue burdens. Their approach is particularly relevant for this article because it treats DRS not as a single technical instrument, but as an institutional configuration composed of interacting actors, flows, responsibilities, and financial obligations.

This study adapts that logic to a two-case comparison by focusing on governance structure, legal and institutional framework, financial incentives, collection and reverse logistics, digital monitoring, stakeholder integration, and circular economy contribution. The study is also aligned with comparative DRS research such as Jacobsen (2017), who examines the Danish and Swedish deposit systems through a comparative case study based on interviews and secondary data analysis, and Lasmanatun (2025), who compares Denmark's mature DRS with Indonesian initiatives, namely Plasticpay and KIBUMI, through a qualitative comparative design using interviews, observations, and document analysis. In addition, the indicator-oriented comparison used by Vuk and Bauerné Gáthy (2025) informs the construction of the analytical tables, particularly regarding return infrastructure, deposit-fee context, system type, and transferable practices.

The case selection follows a purposive and benchmark-oriented logic. Denmark is selected because Dansk Retursystem represents a mature, centralised, and internationally recognised DRS with established operational routines, high consumer participation, and strong institutional coordination. Turkiye is selected because DOA represents an emerging and policy-relevant DRS framework that is still in the process of institutionalisation, scaling, and behavioural adaptation. The comparison is therefore intentionally asymmetrical. This asymmetry is not treated as a methodological weakness, since the article does not aim to compare two systems at the same maturity level. Rather, it uses Denmark as a mature benchmark to identify the institutional and operational conditions that may be relevant for assessing the consolidation of DOA.

The analysis proceeds in three steps. First, the relevant documents are reviewed to identify the institutional design, actors, obligations, incentives, return infrastructure, and monitoring mechanisms of each system. Second, the two cases are assessed according to the analytical dimensions presented below. Third, the findings are interpreted comparatively in order to identify structural similarities, operational differences, and policy-relevant lessons. The comparison is interpretive rather than statistical; therefore, the findings should be understood as an institutional and policy assessment rather than a causal measurement of DRS performance.

The empirical material of the study is based on a triangulated set of secondary sources. Official institutional sources, including DOA/DBYS platforms, ministerial announcements, and Dansk Retursystem documents, are used to identify system scope, institutional actors, operational responsibilities, return channels, and consumer interfaces. Regulatory and policy documents are used to situate both systems within broader circular economy, EPR, packaging recovery, and separate collection objectives. Academic studies on DRS, circular economy, reverse logistics, and packaging waste provide the conceptual and comparative basis for evaluating system design, actor responsibilities, incentive mechanisms, and operational performance conditions. Technical and case-based sources on reverse vending machines, source separation, collection logistics, and material quality are also used to assess the operational relevance of return infrastructure.

Table 2. Methodological Anchors

Reference study	Methodological contribution
Calabrese et al. (2021)	Analyses European DRS models through a building-block approach based on system actors, money-material flows, costs, revenues, and operating modes.
Jacobsen (2017)	Uses a comparative case study of Danish and Swedish deposit organisations based on interviews, secondary data, and supply-chain analysis.
Lasmanatun (2025)	Compares Denmark's mature DRS with Indonesian initiatives, namely Plasticpay and KIBUMI, through interviews, observations, document analysis, and qualitative comparison.
Vuk and Bauerné Gáthy (2025)	Compares international DRS experiences through indicators such as return rates, return points, deposit levels, system types, and best practices.
Beswick-Parsons et al. (2023)	Shows that national variation in reuse and return systems depends on commercial drivers, regulatory factors, and provisioning systems rather than environmental awareness alone.

The methodological positioning of the study is summarised in Table 2. Rather than relying on a single model of DRS evaluation, the present study adapts insights from comparative DRS studies, supply-chain-oriented case analysis, benchmark-based institutional comparison, and socio-technical approaches to reuse and return systems. Building on these methodological

anchors, Table 3 presents the analytical dimensions used to compare DOA and Dansk Retursystem. These dimensions translate the broader literature into an operational comparison framework by focusing on governance structure, legal and institutional framework, financial incentives, collection and reverse logistics, digital monitoring and traceability, stakeholder integration, and circular economy contribution. In this way, the comparison remains structured while avoiding a premature quantitative ranking between a mature system and an emerging framework.

Table 3. Analytical Dimensions for Comparing DOA and Dansk Retursystem

Analytical dimension	**Core analytical question**	**Main indicators examined**	**Expected analytical output**
Governance structure	How is the system coordinated and which actor has central responsibility?	System operator, public oversight, degree of centralisation, institutional mandate	Identification of whether the system operates through centralised, hybrid, or fragmented coordination.
Legal and institutional framework	How clearly are responsibilities and obligations defined?	Regulatory basis, producer/importer obligations, retailer responsibilities, compliance mechanisms	Assessment of institutional clarity and enforceability.
Financial incentive mechanism	How does the deposit create behavioural and operational incentives?	Deposit value, refund mechanism, producer fees, handling fees, unclaimed deposits, system financing	Evaluation of incentive compatibility and financial sustainability.
Collection and reverse logistics	How are returned containers physically collected, transported, sorted, and processed?	Return points, reverse vending machines, manual collection, transport flows, sorting infrastructure	Assessment of accessibility, scalability, and logistical efficiency.
Digital monitoring and traceability	How are sales, returns, refunds, and material flows monitored?	Barcode/deposit mark systems, digital wallet, data reporting, system monitoring, recycling data	Evaluation of transparency, accountability, and data-driven management capacity.
Stakeholder integration	How are consumers, retailers, producers, operators, and recyclers integrated?	Consumer participation, retailer involvement, producer compliance, recycler connection, public communication	Identification of the degree of actor alignment and behavioural embeddedness.
Circular economy contribution	Does the system support high-quality material recovery and reintegration into production?	Source separation, contamination reduction, bottle-to-bottle or can-to-can potential, recycled material quality, leakage reduction	Assessment of whether the system moves beyond waste collection toward circular material governance.

Table 4 provides the qualitative interpretation scale used in the comparative analysis. The scale is designed to avoid premature numerical scoring, since Dansk Retursystem and DOA

are not at the same level of institutional maturity. The comparison therefore focuses on the degree of institutional development, operational consolidation, and circular economy relevance rather than on a mechanical ranking of system performance.

Table 4. Qualitative Interpretation Scale

Assessment category	**Meaning in this study**
Mature	The feature is institutionally established, operationally stable, and supported by routinised stakeholder behaviour.
Developing	The feature exists and is being implemented, but its long-term performance depends on scaling, standardisation, or actor adaptation.
Emerging	The feature is present mainly as a policy design or early implementation element, with limited evidence of system-wide consolidation.
Limited	The feature is weak, fragmented, or insufficiently documented in the available sources.

3. ANALYSIS

The comparative analysis of DOA and Dansk Retursystem requires more than a descriptive distinction between an emerging system and a mature one. Such a distinction is already evident from the institutional histories of the two cases. The more relevant analytical question is how a DRS becomes mature and which institutional conditions would allow DOA to move from formal implementation toward stable circular economy performance. In this study, maturity is understood as the coordinated closure of four interrelated loops: the consumer return loop, the financial settlement loop, the data-recognition loop, and the material recovery loop. Dansk Retursystem is analytically useful because these loops have been routinised over time. DOA is analytically important because it attempts to build these loops through a digitalised and nationally coordinated framework from the beginning.

Table 5. Comparative Assessment of DOA and Dansk Retursystem by Analytical Dimension

Analytical dimension	**DOA assessment**	**Dansk Retursystem assessment**
Governance structure	Developing	Mature
Legal and institutional framework	Developing	Mature
Financial incentive mechanism	Developing	Mature
Collection and reverse logistics	Emerging/ Limited	Mature
Digital monitoring and traceability	Developing/Potentially advanced	Mature
Stakeholder integration	Developing	Mature
Circular economy contribution	Developing potential	Mature

The governance structure is the central dimension because it determines whether a DRS remains a policy design or becomes an operationally disciplined system. Although DOA is defined as "Depozitosu Olan Ambalajlar", the system behind the consumer interface is broader. DOA enables consumers to return deposit-marked PET, glass, and aluminium beverage packaging, receive the refund through the DOA Wallet, and follow return-related transactions through the digital platform. DBYS adds the institutional layer by defining the roles of sales points, return points, system actors, and registration processes. The updated procedures also indicate that the duties, authorities, and responsibilities of the Ministry, provincial directorates, the Agency, DBYS operator, DSYS operator, producers/importers, and sales points are formally specified (DBYS, 2026). This means that DOA's governance architecture is not narrow; it is administrative, digital, financial, logistical, and regulatory at the same time.

This breadth is a strength, but it is also the main governance risk. A system that involves many actors may expand quickly, but it may also generate coordination problems if role boundaries, technical standards, financial obligations, and data responsibilities are not sufficiently internalised by each actor. In DRS design, broad participation is not equivalent to governance maturity. Maturity requires accountable coordination. Calabrese et al. (2021) show that DRS models differ according to the allocation of responsibilities, money-material flows, and cost-revenue burdens among actors. This insight is highly relevant for DOA. The key issue is not only whether the system includes producers, sales points, return points, operators, consumers, and recyclers, but whether the obligations and transaction costs of these actors are predictable enough to sustain repeated participation. If the system produces uncertainty about who registers packaging, who resolves return-machine failures, who bears handling costs, who verifies material flows, and who reports recycling outcomes, the governance architecture may remain formally broad but operationally fragile.

Dansk Retursystem offers a useful contrast because it concentrates operational responsibility around a clearly accountable system operator. It has operated the Danish deposit system since 2002, functions as a non-profit company, and ensures the recycling of disposable beverage packaging made of plastic, aluminium, and glass (Dansk Retursystem, n.d.-a). Producers and importers are required to register beverages and packaging covered by the system before market entry, and deposit marks are linked to product registration, sales reporting, and machine recognition (Dansk Retursystem, n.d.-b, n.d.-c). This creates a governance chain in which market entry, deposit marking, consumer return, machine validation, collection, sorting, and recycling are connected. The policy lesson for DOA is not to copy Denmark's institutional form, but to strengthen the accountability chain from registration to recycling. In practical terms, DOA's route to maturity depends on whether the system can reduce ambiguity at each stage of the chain.

The legal and institutional framework confirms this point. DOA has already defined system boundaries. Eligible containers must carry the DOA mark and include PET, glass, and aluminium beverage packaging within the relevant volume range; unmarked packaging, milk and drinkable dairy packaging, and carton or paper-based packaging are excluded (DOA, n.d.-b). This boundary-setting is more important than it may appear. In DRS, eligibility rules are part of the incentive mechanism. If consumers are uncertain about what can be returned, the effective refund value declines. If producers and importers are uncertain about registration and marking obligations, the system loses traceability. If sales and return points are uncertain about acceptance rules, the consumer experience becomes inconsistent.

Denmark's advantage lies in the conversion of legal categories into everyday market signals. Pant A, Pant B, and Pant C are not only deposit categories; they are visible, standardised, and recognisable markers of refund value. The Danish system differentiates deposits by material, volume, and packaging type, with Pant A, B, and C corresponding to DKK 1.00, DKK 1.50, and DKK 3.00 for one-way packaging (Dansk Retursystem, n.d.-d). Producers and importers must register packaging and decide how it will be deposit-marked before sale (Dansk Retursystem, n.d.-c). The institutional implication is clear: a mature DRS makes legality visible. DOA's comparable policy task is to make the DOA mark socially legible and technically reliable. The mark should become immediately recognisable to consumers, consistently applied by producers, readable by machines, and unambiguous for return points.

The financial incentive mechanism should be assessed through effective incentive value rather than nominal refund value alone. Ministry announcements state that DOA's nationwide phase is associated with a 1 TL return amount per eligible package, transferred to the user's digital wallet; the accumulated balance can be used in shopping, transferred to a bank account, or withdrawn through compatible channels (Ministry of Environment, Urbanization and Climate Change, 2026a). This creates a visible and communicable incentive. The two-day implementation data announced by the Ministry, including 4.475 million returned packages and more than one million registered users, also suggest early consumer attention. These figures are analytically valuable, but they should not yet be treated as evidence of mature behavioural normalisation. Early uptake and long-term habit formation are different phenomena.

From a waste economics perspective, the consumer does not compare 1 TL with zero. The consumer compares the refund with the perceived cost of return. This cost includes distance to the return point, machine availability, waiting time, package rejection risk, storage inconvenience, and the cognitive cost of using the application. In an inflationary environment, the nominal value of the refund may also lose behavioural salience unless return is made sufficiently easy. Denmark's experience suggests that the financial incentive becomes powerful when it is embedded in ordinary retail routines. In other words, the deposit is not

only a monetary signal; it is a convenience-weighted signal. DOA should therefore monitor not only the number of returned packages, but also repeat-user behaviour, average return frequency, machine rejection rates, and the relationship between refund value and consumer effort.

Collection and reverse logistics are where policy design becomes concrete. DOA's infrastructure strategy is ambitious. The dimensions of collection and reverse logistics expose a stark structural vulnerability that limits the scalability of Turkiye's DOA system when contrasted with the Danish benchmark. Denmark's Dansk Retursystem operates within a highly consolidated retail landscape characterized by tight geographic density and dominated by large supermarket chains. This consolidation allows the Danish system to achieve near-universal nationwide coverage with only approximately 3,000 strategically automated return locations, leveraging pre-existing corporate supply chains for centralized compaction and backhauling logistics (Dansk Retursystem, n.d.-e).. In sharp contrast, Turkiye's operational territory spans 81 provinces and 973 districts, featuring a highly fragmented retail ecosystem where extensive traditional small-scale retailers—such as traditional neighborhood groceries (bakkal), small kiosks, and local buffets—coexist alongside modern supermarket chains. This severe fragmentation creates a significant logistical coordination challenge for the DOA framework. While modern chains can readily absorb the capital costs and physical space required for Reverse Vending Machines (RVMs), the traditional retail sector lacks both the financial margins to manage manual collection handling fees and the square footage for container storage. Attempting to deploy standardized reverse logistics across such a geographically dispersed and institutionally fragmented network drastically inflates transaction costs, increases collection truck route inefficiencies, and heightens the risk of material contamination before consolidation. Consequently, while official projections target the recovery of 25 billion packages annually, the real-world operational capacity of Turkiye's collection infrastructure remains functionally 'Emerging / Limited'. The systemic bottleneck for DOA is not the manufacturing of return machines, but rather the structural challenge of organizing an efficient, low-carbon reverse supply chain across a highly fractured retail landscape that inherently resists the centralized consolidation seen in mature European models.

Operational evidence from Turkiye supports the importance of reverse logistics. Yetgin (2025) reports that reverse vending machine use can improve the volume efficiency of PET, aluminium, and glass beverage packaging collection compared with manual collection, partly through compaction or shredding capacity. The same pilot study reports a 47.41% reduction in transportation-related CO_2 emissions in the analysed context (Yetgin, 2025). This should not be generalised as system-wide DOA performance. Its value is more precise: it shows that return machines are not only consumer-facing devices. They are also logistics infrastructure,

volume-management tools, and potential material-quality control points. DOA's policy maturity will depend on whether this operational potential can be scaled without losing reliability.

Digital monitoring and traceability are where DOA may have its most distinctive institutional advantage. The analytical dimension of digital monitoring and traceability reveals a compelling case of 'technological leapfrogging' that skews the traditional asymmetrical comparison between the two nations. When Denmark's Dansk Retursystem was institutionalized in 2002, it was structurally anchored in an analog era, relying on physical barcodes, standard shape-recognition sensors, and localized retail clearing mechanisms that only gradually digitalized over two decades. Conversely, Turkiye's DOA framework bypasses this legacy analog evolution completely by initiating its system-wide rollout in 2026 through a fully integrated, cloud-native digital infrastructure. (DOA, n.d.-a; DBYS, n.d.-a). The institutional core of this infrastructure is driven by a state-backed digital partnership: the central data clearing validation handled by the Deposit Information Management System (DBYS) operates under the direct institutional oversight of the Turkish State Mint (Darphane). By employing unique serialization and dynamic QR coding at the production stage, the DOA model converts each beverage container into a traceable data point before it even enters the retail market.

Consequently, this structural design allows Turkiye to capture highly granular 'big data' regarding consumer return frequencies, geographic material density, and reverse logistics bottlenecks through the DOA Wallet and connected digital applications. While Denmark represents a mature reference point for behavioral routinization, its tracking mechanism remains fundamentally tied to point-of-sale reverse vending machine data. Turkiye's DOA system, by contrast, establishes a direct financial-informational bridge with the individual consumer via real-time mobile wallet settlements. Therefore, while the operational logistics of the Turkish system are still categorized as 'Developing' due to scaling challenges, its digital architecture is analytically assessed as Developing / Potentially Advanced. This leapfrogging design provides a distinct institutional advantage in mitigating fraud, predicting material flows, and implementing automated public oversight, distinguishing it from older European benchmarks.

Nevertheless, digitalisation is not the same as governance. Data become governance only when they are accurate, interoperable, and used for decisions. If DOA data remain limited to refund confirmation, the system may improve consumer experience without necessarily improving circular economy performance. If data are used to adjust machine placement, collection frequency, compliance monitoring, and material-flow verification, then DOA's digital design becomes a genuine institutional advantage. Dansk Retursystem's traceability is more operationally embedded: packaging registration, deposit marks, barcode recognition,

shape recognition, and reverse vending validation are linked to material flows and recycling (Dansk Retursystem, n.d.-c, n.d.-e). DOA's policy opportunity is to combine such operational traceability with stronger consumer-side digital data.

Stakeholder integration should be evaluated through incentive alignment rather than formal inclusion. DOA includes a wide actor base: public institutions, TÜÇA, DBYS, sales points, return points, producers/importers, HORECA businesses, operators, financial infrastructure, consumers, and recycling actors. This scope is necessary for national implementation, but it does not automatically create behavioural embeddedness. Sales points need manageable obligations. Return points need functioning equipment and clear procedures. Producers/importers need predictable registration, marking, and cost obligations. Operators need efficient collection routes. Recyclers need clean and consistent material streams. Public authorities need verifiable environmental outcomes. If these incentives are not aligned, the system may be formally comprehensive but operationally uneven.

The analytical assessment of stakeholder integration exposes a profound divergence between organic behavioral normalization and tech-enforced compliance. In Denmark, public participation in the 'Pant' system has evolved into a deeply ingrained cultural reflex and a collective social norm over more than two decades. The Danish consumer achieves full behavioral integration through a low-barrier, inclusive infrastructure: simply receiving a physical voucher at a Reverse Vending Machine (RVM) or scanning a universal card to complete the circular loop. This friction-free interaction fosters nationwide participation across all age groups and demographics without requiring mandatory digital mediation. In contrast, Turkiye's DOA system mandates an immediate leap into an exclusively digital interface, requiring consumers to utilize a smartphone application, interact with QR-based validation, and manage an isolated digital wallet (DOA Wallet) to reclaim their deposits.

While this highly digitalised architecture generates a highly sophisticated, real-time data stream for system operators, it introduces a severe socioeconomic friction: the digital divide. By treating a smartphone and high digital literacy as baseline prerequisites for participation, the DOA framework inadvertently erects a technological barrier for elderly demographics, low-income citizens, and rural populations who face limited digital access. This design risk may generate digitally mediated participation barriers, potentially depressing grassroots participation rates in non-urban territories. Consequently, while the stakeholder coordination among state institutions and modern retailers is expanding, the behavioural embeddedness on the consumer side remains strictly 'Developing'. The systemic challenge for the DOA framework is navigating this trade-off between maximizing digital traceability for governance and ensuring democratic, friction-free accessibility to prevent civic alienation from the national circular economy agenda.

Jacobsen's (2017) supply-chain analysis is useful here because it frames deposit systems as reverse closed-loop supply chains rather than simple recycling mechanisms. This implies that the performance of a DRS depends on whether the chain can move material backwards without losing value. Dansk Retursystem has routinised this chain over time: producers and importers register packaging, stores and restaurants participate in return processes, consumers use familiar return channels, the system operator collects and sorts materials, and recyclers receive relatively clean material streams (Dansk Retursystem, n.d.-a; Jacobsen, 2017). DOA is currently in the more difficult phase of converting inclusion into coordination. Its policy challenge is to make the system simple enough for consumers, predictable enough for businesses, and valuable enough for recyclers.

The circular economy contribution is where the analysis must be most careful. A DRS can increase collection without achieving circular economy performance if collected materials are contaminated, downcycled, poorly documented, or economically inefficient to process. Therefore, DOA should not be evaluated only through the number of packages returned. The more relevant indicators are contamination rates, the share of collected PET, glass, and aluminium directed to high-quality recycling, rejected-package ratios, verified material destinations, and bottle-to-bottle or can-to-can potential. Dansk Retursystem reports a 93% return rate for deposit-marked bottles and cans in 2024 and states that the high quality of returned material allows an empty bottle or can become almost a new one (Dansk Retursystem, n.d.-f). This is why it can be treated as a mature circular materials governance model rather than merely a high-performing collection scheme.

For DOA, the appropriate interpretation is not that circularity has already been achieved, but that the institutional preconditions for circularity are being constructed. The system attaches value to packaging, defines eligible materials, creates a digital refund channel, expands return infrastructure, and aims to redirect packaging into the recycling chain. These are necessary conditions. They become sufficient only when returned materials remain clean, traceable, and economically usable for high-quality recycling. This distinction matters for policy. If DOA measures success mainly through returned units, it may become a strong collection programme. If it measures success through verified material reintegration, it can become a circular economy instrument.

The main comparative finding is that DRS maturity consists of the closure of four loops. The consumer loop is closed when returning packaging becomes habitual, easy, and trusted. The financial loop is closed when refunds, producer/importer obligations, handling costs, operating fees, unclaimed deposits, and material revenues form a sustainable settlement structure. The data loop is closed when packaging is recognised, transactions are recorded, and data are used for governance. The material loop is closed when returned packaging remains clean and traceable enough to re-enter production as valuable secondary material.

Dansk Retursystem has largely institutionalised these loops. DOA has started to design them simultaneously, with potential in digital refund architecture and national policy visibility.

The policy implication is therefore not that Turkiye should reproduce the Danish model mechanically. DOA operates in a different geography, inflation environment, retail structure, consumer culture, and waste-management context. The more useful lesson is that DOA should be evaluated through operational closure rather than formal establishment. This requires a policy dashboard that goes beyond machine numbers and package counts. It should include return accessibility, machine reliability, repeat-user behaviour, refund-value salience, producer compliance, data quality, material contamination, and verified recycling destinations. If these indicators are monitored transparently and used to adjust implementation, DOA can move from a developing DRS framework toward a mature circular materials governance system adapted to Turkiye's institutional context.

4. CONCLUSION

This study examined Turkiye's DOA framework and Denmark's Dansk Retursystem in order to understand how DRS mechanisms can support the transition from conventional waste management to circular economy. The comparison was intentionally asymmetrical: Dansk Retursystem represents a mature and routinised system, whereas DOA represents a developing framework that is still moving from formal implementation toward operational consolidation. This asymmetry was analytically useful because it allowed the study to move beyond the question of whether Turkiye currently resembles Denmark and instead ask what institutional, economic, logistical, and behavioural conditions would allow DOA to mature.

The analysis shows that the effectiveness of DRS mechanisms cannot be explained by the deposit incentive alone. A deposit creates a price signal, but this signal becomes behaviourally meaningful only when its real value is preserved, the return process is convenient, the system is trusted, and the collected materials are reintegrated into high-quality recycling streams. In this respect, the study achieved its first objective by identifying the main differences between DOA and Dansk Retursystem in terms of governance structure, legal clarity, financial incentives, reverse logistics, digital monitoring, stakeholder integration, and circular economy contribution. The Danish model demonstrates how these dimensions can become embedded in everyday routines, while DOA shows how a developing system can attempt to build them through digital infrastructure and national policy coordination.

The most important economic finding concerns the difference between nominal and effective deposit incentives. In Denmark, Pant A, Pant B, and Pant C values can remain behaviourally meaningful because they operate in a relatively stable monetary environment and are embedded in established retail routines. In Turkiye, the fixed 1 TL deposit value creates an immediate and communicable incentive, but its real behavioural power may weaken over time

under high inflation. The consumer does not evaluate the refund in isolation. The effective incentive is the refund value minus the effort of storing containers, reaching a return point, using the machine or application, and waiting for the transaction to be completed. If ten returned containers generate a refund that no longer compensates for this effort, participation may decline even if the system remains formally available. Therefore, DOA's financial sustainability requires a dynamic deposit adjustment mechanism. Indexing the deposit value to CPI, PPI, or another transparent price indicator would protect the real incentive and prevent the system from becoming progressively less attractive to consumers.

A second policy implication concerns the structure of retail and reverse logistics. Denmark's system benefits from a relatively consolidated retail environment in which large supermarket chains and dense return infrastructure make packaging return part of ordinary shopping behaviour. Turkiye's retail structure is more fragmented. Alongside large chain supermarkets, there is a large network of small groceries, buffets, local markets, and geographically dispersed retail points. This matters because DRS performance depends not only on the number of return machines, but also on who hosts them, who bears the handling cost, who manages rejected packaging, who absorbs space and labour requirements, and how frequently collected materials are removed. If small retailers are expected to participate without adequate handling fees, logistical support, or operational simplicity, their compliance may remain formal rather than functional. DOA's maturity therefore depends on a differentiated retail integration model: large chains may absorb reverse vending infrastructure more easily, while small retailers may require subsidised handling fees, manual return protocols, mobile collection support, or clustered return-point models.

The third policy implication concerns digitalisation. DOA's digital wallet, QR-based return process, and mobile application can create a valuable data infrastructure. This is a genuine advantage because it allows the system to observe return behaviour, identify weak locations, monitor machine use, and potentially optimise logistics. However, digitalisation also creates a participation risk. In Denmark, returning packaging is a long-established social routine that does not depend primarily on digital literacy. In Turkiye, if the return process is experienced as application-dependent, smartphone-dependent, or procedurally complex, certain groups may face barriers to participation. Older consumers, rural users, low-income households, and digitally less confident individuals may be less willing or able to use the system even when they support recycling. For this reason, DOA should not rely exclusively on digital participation. Manual alternatives, assisted return points, cash-compatible refund options, and simplified user interfaces are necessary if the system is to become socially inclusive rather than digitally selective.

The fourth implication concerns logistics and material quality. The evidence from reverse vending machine use in Turkiye is valuable because it shows that collection technology can

reduce volume, improve transport efficiency, and potentially lower emissions. Yet this logistical promise should not be read as automatic system-wide success. A machine is not merely a consumer interface; it is also a compaction device, a recognition device, a data point, and a material-quality gatekeeper. The policy question is therefore whether DOA can scale machine-based collection while preserving reliability. Mature monitoring should include machine uptime, full-machine frequency, rejection rates, collection intervals, storage capacity, transport emissions, and the quality of materials delivered to recyclers. Without these indicators, package counts may overstate circular economy performance.

The study also achieved its second objective by identifying the conditions that determine the circular economy capacity of DRS mechanisms. This capacity depends on the closure of four loops. The consumer loop is closed when returning packaging becomes habitual, convenient, and trusted. The financial loop is closed when the deposit value remains meaningful and system costs are shared predictably among producers, retailers, operators, and consumers. The data loop is closed when digital and technical information is used for governance rather than only for refund confirmation. The material loop is closed when collected packaging remains clean, traceable, and suitable for high-quality recycling. Dansk Retursystem has largely institutionalised these loops. DOA has started to construct them, but their durability will depend on policy adjustment, operational discipline, and behavioural integration.

The third objective of the study was to derive policy-relevant lessons for Turkiye. The main lesson is not that DOA should reproduce the Danish model mechanically. Turkiye has different macroeconomic conditions, retail structures, digital inclusion challenges, geography, and waste-management traditions. The relevant lesson is functional rather than institutional imitation. DOA should be governed through a performance dashboard that goes beyond machine numbers and returned package totals. Such a dashboard should include the real value of the deposit, repeat-user behaviour, return-point accessibility, machine reliability, small-retailer participation, handling-cost compensation, digital inclusion, contamination rates, verified recycling destinations, and the share of materials entering high-quality recycling. These indicators would allow DOA to be evaluated as a circular materials governance system rather than a simple collection mechanism.

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GEOPOLITICAL SHOCKS AND DIGITAL SOVEREIGNTY: ASSESSING THE IMPACT OF THE U.S.–IRAN CONFLICT ON PAKISTAN'S DIGITAL TRANSFORMATION, DATA GOVERNANCE, AND PLATFORM ECONOMY

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Abstract

The escalating U.S.–Iran conflict has transformed geopolitical tensions into a critical determinant of digital governance and economic resilience, generating significant implications for Pakistan's digital transformation agenda. This study examines how geopolitical shocks influence Pakistan's digital sovereignty, data governance frameworks, cybersecurity preparedness, and platform economy. By analyzing the intersection of regional instability and digital development, the research explores emerging challenges related to cross-border data flows, technological dependence, regulatory adaptation, and the resilience of digital platforms. Using a qualitative policy-analysis approach, the study finds that heightened geopolitical uncertainty strengthens the need for robust digital sovereignty measures, localized data governance mechanisms, and secure digital infrastructure. The findings further indicate that geopolitical disruptions can affect digital trade, foreign technology dependence, and platform-based economic activities. The study recommends the development of adaptive digital policies, enhanced cybersecurity capacity, and strategic investments in digital infrastructure to ensure sustainable and resilient digital growth in Pakistan.

Keywords: Geopolitical Shocks, Digital Sovereignty, U.S.–Iran Conflict, Pakistan, Digital Transformation, Data Governance, Cybersecurity, Platform Economy, Digital Resilience, Digital Policy

THE IMPACT OF ENVIRONMENTAL, SOCIAL AND GOVERNANCE CRITERIA ON FIRM PERFORMANCE

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Abstract

This study examines the impact of environmental, social, and governance (ESG) criteria on the performance of companies within the context of the contemporary economy. The primary objective of the study is to identify the correlation between ESG factors and companies' financial and market indicators, drawing systematic conclusions based on existing scientific literature. The research findings indicate that integrating ESG criteria contributes to increasing the investment attractiveness of companies, mitigating risks, and strengthening their long-term sustainability. Furthermore, it was determined that companies with high ESG scores demonstrate stable financial results and a high level of stakeholder trust. Content analysis, comparative analysis, and the synthesis of results were utilized as research methods throughout the study. Consequently, it was established that ESG criteria exert a positive influence on companies' financial performance, market value, risk levels, and investment attractiveness. In addition, some studies highlighted that the extent of this impact varies depending on industry, regional, and temporal factors. The findings prove that incorporating ESG factors plays a vital role in enhancing companies' long-term sustainable development and competitiveness. This work holds both theoretical and practical significance for investors, managers, and policymakers involved in shaping ESG strategies.

Keywords: Firm Performance, Corporate Sustainability, Investment Attractiveness

ÇEVRESEL, SOSYAL VE YÖNETİŞİM KRİTERLERİNİN FİRMA PERFORMANSINA ETKİSİ

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Özet

Bu çalışma, çağdaş ekonomi bağlamında çevresel, sosyal ve yönetişim (ESG) kriterlerinin şirketlerin performansı üzerindeki etkisini incelemektedir. Çalışmanın temel amacı, mevcut bilimsel literatüre dayanarak sistematik sonuçlar çıkararak, ESG faktörleri ile şirketlerin finansal ve piyasa göstergeleri arasındaki korelasyonu belirlemektir. Araştırma bulguları, ESG kriterlerinin entegrasyonunun şirketlerin yatırım çekiciliğini artırmaya, riskleri azaltmaya ve uzun vadeli sürdürülebilirliklerini güçlendirmeye katkıda bulunduğunu göstermektedir. Ayrıca, yüksek ESG puanlarına sahip şirketlerin istikrarlı finansal sonuçlar ve yüksek düzeyde paydaş güveni sergilediği belirlenmiştir. Çalışma boyunca içerik analizi, karşılaştırmalı analiz ve sonuçların sentezi araştırma yöntemleri olarak kullanılmıştır. Sonuç olarak, ESG kriterlerinin şirketlerin finansal performansı, piyasa değeri, risk seviyeleri ve yatırım çekiciliği üzerinde olumlu bir etkiye sahip olduğu tespit edilmiştir. Ek olarak, bazı çalışmalar bu etkinin derecesinin sektör, bölgesel ve zamansal faktörlere bağlı olarak değiştiğini vurgulamıştır. Bulgular, ESG faktörlerinin şirketlerin uzun vadeli sürdürülebilir gelişimini ve rekabet gücünü artırmada hayati bir rol oynadığını kanıtlamaktadır. Bu çalışma, ESG stratejilerini şekillendirmede yer alan yatırımcılar, yöneticiler ve politika yapıcılar için hem teorik hem de pratik öneme sahiptir.

Anahtar Kelimeler: Firma Performansı, Kurumsal Sürdürülebilirlik, Yatırım Çekiciliği

INTRODUCTION

In recent decades, the global economy has undergone significant changes driven by an increasing focus on sustainable development, environmental safety, and corporate social responsibility. Traditional approaches to assessing company performance, which rely primarily on financial metrics, are gradually giving way to more comprehensive models that incorporate the non-financial aspects of organizational operations. In this context, the concept of Environmental, Social, and Governance (ESG) criteria is gaining particular importance, serving as a crucial tool for evaluating corporate sustainability and long-term efficiency.

The relevance of this research topic stems from the fact that under conditions of globalization, intensifying climate change, and rising social inequality, companies face the necessity to adapt to new demands from states, investors, and society. Modern investors focus not only on profit and profitability metrics but also increasingly pay attention to a company's level of environmental responsibility, the quality of its corporate governance, and its social policy. This shift occurs because ESG factors enable a comprehensive assessment of business development risks and prospects, including reputational, operational, and strategic dimensions.

ESG criteria play a unique role in shaping companies' investment attractiveness. According to several studies, organizations that actively implement ESG principles demonstrate stable financial results, lower vulnerability to crises, and higher levels of investor and consumer trust (Friede et al., 2015; Eccles et al., 2014). Furthermore, implementing ESG approaches contributes to reducing the cost of capital and increasing access to financial resources (El Ghoul et al., 2011).

The environmental component (E) of ESG aims to reduce a company's negative footprint on the environment, including mitigating greenhouse gas emissions, rationally utilizing natural resources, and implementing eco-friendly technologies. Amid the global fight against climate change, this aspect is becoming increasingly vital as companies turn into crucial participants in the transition process to a green economy.

The social component (S) covers a wide range of issues regarding a company's relationships with employees, clients, and society as a whole. This includes providing decent working conditions, respecting human rights, developing human capital, and participating in social initiatives. Companies that focus on social aspects gain high reputation and loyalty from consumers.

The governance component (G) is associated with the quality of corporate governance, operational transparency, and ethical compliance. An effective governance system helps mitigate agency conflicts, improve decision-making efficiency, and enhance investor trust.

Despite the growing interest in ESG, a unified approach to assessing the impact of ESG criteria on company performance does not yet exist in the scientific literature. Research findings remain ambiguous: some authors highlight a positive impact of ESG on financial indicators, while others indicate the lack of a significant relationship or even point to the short-term costs of implementing ESG practices. Thus, a need arises for a comprehensive analysis of existing scientific approaches and empirical data to determine the main patterns and mechanisms of the impact of ESG criteria on company performance.

The objective of this study is to analyze the impact of environmental, social, and governance criteria on company performance based on a systematic review of scientific literature. To achieve this objective, the following tasks were defined:

- Study the theoretical foundations of the ESG concept;
- Analyze existing scientific approaches to evaluating company performance;
- Identify the relationship between ESG indicators and financial outcomes;
- Determine the impact of ESG on companies' investment attractiveness and sustainability;
- Summarize the results of empirical research in this field.

1. METHODOLOGY

This study is aimed at a comprehensive investigation of the impact of environmental, social, and governance (ESG) factors on company efficiency through a systematic analysis of scientific literature. The methodological basis of the study relies on a combination of qualitative and quantitative approaches, ensuring depth of analysis, reliability of results, and their theoretical validity. Employing a mixed methodological approach not only helps identify general patterns and trends in the studied field but also enables a comparative analysis of various empirical results presented in scientific publications.

A systematic literature review (SLR) was selected as the primary research design, which is a recognized scientific tool for synthesizing and critically evaluating existing knowledge in a specific field. This approach ensures structural integrity of the analysis, replicability of the results, and minimizes subjectivity in source selection and interpretation.

The systematic review procedure was carried out in several sequential stages:

- Formulation of the research question and setting research objectives;
- Development of a scientific source search strategy;
- Systematic search for publications in international scientific databases;
- Selection of relevant sources based on predefined criteria;

- Critical evaluation of the quality of selected studies;
- Analysis, interpretation, and synthesis of the acquired data.

The conceptual basis of this study consists of articles selected from the literature. These articles represent theoretical and empirical studies examining various aspects of ESG and their impact on organizational productivity. The use of multiple databases increased the completeness of the selection and reduced the risk of overlooking important studies. To be included in the final analysis dataset, articles had to meet the following criteria:

- Presence of a direct analysis of the link between ESG factors and companies' performance metrics;
- Use of quantitative, qualitative, or mixed analysis methods, alongside transparency and replicability of the research methodology;
- Existence of clearly formulated conclusions and interpretations of the results.

A set of analytical methods ensuring a comprehensive interpretation of data was used during the research:

- Content analysis: Applied to systematize scientific approaches to defining ESG and to identify main thematic areas in the literature. This method enabled the classification of studies by types of indicators used, analytical methods, and obtained results.
- Comparative analysis: Used to compare results of different studies to identify similarities, differences, and contradictions in scientific conclusions. Special attention was paid to differences related to industry, region, and time period.
- Synthesis method: Allowed the integration of individual research findings into a unified analytical framework, contributing to forming generalized conclusions regarding the nature and direction of the impact of ESG factors on company performance.

Within the analytical framework, primary groups of independent and dependent variables were distinguished:

Independent variables (ESG factors):

- Environmental indicators: greenhouse gas emissions level, energy efficiency, waste management, natural resource utilization.
- Social indicators: working conditions, level of social responsibility, interaction with stakeholders, corporate social programs.
- Governance indicators: corporate governance structure, operational transparency, protection of shareholders' rights, independence of the board of directors.

Dependent variables (efficiency indicators):

- Financial efficiency (ROA, ROE, net profit);
- Market capitalization and company value;
- Corporate risk level;
- Investment attractiveness and access to capital.

Despite striving for maximum objectivity and completeness of the analysis, this study has several limitations:

- The limited number of selected sources, which may affect the representativeness of the results;
- Differences in methodologies and samples of the studies, making direct comparison difficult;
- Potential presence of publication bias, where positive results are published more frequently than negative ones, as well as limitations in time range and language sources;
- Dependency of conclusions on the quality and reliability of the included studies.

2. CONCEPTUAL FRAMEWORK

The concept of Environmental, Social, and Governance (ESG) criteria represents a modern approach to evaluating company performance that goes beyond traditional financial analysis and accounts for a wide range of non-financial factors. The formation of this concept is linked to the evolution of ideas regarding the role of business in society, transitioning from a model of maximizing shareholder profit to a sustainable development model oriented toward the interests of all stakeholders.

One of the fundamental theoretical bases of ESG is stakeholder theory proposed by Freeman (2010). According to this theory, a company must consider the interests of not only shareholders but also other groups, such as employees, customers, suppliers, the state, and society as a whole. This approach assumes a more balanced and sustainable development of business.

Another key theoretical framework is corporate social responsibility (CSR) theory, which treats business as a socially responsible system obliged to consider the consequences of its actions on society (Carroll, 1999). ESG can be viewed as an evolution and refinement of the CSR concept, as it offers a structured and measurable approach to evaluating the non-financial aspects of companies. Sustainable development theory, formulated in the World Commission on Environment and Development (1987), also plays an important role, stating that development should meet the needs of the present generation without compromising the ability of future generations to meet their own needs. ESG serves as a tool for implementing sustainable development principles at the corporate level.

Furthermore, agency theory highlights the importance of effective corporate governance in minimizing conflicts between managers and shareholders (Jensen & Meckling, 2019). Within the ESG framework, the governance component aims to increase transparency and accountability, which helps reduce agency costs.

The ESG concept encompasses three interconnected components:

- Environmental criteria: The environmental aspect is related to the company's impact on the surrounding environment. It includes indicators such as greenhouse gas emissions, energy efficiency , waste management , and natural resource utilization. Companies that actively implement environmental practices are capable of reducing resource-related costs as well as mitigating environmental risks (Clark et al., 2015). Moreover, environmental responsibility is becoming an important factor in competitiveness, particularly under conditions of tightening environmental regulations.
- Social criteria: The social component reflects the company's interaction with society and includes working conditions and employee safety, respect for human rights, diversity and inclusion, and relationships with customers and suppliers. Studies show that companies with developed social policies exhibit higher labor productivity and employee satisfaction levels (Khan et al., 2016). This, in turn, has a positive impact on overall operational performance.
- Governance criteria: The governance aspect encompasses corporate governance issues, including the Board of Directors structure, reporting transparency, anti-corruption efforts, and the protection of shareholders' rights. Effective corporate governance helps increase investor confidence and reduce financial risks (Gompers et al., 2003).

One of the central issues in the scientific literature is the relationship between ESG criteria and company performance. There are several approaches to explaining this relationship:

- Resource-Based View (RBV): According to this approach, ESG is viewed as a strategic resource that can provide companies with competitive advantages (Barney, 1991). For example, a high reputation and consumer trust can contribute to an increase in market share.
- Signaling Theory: ESG indicators can serve as a signal to investors regarding a company's reliability and stability (Spence, 1973). Companies with high ESG ratings are perceived as having lower risk.
- Institutional Theory: This approach reflects the influence of the external environment (state, society, international organizations) on the implementation of ESG practices

(DiMaggio & Powell, 1983). Companies are forced to adapt to institutional demands to maintain legitimacy.

There is also the issue of ESG measurement, as there are no unified assessment standards, which complicates comparing companies and interpreting results. Based on the analysis of theoretical approaches, the following conceptual model can be formulated:

- ESG Criteria → Risk reduction
- ESG Criteria → Reputation growth
- ESG Criteria → Increased investment attractiveness
- ESG Criteria → Improved financial results

Thus, ESG acts as a comprehensive factor affecting both the internal processes of a company and its external perception. The conceptual framework of the study shows that ESG criteria are a critical element of the modern corporate management model. They integrate economic, social, and environmental aspects of activities, contributing to the formation of a sustainable and efficient business.

To ensure the reliability of the results, only verified scientific sources were used, a systematic approach to analysis was applied, and comparisons across various studies were conducted. The validity of the study is ensured through the use of recognized scientific methods and relevant data. The applied methodology allows for a comprehensive evaluation of the impact of ESG criteria on company performance and the formation of well-founded scientific conclusions.

3. RESULTS

As a result of a systematic analysis of scientific publications, core patterns and trends that characterize the impact of environmental, social, and governance (ESG) criteria on company efficiency were identified. The primary directions of the analysis group the obtained results.

3.1. The Impact of ESG on Financial Efficiency

An analysis of numerous studies indicates the existence of a positive relationship between ESG performance and companies' financial results. Companies with high ESG ratings demonstrate higher return on assets (ROA), stable profitability, and lower earnings volatility. For instance, a meta-analysis of over 2000 empirical studies confirms that in most cases, ESG has a positive or neutral impact on financial indicators (Friede et al., 2015). However, a portion of the research shows that in the short term, implementing ESG practices can be accompanied by rising costs, temporarily reducing profits (Krüger, 2015).

3.2. ESG and Risk Mitigation

One of the most consistent findings is the reduction of risks at high ESG levels. It was found that ESG contributes to mitigating reputational risks, decreasing the probability of corporate conflicts, and enhancing resilience to economic crises. Companies with well-developed social responsibility and transparent management can overcome crisis periods more easily, which is confirmed by the example of the global financial crisis (Lins et al., 2017).

3.3. The Impact of ESG on Investment Attractiveness

Studies show that ESG is becoming an important factor in investment decision-making. Core findings indicate that investors prefer companies with high ESG indicators, ESG lowers the cost of capital (El Ghoul et al., 2011), and sustainable companies enjoy better access to finance (Cheng et al., 2014). This is because ESG is viewed as an indicator of business reliability and long-term stability.

3.4. ESG and Non-Financial Indicators

Beyond financial outcomes, ESG significantly influences non-financial aspects of companies, improving reputation and brand value, increasing customer loyalty , enhancing employee satisfaction , and decreasing employee turnover. Companies that actively implement ESG principles build stable relationships with stakeholders, which positively impacts their long-term efficiency (Khan et al., 2016).

3.5. Sectoral and Regional Differences

The analysis showed that the impact of ESG varies depending on the sector:

- In energy and industry, the environmental factor plays a decisive role;
- In the service sector, the social component is more prominent;
- In the financial sector, corporate governance holds particular significance.

Thus, the effectiveness of ESG depends on the specific nature of the business and its level of impact on society and the environment. The results also reveal differences in the impact of ESG depending on the region: in developed countries, ESG is actively implemented and demonstrates a clear impact, while in developing nations, the ESG impact is less pronounced due to a weaker institutional environment. This is linked to disparities in regulations, market development levels, and societal expectations.

3.6. Contradictions and Limitations of the Results

Despite the predominance of positive outcomes, contradictions were also identified, such as the absence of unified ESG assessment standards, differences in measurement methodologies, and the potential impact of “greenwashing” (formal compliance with ESG without actual

changes). Some studies found no significant correlation between ESG and financial metrics, underscoring the need for further research. Nevertheless, the study results confirm that ESG criteria are a critical factor affecting corporate performance, and integrating them into corporate strategy promotes the formation of a sustainable competitive advantage.

4. THE IMPACT OF ESG ON COMPANY EFFICIENCY: A CASE REVIEW

The modern business environment increasingly shows that implementing ESG principles significantly impacts company efficiency. Consider key examples of the world's largest corporations:

- Tesla: One of the most prominent examples where the business model is entirely built upon the environmental component of ESG. Electric vehicle production, battery technology development, and carbon dioxide emission reductions have enabled the company to secure a leading position in the market. Consequently, Tesla demonstrates high market capitalization, steady growth in investor confidence, and the establishment of an environmental leader image, confirming that the environmental factor can serve as a primary source of competitive advantage.
- Apple: Represents an example of a balanced ESG model. It actively utilizes renewable energy, monitors its supply chain, and maintains high managerial transparency. This approach ensures steady revenue growth, high market reliability, and a reduction in reputational risks, reinforcing the long-term sustainability of the business.
- Unilever: Showcases an example of integrating ESG directly into business strategy. The company executes sustainable development programs, minimizes waste, and actively participates in social initiatives. This ensures stable financial performance, high customer loyalty, and reduced operational risks, validating the effectiveness of ESG as the core of a business model.
- Microsoft: A leader in carbon neutrality. The company implements a plan to achieve carbon negativity, invests in “green” technologies, and ensures transparent reporting. This enhances its investment attractiveness, contributes to leadership in ESG ratings, and strengthens its corporate image.
- Google: Focuses heavily on sustainable innovations. Utilizing renewable energy, creating sustainable data centers, and allocating social investments toward education help reduce costs, increase user trust, and fortify the global brand.
- Amazon: Shows that ESG can be a source of both advantages and risks. Despite the Climate Pledge program and the development of green logistics, the company faces criticism regarding working conditions and a high carbon footprint in its supply chain, demonstrating that ESG directly impacts business reputation.

- Toyota: Successfully applies sustainable manufacturing principles by developing hybrid technologies and reducing emissions, which ensures stable sales and leadership in the sustainable automotive segment.
- Shell: Is in the process of energy transformation by investing in renewable energy sources. However, it faces pressure from environmental organizations, illustrating the difficulty traditional energy companies encounter when transitioning to an ESG model.
- Nestlé: Nestlé focuses on social responsibility through sustainable agriculture, supply chain management and social programs. This allows the company to maintain stable positions in the global market and reduce reputational risks.

Table 1: Global Companies' ESG Strategies, Key Components, and Impacts on Firm Performance

Company	Core ESG Strategy	Key Component	Impact on Firm Performance and Reputation
Tesla	The business model is entirely based on green transformation, electric vehicle production, and battery technologies	Environmental (E)	High market capitalization, consistently increasing investor confidence, and an image as a global environmental leader
Apple	The use of renewable energy, strict control of the supply chain, and managerial transparency	Stable (E, S, G)	Stable revenue growth, high market credibility, and minimized corporate reputational risks
Unilever	Direct integration of sustainable development programs, waste reduction, and social responsibility projects into the core business strategy	Stable / Integrated (E, S, G)	Predictable and stable financial performance, high customer loyalty, and reduced operational risks
Microsoft	Investing in green technologies and transparent corporate reporting in line with the goal of becoming net carbon negative	Environmental (E) and Governance (G)	Significantly increased investment attractiveness, leadership in global ESG ratings, and a strong corporate image

Company	Core ESG Strategy	Key Component	Impact on Firm Performance and Reputation
Google	Sustainable data centers, renewable energy innovations, and massive social investments in education	Environmental (E) and Social (S)	Reducing operational costs, increasing user base trust, and strengthening global brand value
Amazon	"Climate Pledge" commitment and investments in green logistics	Environmental (E) and Social (S) *(Paradoxical Dynamics)*	ESG presents both advantages and risks; reputational damage due to supply chain carbon footprint and criticisms of working conditions
Toyota	Leading the way with hybrid technologies and sustainable manufacturing principles that aim to reduce emissions in production processes	Environmental (E)	Stable sales figures in the automotive market and global market leadership in the sustainable vehicle segment
Shell	A strategy for gradual transition away from fossil fuels by increasing investment in renewable energy sources (energy transition)	Environmental (E) *(Transformation Process)*	The structural challenges of transitioning from the traditional energy model and the continuous legal/reputational pressure from environmental organizations
Nestlé	Sustainable agricultural practices, responsible supply chain management, and social programs for rural development	Social (S)	Maintaining a dominant position in the global food market and mitigating potential reputational risks

The analyzed cases confirm that ESG components affect firm performance not in isolation, but with varying weights depending on sectoral dynamics. Analysis of the cases of leading companies in the world shows that ESG factors have a comprehensive impact on business performance. They contribute to the growth of financial indicators, strengthening investor confidence, reducing risks and creating sustainable competitive advantages. In addition, insufficient attention to ESG can lead to reputational and operational risks.

5. CONCLUSION

The study analyzed the impact of environmental, social, and governance (ESG) criteria on company efficiency in the current economic context. Based on a systematic analysis of scientific publications, core patterns were identified that allow for an evaluation of the role of ESG in shaping sustainable business development and enhancing its competitiveness.

The research results confirm that ESG criteria are gradually becoming an integral part of modern corporate strategy. While company efficiency was previously evaluated primarily through the prism of financial performance metrics, non-financial aspects reflecting environmental responsibility, social orientation, and corporate governance quality are currently becoming increasingly vital.

The practical significance of the study is that its results can be used by company managers when developing sustainable development strategies, as well as by investors when making investment decisions. Thus, it can be concluded that ESG criteria have a significant impact on the efficiency of companies and are an important factor in their long-term development. In the context of the transformation of the global economy, the integration of ESG principles is not only a competitive advantage, but also a necessary condition for the successful operation of a company.

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DIGITAL TRANSFORMATION AND COMPETITIVE ADVANTAGE: A RESOURCE-BASED VIEW

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Abstract

This study is devoted to analyzing the role of digital transformation in achieving competitive advantage in organizations from a resource-based perspective. In today's world, technologies are rapidly developing and fundamentally transforming the way enterprises operate. The effective use of digital tools and solutions enables organizations to modernize their activities and gain a significant advantage over competitors in the market. The main purpose of this essay is to examine the relationship between digital transformation and a company's strategic resources, as well as to explain how they contribute to the formation of competitive advantage. The study employs methods of scientific literature review and comparative analysis. The findings indicate that digital transformation is not limited to improving technological infrastructure alone. It is also closely related to strategic resources within the organization, such as human capital, knowledge and experience, innovative capabilities, and managerial skills.

Keywords: Digital Transformation, Resource-Based View, Competitive Advantage, Strategic Management, Innovation Capability

DİJİTAL DÖNÜŞÜM VE REKABET AVANTAJI: KAYNAK TEMELLİ BİR BAKIŞ AÇISI

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Özet

Bu çalışma, dijital dönüşümün kuruluşlarda rekabet avantajı elde etmedeki rolünü kaynak temelli bir bakış açısıyla analiz etmeye adanmıştır. Günümüz dünyasında teknolojiler hızla gelişmekte ve işletmelerin çalışma biçimini temelden dönüştürmektedir. Dijital araç ve çözümlerin etkin kullanımı, kuruluşların faaliyetlerini modernize etmelerini ve pazardaki rakiplerine karşı önemli bir avantaj elde etmelerini sağlamaktadır. Bu çalışmanın temel amacı, dijital dönüşüm ile bir şirketin stratejik kaynakları arasındaki ilişkiyi incelemek ve bunların rekabet avantajının oluşumuna nasıl katkıda bulunduğunu açıklamaktır. Çalışma, bilimsel literatür incelemesi ve karşılaştırmalı analiz yöntemlerini kullanmaktadır. Bulgular, dijital dönüşümün yalnızca teknolojik altyapıyı iyileştirmekle sınırlı olmadığını göstermektedir. Ayrıca, insan sermayesi, bilgi ve deneyim, yenilikçi yetenekler ve yönetim becerileri gibi kuruluş içindeki stratejik kaynaklarla da yakından ilişkilidir.

Anahtar Kelimeler: Dijital Dönüşüm, Kaynak Temelli Yaklaşım, Rekabet Avantajı, Stratejik Yönetim, İnovasyon Yeteneği

INTRODUCTION

In scientific literature, the concept of digital transformation is explained in various ways. Some authors understand it as a process of implementing and widely utilizing digital technologies (Vial, 2019), while others describe it as restructuring a company's strategic resources and converting digital capabilities into competitive advantages (Bharadwaj et al., 2013). In this regard, the resource-based view (RBV) plays an important role. This theory considers the internal resources and capabilities of an organization as the foundation for achieving a sustainable competitive advantage (Barney, 1991). That is, the unique resources of an enterprise, its innovative capabilities, knowledge and experience, and technological infrastructure make it possible to achieve market dominance.

The resource-based view serves as an effective tool for determining the strategic significance of digital transformation. When digital technologies are transformed into valuable resources, they profoundly affect the long-term success of the enterprise. These technologies should be viewed not as elements dependent on external factors, but as resources directly linked to the internal capabilities of the organization.

1. RELEVANCE OF THE TOPIC

The 21st century is characterized as an era of innovation and technology; hence, digital technologies are being rapidly integrated into daily life and business practices. One of the core dimensions of these processes is digital transformation. Digital transformation is defined as the process of restructuring enterprise operations, business models, and customer interactions through electronic systems, automated processes, and innovative solutions. While technology was once regarded as a simple tool to increase operational efficiency (Westerman et al., 2014), today it has evolved into a core strategic advantage. That is, for modern businesses, utilizing technology is not merely about increasing productivity; it represents a key determinant of market competitiveness.

The strategic importance of digital transformation has been substantiated by numerous experts and scholars. For instance, according to a study by McKinsey, companies that effectively implement digital technologies experience a significant increase in their overall productivity (McKinsey, 2021). Furthermore, by leveraging digital capabilities, enterprises enhance their level of customer interaction, which in turn fosters customer satisfaction and enables them to expand their market share. This trend holds critical importance for developing nations such as Kazakhstan, as digital transformation serves as a catalyst for economic growth, innovation, and international competitiveness.

The research in this scientific paper is primarily grounded in qualitative and comparative methodologies. To this end, scientific articles, practical case studies, and statistical data

sources were comprehensively analyzed. The study is centered on uncovering the nexus between digital transformation and an organization's internal resources. Additionally, it highlights practical examples demonstrating the success of organizations that have deployed digital technologies and evaluates the subsequent shifts in their respective market positions. This methodological approach provides the study with a robust theoretical foundation combined with concrete empirical evidence.

The adoption of digital technologies has emerged as a paramount strategic objective for both nations and corporations. This process ensures the sustainable development of an organization by enhancing operational flexibility, driving efficiency, minimizing costs, and improving customer accessibility. In emerging markets like Kazakhstan, digital transformation directly impacts economic stability, the modernization of industrial sectors, and the acquisition of international competitive advantages. Therefore, this study is intrinsically designed to understand how business enterprises within the country can effectively harness digital capabilities.

2. CONCEPTUAL FRAMEWORK

Digital transformation is the process of restructuring business processes, service delivery methods, and strategic decisions within organizations through the utilization of digital technologies (Vial, 2019). Current research indicates that digital transformation does not merely entail the adoption of technology; rather, it represents the creation of competitive advantages by reshaping organizational culture, internal structures, and the effective utilization of strategic resources (Bharadwaj et al., 2013; Sebastian et al., 2020).

For instance, during the COVID-19 pandemic, numerous multinational companies mitigated operational disruptions and reduced costs by migrating their services to online platforms, thereby fostering higher customer engagement. Market leaders such as Alibaba, Amazon, and Netflix successfully converted digital transformation initiatives into sustainable strategic advantages (Westerman et al., 2014). Similarly, several banks and retail chains in Kazakhstan preserved their market positions by swiftly transitioning to online service delivery. These real-world cases illustrate that digital transformation transcends mere technology, evolving instead into a vital strategic asset.

Digital transformation equips organizations with distinctive advantages, including rapid data processing, operational automation, accelerated decision-making, enhanced customer interaction, and the cultivation of novel business opportunities. Within this framework, integrating an organization's internal resources with digital capabilities paves the way for achieving sustainable competitive advantages (Matt et al., 2015).

The Resource-Based View (RBV) is a foundational theory that explains how an organization can achieve a long-term competitive advantage through its internal resources and capabilities (Barney, 1991). According to this framework, an organization's unique, valuable, rare, and inimitable resources act as the primary drivers of strategic superiority. The RBV theory yields profound relevance within the context of digital transformation. For example, an organization's information systems, analytical platforms, employees' digital literacies, and data analytics capacities collectively function as strategic resources. If an organization manages these assets effectively, it will secure a persistent advantage in the marketplace (Wade & Hulland, 2004).

A number of manufacturing and service-oriented organizations in Kazakhstan have rationally optimized their internal resources to implement digital solutions. A prime example is Kaspi Bank, which automated customer service through its mobile application, substantially increasing customer satisfaction and its overall market share. This stands as a prominent practical demonstration of aligning an organization's resource capabilities with digital transformation objectives.

Competitive advantage refers to an organization's capacity to maintain a more competitive and stable position relative to its rivals in the market (Porter, 2008). Digital transformation serves as a crucial mechanism for securing this advantage. The extant literature underscores that organizations effectively implementing digital technologies significantly enhance their productivity and expand their market presence (Fitzgerald et al., 2014; Chen et al., 2014).

For example, Netflix fundamentally outpaced its global market competitors by pioneering its streaming service. The organization successfully integrated its internal resources—encompassing data analytics, content production, and IT infrastructure—with digital capabilities to establish an enduring competitive advantage. The experiences of e-commerce platforms and online banking institutions in Kazakhstan further validate this theoretical premise (Westerman et al., 2014).

Moreover, research indicates that the ramifications of digital transformation extend far beyond mere technological tools. It remains inextricably linked to organizational culture, administrative decisions, and the innovative capabilities of human capital (Sebastian et al., 2020). For this reason, it is imperative to conceptualize digital transformation as a strategic resource:

- Innovation represents the core element of digital transformation, allowing organizations to develop new products and services, optimize workflows, and refine customer interfaces (Vial, 2019).

- Strategic management entails the rational deployment of organizational resources, establishing clear priorities, and aligning digital capabilities with overarching strategic milestones (Bharadwaj et al., 2013).

Several empirical studies demonstrate that organizations that successfully manage digital transformation markedly improve their market positioning. For instance, Samsung and Huawei leveraged digital technologies to engineer innovative products, thereby outperforming international competitors (Matt et al., 2015). Concurrently, IT companies and startups in Kazakhstan are successfully scaling their market share through digital innovations.

3. METHODOLOGY

The primary objective of this study is to analyze the role of digital transformation in fostering competitive advantages for organizations from a resource-based perspective. In the contemporary business environment, digital technologies have emerged as a critical factor for efficiently organizing corporate activities and consolidating market power. Accordingly, this research focuses on evaluating the avenues through which competitiveness can be augmented via digital integration.

Given that this study is theoretical in nature, the analysis centers on scholarly literature concerning digital transformation and strategic management rather than specific corporate case studies. A research sample comprising scientific articles published in peer-reviewed international journals was selected to form the data core. Literature review and comparative synthesis methods were utilized during data collection and evaluation phases. These qualitative approaches facilitated the identification of the structural dimensions of digital transformation, the strategic role of organizational resources, and their cumulative impact on competitive advantage. Additionally, prominent international practices and empirical examples were systematically reviewed. The limitations of this study stem from its theoretical scope and the bounded number of analyzed literary works. Nonetheless, the chosen reference matrix provides a sufficiently comprehensive lens to address the core research questions.

The study posits the following proposition:

- **P1:** There is a significant relationship between digital transformation and the competitive advantage of organizations.
- **P2:** The level of utilization of digital technologies exerts a positive impact on competitive advantage.
- **P3:** The effective utilization of internal organizational resources facilitates the successful execution of digital transformation initiatives.
- **P4:** Digital transformation positively influences the innovative development of organizations.

4. RESULTS AND DISCUSSION

The overarching purpose of this investigation was to evaluate how digital transformation influences the acquisition of competitive advantage through the lens of the resource-based view. The insights derived from the literature matrix were structured into several focal themes: the impact of digital transformation on organizational efficiency, its role regarding internal resources, its influence on innovative development, and its subsequent effect on market competitiveness.

Within the Resource-Based Approach (RBV), the digital capabilities developed by an organization are not merely technological instruments that increase operational efficiency; they are rare, high-value strategic enterprise resources that are difficult for competitors to imitate (Barney, 1991; Wade & Hulland, 2004). In today's business ecosystem, the “Twin Transition” paradigm necessitates the synchronization of these digital assets with environmental sustainability goals (George et al., 2021). Accordingly, digital capabilities are transforming into proactive, dynamic capabilities that fuel firms' capacity to manage eco-innovation processes and adapt to green transformation (Mikalef et al., 2021). Therefore, strategic resources such as advanced data analytics, cloud computing, and artificial intelligence infrastructure acquired during the digitalization process not only enable businesses to establish a market-oriented advantage but also build corporate resilience and sustainable competitive advantage by minimizing ecological risks.

Particularly in the context of circular economy and resource efficiency, these digital resources act as leverage in critical processes such as product lifecycle tracking, material traceability, and supply chain optimization (Bocken et al., 2016). As noted by Kristoffersen et al. (2020), data transparency achieved through digital capabilities prepares the analytical ground required for waste minimization and the management of closed-loop supply chains. This integration directly aligns with the Natural-Resource-Based View (NRBV) principles developed by Hart (1995), as firms mobilize their digital capabilities as strategic assets to overcome environmental constraints and achieve eco-efficiency. Consequently, the application of digital capabilities to circular business models connects the managerial and operational mechanisms of the twin transformation, guaranteeing long-term success for firms in both financial and sustainability performance.

The findings demonstrate that integrating digital technologies allows organizations to achieve substantial operational efficiencies. As highlighted across the literature, digital transformation enables firms to automate workflows, reduce overhead costs, and elevate service quality. For instance, empirical data shows that organizations leveraging digital platforms exhibit significantly higher productivity compared to those remaining dependent on traditional operational frameworks (Fitzgerald et al., 2014). Furthermore, digital transformation

empowers organizations to execute sophisticated data analysis, thereby accelerating administrative decision-making. By deploying advanced analytical systems and information technologies, firms can rapidly detect market volatility and execute proactive strategic pivots, which directly bolsters organizational sustainability within hyper-competitive landscapes.

The outcomes of this research align closely with the conclusions of contemporary scholars. For instance, Vial (2019) demonstrated that digital transformation not only enhances operational efficiency but also drives the evolution of novel business models. Our study corroborates this finding, emphasizing the mandatory nature of digital tools in maximizing institutional performance.

Furthermore, the study indicates that internal resources act as direct predictors of digital transformation success. In line with the resource-based view, an organization's unique assets and competencies serve as the foundational bedrock of competitive superiority (Barney, 1991). The results show that human capital, technological infrastructure, and managerial expertise are critical prerequisites for the successful execution of digital strategies. For example, employees' digital fluencies and innovative mindsets play a pivotal role during the rollout of digital architectures. This is supported by Wade and Hulland (2004), who argued that information technology resources are vital for building strategic advantages. Our findings reinforce this paradigm, indicating that organizations can fully capture the upside of digital transformation only when their internal resources are rationally aligned.

Additionally, the research indicates that digital transformation positively impacts the innovative trajectory of firms. Digital tools provide organizations with the capability to engineer novel products and services while optimizing internal business models and client interfaces. For example, e-commerce platforms and mobile applications enable seamless customer interactions, allowing firms to respond instantaneously to consumer demand shifts and capture larger market shares. Sebastian et al. (2020) observed that digital transformation significantly expands an organization's innovative capacity and unlocks new strategic horizons, an observation directly backed by our synthesis.

In conclusion, the results substantiate that digital transformation is a critical driver for organizations seeking sustainable competitive advantages. Firms that effectively utilize digital systems can adapt swiftly to market dynamics and better satisfy consumer preferences, thereby strengthening their overall market positioning and ensuring long-term profitability. According to Porter's (2008) generic strategies, organizations can capture competitive advantage via cost leadership or differentiation. Digital technologies powerfully advance both avenues: they simultaneously drive down operational expenditures and facilitate high-value product differentiation. Moreover, digital instruments enable firms to optimize production workflows and achieve superior resource allocation. Chen et al. (2014) confirmed that digital

transformation yields a highly positive impact on financial performance metrics and market share indicators, a view fully supported by our findings. Successful digital adapters are inherently more customer-centric, structurally agile, and capable of executing data-driven risk management strategies, thus securing both short-term and long-term strategic advantages over traditional market competitors.

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VERGİ İDARESİNDE YAPAY ZEKÂ KULLANIMI: DİJİTAL MALİYE YÖNETİMİNİN GELECEĞİ

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Özet

Dijitalleşme süreci, ekonomik faaliyetlerin yapısını dönüştürdüğü kadar kamu mali yönetimi anlayışında da önemli değişimlere yol açmaktadır. Özellikle elektronik ticaretin yaygınlaşması, büyük veri üretim kapasitesinin artması ve dijital ekonomik faaliyetlerin çeşitlenmesi, geleneksel vergi idarelerinin denetim ve hizmet sunum kapasitesini yetersiz hâle getirmiştir. Bu gelişmeler doğrultusunda vergi idareleri; veri temelli, otomasyon odaklı ve yapay zekâ destekli yeni nesil mali yönetim modellerine yönelmektedir. Bu bağlamda ortaya çıkan "Vergi İdaresi 3.0" yaklaşımı, gerçek zamanlı veri işleme, algoritmik risk analizi, dijital platform entegrasyonu ve mükellef odaklı hizmet anlayışını esas alan yeni bir vergi yönetimi paradigmasını ifade etmektedir.

Bu çalışmanın amacı, vergi idarelerinde yapay zekâ kullanımının mevcut ve potansiyel etkilerini inceleyerek dijital maliye yönetiminin geleceğine ilişkin değerlendirmelerde bulunmaktır. Çalışmada öncelikle dijitalleşmenin kamu mali yönetimi üzerindeki dönüştürücü etkileri ele alınmış, ardından yapay zekâ kavramı ve vergi idaresiyle ilişkisi incelenmiştir. Sonrasında Vergi İdaresi 3.0 yaklaşımı çerçevesinde risk analiz sistemleri, büyük veri analitiği, algoritmik denetim mekanizmaları ve otomatik vergi süreçleri değerlendirilmiştir. Ayrıca Türkiye'de Gelir İdaresi Başkanlığı tarafından yürütülen dijital dönüşüm uygulamaları ile yapay zekâ destekli denetim süreçleri analiz edilmiştir.

Çalışmada nitel araştırma yöntemi benimsenmiş; doküman incelemesi ve mukayeseli analiz yöntemlerinden yararlanılmıştır. OECD, IMF ve Birleşmiş Milletler gibi uluslararası kuruluşların raporları ile ulusal literatürde yer alan akademik çalışmalar temel kaynak olarak kullanılmıştır.

Çalışma sonucunda yapay zekâ destekli vergi idarelerinin; vergi uyumunu artırma, kayıt dışı ekonomiyle mücadeleyi güçlendirme, denetim maliyetlerini azaltma ve kamu gelirlerinin sürdürülebilirliğini destekleme potansiyeline sahip olduğu tespit edilmiştir. Bununla birlikte veri güvenliği, algoritmik şeffaflık, hukuki denetim ve mükellef haklarının korunması gibi alanlarda yeni düzenlemelere ihtiyaç duyulduğu sonucuna ulaşılmıştır. Bu çerçevede çalışmanın, dijitalleşme sürecinde sürdürülebilir ve dayanıklı mali yönetim sistemlerinin oluşturulmasına ilişkin literatüre katkı sunması amaçlanmaktadır.

Anahtar Kelimeler: Dijitalleşme, Yapay Zekâ, Vergi İdaresi, Vergi İdaresi 3.0, Dijital Maliye Yönetimi

THE USE OF ARTIFICIAL INTELLIGENCE IN TAX ADMINISTRATION: THE FUTURE OF DIGITAL FISCAL MANAGEMENT

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Abstract

The process of digitalization is not only transforming the structure of economic activities but also leading to significant changes in the approach to public financial management. In particular, the proliferation of e-commerce, the increase in big data generation capacity, and the diversification of digital economic activities have rendered the audit and service delivery capabilities of traditional tax administrations inadequate. In light of these developments, tax administrations are shifting toward new-generation fiscal management models that are data-driven, automation-focused, and supported by artificial intelligence. The "Tax Administration 3.0" approach that has emerged in this context represents a new paradigm of tax management based on real-time data processing, algorithmic risk analysis, digital platform integration, and a taxpayer-centric service philosophy.

The purpose of this study is to assess the future of digital fiscal management by examining the current and potential impacts of artificial intelligence (AI) in tax administrations. The study first addresses the transformative effects of digitalization on public fiscal management, then examines the concept of artificial intelligence and its relationship with tax administration. Subsequently, within the framework of the Tax Administration 3.0 approach, risk analysis systems, big data analytics, algorithmic audit mechanisms, and automated tax processes were evaluated. In addition, digital transformation initiatives carried out by the Turkish Revenue Administration and AI-supported audit processes were analyzed.

The study employed a qualitative research method, utilizing document review and comparative analysis. Reports from international organizations such as the OECD, the IMF, and the United Nations, as well as academic studies in the national literature, were used as primary sources.

The study found that AI-supported tax administrations have the potential to increase tax compliance, strengthen the fight against the informal economy, reduce audit costs, and support the sustainability of public revenues. However, it also concluded that new regulations are needed in areas such as data security, algorithmic transparency, legal oversight, and the protection of taxpayer rights. In this context, the study aims to contribute to the literature on the creation of sustainable and resilient fiscal management systems during the digitalization process.

Keywords: Digitalization, Artificial Intelligence, Tax Administration, Tax Administration 3.0, Digital Fiscal Management

GİRİŞ

Dijitalleşme süreci, ekonomik ve toplumsal yapıda olduğu kadar kamu mali yönetimi anlayışında da köklü dönüşümler meydana getirmiştir. Özellikle veri üretim kapasitesindeki artış, elektronik ticaretin yaygınlaşması, dijital platform ekonomilerinin büyümesi ve sınır aşan ekonomik faaliyetlerin çoğalması, geleneksel vergi idarelerinin işleyişini önemli ölçüde etkilemiştir. Vergi idarelerinin yalnızca vergi toplama fonksiyonunu yerine getiren bürokratik yapılar olmaktan çıkarak veri odaklı, öngörü kapasitesi yüksek ve dijital teknolojilerle entegre çalışan kurumlara dönüşmesi kaçınılmaz hale gelmiştir. OECD tarafından yayımlanan çalışmalarda da vergi idarelerinin dijital dönüşüm yolculuğuna hız verdiği, yeni dijital girişimler ve teknolojik yenilikler aracılığıyla vergi uyumunu artırmayı ve idari yükleri azaltmayı hedeflediği belirtilmektedir.

Kamu yönetiminde dijital dönüşümün en önemli bileşenlerinden biri yapay zekâ teknolojileridir. Yapay zekâ; büyük veri analizi, makine öğrenmesi, doğal dil işleme ve algoritmik karar alma gibi araçlar sayesinde kamu kurumlarının daha etkin, hızlı ve düşük maliyetli hizmet sunmasına olanak tanımaktadır. Birleşmiş Milletler tarafından yayımlanan 2024 E-Government Survey raporunda da yapay zekânın kamu yönetimini daha etkin ve daha duyarlı hale getirme potansiyeline sahip olduğu vurgulanmaktadır. (United Nations, 2024:v).

Vergi idareleri bakımından yapay zekâ teknolojileri; risk analizi, mükellef davranışlarının tahmini, kayıt dışı ekonominin tespiti, vergi kaçakçılığıyla mücadele, denetim süreçlerinin otomasyonu ve vergiye gönüllü uyumun artırılması gibi alanlarda önemli avantajlar sağlamaktadır. Vergi idarelerinde dijital dönüşümün yalnızca teknik bir değişim olmadığı; aynı zamanda yönetsel, hukuki ve kurumsal bir paradigma dönüşümünü ifade ettiği görülmektedir. Türk vergi idaresinin de bu dönüşüm sürecinde önemli ilerlemeler kaydettiği ve dijital dönüşüm olgunluğu bakımından “yerleşik” seviyeye ulaştığı ifade edilmektedir.

Bu çalışmanın amacı, vergi idarelerinde yapay zekâ kullanımının mevcut durumunu ve geleceğe yönelik potansiyel etkilerini incelemektir. Bu kapsamda öncelikle dijitalleşmenin kamu mali yönetimi üzerindeki etkileri ele alınacak, ardından yapay zekâ kavramı ve vergi idaresiyle ilişkisi açıklanacaktır. Sonrasında dünya ve Türkiye örnekleri üzerinden vergi idarelerinde kullanılan yapay zekâ uygulamaları incelenecek; risk analizi, algoritmik denetim ve veri temelli mali yönetim süreçleri değerlendirilecektir. Son bölümde ise yapay zekâ kullanımının vergi uyumu, kamu gelirleri ve mali sürdürülebilirlik üzerindeki etkileri ile veri güvenliği, algoritmik şeffaflık ve mükellef hakları bakımından ortaya çıkardığı sorunlar tartışılacaktır.

1. DİJİTALLEŞME ve KAMU MALİ YÖNETİMİNİN DÖNÜŞÜMÜ

21'inci yüzyılda bilgi ve iletişim teknolojilerinde yaşanan hızlı gelişmeler, ekonomik ve sosyal yapıları olduğu kadar kamu yönetimlerini de önemli ölçüde dönüştürmüştür. Özellikle dijitalleşme sürecinin hız kazanmasıyla birlikte devletlerin hizmet sunum biçimleri değişmiş; kamu yönetiminde veri temelli, hızlı ve elektronik sistemlere dayalı yeni yönetim modelleri ortaya çıkmıştır. Kamu mali yönetimi de bu dönüşümden doğrudan etkilenmiş ve vergi idareleri dijital dönüşüm süreçlerinin merkezinde yer alan kurumlar hâline gelmiştir. Artan veri hacmi, dijital ekonomik faaliyetler, elektronik ticaret işlemleri ve sınır aşan finansal hareketler, geleneksel mali yönetim anlayışının yetersiz kalmasına neden olmuş; bu durum kamu maliyesinde dijitalleşmeyi zorunlu bir politika haline getirmiştir.

Dijitalleşme, en genel anlamıyla verilerin elektronik ortamda işlenebilir hâle gelmesi ve ekonomik-sosyal süreçlerin dijital teknolojiler aracılığıyla yürütülmesi olarak ifade edilmektedir. Bununla birlikte dijitalleşme yalnızca teknik bir dönüşüm olmayıp kamu yönetiminin işleyiş mantığını değiştiren yapısal bir dönüşüm sürecidir. Birleşmiş Milletler tarafından yayımlanan E-Government Survey 2024 raporunda dijital devlet uygulamalarının kamu hizmetlerini daha erişilebilir, kapsayıcı ve sürdürülebilir hâle getirdiği ifade edilmektedir (United Nations, 2024: v-vi). Bu dönüşüm süreci özellikle vergi idarelerinde yoğun biçimde hissedilmektedir.

Vergi idareleri kamu mali yönetiminin temel kurumlarından biridir. Devletin gelir toplama kapasitesi, mali sürdürülebilirliği ve kayıt dışı ekonomiyle mücadele gücü büyük ölçüde vergi idarelerinin etkinliğine bağlıdır. Ancak dijital ekonominin gelişmesiyle birlikte geleneksel vergi yönetimi sistemleri önemli sorunlarla karşı karşıya kalmıştır. Özellikle fiziksel işyeri kavramına dayanan klasik vergilendirme anlayışı, dijital platformlar üzerinden yürütülen ekonomik faaliyetler karşısında yetersiz kalmaya başlamıştır. Bunun yanı sıra artan veri hacmi ve karmaşık ekonomik işlemler, klasik denetim yöntemlerinin etkinliğini azaltmıştır.

Dördüncü Sanayi Devrimi ile birlikte dijitalleşme olgusu vergi idarelerinin işleyişinde de belirgin biçimde kendini göstermiştir (Karataş Durmuş ve Arıtı Erdem, 2023: 226-227). Özellikle akıllı teknolojiler, bulut bilişim sistemleri, robotik uygulamalar ve veri işleme teknolojileri vergi idarelerinin çalışma biçimlerini değiştirmektedir. Geleneksel bürokratik yapılar yerini daha hızlı, veri temelli ve otomasyon odaklı sistemlere bırakmaktadır.

Dijitalleşme süreci kamu mali yönetiminde "dijital devlet" anlayışını güçlendirmiştir. Dijital devlet modeli, kamu hizmetlerinin elektronik ortamda sunulmasını ve devlet-mükellef ilişkilerinin dijital platformlar aracılığıyla yürütülmesini ifade etmektedir. Vergi idareleri açısından bu dönüşüm; elektronik beyanname sistemleri, dijital vergi daireleri, elektronik belge uygulamaları ve çevrim içi ödeme sistemleri gibi uygulamalarla somutlaşmaktadır. OECD tarafından yayımlanan Tax Administration Digitalisation and Digital Transformation

Initiatives raporunda birçok vergi idaresinin kapsamlı dijital dönüşüm programları yürüttüğü ve dijital hizmet altyapılarını geliştirdiği belirtilmektedir (OECD, 2025: 3).

Kamu mali yönetimindeki dijital dönüşümün temel amaçlarından biri vergiye gönüllü uyumun artırılmasıdır. Geleneksel sistemlerde vergi süreçlerinin karmaşık ve zaman alıcı olması, mükelleflerin uyum maliyetlerini artırmakta ve vergi idaresiyle mükellef arasındaki ilişkiyi zorlaştırmaktadır. Dijitalleşme sayesinde ise mükellefler birçok işlemi elektronik ortamda gerçekleştirebilmekte, böylece işlem maliyetleri ve bürokratik yük önemli ölçüde azalmaktadır. OECD Tax Administration 2024 raporunda dijital hizmetlerin mükellef deneyimini geliştirdiği ve vergi uyumunu artırdığı ifade edilmektedir (OECD, 2024: 3-5).

Dijitalleşmenin kamu mali yönetimine etkilerinden biri de veri temelli karar alma süreçlerinin gelişmesidir. Günümüzde vergi idareleri yalnızca beyanname verilerini değil; banka hareketleri, elektronik ticaret işlemleri, POS kayıtları ve dijital ödeme sistemlerinden elde edilen bilgileri de analiz etmektedir. Büyük veri teknolojileri sayesinde milyonlarca işlem çok kısa süre içerisinde değerlendirilebilmekte ve riskli alanlar tespit edilebilmektedir. Bu durum klasik rastgele denetim anlayışından risk odaklı denetim modeline geçişi hızlandırmıştır.

Kamu mali yönetimindeki dijital dönüşüm aynı zamanda yapay zekâ teknolojilerinin kullanımını da beraberinde getirmiştir. Yapay zekâ sistemleri sayesinde vergi idareleri yalnızca geçmiş verileri inceleyen kurumlar olmaktan çıkmakta; geleceğe yönelik tahminlerde bulunan, riskleri önceden belirleyen ve otomatik analiz yapabilen yapılara dönüşmektedir. IMF tarafından yayımlanan “Understanding Artificial Intelligence in Tax and Customs Administration” raporunda yapay zekânın vergi ve gümrük idarelerinde operasyonel etkinliği artırdığı, karar alma süreçlerini hızlandırdığı ve kamu gelirlerinin yönetim kapasitesini güçlendirdiği belirtilmektedir (IMF, 2024:1).

Türkiye’de de kamu mali yönetiminin dijital dönüşüm süreci özellikle Gelir İdaresi Başkanlığının elektronik uygulamalarıyla hız kazanmıştır. E-beyanname, e-fatura, e-defter ve Dijital Vergi Dairesi gibi uygulamalar sayesinde vergi işlemleri büyük ölçüde elektronik ortama taşınmıştır. Gelir İdaresi Başkanlığı Faaliyet Raporu’nda Başkanlığın dijital dönüşüm süreçlerinde öncü rol üstlendiği ve mükelleflere dijital platformlar üzerinden hizmet sunduğu ifade edilmektedir (Gelir İdaresi Başkanlığı, 2025: 2). Bu dönüşüm sayesinde vergi işlemleri hızlanmakta, işlem maliyetleri azalmakta ve denetim kapasitesi güçlenmektedir.

Ancak dijitalleşme süreci bazı sorunları da beraberinde getirmektedir. Özellikle veri güvenliği, kişisel verilerin korunması, teknik altyapı eksiklikleri ve dijital eşitsizlikler kamu mali yönetiminde dikkat edilmesi gereken temel sorun alanlarıdır. Birleşmiş Milletler raporunda dijital kapasite farklılıklarının ülkeler arasında önemli eşitsizlikler yarattığı belirtilmektedir (United Nations, 2024: vii). Bu nedenle dijital dönüşüm süreçlerinin yalnızca

teknolojik yatırımlarla değil; hukuki düzenlemeler, insan kaynağı ve kurumsal kapasiteyle birlikte değerlendirilmesi gerekmektedir.

Sonuç olarak dijitalleşme süreci kamu mali yönetimini köklü biçimde dönüştürmektedir. Vergi idareleri dijital teknolojiler sayesinde daha hızlı, veri temelli ve etkin yapılara dönüşürken; yapay zekâ, büyük veri ve otomasyon sistemleri yeni nesil mali yönetim anlayışının temel unsurları hâline gelmektedir. Bu dönüşüm, kamu gelirlerinin sürdürülebilirliği ve mali yönetimin etkinliği bakımından önemli fırsatlar sunmaktadır.

2. YAPAY ZEKA KAVRAMI ve VERGİ İDARELERİ AÇISINDAN ÖNEMİ

Yapay zekâ teknolojileri, son yıllarda dijital dönüşüm süreçlerinin en önemli unsurlarından biri hâline gelmiştir. Özellikle büyük veri işleme kapasitesinin artması, algoritmik analiz yöntemlerinin gelişmesi ve makine öğrenmesi uygulamalarının yaygınlaşmasıyla birlikte yapay zekâ sistemleri yalnızca özel sektörde değil, kamu yönetiminde de yoğun biçimde kullanılmaya başlanmıştır. Vergi idareleri ise dijitalleşmenin etkilerinin en yoğun hissedildiği kamu kurumları arasında yer almaktadır. Artan veri hacmi, karmaşık ekonomik işlemler ve dijital ekonominin gelişmesi, vergi idarelerini yapay zekâ destekli sistemlere yöneltmiştir.

Yapay zekâ kavramı esas itibarıyla insan zekâsı gerektiren düşünme, öğrenme, problem çözme ve karar verme gibi faaliyetlerin bilgisayar sistemleri tarafından yerine getirilmesini ifade etmektedir. OECD'ye göre yapay zekâ, bilgisayar sistemlerinin öğrenme ve problem çözme gibi normalde insan zekâsı gerektiren görevleri yerine getirme yeteneğidir (OECD, 2020: 3). Benzer biçimde Türkiye'nin Ulusal Yapay Zekâ Stratejisi'nde yapay zekâ; bilgisayarların veya bilgisayar kontrollü sistemlerin insan benzeri faaliyetleri gerçekleştirme kabiliyeti olarak tanımlanmaktadır (Karataş Durmuş ve Arıtı Erdem, 2023: 229).

Yapay zekâ kavramının temelinde insan benzeri düşünme ve rasyonel davranma özellikleri bulunmaktadır. Bu nedenle yapay zekâ yalnızca verilerin dijital ortama aktarılması anlamına gelen dijitalleşmeden farklıdır. Dijitalleşme verilerin bilgisayar tarafından okunabilir hâle getirilmesini ifade ederken, yapay zekâ öğrenebilen, veri analiz edebilen ve karar verebilen daha gelişmiş sistemleri ifade etmektedir (Karataş Durmuş ve Arıtı Erdem, 2023: 230). Bu ayrım özellikle vergi idareleri açısından önem taşımaktadır. Çünkü elektronik belge sistemleri gibi uygulamalar dijitalleşme örneği oluştururken; risk analizi yapan, öğrenen ve tahminde bulunan sistemler yapay zekâ uygulamaları olarak değerlendirilmektedir.

Yapay zekânın gelişim süreci incelendiğinde kavramın ilk kez 1956 yılında Dartmouth Konferansı'nda ortaya çıktığı görülmektedir. Ancak yapay zekânın teorik temelleri daha eskiye dayanmaktadır. Bu alanda yapılan öncü çalışmalar 1943 yılında gerçekleşmiş; 1950 yılında ise yapay sinir ağı sistemlerinin gelişmesiyle makine öğrenmesi kavramı ortaya çıkmıştır (Ömercioğlu, 2024: 1442-1443). Günümüzde ise büyük veri teknolojilerinin

gelişmesi, işlem kapasitesinin artması ve algoritmik sistemlerin yaygınlaşması yapay zekâ uygulamalarının hızlı biçimde gelişmesini sağlamıştır.

Yapay zekâ sistemleri farklı türlerde sınıflandırılabilmektedir. Literatürde genellikle dar/sınırlı yapay zekâ ve kapsamlı/güçlü yapay zekâ ayrımı yapılmaktadır. Dar yapay zekâ belirli görevleri yerine getirebilen sistemleri ifade ederken, kapsamlı yapay zekâ insan benzeri genel düşünme kapasitesine sahip sistemleri ifade etmektedir. Günümüzde kamu yönetiminde ve vergi idarelerinde kullanılan uygulamalar çoğunlukla dar yapay zekâ niteliğindedir. Günümüzde kullanılan yapay zekâ uygulamaları özellikle makine öğrenmesi, yüz tanıma sistemleri, chatbot uygulamaları ve algoritmik analiz mekanizmaları şeklinde ortaya çıkmaktadır (Karataş Durmuş ve Arıtı Erdem, 2023: 232-233).

Vergi idareleri açısından yapay zekânın önemi, büyük miktardaki verinin analiz edilmesini mümkün kılmasından kaynaklanmaktadır. Dijital ekonominin gelişmesiyle birlikte vergi idareleri çok büyük veri setleriyle karşı karşıya kalmıştır. Elektronik ticaret işlemleri, banka kayıtları, elektronik belgeler, POS hareketleri ve dijital ödeme sistemleri gibi alanlardan elde edilen milyonlarca veri insan gücüyle analiz edilemeyecek boyutlara ulaşmıştır. Bu nedenle yapay zekâ destekli sistemler vergi yönetiminde zorunlu hâle gelmiştir.

Vergi idarelerinde yapay zekâ uygulamalarının en önemli kullanım alanlarından biri risk analizidir. Yapay zekâ sistemleri milyonlarca işlem içerisinden olağan dışı hareketleri tespit ederek riskli mükellefleri belirleyebilmektedir. Vergi idarelerinin yapay zekâ uygulamaları özellikle risk değerlendirme, risk puanlaması ve risk yönetimi alanlarında yoğunlaşmaktadır (Karakaş, 2024: 79). Bu sistemler sayesinde vergi kayıp ve kaçağının azaltılması ve denetim kaynaklarının daha etkin kullanılması mümkün hâle gelmektedir.

Yapay zekâ uygulamalarının vergi idareleri açısından bir diğer önemli yönü mükellef hizmetlerinin geliştirilmesidir. Chatbot sistemleri, dijital vergi asistanları ve otomatik yönlendirme mekanizmaları sayesinde mükelleflerin bilgiye erişimi kolaylaşmaktadır. Yapay zekâ uygulamalarının chatbot'lar, dijital asistanlar ve öneri sistemleri gibi çok çeşitli alanlarda kullanılabileceği belirtilmektedir (Karataş Durmuş ve Arıtı Erdem, 2023: 231). Bu durum vergiye gönüllü uyumu artırırken aynı zamanda idari maliyetleri de azaltmaktadır.

Vergi idarelerinde yapay zekâ kullanımının önemli avantajlarından biri de karar alma süreçlerini hızlandırmasıdır. Yapay zekâ sistemleri büyük veri setlerini analiz ederek riskli alanları belirleyebilmekte ve geleceğe yönelik tahminlerde bulunabilmektedir. IMF tarafından yayımlanan "Understanding Artificial Intelligence in Tax and Customs Administration" raporunda yapay zekânın vergi ve gümrük idarelerinde operasyonel etkinliği artırdığı, karar alma süreçlerini güçlendirdiği ve vergi uyumunu geliştirdiği ifade edilmektedir (IMF, 2024, s. 1). Bu nedenle yapay zekâ teknolojileri, modern vergi yönetiminin temel araçlarından biri hâline gelmektedir.

Bununla birlikte yapay zekâ kullanımının bazı riskleri de bulunmaktadır. Özellikle veri güvenliği, kişisel verilerin korunması, algoritmik şeffaflık ve hukuki denetim gibi konular vergi idarelerinde yapay zekâ kullanımının en önemli tartışma alanlarını oluşturmaktadır. Yapay zekâ sistemlerinin yanlış veya eksik veri üzerinden analiz yapması hâlinde mükellef haklarının ihlal edilmesi mümkündür. Ayrıca algoritmaların nasıl karar verdiğinin tam olarak açıklanamaması hukuki güvenlik bakımından sorun yaratabilmektedir.

Vergi idarelerinde yapay zekâ kullanımının gelecekte daha da yaygınlaşması beklenmektedir. Özellikle makine öğrenmesi ve büyük veri teknolojilerindeki gelişmeler, vergi denetimlerinin daha otomatik ve veri temelli hâle gelmesine yol açacaktır. Bu süreçte vergi idareleri yalnızca geçmiş işlemleri denetleyen kurumlar olmaktan çıkacak; riskleri önceden tahmin eden, mükellef davranışlarını analiz eden ve gerçek zamanlı müdahalelerde bulunabilen dijital yapılara dönüşecektir. Dolayısıyla yapay zekâ, dijital maliye yönetiminin en önemli yapı taşlarından biri olarak değerlendirilmektedir.

3. VERGİ İDARESİ 3.0 ve YAPAY ZEKA DESTEKLİ VERGİ YÖNETİMİ

Dijital ekonominin gelişmesiyle birlikte vergi idarelerinin geleneksel işleyiş yapıları önemli ölçüde değişime uğramıştır. Özellikle elektronik ticaretin yaygınlaşması, sınır aşan dijital işlemlerin artması ve ekonomik faaliyetlerin büyük ölçüde veri temelli hâle gelmesi, klasik vergi yönetimi anlayışının yetersiz kalmasına neden olmuştur. Bu dönüşüm süreciyle birlikte ortaya çıkan "Vergi İdaresi 3.0" yaklaşımı, dijital çağın gerektirdiği yeni nesil mali yönetim anlayışını ifade etmektedir. Vergi İdaresi 3.0 modeli; yalnızca geçmiş işlemleri denetleyen geleneksel vergi idaresi anlayışından farklı olarak, gerçek zamanlı veri işleyen, öngörüde bulunabilen, riskleri önceden tespit eden ve mükellef davranışlarını analiz eden dijital vergi yönetim sistemlerini kapsamaktadır.

Vergi İdaresi 3.0 yaklaşımının temelinde, vergi süreçlerinin yalnızca dijital ortama aktarılması değil; aynı zamanda vergi yönetiminin bütüncül biçimde veri temelli ve otomatik çalışan bir yapıya dönüştürülmesi bulunmaktadır. Bu kapsamda OECD Vergi İdaresi Forumu tarafından geliştirilen yaklaşım, elektronik belge sistemleri, dijital platform entegrasyonu ve gerçek zamanlı veri akışıyla desteklenen yeni nesil bir vergi yönetim modelini ifade etmektedir. Dijital dönüşüm süreciyle birlikte vergi idarelerinde geleneksel kâğıt temelli yapılar yerini elektronik ve otomatize süreçlere bırakmakta; bu durum vergi idarelerinin operasyonel yapılarında köklü bir dönüşümü zorunlu hâle getirmektedir (Kaplan Dönmez, 2025: 303).

Vergi İdaresi 3.0 yaklaşımı, dijitalleşmenin vergi idarelerine yansıyan ileri aşamasını temsil etmektedir. Dijitalleşmenin vergi idaresine yansımasıyla birlikte birçok iş ve işlemin dijital ortamda yapılabilmesi mümkün hâle gelmiş ve bu süreç sonucunda "Vergi İdaresi 3.0" kavramı ortaya çıkmıştır (Karataş Durmuş ve Arıtı Erdem, 2023: 227). Bu yeni yaklaşım,

Dördüncü Sanayi Devrimi'nin etkisiyle gelişen dijital teknolojilerin kamu mali yönetimine entegrasyonunu ifade etmektedir.

Vergi İdaresi 3.0 modelinde vergi yönetimi büyük ölçüde veri temelli bir yapıya dönüşmektedir. Geleneksel sistemlerde vergi idareleri çoğunlukla mükellef beyanlarına ve sonradan yapılan incelemelere dayanırken, yeni nesil dijital vergi yönetiminde gerçek zamanlı veri akışı esas alınmaktadır. Bu sistemde elektronik faturalar, banka hareketleri, POS cihazı verileri, elektronik ticaret işlemleri ve dijital ödeme sistemlerinden elde edilen bilgiler sürekli olarak analiz edilmekte ve riskli işlemler anlık biçimde tespit edilebilmektedir. Böylece vergi idaresi yalnızca "sonradan müdahale eden" bir yapı olmaktan çıkarak, riskleri önceden tahmin eden proaktif bir yapıya dönüşmektedir.

Vergi İdaresi 3.0 yaklaşımının temel özelliklerinden biri dijital platform entegrasyonudur. Günümüzde ekonomik faaliyetlerin önemli bir kısmı dijital platformlar üzerinden gerçekleşmektedir. Elektronik ticaret siteleri, dijital ödeme sistemleri, mobil uygulamalar ve çevrim içi hizmet platformları vergi idareleri açısından büyük veri kaynağı oluşturmaktadır. OECD tarafından yayımlanan dijital dönüşüm raporunda uygulama programlama arayüzleri (API), robotik süreç otomasyonu (RPA), blok zinciri teknolojileri ve yapay zekâ uygulamalarının vergi idarelerinin yeni dönüşüm araçları olduğu ifade edilmektedir (OECD, 2025: 3-4). Bu sistemler sayesinde vergi idareleri farklı dijital platformlardan veri çekebilmekte ve ekonomik faaliyetleri gerçek zamanlı takip edebilmektedir.

Vergi İdaresi 3.0 yaklaşımında yapay zekâ destekli analiz sistemleri önemli bir yere sahiptir. Yapay zekâ uygulamaları sayesinde milyonlarca işlem çok kısa süre içerisinde analiz edilebilmekte ve olağan dışı hareketler tespit edilebilmektedir. Yeni teknolojilerin geliştirilmesi ve mali amaçlarla elde edilen bilgilerin artması, vergi idaresinin fonksiyonlarını güçlendirme fırsatı sunmaktadır (Karataş Durmuş ve Arıtı Erdem, 2023: 227). Özellikle makine öğrenmesi algoritmaları geçmiş verilerden öğrenebilme kapasitesine sahip olduğundan, sistemler zaman içerisinde daha doğru risk analizleri yapabilmektedir.

Vergi İdaresi 3.0'ın en önemli unsurlarından biri otomatik vergi süreçleridir. Günümüzde birçok vergisel işlem insan müdahalesine gerek kalmadan elektronik ortamda gerçekleştirilmektedir. E-beyanname, e-fatura, e-defter ve dijital vergi dairesi uygulamaları sayesinde mükellefler vergisel işlemlerini çevrim içi olarak yerine getirebilmektedir. Bu durum hem işlem maliyetlerini azaltmakta hem de vergi süreçlerini hızlandırmaktadır. OECD Tax Administration 2024 raporunda dijital vergi hizmetlerinin mükellef uyumunu artırdığı ve idari maliyetleri azalttığı ifade edilmektedir (OECD, 2024: 3-5).

Vergi İdaresi 3.0 yaklaşımının bir diğer önemli yönü mükellef odaklı hizmet anlayışıdır. Geleneksel vergi idarelerinde mükellefler çoğunlukla denetlenen ve kontrol edilen taraf olarak görülürken, yeni nesil dijital mali yönetimde mükellef memnuniyeti ve gönüllü uyum

ön plana çıkmaktadır. Yapay zekâ destekli chatbot sistemleri, dijital vergi asistanları ve mobil uygulamalar sayesinde mükelleflerin bilgiye erişimi kolaylaşmakta ve işlem süreçleri hızlanmaktadır. Gelir İdaresi Başkanlığı Faaliyet Raporu'nda Dijital Vergi Dairesi ve Dijital Vergi Asistanı uygulamalarıyla mükelleflere zaman ve mekândan bağımsız hizmet sunulduğu belirtilmektedir (Gelir İdaresi Başkanlığı, 2025: 2). Böylece vergiye gönüllü uyumun artırılması hedeflenmektedir.

Vergi İdaresi 3.0 modelinde veri temelli karar alma mekanizmaları da önemli bir yer tutmaktadır. Yapay zekâ sistemleri sayesinde vergi idareleri yalnızca geçmiş verileri değerlendirmekle kalmamakta, aynı zamanda geleceğe yönelik tahminlerde de bulunabilmektedir. Riskli sektörlerin belirlenmesi, vergi kayıp ve kaçağının yoğunlaştığı alanların tespiti ve mükellef davranışlarının öngörülmesi bu sistemler sayesinde mümkün hâle gelmektedir. IMF tarafından yayımlanan yapay zekâ raporunda, yapay zekâ teknolojilerinin vergi ve gümrük idarelerinde operasyonel etkinliği artırdığı ve karar alma süreçlerini güçlendirdiği ifade edilmektedir (IMF, 2024: 1).

Bu dönüşüm süreci kamu mali yönetimine önemli avantajlar sağlamaktadır. Öncelikle vergi kayıp ve kaçağının azaltılması mümkün hâle gelmektedir. Risk analiz sistemleri sayesinde kayıt dışı faaliyetler daha kolay tespit edilmekte ve sahte belge düzenleme faaliyetleriyle mücadele güçlenmektedir. Ayrıca dijital denetim uygulamaları sayesinde denetim maliyetleri düşmekte ve insan kaynağı daha etkin kullanılabilmektedir. Bunun yanında otomatik işlem süreçleri vergi tahsilat oranlarını artırmakta ve mükelleflerin uyum maliyetlerini azaltmaktadır.

Vergi İdaresi 3.0 yaklaşımının temelinde "risk odaklı denetim" anlayışı bulunmaktadır. Geleneksel sistemlerde tüm mükelleflerin ayrıntılı biçimde denetlenmesi mümkün olmadığından denetim kapasitesi sınırlı kalmaktadır. Yapay zekâ destekli sistemler ise milyonlarca işlem arasından riskli örüntüleri tespit ederek denetim kaynaklarının daha etkin kullanılmasını sağlamaktadır. Yapay zekâ uygulamaları özellikle risk değerlendirme, risk puanlaması ve risk yönetimi alanlarında yoğunlaşmaktadır (Karakaş, 2024: 79). Böylece vergi idareleri yüksek risk taşıyan mükelleflere odaklanabilmekte ve denetim etkinliği artırılmaktadır.

Sonuç olarak Vergi İdaresi 3.0 yaklaşımı, dijital ekonominin gerektirdiği yeni nesil mali yönetim modelini temsil etmektedir. Yapay zekâ destekli vergi yönetim sistemleri sayesinde gerçek zamanlı veri işleme, risk analizi, otomatik süreç yönetimi ve mükellef odaklı hizmet anlayışı güçlenmektedir. Bu dönüşüm vergi idarelerinin etkinliğini artırırken aynı zamanda kamu gelirlerinin sürdürülebilirliğine de katkı sağlamaktadır. Bununla birlikte veri güvenliği, algoritmik şeffaflık ve hukuki denetim gibi konular gelecekte bu sistemlerin en önemli tartışma alanları olmaya devam edecektir.

4. VERGİ DENETİMLERİNDE YAPAY ZEKA KULLANIMI

Vergi denetimleri, vergi sisteminin etkin biçimde işlemesini sağlayan temel araçlardan biridir. Vergi kayıp ve kaçağının önlenmesi, kayıt dışı ekonomiyle mücadele edilmesi ve vergiye gönüllü uyumun artırılması bakımından denetim mekanizmaları büyük önem taşımaktadır. Ancak geleneksel vergi denetim yöntemleri; yüksek maliyet, zaman kaybı, sınırlı insan kaynağı ve artan veri hacmi gibi nedenlerle günümüz dijital ekonomisinin ihtiyaçlarını karşılamakta yetersiz kalmaktadır. Özellikle dijitalleşmenin hız kazanmasıyla birlikte ekonomik faaliyetlerin elektronik ortama taşınması, vergi idarelerinin klasik denetim yöntemlerinden veri temelli dijital denetim sistemlerine yönelmesine neden olmuştur.

Vergi denetimlerinde dijitalleşme süreci, elektronik belge sistemlerinin yaygınlaşmasıyla birlikte hız kazanmıştır. Elektronik fatura, elektronik defter ve elektronik arşiv uygulamaları sayesinde vergi idareleri çok büyük miktarda veriye anlık olarak erişebilmektedir. Vergilendirme işlemlerinin dijitalleşmesi ve yapay zekâ teknolojilerinin vergi idaresi sistemlerine adapte edilmesi sayesinde işlemler daha hızlı, düşük maliyetli ve doğru biçimde gerçekleştirilebilmektedir (Ömercioğlu, 2024: 1439-1440). Bu durum vergi denetimlerinin kapsamını ve niteliğini önemli ölçüde değiştirmiştir.

Vergi denetimlerinde yapay zekâ kullanımının temel amacı, riskli mükelleflerin daha hızlı ve doğru biçimde tespit edilmesini sağlamaktır. Geleneksel denetim yöntemlerinde denetçiler çoğunlukla sınırlı veri üzerinden değerlendirme yaparken, yapay zekâ destekli sistemler milyonlarca işlemi aynı anda analiz edebilmektedir. Bu sistemler sayesinde olağan dışı finansal hareketler, sahte belge düzenleme faaliyetleri ve vergi kaçırma ihtimali taşıyan işlemler otomatik olarak belirlenebilmektedir. Yapay zekâ destekli vergi denetim sistemlerinin detaylı risk analizleri yapabildiğini ve vergi kaçırma potansiyeli bulunan mükelleflerin tespit edilmesine yardımcı olduğunu ifade etmektedir (Ömercioğlu, 2024: 1440-1441).

Yapay zekâ destekli vergi denetimlerinde en yaygın kullanılan yöntemlerden biri risk analiz sistemleridir. Risk analizi uygulamaları, mükelleflerin davranış biçimlerini inceleyerek olağan dışı hareketleri tespit etmektedir. Bu sistemlerde mükelleflerin geçmiş beyannameleri, banka kayıtları, POS hareketleri, elektronik belge verileri ve sektör ortalamaları birlikte analiz edilmektedir. Özellikle beyan edilen gelir ile harcamalar arasındaki uyumsuzluklar, sektör ortalamalarının dışında kalan kâr marjları, sahte fatura zincirleri ve şüpheli para hareketleri algoritmalar aracılığıyla belirlenebilmektedir. Karakaş'a göre yapay zekâ uygulamaları özellikle risk değerlendirme, risk puanlaması ve risk yönetimi alanlarında yoğunlaşmaktadır (Karakaş, 2024: 79). Bu sistemler sayesinde vergi idareleri denetim kaynaklarını daha etkin kullanabilmekte ve yüksek riskli alanlara odaklanabilmektedir.

Vergi denetimlerinde yapay zekâ kullanımının temel unsurlarından biri büyük veri analitiğidir. Günümüzde vergi idareleri yalnızca beyanname verilerini değil; banka kayıtlarını, elektronik ticaret işlemlerini, sosyal medya hareketlerini, POS cihazı verilerini, elektronik belgeleri ve dijital ödeme sistemlerinden elde edilen bilgileri de analiz etmektedir. Dijital ekonomik faaliyetlerin artmasıyla birlikte oluşan veri miktarı insan gücüyle analiz edilemeyecek boyutlara ulaşmıştır. Bu nedenle yapay zekâ destekli büyük veri sistemleri vergi idareleri açısından zorunlu hâle gelmiştir.

Dijitalleşme süreciyle birlikte vergi idarelerinin gündeminde uygulama programlama arayüzleri (API), robotik süreç otomasyonu, blok zinciri ve yapay zekâ gibi çok çeşitli teknolojiler yer almaktadır (Karataş Durmuş ve Arıtı Erdem, 2023: 227). Bu teknolojiler sayesinde vergi idareleri daha geniş veri setlerine erişebilmekte ve nokta atışı risk analizleri gerçekleştirebilmektedir. Özellikle makine öğrenmesi algoritmaları geçmiş denetim sonuçlarından öğrenme kapasitesine sahip olduğundan, sistemlerin hata payı zamanla azalmaktadır.

Vergi denetimlerinde yapay zekâ kullanımının bir diğer önemli boyutu dijital denetim uygulamalarıdır. Elektronik ortamda tutulan defter ve belgeler sayesinde vergi incelemeleri uzaktan ve çevrimiçi biçimde yapılabilmektedir. Ömercioğlu, teknolojik gelişmeler sayesinde denetim işlemlerinin elektronik ortamda gerçekleştirilebildiğini ve dijital denetim sistemlerinin klasik vergi incelemelerinin yerini almaya başladığını ifade etmektedir (Ömercioğlu, 2024: 1448). Bu dönüşüm, vergi denetim süreçlerinde hız ve maliyet avantajı sağlamaktadır.

Vergi denetimlerinde yapay zekâ kullanımının geleceğe yönelik en dikkat çekici yönlerinden biri otonom denetim sistemleridir. Literatürde yapay zekâ teknolojilerinin ilerleyen dönemde tam otonom vergi denetimlerini mümkün kılabileceği ifade edilmektedir. Ömercioğlu, gelecekte vergi denetimlerinin doğrudan yapay zekâ sistemleri tarafından yürütülebileceğini ve insan unsurunun minimum seviyeye indirgenebileceğini belirtmektedir (Ömercioğlu, 2024: 1442). Böyle bir sistemde yapay zekâ algoritmaları; verileri analiz edecek, risk puanı oluşturacak, inceleme başlatacak ve hatta denetim raporlarını hazırlayabilecektir.

Ancak tam otonom denetim sistemleri önemli hukuki ve etik sorunları da beraberinde getirmektedir. Özellikle algoritmaların verdiği kararların nasıl denetleneceği, mükellef haklarının nasıl korunacağı ve yapay zekâ sistemlerinin hukuki sorumluluğunun nasıl belirleneceği önemli tartışma alanlarıdır. Yapay zekâ sistemlerinin kullandığı veri setlerinin güvenliği ve kişisel verilerin korunması da kritik öneme sahiptir. Ömercioğlu, büyük verinin oluşturulması sürecinde veri güvenliği ve mahremiyetin sağlanmasının zorunlu olduğunu ifade etmektedir (Ömercioğlu, 2024, s. 1440).

Bunun yanı sıra algoritmik karar alma süreçlerinin şeffaf olmaması, vergi hukukunun temel ilkeleri bakımından sorun yaratabilmektedir. Yapay zekâ sistemlerinin "kara kutu" biçiminde çalışması, mükelleflerin kendileri hakkında verilen kararların gerekçelerini anlayamamalarına yol açabilir. Bu durum hukuki güvenlik ve verginin yasallığı ilkesi bakımından dikkatle değerlendirilmesi gereken bir meseledir. Ayrıca farklı algoritmaların aynı olay hakkında farklı sonuçlara ulaşması, vergi uyuşmazlıklarının artmasına neden olabilir. Gelecekte vergi uyuşmazlıklarının yapay zekâ sistemleri arasındaki yorum farklılıklarından kaynaklanabileceği düşünülmektedir (Ömercioğlu, 2024, s. 1440).

Sonuç olarak yapay zekâ teknolojileri, vergi denetim süreçlerinde etkinliği artıran ve mali yönetimin dijital dönüşümünü hızlandıran önemli araçlar hâline gelmiştir. Risk analizi, büyük veri analitiği ve dijital denetim sistemleri sayesinde vergi kayıp ve kaçağının azaltılması mümkün hâle gelmektedir. Bununla birlikte yapay zekâ destekli denetim sistemlerinin hukuki denetime açık, şeffaf ve mükellef haklarını koruyacak biçimde geliştirilmesi büyük önem taşımaktadır.

5. TÜRKİYE'DE VERGİ İDARESİNİN DİJİTAL DÖNÜŞÜMÜ ve YAPAY ZEKA UYGULAMALARI

Kamu yönetiminde dijitalleşme sürecinin hız kazanması, Türkiye'de vergi idaresinin de teknolojik dönüşümünü zorunlu hâle getirmiştir. Özellikle bilgi ve iletişim teknolojilerindeki gelişmeler, vergi idarelerinin klasik bürokratik yapılarının değişmesine yol açmış; elektronik vergilendirme sistemleri, veri analitiği ve yapay zekâ destekli uygulamalar Türk vergi sisteminin temel bileşenleri arasına girmiştir. Günümüzde Gelir İdaresi Başkanlığı (GİB), dijital dönüşüm süreçlerini yalnızca hizmet sunumunu kolaylaştıran teknik uygulamalar olarak değil, aynı zamanda vergiye gönüllü uyumu artıran ve kayıt dışı ekonomiyle mücadeleyi güçlendiren stratejik araçlar olarak değerlendirmektedir.

Vergi idarelerinin dijital dönüşümü, kamu mali yönetimindeki genel dijitalleşme eğiliminin bir sonucu olarak ortaya çıkmıştır. "Dijital devlet" anlayışının gelişmesiyle birlikte kamu kurumlarının elektronik ortamda hizmet sunması yaygınlaşmış ve bu durum vergi idarelerinde de köklü değişimlere yol açmıştır. Dijital dönüşüm süreci, vergi idarelerinde "hızlı" ve "acil" bir değişimi zorunlu kılmaktadır (Keskin Çakmak, 2025: 215-216). Vergi idarelerinin dijitalleşmesi yalnızca teknolojik bir yenilik değil; aynı zamanda mali yönetim anlayışının veri temelli bir yapıya dönüşmesini ifade etmektedir.

Türkiye'de vergi idaresinin dijitalleşme süreci özellikle 2000'li yıllardan sonra hız kazanmıştır. Elektronik beyanname sistemi, e-fatura, e-defter, e-arşiv, elektronik yoklama ve dijital vergi dairesi uygulamaları bu dönüşümün temel unsurlarını oluşturmaktadır. Gelir İdaresi Başkanlığı Faaliyet Raporu'nda Başkanlığın "kamuda dijital dönüşümün öncüsü" olduğu ifade edilmekte; Dijital Vergi Dairesi, GİB Mobil ve Dijital Vergi Asistanı gibi

uygulamalar sayesinde mükelleflere zaman ve mekândan bağımsız hizmet sunulduğu belirtilmektedir (Gelir İdaresi Başkanlığı, 2025: 2). Bu uygulamalar sayesinde mükellefler birçok vergisel işlemi fiziksel vergi dairesine gitmeden gerçekleştirebilmekte, böylece işlem maliyetleri önemli ölçüde azalmaktadır.

Türkiye'de dijital vergi idaresinin gelişiminde "Vergi İdaresi 3.0" yaklaşımı önemli bir yere sahiptir. Vergi İdaresi 3.0, dijitalleşmenin ileri aşamasını temsil eden; büyük veri, yapay zekâ, API sistemleri ve otomasyon teknolojilerinin vergi süreçlerine entegre edildiği yeni nesil vergi yönetim modelidir. Dijitalleşme ile birlikte vergi idareleri artık yalnızca denetim yapan kurumlar olmaktan çıkmakta; verginin mükelleflerin ekonomik yaşamına gerçek zamanlı entegre edildiği sistemlere dönüşmektedir (Karataş Durmuş ve Arıtı Erdem, 2023: 227). Bu yaklaşım, vergiye gönüllü uyumu artırmayı ve denetim süreçlerini daha etkin hâle getirmeyi amaçlamaktadır.

Türkiye'de yapay zekâ destekli vergi uygulamalarının temel kullanım alanlarından biri risk analiz sistemleridir. Risk analiz merkezleri sayesinde milyonlarca mükellef verisi elektronik ortamda analiz edilmekte ve riskli görülen işlemler otomatik olarak belirlenebilmektedir. Özellikle e-fatura ve e-defter sistemlerinden elde edilen büyük veri setleri, yapay zekâ destekli analiz programları aracılığıyla değerlendirilmekte ve vergi kaçırma ihtimali taşıyan mükellefler tespit edilmektedir. Bu durum klasik rastgele denetim anlayışından risk odaklı denetim modeline geçişi hızlandırmıştır.

Vergi denetimlerinde yapay zekâ kullanımının temel amacı, denetim kaynaklarının daha etkin kullanılmasını sağlamaktır. Yapay zekâ destekli vergi denetim sistemleri, detaylı risk analizi yapabilmekte ve vergi kaçırma potansiyeli bulunan mükellefleri belirleyebilmektedir (Ömercioğlu, 2024: 1440-1441). Bu sistemler sayesinde sahte belge düzenleme, kayıt dışı faaliyetler ve olağan dışı finansal hareketler daha hızlı biçimde tespit edilebilmektedir.

Türkiye'de dijitalleşmenin önemli çıktılarından biri de elektronik belge sistemlerinin yaygınlaşmasıdır. Elektronik fatura ve elektronik defter uygulamaları sayesinde vergi idaresi mükellef işlemlerini anlık olarak takip edebilmekte ve büyük veri analitiğinden yararlanabilmektedir. Dijital denetim uygulamaları sayesinde fiziksel belge incelemelerinin yerini elektronik analiz sistemleri almaya başlamış ve elektronik ortamda tutulan defter ve belgelerin dijital vergi denetimi mümkün hâle gelmiştir (Ömercioğlu, 2024: 1448). Böylece vergi incelemeleri daha hızlı yürütülmekte ve denetim maliyetleri azaltılmaktadır.

Türk vergi idaresinin dijital dönüşüm sürecinde mükellef hizmetleri de önemli ölçüde değişmiştir. Dijital Vergi Asistanı (GİBİ), chatbot teknolojileri ve mobil uygulamalar sayesinde mükelleflerin bilgiye erişimi kolaylaşmıştır. Yapay zekâ destekli bu sistemler mükellef sorularına otomatik yanıt verebilmekte, yönlendirme yapabilmekte ve işlem

süreçlerini hızlandırabilmektedir. Bu durum hem vergi idaresinin iş yükünü azaltmakta hem de mükellef memnuniyetini artırmaktadır.

OECD tarafından yayımlanan dijital dönüşüm raporunda, birçok vergi idaresinin dijital teknolojileri kullanarak vergi uyumunu artırmaya ve idari yükleri azaltmaya çalıştığı belirtilmektedir (OECD, 2025: 3). Türkiye'nin de bu küresel dönüşüm sürecine uyum sağlayarak dijital vergi uygulamalarını yaygınlaştırdığı görülmektedir. Özellikle son yıllarda elektronik hizmet altyapısının genişletilmesi, mobil uygulamaların geliştirilmesi ve veri temelli analiz sistemlerinin güçlendirilmesi, Türk vergi idaresinin dijital olgunluk seviyesini artırmıştır.

Bugün Türk vergi idaresinin dijital dönüşüm bakımından genel olarak "yerleşik" seviyede bulunduğunu ifade edilmektedir (Keskin Çakmak, 2025: 220-221). Bununla birlikte yapay zekâ teknolojilerinin gelişmesiyle birlikte Türk vergi idaresinin gelecekte daha ileri düzey otomasyon sistemlerine yönelmesi beklenmektedir. Özellikle gerçek zamanlı denetim, algoritmik risk analizi ve otomatik vergi uyum sistemleri önümüzdeki dönemde daha fazla önem kazanacaktır.

Ancak Türkiye'de vergi idaresinin dijital dönüşüm süreci bazı sorunları da beraberinde getirmektedir. Veri güvenliği, kişisel verilerin korunması, teknik altyapı eksiklikleri ve algoritmik şeffaflık gibi konular bu süreçte dikkat edilmesi gereken temel alanlardır. Yapay zekâ destekli sistemlerin etkin çalışabilmesi için yüksek kaliteli veri altyapısına, uzman insan kaynağına ve güçlü hukuki düzenlemelere ihtiyaç bulunmaktadır. Dolayısıyla Türkiye'de dijital vergi idaresinin geleceği, yalnızca teknolojik kapasitenin geliştirilmesine değil; aynı zamanda hukuki ve kurumsal altyapının güçlendirilmesine de bağlıdır.

6. YAPAY ZEKA KULLANIMININ VERGİ UYUMUNA ve KAMU GELİRLERİNE ETKİSİ

Dijitalleşmenin kamu mali yönetiminde yarattığı dönüşüm, vergi idarelerinin işleyişini yalnızca teknik açıdan değil, mali kapasite ve vergi uyumu bakımından da önemli ölçüde değiştirmiştir. Özellikle yapay zekâ teknolojilerinin vergi süreçlerine entegre edilmesiyle birlikte vergi idareleri; daha hızlı veri işleyebilen, riskleri önceden tespit edebilen ve denetim kaynaklarını daha etkin kullanabilen yapılar hâline dönüşmektedir. Bu süreç, vergi uyumunun artırılması ve kamu gelirlerinin sürdürülebilirliğinin sağlanması bakımından stratejik bir önem taşımaktadır.

Vergi uyumu, mükelleflerin vergiye ilişkin yükümlülüklerini zamanında ve doğru biçimde yerine getirmesini ifade etmektedir. Geleneksel vergi idarelerinde vergi uyumunun sağlanması çoğunlukla fiziki denetimlere ve sonradan kontrol mekanizmalarına dayanırken, dijital vergi idarelerinde gerçek zamanlı analiz ve otomatik kontrol sistemleri ön plana

çıkmaktadır. OECD tarafından yayımlanan Tax Administration 2024 raporunda, e-beyanname, e-ödeme, API sistemleri ve yapay zekâ uygulamalarının vergi idarelerinde yaygınlaşmasının vergi süreçlerini hızlandırdığı ve idari etkinliği artırdığı düşünülmektedir (OECD, 2024: 3-4).

Yapay zekâ destekli sistemlerin vergi uyumu üzerindeki en önemli etkilerinden biri risk odaklı denetim kapasitesini geliştirmesidir. Geleneksel denetim sistemlerinde riskli mükelleflerin belirlenmesi çoğunlukla insan analizine dayanmakta ve bu durum hem zaman kaybına hem de kaynak israfına yol açmaktadır. Oysa yapay zekâ sistemleri milyonlarca işlem içerisinden olağan dışı hareketleri çok kısa süre içerisinde tespit edebilmektedir. Bu durum özellikle sahte belge düzenleme, kayıt dışı faaliyetler ve düşük matrah beyanı gibi risklerin belirlenmesini kolaylaştırmaktadır. Vergi idarelerinde yapay zekâ uygulamaları özellikle risk değerlendirme, risk analizi ve risk puanlaması alanlarında yoğunlaşmaktadır (Karakaş, 2024, s. 79).

Vergi uyumunun artırılmasında büyük veri analitiği önemli bir rol oynamaktadır. Günümüzde dijital ekonomik faaliyetlerin artmasıyla birlikte vergi idareleri çok büyük miktarda veriyle karşı karşıya kalmaktadır. E-fatura, e-defter, banka kayıtları, POS hareketleri, elektronik ticaret verileri ve sosyal medya hareketleri gibi çok çeşitli kaynaklardan elde edilen bilgiler, yapay zekâ sistemleri tarafından analiz edilerek mükellef davranışları tahmin edilmektedir. Vergi İdaresi 3.0 yaklaşımında bu durum "verginin mükelleflerin günlük ekonomik faaliyetlerine entegre edilmesi" şeklinde ifade edilmektedir (Karataş Durmuş ve Arıtı Erdem, 2023: 227-228).

Yapay zekâ sistemleri yalnızca denetim süreçlerini değil, mükellef hizmetlerini de geliştirmektedir. Dijital asistanlar, chatbot uygulamaları ve otomatik yönlendirme sistemleri sayesinde mükelleflerin bilgiye erişim maliyetleri düşmekte ve vergiye gönüllü uyum artmaktadır. Gelir İdaresi Başkanlığı Faaliyet Raporu'nda Dijital Vergi Dairesi, GİB Mobil ve Dijital Vergi Asistanı gibi uygulamaların mükellef hizmetlerinde aktif biçimde kullanıldığı belirtilmektedir (Gelir İdaresi Başkanlığı, 2025: 2). Bu uygulamalar sayesinde mükellefler birçok işlemi fiziksel vergi dairesine gitmeden gerçekleştirebilmekte, böylece işlem maliyetleri ve bürokratik yük azalmaktadır.

Yapay zekânın kamu gelirleri üzerindeki etkisi de oldukça önemlidir. Vergi kayıp ve kaçağının azaltılması, kamu gelirlerinin sürdürülebilirliği bakımından kritik bir unsurdur. Özellikle kayıt dışı ekonomiyle mücadelede yapay zekâ destekli analiz sistemleri önemli avantajlar sağlamaktadır. Gelir İdaresi Başkanlığı'nın risk analizleriyle desteklenmiş analitik yaklaşımlar kullandığı ve kayıt dışı ekonomiyle mücadelede dijital yöntemlerden yararlandığı ifade edilmektedir (Gelir İdaresi Başkanlığı, 2025: 2). Böylece denetim kapasitesi daha etkin kullanılmakta ve kamu gelirlerinin tahsil oranı artmaktadır.

IMF tarafından yayımlanan "Understanding Artificial Intelligence in Tax and Customs Administration" raporunda yapay zekânın vergi ve gümrük idarelerinde operasyonel etkinliği artırdığı, karar alma süreçlerini hızlandırdığı ve vergi uyumunu geliştirdiği belirtilmektedir (IMF, 2024: 1). Bu durum kamu mali yönetiminde mali kapasitenin güçlenmesine katkı sağlamaktadır. Özellikle gelişmekte olan ülkelerde sınırlı insan kaynağına rağmen daha geniş mükellef kitlesinin denetlenebilmesi, yapay zekâ teknolojileri sayesinde mümkün hâle gelmektedir.

Öte yandan yapay zekâ destekli sistemlerin gelecekte vergi idarelerinin organizasyon yapısını da değiştirmesi beklenmektedir. Dijitalleşmenin ilerlemesiyle birlikte vergi idareleri daha az bürokratik, daha veri temelli ve daha otomatik çalışan yapılara dönüşmektedir. OECD tarafından hazırlanan dijital dönüşüm raporunda birçok vergi idaresinin kapsamlı dijital dönüşüm süreçlerine yöneldiği ifade edilmektedir (OECD, 2025: 3). Bu dönüşüm, vergi yönetiminde hız, etkinlik ve mali sürdürülebilirlik bakımından önemli fırsatlar ortaya çıkarmaktadır.

Ancak yapay zekâ sistemlerinin vergi uyumu üzerindeki etkileri yalnızca olumlu yönleriyle değerlendirilmemelidir. Yapay zekâ destekli analizlerin yanlış veri setleriyle çalışması hâlinde hatalı risk skorlamaları ortaya çıkabilmekte ve bu durum mükellef hakları bakımından sorun yaratabilmektedir. Dolayısıyla yapay zekâ sistemlerinin insan denetiminden tamamen bağımsız şekilde çalışması yerine, karar destek sistemi olarak değerlendirilmesi daha uygun görünmektedir.

7. YAPAY ZEKA KULLANIMININ HUKUKİ ve ETİK BOYUTU

Vergi idarelerinde yapay zekâ kullanımının yaygınlaşması, önemli avantajlar sağlamakla birlikte çeşitli hukuki ve etik sorunları da gündeme getirmektedir. Özellikle büyük veri kullanımının yaygınlaşmasıyla birlikte kişisel verilerin korunması, veri güvenliği, algoritmik şeffaflık ve mükellef haklarının korunması gibi meseleler kamu mali yönetiminin temel tartışma alanlarından biri hâline gelmiştir.

Yapay zekâ sistemleri çok büyük miktarda veriyi analiz ederek karar alma süreçlerine katkı sağlamaktadır. Ancak bu durum aynı zamanda kişisel verilerin yoğun biçimde işlenmesi anlamına gelmektedir. Vergi idareleri; banka kayıtları, elektronik ticaret verileri, dijital ödeme sistemleri ve finansal hareketler gibi oldukça hassas verilere erişebilmektedir. Bu nedenle veri güvenliği meselesi, yapay zekâ destekli mali yönetim sistemlerinin en kritik unsurlarından biridir. Otonom vergi denetimine kaynak oluşturacak büyük verinin oluşturulmasında veri güvenliği ve mahremiyetin sağlanmasının zorunlu olduğunu düşünülmektedir (Ömercioğlu, 2024: 1440).

Yapay zekâ sistemlerinin hukuki açıdan en tartışmalı yönlerinden biri algoritmik karar alma süreçleridir. Geleneksel vergi denetimlerinde kararlar insan denetçiler tarafından alınırken, yapay zekâ sistemlerinde algoritmalar belirleyici rol üstlenmektedir. Bu durum "algoritmik şeffaflık" sorununu ortaya çıkarmaktadır. Çünkü birçok yapay zekâ sistemi "kara kutu" şeklinde çalışmakta ve sistemin nasıl karar verdiği tam olarak açıklanamamaktadır. Vergi incelemesi gibi hukuki sonuç doğuran işlemlerde bu durum ciddi sorunlara yol açabilir. Gerçekten de yapay zekâ sistemlerinin hangi ölçüde özerk hareket edeceği ve hangi kararların insan kontrolüne tabi olması gerektiği konusu hâlen net değildir.

Vergi hukukunun temel ilkeleri bakımından da çeşitli sorunlar ortaya çıkmaktadır. Verginin yasallığı ilkesi gereği vergisel işlemlerin açık ve belirli hukuk kurallarına dayanması gerekmektedir. Ancak yapay zekâ sistemlerinin kendi öğrenme süreçleri doğrultusunda farklı sonuçlar üretmesi, hukuki öngörülebilirlik bakımından sorun yaratabilir. Özellikle farklı algoritmaların aynı olay hakkında farklı sonuçlara ulaşması hâlinde hukuki güvenlik ilkesi zedelenebilir. Gelecekte vergi uyuşmazlıklarının yapay zekâ programları arasındaki yorum farklılıklarından kaynaklanabileceği düşünülmektedir (Ömercioğlu, 2024: 1440).

Yapay zekâ kullanımının etik boyutlarından biri de ayrımcılık riskidir. Algoritmalar geçmiş veriler üzerinden çalıştığından, veri setlerindeki önyargılar sistem tarafından yeniden üretilebilmektedir. Bu durum bazı mükellef gruplarının sistem tarafından daha yüksek riskli olarak değerlendirilmesine yol açabilir. Özellikle otomatik risk puanlama sistemlerinde bu sorun önem kazanmaktadır.

Birleşmiş Milletler E-Government Survey 2024 raporunda dijital dönüşüm süreçlerinin ülkeler arasında kapasite farklılıkları yarattığı ve dijital uçurumun önemli bir sorun olmaya devam ettiği belirtilmektedir (United Nations, 2024, s. v). Benzer biçimde yapay zekâ teknolojilerine erişim ve bu sistemleri etkin kullanabilme kapasitesi bakımından da ülkeler arasında ciddi eşitsizlikler bulunmaktadır. Bu durum özellikle gelişmekte olan ülkelerin dijital mali yönetim kapasitesini sınırlayabilmektedir.

Vergi idarelerinde yapay zekâ kullanımının bir diğer önemli boyutu insan unsurunun dönüşümüdür. Dijitalleşmenin ilerlemesiyle birlikte birçok rutin işlem otomatik sistemler tarafından gerçekleştirilmektedir. Bu durum vergi idarelerinde çalışan personelin niteliğini değiştirmekte ve veri analitiği, yazılım yönetimi ve algoritmik denetim gibi yeni uzmanlık alanlarını ön plana çıkarmaktadır. Bununla birlikte tamamen otonom vergi denetimi sistemlerinin uygulanması hâlinde insan denetiminin azalması, idarenin hesap verebilirliği bakımından yeni tartışmalar yaratabilir.

Sonuç olarak yapay zekâ teknolojileri vergi idarelerinin etkinliğini artırma potansiyeline sahip olmakla birlikte, bu teknolojilerin hukuki ve etik sınırlar içerisinde kullanılması büyük önem taşımaktadır. Veri güvenliği, algoritmik şeffaflık, hukuki denetim ve mükellef haklarının

korunması sağlanmadığı takdirde yapay zekâ uygulamaları kamu mali yönetiminde güven sorunlarına yol açabilir. Bu nedenle gelecekte yapay zekâ destekli vergi idarelerinin başarısı yalnızca teknolojik kapasiteye değil; aynı zamanda güçlü hukuki düzenlemelere, etik standartlara ve demokratik denetim mekanizmalarına bağlı olacaktır.

8. SONUÇ

Dijitalleşme süreci, kamu mali yönetimi anlayışında köklü bir dönüşüm meydana getirmiş ve vergi idarelerinin işleyiş yapısını önemli ölçüde değiştirmiştir. Özellikle büyük veri üretim kapasitesindeki artış, elektronik ticaretin yaygınlaşması, dijital ekonomik faaliyetlerin çeşitlenmesi ve sınır aşan finansal işlemlerin çoğalması, geleneksel vergi yönetimi modellerinin yetersiz kalmasına neden olmuştur. Bu gelişmeler doğrultusunda vergi idareleri; veri temelli, otomasyon odaklı ve yapay zekâ destekli yeni nesil mali yönetim sistemlerine yönelmektedir. Çalışmada ele alınan "Vergi İdaresi 3.0" yaklaşımı da bu dönüşümün kurumsal ve teknolojik boyutunu temsil etmektedir.

Çalışma kapsamında yapılan değerlendirmeler, yapay zekâ teknolojilerinin vergi idareleri açısından yalnızca teknik bir yenilik olmadığını; aynı zamanda mali yönetim anlayışını dönüştüren yapısal bir paradigma değişimini ifade ettiğini göstermektedir. Yapay zekâ destekli sistemler sayesinde vergi idareleri artık yalnızca geçmiş işlemleri denetleyen kurumlar olmaktan çıkmakta; riskleri önceden tahmin edebilen, mükellef davranışlarını analiz edebilen ve gerçek zamanlı müdahalelerde bulunabilen dijital yapılara dönüşmektedir. Özellikle risk analizi, büyük veri analitiği, algoritmik denetim mekanizmaları ve otomatik vergi süreçleri; denetim kapasitesinin güçlendirilmesi, kayıt dışı ekonomiyle mücadele edilmesi ve kamu gelirlerinin sürdürülebilirliğinin sağlanması bakımından önemli avantajlar sunmaktadır.

Vergi denetimlerinde yapay zekâ kullanımının en önemli sonuçlarından biri, denetim kaynaklarının daha etkin kullanılabilmesidir. Geleneksel vergi denetimlerinde sınırlı insan kaynağı ve zaman kısıtı nedeniyle tüm mükelleflerin ayrıntılı biçimde incelenmesi mümkün olmamaktadır. Buna karşılık yapay zekâ destekli sistemler milyonlarca işlemi kısa süre içerisinde analiz ederek riskli mükellefleri tespit edebilmekte ve denetim süreçlerini hızlandırabilmektedir. Böylece vergi kayıp ve kaçağının azaltılması, sahte belge düzenleme faaliyetlerinin tespit edilmesi ve vergi uyumunun artırılması mümkün hâle gelmektedir. Ayrıca dijital vergi hizmetleri sayesinde mükelleflerin işlem maliyetleri azalmakta, vergi idaresiyle mükellef arasındaki iletişim güçlenmekte ve gönüllü uyum düzeyi yükselmektedir.

Türkiye açısından değerlendirildiğinde ise Gelir İdaresi Başkanlığının son yıllarda dijital dönüşüm sürecinde önemli ilerlemeler kaydettiği görülmektedir. E-beyanname, e-fatura, e-defter, Dijital Vergi Dairesi, GİB Mobil ve Dijital Vergi Asistanı gibi uygulamalar Türk vergi idaresinin dijital kapasitesini güçlendirmiştir. Risk analiz merkezleri ve veri temelli denetim

sistemleri sayesinde vergi incelemelerinde daha hedef odaklı bir yaklaşım benimsenmeye başlanmıştır. Bu durum Türkiye'de vergi yönetiminin giderek daha dijital, daha otomatik ve daha veri temelli bir yapıya dönüştüğünü göstermektedir.

Bununla birlikte yapay zekâ teknolojilerinin vergi idarelerinde yaygınlaşması çeşitli hukuki, etik ve yönetsel sorunları da beraberinde getirmektedir. Özellikle kişisel verilerin korunması, veri güvenliği, algoritmik şeffaflık ve mükellef haklarının korunması gibi meseleler gelecekte daha fazla önem kazanacaktır. Yapay zekâ sistemlerinin "kara kutu" biçiminde çalışması ve karar alma süreçlerinin tam olarak açıklanamaması, hukuki güvenlik ve hesap verebilirlik bakımından ciddi tartışmalar yaratmaktadır. Ayrıca algoritmik önyargılar ve hatalı risk skorlamaları bazı mükellef gruplarının sistem tarafından yanlış değerlendirilmesine yol açabilmektedir. Bu nedenle yapay zekâ sistemlerinin tamamen insan unsurunun yerine geçen otonom yapılar şeklinde değil; insan denetimini destekleyen karar destek sistemleri biçiminde geliştirilmesi daha uygun görünmektedir.

Sonuç olarak yapay zekâ teknolojileri, dijital maliye yönetiminin geleceğinde merkezi bir konuma sahip olacaktır. Vergi idarelerinin önümüzdeki dönemde daha veri temelli, daha hızlı, daha öngörülebilir ve daha otomatik çalışan yapılara dönüşmesi beklenmektedir. Ancak bu dönüşümün başarılı olabilmesi yalnızca teknolojik altyapının geliştirilmesine bağlı değildir. Aynı zamanda güçlü hukuki düzenlemelere, veri güvenliği standartlarına, nitelikli insan kaynağına ve algoritmik denetim mekanizmalarına ihtiyaç bulunmaktadır. Dolayısıyla sürdürülebilir ve dayanıklı bir dijital mali yönetim sistemi oluşturulabilmesi için teknolojik dönüşüm ile hukuki ve kurumsal dönüşümün birlikte yürütülmesi gerekmektedir. Bu çerçevede yapay zekâ destekli vergi yönetimi sistemleri, geleceğin kamu mali yönetiminde etkinlik ve mali sürdürülebilirlik açısından önemli fırsatlar sunarken; mükellef haklarını ve hukuki güvenliği koruyan dengeli bir dijital yönetim modelinin oluşturulması temel önceliklerden biri olmalıdır.

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DİJİTAL MUHASEBE VERİLERİNDEN YEŞİL PAZAR GÜVENİNE: İKİZ DÖNÜŞÜMDE KOBİ DÖNGÜSEL PERFORMANS AÇIKLAMASI VE TÜKETİCİ TEPKİSİ

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Özet

KOBİ'ler, ikiz dönüşüm sürecinde dijitalleşme ve sürdürülebilirlik baskılarına eş zamanlı olarak yanıt vermek zorundadır. E-fatura, e-defter, bulut muhasebe, büyük veri analitiği ve blokzincir gibi dijital muhasebe teknolojileri, işletmelerin finansal ve operasyonel verilerini daha doğru, izlenebilir ve denetlenebilir hale getirmektedir. Ancak literatürde giderek daha fazla vurgulanan temel mesele, bu dijital verilerin yalnızca yasal uyum veya iç raporlama amacıyla değil, aynı zamanda döngüsel ekonomi performansının açıklanması ve pazarda güven oluşturulması için nasıl kullanılabileceğidir. Bu bağlamda çalışmanın amacı, dijital muhasebe olgunluğu, veri yönetişimi, döngüsel performans açıklaması, yeşil pazarlama güvenilirliği ve tüketici tepkisi arasındaki ilişkilere dair literatürdeki mevcut durumu değerlendirmektir. Çalışmada bu kapsamda ikincil veriler üzerinden literatür incelenerek, teorik çerçevede kavramsal bir değerlendirme yapılacaktır. Literatür, dijital muhasebe sistemlerinin kaynak kullanımı, atık azaltımı, enerji tüketimi, maliyet yapıları ve tedarik zinciri işlemleri gibi sürdürülebilirlik göstergelerinin izlenmesini kolaylaştırabileceğini göstermektedir. Bununla birlikte bu verilerin tüketici güveni, yeşil iddiaların inandırıcılığı ve sürdürülebilir satın alma niyeti üzerinde etkili olabilmesi için açıklamaların karşılaştırılabilir, anlaşılır, doğrulanabilir ve pazarlama iletişimine uygun biçimde sunulması gerekmektedir. Bu bağlamda çalışma, muhasebe temelli dijital verilerin yeşil pazar güvenine dönüşebilmesi için kurumsal raporlama, veri güvenilirliği ve tüketici algısı arasında kurulması gereken bağlantıları tartışmaktadır. Çalışmanın katkısı, dijital muhasebe literatürü ile sürdürülebilir pazarlama ve tüketici davranışı literatürü arasında kavramsal bir köprü kurmasıdır.

Anahtar Kelimeler: Dijital Muhasebe, Döngüsel Performans Açıklaması, Tüketici Güveni, Yeşil Dönüşüm, Veri Yönetişimi

FROM DIGITAL ACCOUNTING DATA TO GREEN MARKET TRUST: SME CIRCULAR PERFORMANCE DISCLOSURE AND CONSUMER RESPONSE IN THE TWIN TRANSITION

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Abstract

SMEs are expected to respond simultaneously to digitalisation and sustainability pressures within the twin transition. Digital accounting technologies such as e-invoicing, e-ledger systems, cloud accounting, big data analytics and blockchain make financial and operational data more accurate, traceable and auditable. However, an increasingly important issue in the literature is how such digital data can be used not only for regulatory compliance or internal reporting, but also for circular performance disclosure and the creation of trust in green markets. Accordingly, the study evaluates the current state of the literature on the relationships among digital accounting maturity, data governance, circular performance disclosure, green marketing credibility and consumer response. In this study, a conceptual evaluation will be made within a theoretical framework by examining the literature through secondary data. The literature suggests that digital accounting systems may facilitate the monitoring of sustainability indicators such as resource use, waste reduction, energy consumption, cost structures and supply chain transactions. Nevertheless, for these data to influence consumer trust, green claim credibility and sustainable purchase intention, disclosures must be comparable, understandable, verifiable and suitable for marketing communication. In this respect, the study discusses the connections that need to be established among corporate reporting, data reliability and consumer perception in order to transform accounting-based digital data into green market trust. The contribution of the study is to build a conceptual bridge between the digital accounting literature and the literature on sustainable marketing and consumer behaviour. It also highlights the role of accounting professionals as key actors who can translate digital data into circular economy intelligence for SMEs, policymakers and market stakeholders.

Keywords: Digital Accounting, Circular Performance Disclosure, Consumer Trust, Green Transformation, Data Governance

GİRİŞ

Günümüzün hızla değişen küresel rekabet ortamında mikro, küçük ve orta büyüklükteki işletmeler (KOBİ'ler), dijitalleşme ve çevresel sürdürülebilirlik süreçlerini eş zamanlı olarak benimseme baskısıyla karşı karşıyadır. Literatürde ikiz dönüşüm olarak adlandırılan bu süreç, işletmelerin teknolojik yenilikleri yalnızca verimlilik sağlayan araçlar olarak değil, aynı zamanda çevresel ve toplumsal değer üretimini destekleyen kurumsal kapasiteler olarak ele almalarını gerektirmektedir (Hernández, 2024; Brenner & Hartl, 2021). KOBİ'ler açısından bu dönüşüm, büyük işletmelere kıyasla daha sınırlı finansal, beşeri ve teknolojik kaynaklarla yürütüldüğünden, stratejik önceliklendirme ve kurumsal öğrenme gerektiren çok boyutlu bir mesele haline gelmektedir (Denicolai et al., 2021; Zattoni & Pugliese, 2021).

İkiz dönüşümün işletmeler üzerindeki etkisi, yalnızca üretim süreçleri veya operasyonel verimlilik alanıyla sınırlı değildir. Sürdürülebilirlik uygulamalarının pazarda mecburi bir rekabet unsuruna dönüşmesi, işletmeleri döngüsel ekonomi eksenindeki çevresel ve sosyal taahhütlerini daha şeffaf, ölçülebilir ve hesap verebilir biçimde ortaya koymaya yöneltmektedir (Brenner & Hartl, 2021; Zattoni & Pugliese, 2021). Bu nedenle sürdürülebilirlik performansının güvenilir biçimde raporlanması, KOBİ'lerin hem finansal paydaşlar hem de tüketiciler nezdinde meşruiyet kazanmasında kritik bir işlev üstlenmektedir.

Bu noktada geleneksel muhasebe ve denetim pratiklerinin dijital bir evrim geçirmesi gerekmektedir. E-fatura, e-defter, bulut muhasebe, büyük veri analitiği ve blokzincir gibi dijital muhasebe araçları, işletmelerin finansal ve operasyonel verilerini daha izlenebilir, şeffaf ve denetlenebilir hale getirmektedir (Dai & Vasarhelyi, 2017; Lombardi et al., 2021). Blokzincir teknolojisinin merkeziyetsiz ve değiştirilemez kayıt yapısı, geleneksel çift taraflı muhasebe sisteminden üç taraflı kayıt sistemine geçiş tartışmalarını güçlendirmekte ve finansal verinin doğrulanabilirliğini artırmaktadır (Chowdhury, 2021; Dai & Vasarhelyi, 2017). Bulut tabanlı sistemler ve büyük veri analitiği ise karbon ayak izi, kaynak kullanımı, atık yönetimi ve tedarik zinciri işlemleri gibi karmaşık sürdürülebilirlik göstergelerinin gerçek zamanlı izlenmesine olanak tanımaktadır (Awan et al., 2021).

Bununla birlikte dijital muhasebe altyapılarının ürettiği verinin kurumsal raporlama içinde yer alması, tek başına pazarda güven oluşması için yeterli değildir. Son yıllarda yeşil aklama ve buna bağlı tüketici şüpheciliği tartışmaları, sürdürülebilirlik iddialarının yalnızca beyana değil, kanıtlanabilir ve anlaşılabilir bilgiye dayanması gerektiğini göstermektedir (Bernini & La Rosa, 2024; Seele & Schultz, 2022). Bu nedenle KOBİ'lerin dijital muhasebe verilerini yalnızca mevzuata uyum veya iç raporlama amacıyla değil, döngüsel performans açıklaması ve yeşil pazar güveni üretimi için stratejik bir araç olarak kullanmaları gerekmektedir.

Bu çalışmanın amacı, KOBİ'lerin ikiz dönüşüm sürecinde kullandıkları dijital muhasebe verilerinin, döngüsel ekonomi performansını açıklama ve tüketiciler nezdinde yeşil pazar

güveni oluşturma kapasitesini literatür temelinde bütüncül olarak değerlendirmektir. Bu amaç doğrultusunda dijital muhasebe olgunluğu, veri yönetişimi, döngüsel performans açıklaması, yeşil pazarlama güvenilirliği, tüketici güveni ve muhasebe profesyonellerinin aracılık rolü arasında kavramsal bir bağlantı kurulmaktadır. Çalışmanın temel katkısı, dijital muhasebe literatürü ile sürdürülebilir pazarlama ve tüketici davranışı literatürü arasında kavramsal bir köprü kurarak, muhasebe temelli dijital verinin pazarda güven üreten bir sürdürülebilirlik iletişimi unsuruna nasıl dönüşebileceğini tartışmasıdır.

1. İKİZ DÖNÜŞÜM BAĞLAMINDA KOBİ'LER VE DİJİTAL MUHASEBE

İkiz dönüşüm, işletmelerin yeşil dönüşüm ve dijitalleşme süreçlerini birbirinden bağımsız iki ayrı gündem olarak değil, karşılıklı olarak birbirini destekleyen stratejik dönüşüm alanları olarak ele almasını ifade etmektedir (Liakh, 2021; Radavičiūtė & Meidutė-Kavaliauskienė, 2025). KOBİ'ler açısından bu süreç, yalnızca teknolojik araçlara yatırım yapmak ya da çevresel performansı iyileştirmek anlamına gelmemekte; aynı zamanda kaynakların daha verimli kullanılması, veri temelli karar alma kültürünün güçlendirilmesi ve sürdürülebilir girişimcilik kapasitesinin artırılması anlamına gelmektedir (Alajmi, 2025; Hernández, 2024).

Dijital muhasebe olgunluğu, bu dönüşümün finansal ve operasyonel altyapısını oluşturan temel unsurlardan biridir. E-belge kullanımı, bulut tabanlı muhasebe sistemleri, süreç otomasyonu, veri entegrasyonu, büyük veri analitiği ve denetlenebilirlik kapasitesi, dijital muhasebe olgunluğunun başlıca bileşenleri arasında yer almaktadır (Al-Okaily et al., 2023; Ladu et al., 2024). Bu olgunluk düzeyine sahip işletmeler, finansal işlemleri gerçek zamanlı izleyebilmekte, departmanlar arası veri entegrasyonu sağlayabilmekte ve insan hatasından kaynaklanan riskleri azaltabilmektedir. Böylece muhasebe sistemi, yalnızca geçmiş işlemlerin kaydedildiği teknik bir yapı olmaktan çıkarak stratejik karar alma süreçlerini destekleyen dijital bir bilgi altyapısına dönüşmektedir.

KOBİ'ler için dijital muhasebe olgunluğu, çevresel performansın ölçülmesi ve sürdürülebilirlik verisinin yönetilmesi açısından da önemlidir. Büyük veri ve pazarlama analitiği gibi araçlar, KOBİ'lerde inovasyon ve rekabet avantajı yaratma potansiyeline sahiptir (Cadden et al., 2023). Benzer biçimde büyük veri ve öngörücü analitik, işletmelerin sosyal ve çevresel sürdürülebilirlik performansını izleyebilmesi ve iyileştirebilmesi için daha güçlü bir veri zemini sunmaktadır (Dubey et al., 2019). Bu nedenle dijital muhasebe olgunluğu, yalnızca muhasebe fonksiyonunun verimliliğini artıran bir unsur değil, aynı zamanda döngüsel ekonomi hedeflerinin izlenmesini ve raporlanmasını mümkün kılan kurumsal bir kapasite olarak değerlendirilmelidir.

Bu kapsamda KOBİ'lerin dijital muhasebe olgunluğuna ulaşmasını sınırlayan önemli yapısal güçlükler bulunmaktadır. Geleneksel iş yapma biçimlerinden kaynaklanan organizasyonel direnç, sınırlı finansal kaynaklar, dijital analitik beceri eksikliği ve veri kalitesi sorunları,

KOBİ'lerde ileri teknolojilerin benimsenmesini zorlaştırmaktadır (Tawil et al., 2024; Wang & Zhang, 2025). Ayrıca dijitalleşme sürecinin çoğu zaman mevzuata uyum baskısıyla başlaması, KOBİ'lerin dijital araçları stratejik bir rekabet unsuru yerine zorunlu bir uyum aracı olarak görmesine yol açabilmektedir. Bu nedenle dijital muhasebe olgunluğu, yalnızca teknolojik altyapı yatırımıyla değil, yönetsel vizyon, dijital kültür ve sürdürülebilirlik odaklı veri kullanımıyla birlikte ele alınmalıdır.

2. VERİ YÖNETİŞİMİ VE SÜRDÜRÜLEBİLİRLİK VERİSİNİN GÜVENİLİRLİĞİ

Dijital muhasebe sistemlerinin sürdürülebilirlik açısından değer üretebilmesi, üretilen verinin güvenilirliği ve doğru yönetilmesiyle yakından ilişkilidir. Veri yönetişimi; verinin doğruluğu, zamanındalığı, tutarlılığı, erişilebilirliği, bütünlüğü, karşılaştırılabilirliği, doğrulanabilirliği ve güvenliği gibi unsurları kapsayan bütüncül bir yönetim çerçevesidir (Liakh, 2021). Özellikle çevresel performans, döngüsel materyal kullanımı, enerji tüketimi ve atık azaltımı gibi finansal olmayan göstergeler söz konusu olduğunda, verinin farklı sistemlerden toplanması ve ortak bir anlam çerçevesinde raporlanması daha karmaşık hale gelmektedir.

Sürdürülebilirlik verisinin güvenilirliği, yalnızca kurumsal raporlamanın teknik doğruluğu açısından değil, aynı zamanda paydaş güveni açısından da belirleyicidir. Eksik, tutarsız veya doğrulanamayan verilerle hazırlanan raporlar, işletmelerin sürdürülebilirlik iddialarını zayıflatmakta ve yeşil aklama şüphelerini güçlendirmektedir (Bernini & La Rosa, 2024; Seele & Schultz, 2022). Bu nedenle dijital muhasebe sistemleri, finansal kayıtların yanında kaynak kullanımı, enerji tüketimi, maliyet yapıları ve tedarik zinciri işlemleri gibi sürdürülebilirlik göstergelerinin izlenmesini sağlayan güvenilir bir veri zemini oluşturmalıdır.

Bulut tabanlı kurumsal kaynak planlama sistemleri ve büyük veri analitiği, sürdürülebilirlik verisinin gerçek zamanlı izlenmesi açısından önemli olanaklar sunmaktadır. Ürün tedarikinden üretim ve dağıtıma kadar uzanan süreçlerde karbon ayak izi, enerji tüketimi ve kaynak kullanımı gibi metriklerin muhasebe ve operasyon verileriyle entegre biçimde izlenmesi, dijitalleşmenin sürdürülebilirlik performansına katkısını artırmaktadır (Trueba-Castañeda et al., 2024; Novicka, 2025). Bu sistemler, sürdürülebilirlik göstergelerini yalnızca raporlanan çıktılar olmaktan çıkararak, yönetim kararlarına rehberlik eden akıllı göstergelere dönüştürebilir (Alajmi, 2025; Dubey et al., 2019).

Bu aşamada önemli olan husus, veri yönetişiminin sadece teknik bir bilgi teknolojileri meselesi olarak görülmemesidir. Dijital muhasebe verisinin değer üretebilmesi için, verinin kim tarafından üretildiği, nasıl doğrulandığı, hangi standartlara göre sınıflandırıldığı ve hangi paydaşlara ne şekilde sunulduğu açık biçimde belirlenmelidir. Bu çerçeve kurulmadığında, dijitalleşme yatırımları işletmeye daha fazla veri sağlasa bile bu verinin güvenilir sürdürülebilirlik bilgisine dönüşmesi güçleşir. Dolayısıyla KOBİ'lerin dijitalleşme yatırımlarından tam değer elde edebilmesi, muhasebe verisinin mevzuat uyumu yanında

stratejik karar alma ve sürdürülebilirlik raporlaması için de kullanılmasına bağlıdır (Liakh, 2021; Novicka, 2025).

3. DÖNGÜSEL PERFORMANS AÇIKLAMASI VE RAPORLAMANIN PAZAR İLETİŞİMİNE ETKİSİ

Döngüsel ekonomi bağlamında sürdürülebilirlik performansı; kaynak verimliliği, geri dönüşüm ve yeniden kullanım oranları, ürün yaşam döngüsünü uzatma stratejileri, karbon emisyonları, enerji tüketimi ve atık yönetimi gibi göstergeler üzerinden açıklanmaktadır (Fernando et al., 2022; Le et al., 2022). Bu göstergeler, işletmelerin doğrusal üretim ve tüketim mantığından onarıcı, yenileyici ve kaynakları sistem içinde tutmaya çalışan döngüsel bir modele geçişini görünür hale getirmektedir. Literatürde döngüsel materyal kullanımı, ürün döngüselliği ve yaşam döngüsü karbon yoğunluğu gibi ölçülebilir metriklerin öne çıkması, döngüsel performansın yalnızca normatif bir iddia olmaktan çıkarılıp izlenebilir bir performans alanına dönüştüğünü göstermektedir (Ahmad et al., 2023; Fatimah et al., 2023).

Döngüsel performansın dış paydaşlara açıklanması ise iki farklı iletişim düzeyini gerektirir. Birinci düzey, yatırımcılar, denetleyiciler ve düzenleyici kurumlar için hazırlanan teknik kurumsal raporlama dilidir. Bu düzeyde güvenilirlik, ölçülebilirlik, denetlenebilirlik ve standartlara uygunluk öne çıkmaktadır (Adams & Larrinaga-González, 2007; Al-Shaer & Zaman, 2018). İkinci düzey ise tüketicilere yönelik pazar iletişimidir. Bu düzeyde asıl mesele, teknik ve karmaşık sürdürülebilirlik verisinin tüketici tarafından anlaşılabilir, karşılaştırılabilir ve anlamlı bir kalite sinyaline dönüştürülmesidir.

Kurumsal sürdürülebilirlik raporları, genellikle teknik, finansal ve yasal uyum odaklı bir dil kullanır. Ancak tüketiciler, bu raporlarda yer alan karmaşık metrikleri çoğu zaman doğrudan yorumlayamaz. Bu nedenle pazarlama iletişiminin görevi, dijital muhasebe ve büyük veri analitiğiyle üretilen çevresel performans bilgisini sadeleştirmek, bağlamlandırmak ve tüketici için anlamlı bir değer önerisine dönüştürmektir (Novicka, 2025; Pozelli Sabio & Spers, 2022). Bu dönüşüm başarıyla sağlandığında döngüsel performans açıklaması, yalnızca kurumsal sorumluluk göstergesi değil, aynı zamanda yeşil pazar güvenini destekleyen bir iletişim aracı haline gelir.

Bu noktada dijital muhasebe verisi ile yeşil pazarlama iletişimi arasında kurulacak bağ kritik önem taşır. Teknik olarak doğrulanmış bir veri seti, ancak sade, karşılaştırılabilir, bağımsız biçimde doğrulanabilir ve tüketici bağlamında anlamlandırılmış biçimde sunulduğunda yeşil iddiaları destekleyen güçlü bir kanıt setine dönüşebilir. Aksi durumda, en doğru veriler bile tüketici nezdinde anlaşılmadığı veya güvenilir bulunmadığı için pazarda beklenen karşılığı üretmeyebilir. Bu nedenle döngüsel performans açıklaması, raporlama ve iletişim fonksiyonlarını birlikte ele alan bütünleşik bir yaklaşım gerektirir.

4. YEŞİL PAZARLAMA, TÜKETİCİ GÜVENİ VE SATIN ALMA NİYETİ

Yeşil iddiaların tüketici pazarında karşılık bulması, algılanan şeffaflık, iddiaların güvenilirliği ve marka güveni arasındaki güçlü bağlantılara dayanmaktadır. Tüketiciler, çevre dostu veya döngüsel olduğu iddia edilen ürünlerle karşılaştıklarında, bu iddiaların somut ve doğrulanabilir bilgiye dayanmasını beklemektedir (Pozelli Sabio & Spers, 2022). Yeşil güven, tüketicinin çevresel iddialara, markaya ve sunulan performans bilgisine duyduğu güveni ifade etmekte; algılanan riski azaltarak sürdürülebilir satın alma niyetini güçlendirmektedir (Chen & Chang, 2012; Wu & Long, 2024).

Buna karşılık, şeffaflığın eksik olduğu durumlarda abartılı, belirsiz veya kanıta dayanmayan yeşil iddialar, tüketicide yeşil aklama algısını tetikleyebilmektedir. Yeşil aklama, işletmelerin çevresel performanslarını olduğundan daha olumlu göstermeleri ya da olumsuz çevresel etkileri gizleyerek seçici bir iletişim stratejisi izlemeleri olarak değerlendirilmektedir (Delmas & Burbano, 2011; Lyon & Montgomery, 2015). Algılanan yeşil aklama, markaya yönelik güveni zayıflatmakta, marka kaçınması ve olumsuz ağızdan ağıza iletişim gibi sonuçlar doğurabilmektedir (Ghitti et al., 2024; Sajid et al., 2024). Bu durum, gerçek sürdürülebilirlik çabalarının da tüketici tarafından şüpheyle karşılanmasına neden olarak pazar genelinde güven krizini derinleştirebilir.

Tüketici algısı ve satın alma niyeti, Sinyal Teorisi bağlamında ele alındığında daha açık biçimde anlaşılmaktadır. Çevresel performans ve etik üretim gibi sürdürülebilirlik nitelikleri tüketici tarafından doğrudan gözlemlenemeyen güven nitelikleri olduğundan, işletmeler bu nitelikleri pazara sinyal olarak göndermek zorundadır (Connelly et al., 2011). Ancak bu sinyallerin inandırıcı olabilmesi için görünür, anlaşılır ve teknolojik ya da kurumsal maliyet içeren doğrulama mekanizmalarıyla desteklenmesi gerekir. Bu nedenle dijital muhasebe verisiyle desteklenen yeşil iddialar, yalnızca pazarlama mesajı değil, tüketicinin karar verme sürecinde belirsizliği azaltan bir güven sinyali olarak işlev görür.

Yeşil satın alma davranışı üzerine yapılan çalışmalar, tüketici güveni ve algılanan değer arttıkça sürdürülebilir ürünlere yönelik satın alma niyetinin de güçlendiğini göstermektedir (Jaiswal & Kant, 2018; Chen & Chang, 2012). Ancak bu ilişkinin güçlü biçimde kurulabilmesi için çevresel iddiaların tüketici tarafından anlaşılır ve güvenilir bulunması gerekir. Bu bağlamda dijital muhasebe sistemlerinin ürettiği verinin pazarlama iletişimine uygun biçimde kullanılması, çevresel duyarlılığın fiili satın alma niyetine dönüşmesini destekleyen temel mekanizmalardan biri olarak değerlendirilebilir.

5. MUHASEBE UZMANLARININ ARACILIK ROLÜ

İkiz dönüşüm sürecinde işletmelerin ürettiği büyük miktardaki verinin stratejik değere dönüşebilmesi, yalnızca kullanılan teknolojilere değil, bu teknolojileri anlamlandıran insan

kaynağına da bağlıdır. Bu bağlamda muhasebe profesyonelleri, geleneksel olarak finansal işlemleri kaydeden aktörler olmanın ötesine geçerek, dijital veriyi doğrulayan, sürdürülebilirlik göstergelerine dönüştüren ve paydaşlara hesap verebilir bilgi olarak sunan stratejik aracılar haline gelmektedir (Liakh, 2021; Abdelhalim, 2024).

Büyük veri analitiği, bulut bilişim ve blokzincir gibi teknolojiler, işletmelere ham veriyi üretme ve saklama imkânı sağlamaktadır. Ancak bu verinin karbon ayak izi, kaynak verimliliği, döngüsel materyal kullanımı veya sürdürülebilirlik performansı gibi anlamlı göstergelere dönüştürülmesi muhasebe profesyonellerinin yorumlama, sınıflandırma ve doğrulama kapasitesini gerektirir (Serag, 2024; Abdelhalim, 2024). Bu nedenle muhasebe profesyonelleri, veri mimarisi ile kurumsal hesap verebilirlik arasında köprü kurarak sürdürülebilirlik raporlamasının güvenilirliğini desteklemektedir.

KOBİ'ler açısından bu aracılık rolü daha da önemlidir. Sınırlı finansal ve teknik kaynaklar, KOBİ'lerin dijital muhasebe, bulut sistemleri ve blokzincir gibi teknolojileri benimsemesini zorlaştırabilmektedir (Denicolai et al., 2021; Saratchandra et al., 2022). Ayrıca bulut muhasebe uygulamalarının benimsenmesi, performans ve verimlilik açısından fırsatlar sunsa da veri güvenliği, dijital yetkinlik ve organizasyonel hazırlık gibi konularda çeşitli zorluklar doğurabilmektedir (Murdianingrum & Widiastutik, 2024; Jena, 2025). Bu nedenle muhasebe profesyonellerinin dijital becerilerinin geliştirilmesi ve sürdürülebilirlik okuryazarlığıyla desteklenmesi, KOBİ'lerin ikiz dönüşüm sürecindeki başarı şansını artırmaktadır.

Muhasebe profesyonellerinin bu yeni rolü, aynı zamanda pazar iletişimi açısından da dolaylı bir etki üretir. Doğru sınıflandırılmış, güvenilir ve doğrulanabilir muhasebe verisi, sürdürülebilirlik raporlamasının kalitesini artırırken, pazarlama iletişiminde kullanılacak yeşil iddiaların kanıta dayalı biçimde oluşturulmasına katkı sağlar. Cascavilla et al. (2025) dijital ürün pasaportları bağlamında dijital araçlar ile insan becerilerinin birlikte değerlendirilmesi gerektiğini vurgulamaktadır. Bu perspektif, KOBİ'lerde dijital muhasebe altyapısı kadar bu altyapıyı yönetecek uzmanlık kapasitesinin de yeşil pazar güveni açısından belirleyici olduğunu göstermektedir.

6. DİJİTAL MUHASEBE VERİSİNDEN YEŞİL PAZAR GÜVENİNE GEÇİŞ

Çalışmanın bütünleştirici kavramsal omurgası, dijital muhasebe olgunluğu, veri güvenilirliği, döngüsel performans açıklaması, yeşil iddia güvenilirliği ve tüketici güveni arasındaki ardışık ilişkiye dayanmaktadır. Gelişmiş dijital muhasebe sistemleri, işletme içinde yüksek kaliteli, izlenebilir ve denetlenebilir veri üretilmesini sağlayarak veri güvenilirliğini güçlendirir. Güvenilir veri ise kurumsal raporlama, sürdürülebilirlik açıklamaları ve dijital ürün pasaportları gibi uygulamalar aracılığıyla işletmenin döngüsel performansını daha objektif biçimde görünür kılar (Novicka, 2025; Gieß & Möller, 2025).

Dijital ürün pasaportları ve QR kod temelli izlenebilirlik uygulamaları, tüketicilere ürün geçmişi, malzeme içeriği, çevresel etki ve geri dönüşüm potansiyeli hakkında erişilebilir bilgi sunarak pazar iletişimi ile veri yönetişimi arasındaki bağı güçlendirmektedir (Gieß & Möller, 2025; Le, 2024). Bu tür uygulamalar, yalnızca teknik bir veri paylaşım aracı olarak değil, aynı zamanda tüketicinin markaya ve çevresel iddialara duyduğu güveni güçlendiren bir iletişim mekanizması olarak değerlendirilebilir. Blokzincir teknolojisinin yeşil tüketicileri güçlendirme potansiyeli de bu bağlamda önemlidir (Nygaard & Silkoset, 2023).

Bu kavramsal geçiş, KOBİ'lerin dijitalleşme vizyonunu yeniden değerlendirmesini gerektirir. E-fatura, bulut muhasebe, ERP ve büyük veri analitiği gibi dijital araçlar yalnızca yasal uyum veya operasyonel verimlilik aracı olarak görülmemelidir. Aksine bu araçlar, paydaşlara şeffaflık sağlayan, yeşil iddiaların meşruiyetini kanıtlayan ve sürdürülebilir rekabet avantajı oluşturan stratejik varlıklar olarak konumlandırılmalıdır (Hernández, 2024; Vrontis et al., 2022). KOBİ'ler için veriye dayalı sürdürülebilirlik iletişimi, güvenin giderek daha değerli hale geldiği pazarlarda güçlü bir farklılaşma stratejisi sunmaktadır.

Bununla birlikte dijital muhasebe verisinin tüketici güvenine dönüştürülmesi sürecinde çeşitli sınırlılıklar bulunmaktadır. Farklı sistemlerden gelen verilerin standartlaştırılamaması, kurumsal sistemlerin tam entegre olamaması ve şeffaflığın sınırlarına ilişkin yapısal sorunlar, verinin karşılaştırılabilirliğini ve güvenilirliğini azaltabilmektedir (Krupitzer & Stein, 2021). Gelişmiş doğrulama ve raporlama altyapılarının maliyeti, özellikle KOBİ'ler için önemli bir benimseme engeli yaratabilmektedir (Boral et al., 2025). Ayrıca döngüsel performansın ölçülmesi ve izlenebilirliğin sağlanması, farklı aktörlerin sorumluluklarını net biçimde tanımlayan sistemsel bir çerçeve gerektirmektedir (Gall et al., 2025). Son olarak, teknik muhasebe ve çevresel etki verilerinin tüketici tarafından kolayca yorumlanamaması, şeffaf verinin pazarlama mesajı olarak doğrudan karşılık bulmasını engelleyebilir (Adams & Larrinaga-González, 2007).

7. SONUÇ VE ÖNERİLER

Bu çalışma, KOBİ'lerin ikiz dönüşüm sürecinde dijital muhasebe verilerini yalnızca yasal uyum ve iç raporlama aracı olarak değil, döngüsel performansın açıklanması ve yeşil pazar güveninin oluşturulması açısından stratejik bir unsur olarak ele alması gerektiğini ortaya koymaktadır. Dijital muhasebe sistemleri, işletmelere daha doğru, izlenebilir ve denetlenebilir veri üretme kapasitesi kazandırmaktadır. Ancak bu kapasitenin pazarda güvene dönüşebilmesi, verinin yalnızca teknik doğruluğuna değil, aynı zamanda anlaşılabilir, karşılaştırılabilir, doğrulanabilir ve tüketiciye anlamlı gelecek biçimde sunulmasına bağlıdır.

Çalışmada kurulan kavramsal çerçeve, dijital muhasebe olgunluğundan yeşil pazar güvenine uzanan sürecin çok aşamalı bir yapı taşıdığını göstermektedir. Bu süreçte önce güvenilir veri üretilmekte, ardından bu veri döngüsel performans açıklamasına dönüştürülmekte, daha sonra

yeşil pazarlama iletişiminde iddiaların inandırıcılığını desteklemekte ve nihayetinde tüketici güveni ile sürdürülebilir satın alma niyetine katkı sağlamaktadır. Dolayısıyla muhasebe, sürdürülebilirlik raporlaması ve pazarlama iletişimi birbirinden ayrı fonksiyonlar olarak değil, ortak bir güven üretim zincirinin parçaları olarak değerlendirilmelidir.

KOBİ'ler açısından öncelikli öneri, dijital muhasebe altyapılarının yalnızca operasyonel verimlilik veya mevzuata uyum gerekçesiyle değil, sürdürülebilirlik performansını ölçme ve açıklama kapasitesiyle birlikte planlanmasıdır. E-fatura, e-defter, bulut muhasebe, ERP, büyük veri analitiği ve izlenebilirlik sistemleri, işletmenin çevresel performansını destekleyen bütünleşik bir veri mimarisi içinde ele alınmalıdır. Bu mimari kurulmadığında, işletme daha fazla veri üretse bile bu verinin raporlanabilir, doğrulanabilir ve pazarda güven yaratabilir bilgiye dönüşmesi sınırlı kalacaktır.

İkinci olarak, KOBİ'lerin muhasebe profesyonellerinin rolünü yeniden tanımlaması gerekmektedir. Muhasebe uzmanları yalnızca kayıt ve raporlama sorumlusu değil, dijital veriyi sürdürülebilirlik göstergelerine dönüştüren, verinin güvenilirliğini sağlayan ve kurumsal hesap verebilirliği destekleyen stratejik aktörler olarak konumlandırılmalıdır. Bu nedenle dijital muhasebe, veri analitiği, sürdürülebilirlik raporlaması ve yeşil pazarlama iletişimi alanlarında disiplinler arası yetkinlik geliştirme faaliyetleri önem taşımaktadır.

Üçüncü olarak, yeşil iddiaların tüketiciyle buluştuğu pazarlama iletişimi dili sadeleştirilmeli ve teknik raporlama diliyle tüketici algısı arasında köprü kurulmalıdır. Tüketiciye sunulan çevresel bilgiler aşırı teknik, soyut veya bağlamdan kopuk olduğunda güven üretmek yerine bilişsel yük ve şüphe yaratabilir. Bu nedenle KOBİ'ler, sürdürülebilirlik verilerini kısa, açık, kanıta dayalı ve tüketicinin karar sürecinde kullanabileceği biçimde sunmalıdır.

Son olarak, politika yapıcılar ve destekleyici kurumlar, KOBİ'lerin dijital muhasebe ve sürdürülebilirlik raporlaması kapasitelerini güçlendirecek programları daha bütünleşik biçimde tasarlamalıdır. KOBİ'lere yalnızca teknoloji yatırımı desteği sağlanması yeterli değildir; veri yönetişimi, raporlama standardizasyonu, insan kaynağı eğitimi ve pazara yönelik sürdürülebilirlik iletişimi de destek mekanizmalarının parçası haline getirilmelidir. Bu şekilde dijitalleşme, KOBİ'ler için yalnızca teknik bir modernizasyon süreci olmaktan çıkıp, güvene dayalı yeşil pazarların oluşumuna katkı sağlayan stratejik bir dönüşüm alanına dönüşebilir.

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DİJİTAL GÜVEN, YEŞİL İDDİALAR VE DÖNGÜSEL EKONOMİDE TÜKETİCİ TEPKİSİ: BLOKZİNCİR DESTEKLİ ŞEFFAFLIĞIN ROLÜ

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Özet

İkiz dönüşüm süreci, işletmelerin döngüsel ekonomi uygulamalarını yalnızca üretim ve tedarik zinciri düzeyinde geliştirmelerini değil, aynı zamanda bu uygulamaları tüketicilere güvenilir, anlaşılabilir ve doğrulanabilir biçimde aktarmalarını da gerekli kılmaktadır. Sürdürülebilirlik iddialarının yaygınlaşması, tüketici tarafında yeşil aklama şüphesi, bilgi asimetrisi ve güven sorunu gibi tartışmaları güçlendirmiştir. Bu çerçevede çalışmanın amacı, döngüsel ekonomi bağlamında yeşil iddialar, dijital güven, tüketici tepkisi ve blokzincir destekli şeffaflık konularında mevcut literatürde ortaya çıkan temel eğilimleri bütüncül biçimde değerlendirmektir. Literatürde blokzincir teknolojisi; izlenebilirlik, değiştirilemez kayıt yapısı, ürün geçmişinin doğrulanması, dijital ürün pasaportları ve tedarik zinciri şeffaflığı gibi özellikleriyle sürdürülebilirlik iletişimini güçlendirebilecek bir araç olarak ele alınmaktadır. Bununla birlikte mevcut çalışmalar, teknik olarak doğrulanabilir bilginin her durumda tüketici güvenine dönüşmediğini; bilginin sade, erişilebilir ve pazarlama iletişimi açısından anlamlı biçimde sunulmasının kritik olduğunu göstermektedir. Bu nedenle çalışma, blokzincir destekli şeffaflığın yeşil iddiaların güvenilirliği, algılanan yeşil aklama, marka güveni ve sürdürülebilir satın alma niyetiyle ilişkisini literatür temelli bir çerçevede tartışmaktadır. Çalışmanın beklenen katkısı, döngüsel ekonomi ve dijitalleşme literatürünü tüketici davranışı ve sürdürülebilir pazarlama bakış açısıyla birleştirmesi; blokzinciri yalnızca teknik bir altyapı değil, aynı zamanda pazarda güven üretme potansiyeli taşıyan bir şeffaflık mekanizması olarak konumlandırmasıdır.

Anahtar Kelimeler: Dijital Güven, Yeşil Dönüşüm, Blokzincir, Döngüsel Ekonomi, Tüketici Davranışı

DIGITAL TRUST, GREEN CLAIMS AND CONSUMER RESPONSE IN THE CIRCULAR ECONOMY: THE ROLE OF BLOCKCHAIN-ENABLED TRANSPARENCY

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Abstract

The twin transition requires firms not only to develop circular economy practices at the production and supply chain levels, but also to communicate these practices to consumers in a credible, understandable and verifiable manner. The increasing use of sustainability claims has intensified discussions on perceived greenwashing, information asymmetry and consumer trust. Against this background, the study aims to synthesize the current literature on green claims, digital trust, consumer response and blockchain-enabled transparency in the context of the circular economy. Existing studies position blockchain as a potentially valuable tool for sustainability communication because of its traceability, immutable record structure, product history verification, digital product passport applications and supply chain transparency. However, the literature also indicates that technically verifiable information does not automatically translate into consumer trust. For blockchain-enabled transparency to influence market responses, sustainability-related information must be simple, accessible, interpretable and meaningful from a marketing communication perspective. Accordingly, this study discusses the relationship between blockchain-enabled transparency, green claim credibility, perceived greenwashing, brand trust and sustainable purchase intention through a literature-based conceptual lens. The expected contribution of the study is to integrate circular economy and digitalisation debates with consumer behaviour and sustainable marketing perspectives. It also positions blockchain not merely as a technical infrastructure, but as a transparency mechanism with the potential to generate trust in green markets. The review is expected to provide a conceptual basis for future studies and practical implications for firms seeking to communicate circular economy practices more credibly.

Keywords: Digital Security, Green Transformation, Blockchain, Circular Economy, Consumer Behavior

GİRİŞ

Günümüzde sürdürülebilirlik ve dijitalleşmenin eşzamanlı entegrasyonunu ifade eden ikiz dönüşüm, endüstriyel sistemlerde rekabet gücünün, kaynak verimliliğinin ve çevresel dayanıklılığın temel belirleyicilerinden biri haline gelmiştir (Cascavilla et al., 2026; D'Adamo et al., 2025). Bu dönüşüm süreci, işletmeleri yalnızca döngüsel ekonomi uygulamalarını geliştirmeye değil, aynı zamanda bu uygulamaların çevresel ve toplumsal değerini tüketicilere şeffaf, güvenilir ve anlaşılabilir biçimde aktarmaya zorlamaktadır (Colasante et al., 2025). Dolayısıyla ikiz dönüşüm, teknik bir verimlilik gündeminin ötesine geçerek pazarlama iletişimi, tüketici güveni ve kurumsal meşruiyet alanlarını da doğrudan etkileyen bütüncül bir dönüşüm alanı yaratmaktadır.

Sürdürülebilir ürünlere yönelik talebin artmasıyla birlikte işletmeler pazarda daha fazla yeşil iddia kullanmaya başlamıştır (Delmas & Burbano, 2011). Ancak bu iddiaların sayısındaki artış, şeffaflık eksikliği ve bağımsız doğrulama mekanizmalarının zayıflığı nedeniyle işletmeler ile tüketiciler arasında bilgi asimetrisini derinleştirmektedir (Jia et al., 2024). Tüketicilerin çevresel beyanların doğruluğunu kolayca teyit edememesi, sürdürülebilirlik iletişimine yönelik şüpheciliği artırmakta ve yeşil aklama algısını güçlendirmektedir (Nygaard & Silkoset, 2023). Yeşil aklama, yalnızca yanıltıcı bir pazarlama uygulaması değil; tüketici güvenini, yatırımcı algısını ve sürdürülebilirlik ekosisteminin bütünlüğünü zedeleyen yapısal bir sorun olarak değerlendirilmektedir (Bernini & La Rosa, 2024; Bodellini, 2023).

Bu güven krizinin aşılmasında blokzincir destekli sistemler, dijital izlenebilirlik ve kanıtlanabilir şeffaflık açısından önemli bir araç olarak öne çıkmaktadır. Blokzincirin sunduğu değiştirilemez kayıt yapısı, ürün geçmişinin doğrulanması ve tedarik zinciri boyunca veri bütünlüğünün korunması, yeşil iddiaların daha güvenilir pazar sinyallerine dönüşmesini sağlayabilecek bir altyapı sunmaktadır (Centobelli et al., 2022; Saberi et al., 2019). Bununla birlikte teknik doğrulanabilirliğin tüketici güvenine otomatik olarak dönüşmediği de açıktır. Bu nedenle blokzincir destekli şeffaflık, yalnızca veri kayıt teknolojisi olarak değil, aynı zamanda tüketiciye anlamlı, erişilebilir ve güven veren sürdürülebilirlik iletişimi üreten bir mekanizma olarak değerlendirilmelidir.

Bu çalışmanın amacı, döngüsel ekonomi bağlamında yeşil iddialar, dijital güven, tüketici tepkisi ve blokzincir destekli şeffaflık konularında literatürde ortaya çıkan temel eğilimleri bütüncül biçimde değerlendirmektir. Çalışma, yeşil iddia güvenilirliği, algılanan yeşil aklama, marka güveni ve sürdürülebilir satın alma niyeti arasındaki ilişkileri kavramsal bir akış içinde tartışarak, blokzincirin teknik bir altyapıdan pazar güveni üreten bir şeffaflık mekanizmasına nasıl dönüşebileceğini açıklamaya odaklanmaktadır.

1. DÖNGÜSEL EKONOMİ VE YEŞİL İDDİALARIN PAZARLAMA İLETİŞİMİNDEKİ YERİ

Geleneksel al-yap-at mantığına dayanan doğrusal ekonomi modeli, kaynak kıtlığı, atık birikimi ve çevresel bozulma gibi sorunlar karşısında sürdürülebilirlik açısından yetersiz kalmaktadır. Döngüsel ekonomi bu sınırlılığı aşmak üzere atıkların sistem dışına itilmediği, kaynakların yeniden kullanıldığı, ürün yaşam döngülerinin uzatıldığı ve değer yaratımının kapalı döngüler üzerinden yeniden tasarlandığı bir yaklaşım sunmaktadır (Geissdoerfer et al., 2017; Kirchherr et al., 2017). Bu model, yeniden kullanım, geri dönüşüm, onarım, kaynak verimliliği ve ürün yaşam döngüsü yönetimi gibi ilkeler aracılığıyla hem çevresel hem de ekonomik değer üretmeyi hedeflemektedir (Lieder & Rashid, 2016).

Döngüsel ekonomi, işletmeler açısından yalnızca operasyonel bir sürdürülebilirlik gündemi değil, aynı zamanda pazarlama iletişimi bakımından güçlü bir değer önerisidir. Kapalı döngü tedarik zincirlerinin, döngüsel iş modellerinin ve sürdürülebilir ürün tasarımlarının benimsenmesi, markalara çevresel duyarlılık temelinde farklılaşma imkânı sağlamaktadır (Bocken et al., 2016). Yeşil iddialar bu noktada işletmelerin sürdürülebilirlik performansını tüketiciye aktarmasının temel araçlarından biri haline gelmektedir. Bu iddialar, ürün farklılaştırması, sürdürülebilir marka konumlandırması ve yeşil tüketim davranışının teşvik edilmesi açısından stratejik bir işlev üstlenmektedir (Sharma, 2021; White et al., 2019).

Bununla birlikte yeşil iddiaların pazarlama iletişiminde etkili olabilmesi, yalnızca çevresel faydayı vurgulayan mesajların varlığına bağlı değildir. Sinyal teorisi açısından sürdürülebilirlik iddialarının tüketici tarafından güvenilir bir kalite sinyali olarak algılanabilmesi için görünür, anlaşılır ve kanıtlanabilir olması gerekir (Connelly et al., 2011). Tüketiciler sürdürülebilirlik beyanlarını çoğu zaman doğrudan doğrulama imkânına sahip olmadığından, yeşil iddiaların somut verilerle desteklenmesi ve tüketici açısından anlamlı bir iletişim formatına dönüştürülmesi önem taşımaktadır (Chen & Chang, 2012).

Bu çerçevede döngüsel ekonomi uygulamaları ile yeşil pazarlama iletişimi arasında güçlü ancak kırılgan bir ilişki bulunmaktadır. İşletmelerin döngüsel performanslarını görünür kılmaları, sürdürülebilirlik mesajlarını güçlendirebilir; ancak bu görünürlük doğrulanabilirlik ve şeffaflıkla desteklenmediğinde, aynı mesajlar tüketici nezdinde şüphe yaratabilmektedir. Dolayısıyla yeşil iddiaların pazarda güven üretmesi için çevresel performans, veri temelli kanıt ve tüketiciye uygun iletişim biçimi birlikte ele alınmalıdır.

2. YEŞİL AKLAMA, BİLGİ ASİMETRİSİ VE TÜKETİCİ GÜVENİ

Sürdürülebilirlik iletişiminin yaygınlaşması, yeşil iddiaların sayısını artırırken yeşil aklama sorununu da daha görünür hale getirmiştir. Yeşil aklama, işletmelerin çevresel performanslarını abartılı, belirsiz, doğrulanamayan veya yanıltıcı beyanlarla olduğundan daha

olumlu göstermeleri olarak tanımlanabilir (de Freitas Netto et al., 2020; Delmas & Burbano, 2011). Bu durum, işletmenin söylemi ile gerçek uygulamaları arasındaki uyumsuzluğu derinleştirerek pazarlama etiği ve sürdürülebilirlik güvenilirliği açısından önemli bir sorun yaratmaktadır (Bernini & La Rosa, 2024).

Yeşil aklamanın temelinde çoğu zaman bilgi asimetrisi yer almaktadır. Tüketiciler, bir ürünün gerçekten sürdürülebilir biçimde üretilip üretilmediğini, çevresel etkilerinin azaltılıp azaltılmadığını veya tedarik zinciri boyunca etik standartlara uyulup uyulmadığını doğrudan gözlemleyemez. Bu nedenle sürdürülebilirlik ve çevresel performans gibi özellikler, tüketici açısından güven nitelikleri kapsamında değerlendirilmektedir (Hobbs, 2004). Özellikle gıda, tekstil ve hızlı tüketim gibi tedarik zinciri karmaşık sektörlerde tüketici, yeşil iddiaların doğruluğunu teyit edebilmek için şeffaf veri ve güvenilir doğrulama mekanizmalarına ihtiyaç duymaktadır (Jia et al., 2024).

Bilgi asimetrisinin arttığı durumlarda tüketici güveni, sürdürülebilir satın alma kararının merkezine yerleşmektedir. Güven, algılanan riski azaltan, belirsizliği yönetilebilir kılan ve tüketicinin yeşil iddiaları daha olumlu değerlendirmesini sağlayan psikolojik bir mekanizma olarak işlev görmektedir (Wu & Long, 2024). Buna karşılık algılanan yeşil aklama, marka güvenini zayıflatmakta, reklam mesajlarına yönelik şüpheciliği artırmakta ve sürdürülebilir tüketim niyetinin davranışa dönüşmesini engelleyebilmektedir (Nyilasy et al., 2014). Bu noktada tüketici tepkisi yalnızca rasyonel bilgi değerlendirmesine indirgenemez. Tüketiciler yeşil iddiaları değerlendirirken bilginin kaynağına, mesajın açıklığına, markanın önceki itibarı ve iddianın doğrulanabilirliğine dikkat etmektedir. Yeşil iddiaların inandırıcılığı ve marka güveni yükseldiğinde tüketicilerin sürdürülebilir ürünlere yönelik satın alma niyetleri ve bu ürünlere daha yüksek fiyat ödeme isteklilikleri artabilmektedir (Treiblmaier & Garaus, 2023). Bu nedenle yeşil iddiaların pazarlama değerine dönüşebilmesi için şeffaflık, güven ve doğrulanabilirlik birlikte düşünülmelidir.

3. BLOKZİNCİR DESTEKLİ ŞEFFAFLIK VE DİJİTAL ÜRÜN PASAPORTLARI

Blokzincir, işlemlerin kronolojik olarak birbirine bağlandığı, kriptografik yöntemlerle güvence altına alındığı ve geriye dönük değiştirmenin son derece güç olduğu dağıtık bir kayıt sistemidir (Llach et al., 2026). Bu yapının en önemli özelliklerinden biri olan değiştirilemezlik, ürünlerin tedarik zinciri boyunca geçirdiği süreçlerin güvenilir biçimde izlenebilmesine imkân tanımaktadır (Saberi et al., 2019). Blokzincir bu yönüyle, çok aktörlü tedarik zincirlerinde güvenin yalnızca merkezi otoriteler veya işletme beyanları üzerinden değil, dijital olarak doğrulanabilir kayıtlar üzerinden inşa edilmesini sağlayabilecek bir altyapı sunmaktadır (Centobelli et al., 2022).

Döngüsel ekonomi bağlamında blokzincir teknolojisinin en önemli uygulama alanlarından biri dijital ürün pasaportlarıdır. Dijital ürün pasaportları, bir ürünün malzeme bileşimi, üretim

süreçleri, çevresel etkileri, onarılabilirliği, yeniden kullanım olanakları ve geri dönüşüm potansiyeli gibi yaşam döngüsü verilerinin standartlaştırılmış ve erişilebilir biçimde paylaşılmasına imkân tanımaktadır (Cascavilla et al., 2026; Gieß & Möller, 2025). Bu bilgiler QR kodlar, RFID etiketler veya benzeri dijital arayüzler aracılığıyla üretici, tedarikçi, düzenleyici kurum ve tüketici gibi farklı paydaşlara aktarılabilmektedir (Phan et al., 2026).

Blokzincir destekli dijital ürün pasaportları, sürdürülebilirlik iddialarını yalnızca sözel beyan olmaktan çıkarıp veri temelli kanıtlara dönüştürme potansiyeline sahiptir. Akıllı sözleşmelerin, izlenebilirlik kayıtlarının ve otomatik doğrulama mekanizmalarının sürece entegre edilmesi; geri dönüşüm, atık yönetimi, onarım ve yeniden kullanım süreçlerinin daha şeffaf biçimde takip edilmesini sağlayabilmektedir (Wang et al., 2019). Böylece döngüsel ekonomi uygulamaları hem işletme içi operasyonel süreçlerde hem de pazara dönük iletişimde daha güvenilir hale gelebilmektedir.

Bununla birlikte teknik doğrulanabilirlik tüketici güveni açısından tek başına yeterli değildir. Tüketicilerin karmaşık blokzincir kayıtlarını veya ayrıntılı izlenebilirlik verilerini doğrudan anlamlandırması her zaman mümkün olmayabilir. Fazla teknik, parçalı veya yoruma kapalı veri sunumu tüketicinin bilişsel yükünü artırarak şeffaflığın beklenen güven etkisini zayıflatabilir (Tran et al., 2024). Bu nedenle blokzincir destekli şeffaflığın pazarlama iletişimine dönüşebilmesi için verilerin sade, karşılaştırılabilir, erişilebilir ve tüketici açısından anlamlı bir hikâyeye bağlanması gerekmektedir (Treiblmaier & Garaus, 2023).

4. BLOKZİNCİR, YEŞİL İDDİA GÜVENİLİRLİĞİ VE TÜKETİCİ TEPKİSİ ARASINDAKİ KAVRAMSAL BAĞLANTI

Yeşil iddiaların tüketici pazarında inandırıcılık kazanabilmesi, sürdürülebilir tedarik zinciri yönetimi ile pazarlama iletişiminin kesiştiği temel tartışma alanlarından biridir. Sinyal teorisi temelinde değerlendirildiğinde, işletmelerin çevresel performansa ilişkin beyanları tüketiciye bir kalite ve sorumluluk sinyali göndermektedir; ancak bu sinyalin etkili olabilmesi, iddianın doğrulanabilirliğine bağlıdır (Connelly et al., 2011; George et al., 2019). Blokzincir destekli şeffaflık bu noktada, yeşil iddiaların yalnızca kurumsal söylem olarak kalmasını engelleyerek onları veriyle desteklenen pazar sinyallerine dönüştürebilir (Zhou et al., 2023).

Kavramsal olarak bu ilişki üç aşamada açıklanabilir. İlk aşamada blokzincir, tedarik zincirindeki ürün geçmişi, kaynak kullanımı, sertifikasyon, taşıma, geri dönüşüm ve yaşam döngüsü verilerini kayıt altına alarak yeşil iddiaların kanıt temelini güçlendirir. İkinci aşamada bu kanıt temeli, tüketicinin algıladığı yeşil aklama riskini azaltır ve markaya yönelik güveni destekler (Sun & Shi, 2022; Wu & Long, 2024). Üçüncü aşamada artan güven, sürdürülebilir satın alma niyeti, markaya yönelik olumlu tutum ve sürdürülebilir ürünlere daha yüksek fiyat ödeme istekliliği gibi tüketici tepkilerine yansıyabilir (Phan et al., 2026; Treiblmaier & Garaus, 2023). Bu akış, blokzincirin yalnızca teknik bir kayıt sistemi olarak

değil, tüketiciyle marka arasında güven aracılığı yapan sosyo-teknik bir mekanizma olarak değerlendirilmesi gerektiğini göstermektedir. Dijital izlenebilirlik sistemleri, tüketicinin bilgiye erişimini kolaylaştırdığı ölçüde değer yaratır. Ancak tüketicinin bu veriyi anlamlı bulması, verinin nasıl çerçevelendiği ve hangi iletişim bağlamında sunulduğu ile yakından ilişkilidir. Bu nedenle blokzincir destekli şeffaflık, veri güvenilirliği ile pazarlama anlatısını bir araya getiren bütüncül bir iletişim tasarımı gerektirir.

Bu bağlamda tüketici davranışı ve sürdürülebilir pazarlama literatürü, blokzincir destekli doğrulama mekanizmalarının pazarda güven üretme potansiyelini açıklamak için önemli bir zemin sunmaktadır. İşletmeler çevresel performanslarını şeffaf, kanıtlanabilir ve kullanıcı dostu biçimde sunduklarında tüketici yalnızca pasif bir alıcı olmaktan çıkar; sürdürülebilirlik ekosisteminin izleyicisi, denetleyicisi ve değer ortak üreticisi haline gelir (Centobelli et al., 2022; Nicolau & Petcu, 2026). Böylece yeşil iddialar soyut bir iletişim unsuru olmaktan çıkarak tüketici güvenini ve sürdürülebilir pazar davranışını destekleyen somut bir mekanizmaya dönüşebilir.

5. SONUÇ VE ÖNERİLER

Bu çalışma, döngüsel ekonomi bağlamında yeşil iddiaların tüketici nezdinde güvenilir hale gelebilmesi için dijital şeffaflık, veri doğrulanabilirliği ve pazarlama iletişiminin birlikte ele alınması gerektiğini ortaya koymaktadır. Yeşil dönüşüm söyleminin pazarda karşılık bulması, yalnızca çevresel performansın varlığına değil, bu performansın tüketiciye nasıl aktarıldığına da bağlıdır. Bu nedenle işletmelerin sürdürülebilirlik iletişiminde genel, belirsiz ve doğrulanamayan mesajlar yerine, somut veriyle desteklenen, anlaşılır ve erişilebilir açıklamalara yönelmesi gerekmektedir.

Blokzincir destekli şeffaflık, bu ihtiyaca cevap verebilecek güçlü bir altyapı sunmaktadır. Ancak bu altyapının etkili olabilmesi için teknik doğrulama sistemleri tüketici odaklı iletişim tasarımıyla tamamlanmalıdır. Ürün geçmişi, malzeme içeriği, kaynak kullanımı, geri dönüşüm bilgisi veya tedarik zinciri verileri tüketiciye karmaşık teknik tablolar halinde değil; sade, karşılaştırılabilir ve karar vermeyi kolaylaştıran formatlarda sunulmalıdır. Bu noktada dijital ürün pasaportları, QR kod temelli izlenebilirlik çözümleri ve kullanıcı dostu sürdürülebilirlik panelleri önemli uygulama alanları olarak değerlendirilebilir.

İşletmeler açısından temel öneri, yeşil iddiaların pazarlama kampanyalarına eklenen ikincil mesajlar olarak değil, kurumsal veri yönetişimi ve tedarik zinciri şeffaflığıyla desteklenen stratejik güven unsurları olarak ele alınmasıdır. Sürdürülebilirlik iddialarının marka güvenine katkı sağlaması için operasyonel gerçeklik, veri altyapısı ve iletişim dili arasında tutarlılık kurulmalıdır. Bu tutarlılık sağlanmadığında, en güçlü yeşil mesajlar dahi tüketicide şüphe yaratabilir ve yeşil aklama algısını artırabilir.

Politika yapıcılar ve düzenleyici kurumlar açısından ise dijital ürün pasaportları, sürdürülebilirlik beyanlarının standardizasyonu ve doğrulanabilir yeşil iddia çerçeveleri üzerinde durulması önemlidir. Ortak standartların geliştirilmesi, tüketicilerin farklı ürün ve markalar arasında sağlıklı karşılaştırma yapmasını kolaylaştıracaktır. Ayrıca KOBİ'ler başta olmak üzere işletmelerin bu tür dijital şeffaflık sistemlerini uygulayabilmeleri için teknik kapasite, dijital beceri ve maliyet desteği sağlayan mekanizmalar geliştirilmelidir.

Gelecek çalışmalar bakımından, blokzincir destekli şeffaflık mekanizmalarının farklı sektörlerde tüketici güveni, yeşil iddia algısı ve sürdürülebilir satın alma davranışı üzerindeki etkilerinin daha ayrıntılı incelenmesi yararlı olacaktır. Ayrıca tüketicilerin teknik izlenebilirlik bilgilerini nasıl yorumladığı, hangi bilgi formatlarının güven duygusunu güçlendirdiği ve hangi durumlarda veri yoğunluğunun ters etki yarattığı gibi konular daha fazla araştırmaya ihtiyaç duymaktadır. Sonuç olarak blokzincir, döngüsel ekonomi ve sürdürülebilir pazarlama kesişiminde yalnızca teknolojik bir araç değil, güvene dayalı yeşil pazarların oluşumunu destekleyebilecek stratejik bir şeffaflık mekanizması olarak değerlendirilebilir.

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DİJİTAL EKONOMİNİN VERGİLENDİRİLMESİNDE YENİ PARADİGMA: BEPS EYLEM 1 KAPSAMINDA KÜRESEL VERGİ DÖNÜŞÜMÜNÜN DEĞERLENDİRİLMESİ

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Özet

Dijitalleşme, ekonomik faaliyetlerin yapısını dönüştürmekle kalmayıp uluslararası vergi sistemlerinin temel işleyişlerini tartışmaya açmıştır. Konvansiyonel vergi sistemlerinin benimsediği fiziksel varlık, daimi işyeri ve coğrafi bağ temeline dayalı vergilendirme süreçleri; dijital platformlar, veri temelli iş modelleri ve sınır aşan elektronik ticaret faaliyetleri karşısında yetersiz kalmıştır. Özellikle dijital ürünler üreten çok uluslu şirketlerin bu ürünleri ürettikleri ülkelerde fiziki mevcudiyet bulundurmaksızın yüksek gelirler elde etmeleri, kar aktarımı yoluyla vergi matrahlarının aşındırılması sorunlarını (Base Erosion and Profit Shifting-BEPS) küresel mali gündemin merkezine taşımıştır.

Bu tebliğ, dijital ekonominin vergilendirilmesinde ortaya çıkan dönüşümü, OECD tarafından tasarlanan BEPS Eylem Planı'nın ilk eylemi olan "Eylem 1: Dijital Ekonominin Vergilendirilmesi" kapsamında incelemeyi amaçlamaktadır. Tebliğin başlangıcında dijital ekonominin konvansiyonel vergi sistemleri açısından yarattığı sorunlar ele alınacak, sonrasında Eylem 1 kapsamında nexus (vergileme bağlantısı), değer yaratımı, kullanıcı katkısı ve kar tahsisi gibi temel tartışmalar değerlendirilerek dijital hizmet vergileri ile OECD'nin iki sütunlu çözüm yaklaşımının (Pillar One ve Pillar Two) dijital ticari faaliyetlerin vergilendirilmesine dair etkileri incelenecektir.

Tebliğde nitel araştırma yöntemleri kullanılarak OECD raporları, uluslararası vergi düzenlemeleri ve ülke uygulamaları üzerinden dijital ekonominin vergisel dönüşümü analiz edilecektir. Çalışmanın sonucunda BEPS Eylem 1'in dijital ekonominin vergilendirilmesinde önemli bir paradigma değişikliğini temsil ettiği, ancak dijital faaliyetlerin hızla dönüşen yapısı nedeniyle mevcut düzenlemelerin tek başına yeterli olmadığı ve uluslararası vergi koordinasyonunun güçlendirilmesi gerektiği ileri sürülmektedir. Bunlara ek olarak dijital vergilendirme kapasitesinin, devletin mali sürdürülebilirliği ve ekonomik dayanıklılığı açısından stratejik önem arz ettiği sonucuna ulaşılmaktadır.

Anahtar Kelimeler: Dijital Ekonomi, BEPS Eylem Planı, Dijital Vergilendirme, Küresel Vergi Dönüşümü

A NEW PARADIGM IN THE TAXATION OF THE DIGITAL ECONOMY: AN ASSESSMENT OF GLOBAL TAX REFORM UNDER BEPS ACTION 1

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Abstract

Digitalization has not only transformed the structure of economic activities but has also called into question the fundamental workings of international tax systems. Taxation processes based on physical presence, permanent establishments, and geographic ties—as adopted by conventional tax systems—have proven inadequate in the face of digital platforms, data-driven business models, and cross-border e-commerce activities. In particular, the fact that multinational companies producing digital products generate high revenues without maintaining a physical presence in the countries where they produce these products has brought the issues of tax base erosion and profit shifting (BEPS) to the forefront of the global fiscal agenda.

This paper aims to examine the transformation occurring in the taxation of the digital economy within the framework of "Action 1: Taxation of the Digital Economy," the first action of the BEPS Action Plan designed by the OECD. The paper will begin by addressing the challenges the digital economy poses to conventional tax systems, followed by an evaluation of key debates under Action 1—such as nexus (tax connection), value creation, user contribution, and profit allocation—to examine the impact of digital services taxes and the OECD's two-pillar solution (Pillar One and Pillar Two) on the taxation of digital commercial activities.

The paper will analyze the tax transformation of the digital economy by examining OECD reports, international tax regulations, and national practices using qualitative research methods. The study concludes that BEPS Action 1 represents a significant paradigm shift in the taxation of the digital economy; however, due to the rapidly evolving nature of digital activities, current regulations alone are insufficient, and international tax coordination must be strengthened. In addition, the study concludes that digital taxation capacity is of strategic importance for the government's fiscal sustainability and economic resilience.

Keywords: Digital Economy, BEPS Action Plan, Digital Taxation, Global Tax Reform

GİRİŞ

Bilgi ve iletişim teknolojilerinde meydana gelen gelişmeler, ekonomik faaliyetlerin yapısını köklü biçimde dönüştürmüş ve dijital ekonomi olarak adlandırılan yeni bir ekonomik sistemin ortaya çıkmasına neden olmuştur. Dijitalleşme ile birlikte ticari faaliyetler fiziksel sınırların ötesine taşınmış; veri, algoritma, platform ve kullanıcı katkısı ekonomik değer üretiminin temel unsurları haline gelmiştir. Bu dönüşüm yalnızca üretim ve ticaret süreçlerini değil, aynı zamanda kamu maliyesi ve uluslararası vergilendirme sistemlerini de doğrudan etkilemiştir. Dijital ekonominin yükselişi, özellikle geleneksel vergi sistemlerinin dayandığı fiziksel varlık, işyeri ve coğrafi bağlantı esaslı vergileme anlayışını önemli ölçüde tartışmalı hale getirmiştir (Budak, 2017: 297).

Geleneksel uluslararası vergi sistemi, ekonomik faaliyetlerin belirli bir fiziki mekânda yürütüldüğü varsayımına dayanırken dijitalleşme ile birlikte çok uluslu şirketler herhangi bir ülkede fiziksel varlık bulundurmaksızın yüksek gelir elde edebilme kapasitesine ulaşmıştır. Özellikle Google, Amazon, Meta ve Apple gibi dijital şirketlerin faaliyet gösterdikleri ülkelerde sınırlı vergisel yükümlülüklere tabi olmaları, vergi matrahının aşındırılması ve kar aktarımı sorunlarını küresel mali gündemin merkezine taşımıştır. OECD'ye göre mevcut uluslararası vergi kuralları, ekonomik faaliyetlerin gerçekleştiği ve değerin yaratıldığı yerlerde vergilendirmeyi sağlayacak yeterlilikten uzaklaşmıştır (OECD, 2015: 3).

Dijital ekonominin vergilendirilmesine ilişkin tartışmalar özellikle 2008 küresel finans krizinden sonra yoğunlaşmıştır. Kriz sonrasında kamu gelirlerinde yaşanan azalma ve çok uluslu şirketlerin agresif vergi planlamaları yoluyla vergi yükümlülüklerini minimize etmeleri, devletleri yeni çözüm arayışlarına yöneltmiştir. Bu çerçevede OECD ve G20 ülkeleri tarafından 2013 yılında "Base Erosion and Profit Shifting (BEPS)" Eylem Planı hazırlanmış ve dijital ekonominin vergilendirilmesi sorunu Eylem 1 kapsamında ele alınmıştır (Özcan, 2016: 73-74).

BEPS Eylem 1, dijital ekonominin vergisel açıdan ortaya çıkardığı nexus (vergileme bağlantısı), veri kullanımı, kullanıcı katkısı ve kar tahsisi gibi sorunları incelemekte; aynı zamanda dijital faaliyetlerin etkin biçimde vergilendirilebilmesi için alternatif çözüm önerileri geliştirmektedir. OECD tarafından yayımlanan 2015 Final Raporu, uluslararası vergi sisteminin yaklaşık bir asır sonra ilk büyük dönüşüm sürecine girdiğini ortaya koymuştur (OECD, 2015: 3).

Bu süreçte birçok ülke dijital hizmet vergileri gibi tek taraflı vergisel düzenlemelere yönelmiş; OECD ise küresel ölçekte ortak çözüm oluşturmak amacıyla Pillar One ve Pillar Two olarak adlandırılan iki sütunlu çözüm yaklaşımını geliştirmiştir. Söz konusu yaklaşım, vergileme hakkının yeniden dağıtılmasını ve küresel asgari kurumlar vergisi uygulamasını öngörmektedir (OECD, 2020: 3-4).

Bu çalışmanın amacı, dijital ekonominin vergilendirilmesinde ortaya çıkan dönüşümü OECD BEPS Eylem 1 çerçevesinde incelemek ve küresel vergi sisteminde yaşanan paradigma değişimini değerlendirmektir. Çalışmada öncelikle dijital ekonominin temel özellikleri ve geleneksel vergi sistemleri açısından ortaya çıkardığı sorunlar ele alınacak; daha sonra BEPS Eylem 1 kapsamında geliştirilen çözüm önerileri, dijital hizmet vergileri ve OECD'nin iki sütunlu çözüm yaklaşımı incelenecektir. Çalışmanın sonunda ise dijital vergilendirme sürecinin mali sürdürülebilirlik, vergi adaleti ve küresel mali yönetişim açısından taşıdığı önem değerlendirilecektir.

1. DİJİTAL EKONOMİNİN KAVRAMSAL ÇERÇEVESİ ve TEMEL ÖZELLİKLERİ

Dijital ekonomi, bilgi ve iletişim teknolojilerinin ekonomik faaliyetlerin merkezine yerleşmesiyle ortaya çıkan yeni ekonomik yapıyı ifade etmektedir. Bu yapı içerisinde üretim, tüketim, ticaret ve hizmet sunumu dijital platformlar aracılığıyla gerçekleştirilmektedir. Dijital ekonominin temelinde veri, yazılım, internet altyapısı ve elektronik ağ sistemleri bulunmaktadır. Bilgi teknolojilerinin gelişmesiyle birlikte ekonomik ilişkiler yeniden şekillenmiş ve dijitalleşme küresel ekonominin temel belirleyicilerinden biri haline gelmiştir (Mastar Özcan, 2016: 73).

OECD'ye göre dijital ekonomi artık ekonominin ayrı bir parçası olmaktan çıkmış ve ekonomik sistemin tamamına nüfuz eden bir yapı haline dönüşmüştür. Bu nedenle dijital ekonomi ile geleneksel ekonomi arasında kesin sınırlar çizmek giderek zorlaşmaktadır (OECD, 2015: 54-55). Dijital ekonominin yaygınlaşmasıyla birlikte elektronik ticaret, çevrimiçi reklamcılık, bulut bilişim, dijital platformlar ve veri temelli iş modelleri ekonomik sistem içerisinde önemli bir yer edinmiştir.

Dijital ekonomi, klasik ekonomik yapılardan farklı olarak maddi olmayan varlıklara dayalı bir üretim ve gelir modeli ortaya çıkarmaktadır. Algoritmalar, yazılımlar, kullanıcı verileri ve dijital platformlar ekonomik değerin temel unsurları haline gelirken; fiziksel üretim araçlarının önemi görece azalmaktadır. Bu durum vergi sistemleri açısından da yeni sorunları beraberinde getirmektedir.

Dijital ekonominin en önemli özelliklerinden biri maddi olmayan varlıkların ekonomik faaliyetlerde belirleyici hale gelmesidir. Patentler, yazılımlar, ticari markalar, veri tabanları ve algoritmalar çok uluslu dijital şirketlerin temel gelir kaynaklarını oluşturmaktadır. Maddi olmayan varlıkların mobil niteliği, şirketlerin gelirlerini düşük vergili ülkelere aktarabilmelerini kolaylaştırmaktadır (Yüce ve Akbulut, 2018: 105-106).

Bir diğer önemli özellik kullanıcı katkısına dayalı değer yaratımıdır. Özellikle sosyal medya platformları ve dijital reklam şirketleri, kullanıcıların oluşturduğu veri ve içerikler üzerinden ekonomik değer üretmektedir. Kullanıcıların sisteme sağladığı veri akışı ve ağ etkileri

şirketlerin piyasa değerini artırırken mevcut uluslararası vergi kuralları kullanıcı katkısını yeterince dikkate almamaktadır (Hadzhieva, 2016: 17).

Dijital ekonominin sınır aşan yapısı da vergisel sorunların temel kaynaklarından biridir. Şirketler fiziksel bir işyeri bulundurmaksızın farklı ülkelerde faaliyet gösterebilmekte ve gelir elde edebilmektedir. Mevcut uluslararası vergi sistemi ise vergileme hakkını büyük ölçüde fiziki mevcudiyet esasına dayandırmaktadır. Bu durum dijital şirketlerin vergilendirilmesinde önemli boşluklar yaratmaktadır (Gianni, 2018: 255).

Ayrıca dijital şirketlerin yüksek ölçeklenebilirlik kapasitesine sahip olmaları, kısa sürede küresel pazarlara ulaşmalarını mümkün kılmaktadır. Düşük marjinal maliyetlerle geniş kullanıcı kitlelerine ulaşabilen dijital şirketler, uluslararası piyasalarda geleneksel işletmelere kıyasla önemli rekabet avantajları elde etmektedir.

2. GELENEKSEL VERGİ SİSTEMİNİN DİJİTAL EKONOMİ KARŞISINDA YETERSİZLİĞİ

Uluslararası vergi sistemi büyük ölçüde 20. yüzyılın başlarında şekillenen ekonomik yapıya göre oluşturulmuştur. Bu sistemin temelinde ekonomik faaliyetlerin belirli bir coğrafi alan içerisinde, fiziki işyeri ve maddi üretim unsurları aracılığıyla gerçekleştirildiği varsayımı bulunmaktadır. Özellikle kurum kazançlarının vergilendirilmesinde "daimi işyeri" (permanent establishment) kavramı temel vergileme ölçütü olarak kabul edilmiştir. Buna göre bir devletin vergileme yetkisini kullanabilmesi için ilgili işletmenin o ülkede fiziki bir mevcudiyetinin bulunması gerekmektedir. Ancak dijitalleşme ile birlikte ekonomik faaliyetlerin fiziksel mekândan bağımsız hale gelmesi, geleneksel vergilendirme sisteminin etkinliğini önemli ölçüde azaltmıştır.

Bilgi ve iletişim teknolojilerindeki gelişmeler sayesinde çok uluslu şirketler, herhangi bir ülkede fiziki varlık bulundurmaksızın o ülkenin tüketici piyasasına erişebilmekte ve önemli düzeyde gelir elde edebilmektedir. Özellikle dijital platformlar, çevrimiçi reklamcılık, elektronik ticaret ve veri temelli iş modelleri üzerinden faaliyet gösteren şirketler, mevcut uluslararası vergi sistemindeki boşluklardan yararlanarak vergisel yükümlülüklerini minimize edebilmektedir. Bu durum, mevcut vergilendirme kurallarının dijital ekonomi karşısında yetersiz kaldığını göstermektedir (Budak, 2017: 297-298).

Dijital ekonominin vergilendirilmesinde ortaya çıkan temel sorunlardan biri nexus, yani vergileme bağlantısının belirlenmesidir. Geleneksel sistemde vergileme hakkı büyük ölçüde fiziksel varlık kriterine dayandırılırken dijital ekonomide şirketlerin ekonomik faaliyetleri sanal ortamda gerçekleşmektedir. Bu nedenle dijital şirketler, ekonomik değer yaratmalarına rağmen birçok ülkede vergi mükellefi olarak kabul edilmemektedir. OECD tarafından yayımlanan BEPS Eylem 1 Raporu'nda mevcut uluslararası vergi kurallarının ekonomik

faaliyetlerin gerçekleştiği ve değerin yaratıldığı yerde vergileme yapılmasını sağlamada yetersiz kaldığı ifade edilmektedir (OECD, 2015: 3).

Dijital ekonomiyle birlikte ortaya çıkan bir diğer önemli sorun ise vergi matrahının aşındırılması ve kar aktarımıdır (Base Erosion and Profit Shifting-BEPS). Çok uluslu şirketler, özellikle maddi olmayan varlıkların mobil niteliğinden yararlanarak gelirlerini düşük vergili ülkelere aktarabilmektedir. Patentler, algoritmalar, ticari markalar, yazılımlar ve kullanıcı verileri gibi maddi olmayan varlıklar kolaylıkla farklı ülkelere transfer edilebilmekte; böylece şirketler faaliyet gösterdikleri ülkelerde düşük düzeyde vergi ödeyebilmektedir. Dijital ekonomide maddi olmayan varlıkların ağırlık kazanması, transfer fiyatlandırması uygulamalarını da daha karmaşık hale getirmiştir (Yüce ve Akbulut, 2018: 105-106).

Özellikle Google, Amazon, Apple ve Meta gibi çok uluslu teknoloji şirketleri, farklı ülkelerde elde ettikleri gelirleri düşük vergili yargı bölgelerine kaydırmak suretiyle önemli vergi avantajları elde etmektedir. Bu durum hem gelişmiş hem de gelişmekte olan ülkelerde kamu gelirlerinin azalmasına yol açmaktadır. Avrupa Parlamentosu tarafından hazırlanan çalışmada dijital şirketlerin agresif vergi planlamaları ve vergi kaçınma stratejilerinin Avrupa Birliği ülkelerinde ciddi vergi kayıpları oluşturduğu belirtilmektedir (Hadzhieva, 2016, s. 8).

Dijital ekonominin mevcut vergi sistemleri açısından yarattığı sorunlar yalnızca doğrudan vergilerle sınırlı değildir. Katma değer vergisi (KDV) gibi dolaylı vergiler açısından da önemli sorunlar ortaya çıkmaktadır. Özellikle fiziksel ürünler ile dijital ürünler arasındaki ayrımın belirsizleşmesi, elektronik ortamda sunulan hizmetlerin hangi ülkede vergilendirileceği sorununu gündeme getirmiştir. Artar'a göre dijital ekonominin vergilendirilmesinde doğrudan vergiler açısından nexus, veri ve gelirin niteliği temel sorun alanlarını oluştururken; dolaylı vergiler açısından ise dijital ürünlerin vergisel sınıflandırılması önemli güçlükler yaratmaktadır (Artar, 2020: 21-22).

Dijital ekonominin vergilendirilmesinde yaşanan bir diğer problem ise kullanıcı katkısının vergisel açıdan nasıl değerlendirileceğidir. Geleneksel ekonomik yapılarda değer üretimi büyük ölçüde fiziksel üretim faktörlerine dayanırken dijital ekonomide kullanıcıların oluşturduğu veri ve içerikler ekonomik değerin önemli bir parçası haline gelmiştir. Sosyal medya platformları, arama motorları ve dijital reklam şirketleri kullanıcıların sisteme sağladığı veri akışı üzerinden gelir elde etmektedir. Ancak mevcut uluslararası vergi sistemi kullanıcı katkısını yeterince dikkate almamaktadır. Bu durum özellikle dijital platformların hangi ülkede ve hangi ölçütlere göre vergilendirileceği konusunda önemli tartışmalara yol açmaktadır (Hadzhieva, 2016: 17).

Mevcut vergi sisteminin dijital ekonomi karşısında yetersiz kalması, aynı zamanda vergi adaleti ve vergi egemenliği tartışmalarını da gündeme taşımıştır. Yerel işletmeler faaliyet

gösterdikleri ülkelerde tam vergi yükümlülüğüne tabi olurken çok uluslu dijital şirketlerin düşük vergi yüküyle faaliyet göstermesi haksız rekabet yaratmaktadır. Ayrıca dijital şirketlerin vergi yükümlülüklerinden kaçınabilmesi, devletlerin mali kapasitesini ve kamu gelirlerini olumsuz etkilemektedir. Bu durum özellikle gelişmekte olan ülkelerde mali sürdürülebilirlik açısından önemli riskler doğurmaktadır.

2008 küresel finans krizinden sonra kamu gelirlerinde yaşanan azalma ve vergi kayıplarının artması, devletleri dijital ekonominin vergilendirilmesi konusunda daha aktif politikalar geliştirmeye yöneltmiştir. OECD ve G20 ülkeleri tarafından 2013 yılında yayımlanan BEPS Eylem Planı, bu sorunlara küresel ölçekte çözüm üretme amacı taşımaktadır. Eylem Planı'nın ilk maddesi olan "Dijital Ekonominin Vergilendirilmesi", dijitalleşmenin uluslararası vergi sisteminde yarattığı sorunları ele almakta ve mevcut vergilendirme anlayışının yeniden yapılandırılması gerektiğini ortaya koymaktadır (Özcan, 2016: 73-74).

Sonuç olarak dijital ekonomi, uluslararası vergi sisteminin temel dayanaklarını önemli ölçüde sarsmış ve geleneksel vergilendirme anlayışının yetersizliklerini görünür hale getirmiştir. Fiziksel varlık esasına dayalı vergileme modeli, dijitalleşmenin sınır aşan ve veri temelli ekonomik yapısı karşısında işlevini büyük ölçüde kaybetmiştir. Bu nedenle dijital ekonominin etkin biçimde vergilendirilebilmesi için uluslararası vergi kurallarının ekonomik gerçekliklere uygun biçimde yeniden düzenlenmesi gerekmektedir. OECD tarafından geliştirilen BEPS Eylem 1 süreci, bu dönüşümün en önemli aşamalarından biri olarak değerlendirilmektedir.

3. OECD BEPS EYLEM 1 ve DİJİTAL VERGİLENDİRME SÜRECİ

Küreselleşme ve dijitalleşme süreçlerinin hız kazanmasıyla birlikte uluslararası vergi sistemi önemli sorunlarla karşı karşıya kalmıştır. Özellikle çok uluslu şirketlerin dijital teknolojiler aracılığıyla fiziksel varlık bulundurmaksızın farklı ülkelerde gelir elde edebilmesi, mevcut vergileme sisteminin etkinliğini azaltmıştır. Bu süreçte dijital şirketlerin agresif vergi planlamaları yoluyla vergi yükümlülüklerini minimize etmeleri, devletlerin vergi gelirlerinde ciddi kayıplara yol açmıştır. 2008 küresel finans krizinin ardından kamu gelirlerinde yaşanan daralma, vergi kayıplarıyla mücadeleyi küresel mali gündemin temel konularından biri haline getirmiştir. Bu gelişmeler doğrultusunda OECD ve G20 ülkeleri tarafından 2013 yılında "Base Erosion and Profit Shifting (BEPS)" Eylem Planı hazırlanmıştır.

BEPS Eylem Planı, vergi matrahının aşındırılması ve kar aktarımı sorunlarına karşı uluslararası ölçekte ortak çözüm geliştirmeyi amaçlayan kapsamlı bir reform sürecidir. OECD tarafından hazırlanan raporda, mevcut uluslararası vergi kurallarının ekonomik faaliyetlerin gerçekleştiği ve değerin yaratıldığı yerde vergileme yapılmasını yeterince sağlayamadığı belirtilmiştir (OECD, 2015: 3). Bu nedenle BEPS Projesi, uluslararası vergi sisteminin yeniden yapılandırılmasına yönelik en kapsamlı girişimlerden biri olarak değerlendirilmektedir.

BEPS Eylem Planı toplam on beş eylemden oluşmakta olup ilk eylem maddesi dijital ekonominin vergilendirilmesine ayrılmıştır. "Action 1: Addressing the Tax Challenges of the Digital Economy" başlıklı bu düzenleme, dijital ekonominin mevcut vergi sistemlerinde ortaya çıkardığı sorunları incelemekte ve çözüm önerileri geliştirmektedir. OECD'ye göre dijital ekonomi, geleneksel ekonomik yapılardan farklı özellikler taşıdığı için mevcut vergileme ilkelerinin yeniden değerlendirilmesini gerekli kılmaktadır (OECD, 2015: 15).

BEPS Eylem 1 kapsamında ele alınan temel sorun alanlarından biri nexus, yani vergileme bağlantısıdır. Geleneksel uluslararası vergi sistemi, bir devletin vergileme yetkisini kullanabilmesi için şirketin o ülkede fiziki bir işyerine sahip olmasını şart koşmaktadır. Ancak dijital ekonomide şirketler internet ve dijital platformlar aracılığıyla fiziksel varlık olmaksızın önemli düzeyde gelir elde edebilmektedir. Bu durum, mevcut nexus anlayışının dijital ekonomi açısından yetersiz kalmasına neden olmaktadır. OECD tarafından hazırlanan raporda dijital ekonominin mevcut vergileme kurallarını zorladığı ve ekonomik mevcudiyetin fiziki mevcudiyetten bağımsız şekilde değerlendirilmesi gerektiği vurgulanmaktadır (OECD, 2015: 84-85).

Bu kapsamda OECD tarafından "significant economic presence" (önemli ekonomik mevcudiyet) yaklaşımı gündeme getirilmiştir. Bu yaklaşım, şirketlerin fiziksel varlık şartı aranmaksızın ekonomik faaliyet yürüttükleri ülkelerde vergilendirilebilmesini amaçlamaktadır. Gianni'ye göre dijital ekonomide fiziki varlık esasının sürdürülmesi, çok uluslu şirketlerin vergiden kaçınmalarına olanak sağlamaktadır. Bu nedenle vergileme bağlantısının ekonomik faaliyetler temelinde yeniden tanımlanması gerekmektedir (Gianni, 2018: 255-256).

BEPS Eylem 1 kapsamında öne çıkan bir diğer konu ise kullanıcı katkısı ve değer yaratımı tartışmalarıdır. Geleneksel ekonomik yapılarda değer üretimi büyük ölçüde emek, sermaye ve fiziksel üretim araçları üzerinden gerçekleşirken dijital ekonomide kullanıcı verileri ve dijital etkileşimler ekonomik değerin önemli bir parçası haline gelmiştir. Özellikle sosyal medya platformları, dijital reklam şirketleri ve çevrimiçi pazaryerleri kullanıcıların sisteme sağladığı veri ve içeriklerden önemli gelirler elde etmektedir. Ancak mevcut vergi sistemi kullanıcı katkısını yeterince dikkate almamaktadır. Avrupa Parlamentosu tarafından hazırlanan çalışmada nexus, veri ve karakterizasyon sorunlarının dijital ekonominin vergilendirilmesindeki temel problem alanları olduğu ifade edilmektedir (Hadzhieva, 2016: 17).

Dijital ekonominin vergilendirilmesine ilişkin bir diğer önemli tartışma ise kar tahsisi problemidir. Çok uluslu şirketlerin farklı ülkelerde faaliyet göstermeleri ve gelirlerini düşük vergili ülkelere aktarabilmeleri, karın hangi ülkede vergilendirileceği sorununu gündeme getirmektedir. Özellikle maddi olmayan varlıkların mobil yapısı, transfer fiyatlandırması

uygulamalarını daha karmaşık hale getirmiştir. OECD, karların ekonomik faaliyetin gerçekleştiği ve değerin yaratıldığı yerde vergilendirilmesi gerektiğini vurgulamaktadır (OECD, 2015 :3). Bu yaklaşım, uluslararası vergi sisteminde "value creation" ilkesinin önem kazanmasına neden olmuştur.

BEPS Eylem 1 kapsamında geliştirilen çözüm önerileri arasında eşitleme vergisi (equalisation levy), dijital işlemler üzerinden stopaj uygulanması ve significant economic presence yaklaşımı yer almaktadır. Ancak OECD, bu çözümlerin tek taraflı biçimde uygulanmasının uluslararası vergi uyuşmazlıklarını artırabileceğini belirtmiştir. Bu nedenle dijital ekonominin vergilendirilmesine ilişkin küresel ölçekte ortak çözüm geliştirilmesi gerektiği vurgulanmaktadır (OECD, 2015: 11-12).

BEPS sürecinin ilerleyen aşamalarında OECD tarafından Pillar One ve Pillar Two olarak adlandırılan iki sütunlu çözüm yaklaşımı geliştirilmiştir. Pillar One, çok uluslu şirketlerin artık karlarının faaliyet gösterdikleri pazar ülkelerine yeniden dağıtılmasını hedeflemektedir. Böylece fiziksel varlık bulunmasa dahi ekonomik faaliyet yürütülen ülkelerin vergileme hakkı güçlendirilmektedir. Pillar Two ise küresel asgari kurumlar vergisi uygulamasını öngörmekte ve vergi cennetlerine yönelen kar aktarımı stratejilerini sınırlandırmayı amaçlamaktadır (OECD, 2020: 3-4).

OECD tarafından yayımlanan "Tax Challenges Arising from Digitalisation – Economic Impact Assessment" raporunda dijitalleşmenin uluslararası vergi sistemi üzerinde ciddi baskılar oluşturduğu ve mevcut kuralların ekonomik gerçekliklere uyum sağlayamadığı belirtilmektedir. Rapora göre dijitalleşme, yalnızca vergi gelirlerini değil aynı zamanda küresel yatırım yapısını ve uluslararası ticaret ilişkilerini de etkilemektedir (OECD, 2020: 3).

Bununla birlikte BEPS Eylem 1 süreci çeşitli eleştirilere de konu olmuştur. Özellikle gelişmekte olan ülkeler, OECD'nin çözüm önerilerinin gelişmiş ülkelerin çıkarlarını daha fazla koruduğunu ileri sürmektedir. Ayrıca dijital ekonominin hızlı dönüşümü karşısında mevcut düzenlemelerin yetersiz kalabileceği ve tek taraflı dijital hizmet vergilerinin artmaya devam edeceği belirtilmektedir. Gianni, OECD'nin dijital ekonomide fiziksel varlık sorununa uzun süre kesin çözüm geliştiremediğini ve bu nedenle birçok ülkenin kendi ulusal düzenlemelerine yöneldiğini ifade etmektedir (Gianni, 2018: 255).

Sonuç olarak BEPS Eylem 1, dijital ekonominin vergilendirilmesine ilişkin küresel çözüm arayışlarının temelini oluşturan önemli bir reform sürecidir. Nexus, kullanıcı katkısı, değer yaratımı ve kar tahsisi gibi kavramlar uluslararası vergilendirme sisteminin merkezine yerleşmiş; geleneksel vergileme anlayışı dijitalleşme doğrultusunda yeniden şekillenmeye başlamıştır. Ancak dijital ekonominin sürekli değişen yapısı dikkate alındığında, uluslararası vergi sisteminin gelecekte de yeni düzenlemelere ihtiyaç duyacağı açıktır.

4. DİJİTAL HİZMET VERGİLERİ ve ULUSAL UYGULAMALAR

Dijital ekonominin vergilendirilmesine ilişkin küresel düzeyde ortak çözüm arayışlarının uzun sürmesi, birçok ülkenin tek taraflı vergisel düzenlemelere yönelmesine neden olmuştur. Özellikle çok uluslu dijital şirketlerin faaliyet gösterdikleri ülkelerde düşük düzeyde vergi ödemeleri, devletleri yeni vergi araçları geliştirmeye zorlamıştır. Bu süreçte "Dijital Hizmet Vergisi" (Digital Services Tax-DST), dijital ekonominin vergilendirilmesine yönelik en yaygın ulusal çözüm araçlarından biri olarak ortaya çıkmıştır. Dijital hizmet vergileri, genellikle dijital reklamcılık, çevrimiçi platform hizmetleri, veri satışı ve dijital içerik hizmetlerinden elde edilen gelirlerin vergilendirilmesini amaçlamaktadır.

Dijital hizmet vergilerinin ortaya çıkışındaki temel neden, mevcut uluslararası vergi sisteminin dijital faaliyetlerden elde edilen gelirleri etkin biçimde vergilendirememesidir. Geleneksel vergi sistemleri fiziki işyeri esasına dayanırken dijital şirketler fiziksel varlık olmaksızın farklı ülkelerde yüksek gelir elde edebilmektedir. Bu durum özellikle Google, Amazon, Apple ve Meta gibi teknoloji şirketlerinin faaliyet gösterdikleri ülkelerde sınırlı vergi ödemelerine neden olmuş ve kamuoyunda vergi adaleti tartışmalarını gündeme taşımıştır. Avrupa Parlamentosu tarafından hazırlanan çalışmada dijital şirketlerin agresif vergi planlamaları yoluyla vergi kaçınma stratejileri geliştirdikleri ve bunun devletlerin vergi gelirlerinde önemli kayıplara yol açtığı belirtilmektedir (Hadzhieva, 2016: 8).

OECD'nin dijital ekonominin vergilendirilmesine ilişkin çalışmaları devam ederken Avrupa Birliği ülkeleri başta olmak üzere birçok devlet dijital hizmet vergilerini geçici çözüm aracı olarak uygulamaya başlamıştır. Avrupa Komisyonu tarafından önerilen dijital hizmet vergisinin temel amacı, dijital şirketlerin kullanıcıların bulunduğu ülkelerde vergi ödemelerini sağlamaktır. Bu yaklaşım, dijital ekonomide kullanıcı katkısının ekonomik değer yaratımındaki rolüne dayanmaktadır. Durdu'ya göre Avrupa Birliği tarafından önerilen Dijital Hizmet Vergisi, dijital faaliyetlerden elde edilen gelirlerin kullanıcıların bulunduğu ülkelerde vergilendirilmesini hedeflemektedir (Durdu, 2020: 1961-1962).

Fransa, dijital hizmet vergisini uygulamaya koyan ilk ülkelerden biri olmuştur. Fransız dijital hizmet vergisi; dijital reklamcılık, dijital aracı platform hizmetleri ve kullanıcı verilerinin satışından elde edilen gelirleri kapsamaktadır. Vergi özellikle büyük teknoloji şirketlerini hedef almakta ve belirli gelir eşiğini aşan şirketlere uygulanmaktadır. İngiltere de benzer şekilde dijital reklam hizmetleri ve çevrimiçi platform gelirleri üzerinden dijital hizmet vergisi uygulamasına geçmiştir. Hindistan ise "equalisation levy" adı verilen düzenlemeyle dijital reklam gelirleri üzerinden vergileme yapmaya başlamıştır. Bu uygulamalar, devletlerin dijital ekonomiden kaynaklanan vergi kayıplarını azaltma çabalarının bir sonucu olarak değerlendirilmektedir.

Bununla birlikte dijital hizmet vergileri uluslararası düzeyde çeşitli eleştirilere de konu olmuştur. Özellikle tek taraflı vergisel düzenlemelerin uluslararası ticaret ilişkilerini olumsuz etkileyebileceği ve vergi savaşlarına yol açabileceği ileri sürülmektedir. ABD, dijital hizmet vergilerinin ağırlıklı olarak Amerikan teknoloji şirketlerini hedef aldığını savunarak bazı ülkelere karşı ticari yaptırım tehdidinde bulunmuştur. OECD de tek taraflı dijital vergilerin uluslararası vergi uyuşmazlıklarını artırabileceğini ve küresel ölçekte ortak çözüm geliştirilmesinin daha uygun olacağını belirtmektedir (OECD, 2015: 11-12).

Dijital hizmet vergilerine yönelik bir diğer eleştiri ise çifte vergilendirme riskidir. Çok uluslu şirketlerin hem faaliyet gösterdikleri ülkelerde dijital hizmet vergisine tabi tutulmaları hem de merkez ülkelerinde kurumlar vergisi ödemeleri, aynı gelir üzerinden birden fazla vergileme yapılmasına neden olabilmektedir. Ayrıca dijital hizmet vergilerinin maliyetlerinin tüketicilere yansıtılması ihtimali de tartışma konusu olmaktadır. Bu durum dijital hizmetlerin fiyatlarının artmasına ve piyasa yapısının olumsuz etkilenmesine yol açabilmektedir.

Türkiye'de dijital ekonominin vergilendirilmesine ilişkin ilk önemli düzenlemeler 2017 yılında yapılmıştır. 7061 sayılı Kanun ile Katma Değer Vergisi Kanunu'nda değişiklikler gerçekleştirilmiş ve elektronik ortamda sunulan hizmetlerin vergilendirilmesine yönelik adımlar atılmıştır. Daha sonra 7194 sayılı Kanun ile "Dijital Hizmet Vergisi" yürürlüğe girmiştir (Özcan, 2020: 173). Türkiye'de uygulanan dijital hizmet vergisi; dijital reklam hizmetleri, dijital içerik satışları, sosyal medya platformları ve dijital aracı hizmetlerden elde edilen gelirleri kapsamaktadır.

Türk Dijital Hizmet Vergisi'nin temel amacı, Türkiye'de kullanıcı kitlesi bulunan dijital şirketlerin ekonomik faaliyetlerinden doğan gelirlerin vergilendirilmesini sağlamaktır. Vergi, belirli küresel ve ulusal hasılat eşiklerini aşan şirketlere uygulanmaktadır. Böylece küçük ölçekli işletmeler kapsam dışında bırakılırken büyük çok uluslu dijital şirketlerin vergilendirilmesi hedeflenmiştir. Yayman'a göre dijital hizmet vergisi uygulamaları, dijital şirketlerin fiziki varlıkları olmasa dahi ekonomik faaliyet yürüttükleri ülkelerde vergilendirilmelerini sağlamaya yönelik önemli bir adım niteliğindedir (Yayman, 2022: 114-116).

Ancak Türkiye'deki dijital hizmet vergisi uygulaması da çeşitli tartışmaları beraberinde getirmiştir. Özellikle vergi oranının Avrupa Birliği örneklerine kıyasla yüksek olduğu yönünde eleştiriler yapılmıştır. Ayrıca dijital hizmet sağlayıcılarının vergiye uyumunun nasıl sağlanacağı ve uluslararası şirketlerin denetiminin nasıl gerçekleştirileceği önemli sorun alanları olarak ortaya çıkmıştır. Durdu'ya göre dijital hizmet vergisine uyum sağlamayan şirketlere internet erişim engeli uygulanabilmesi, hukuki açıdan tartışmalı bir düzenleme niteliği taşımaktadır (Durdu, 2020: 1965-1967).

Türkiye açısından dijital hizmet vergisi, kısa vadede vergi gelirlerini artırma potansiyeline sahip olmakla birlikte uzun vadede uluslararası koordinasyon eksikliği nedeniyle çeşitli riskler taşımaktadır. OECD düzeyinde küresel uzlaşı sağlanmadan uygulanan ulusal dijital vergiler, çifte vergilendirme riskini artırabileceği gibi uluslararası yatırım ortamı üzerinde de olumsuz etkiler yaratabilmektedir. Bu nedenle dijital hizmet vergilerinin geçici çözüm aracı olarak değerlendirilmesi ve küresel ölçekte ortak vergilendirme mekanizmalarının geliştirilmesi önem taşımaktadır.

Sonuç olarak dijital hizmet vergileri, dijital ekonominin vergilendirilmesinde ortaya çıkan boşlukları doldurmaya yönelik önemli araçlardan biri haline gelmiştir. Özellikle çok uluslu dijital şirketlerin faaliyet gösterdikleri ülkelerde vergi ödemelerini sağlamaya yönelik bu düzenlemeler, vergi adaleti ve kamu gelirlerinin korunması açısından önem taşımaktadır. Ancak tek taraflı dijital vergilerin uluslararası ticaret ilişkileri ve küresel vergi sistemi üzerindeki etkileri dikkate alındığında, uzun vadeli çözümün OECD öncülüğünde geliştirilen küresel koordinasyon mekanizmalarına dayandığı görülmektedir.

5. OECD'NİN İKİ SÜTUNLU ÇÖZÜM YAKLAŞIMI: PILLAR ONE ve PILLAR TWO

Dijital ekonominin vergilendirilmesine ilişkin sorunların küresel ölçekte giderek derinleşmesi, OECD ve G20 ülkelerini daha kapsamlı ve ortak bir çözüm mekanizması geliştirmeye yöneltmiştir. BEPS Eylem 1 kapsamında başlatılan çalışmalar, zaman içerisinde yalnızca dijital şirketlerin değil, genel olarak çok uluslu işletmelerin vergilendirilmesine ilişkin yapısal sorunları da kapsayan daha geniş bir reform sürecine dönüşmüştür. Bu doğrultuda OECD tarafından "Pillar One" ve "Pillar Two" olarak adlandırılan iki sütunlu çözüm yaklaşımı geliştirilmiştir. Söz konusu yaklaşım, dijitalleşmenin uluslararası vergi sistemi üzerinde yarattığı etkileri azaltmayı ve küresel ölçekte daha adil bir vergileme yapısı oluşturmayı amaçlamaktadır.

OECD'ye göre dijitalleşme, mevcut uluslararası vergi sisteminin ekonomik faaliyetlerin gerçekleştiği ve değerin yaratıldığı yerlerde etkin vergilendirme yapılmasını zorlaştırmaktadır. Bu nedenle yeni çözüm yaklaşımı, hem vergileme hakkının yeniden dağıtılmasını hem de vergi matrahının aşındırılmasını önlemeyi hedeflemektedir (OECD, 2020: 3). OECD/G20 Inclusive Framework kapsamında geliştirilen iki sütunlu model, uluslararası vergi sisteminde yaklaşık bir asır sonra gerçekleştirilen en önemli reform girişimlerinden biri olarak değerlendirilmektedir.

5.1. Pillar One: Vergileme Hakkının Yeniden Dağıtılması

Pillar One'ın temel amacı, çok uluslu şirketlerin elde ettikleri karların faaliyet gösterdikleri pazar ülkelerine yeniden dağıtılmasıdır. Geleneksel uluslararası vergi sistemi, vergileme hakkını büyük ölçüde şirketlerin fiziki varlığına dayandırırken dijital ekonomide ekonomik faaliyetler fiziksel mevcudiyetten bağımsız hale gelmiştir. Bu durum özellikle dijital platformların kullanıcıların bulunduğu ülkelerde yüksek gelir elde etmelerine rağmen düşük düzeyde vergi ödemelerine yol açmaktadır.

OECD tarafından geliştirilen Pillar One yaklaşımı, nexus kavramını yeniden yorumlayarak ekonomik faaliyetlerin yürütüldüğü pazar ülkelerine daha fazla vergileme yetkisi verilmesini amaçlamaktadır. Böylece şirketlerin bir ülkede fiziksel işyeri bulunmasa dahi ekonomik faaliyet yürütmeleri halinde ilgili ülkenin vergileme hakkı doğabilecektir. OECD raporunda Pillar One'ın özellikle nexus ve kar tahsisi sorunlarına çözüm geliştirmeyi hedeflediği belirtilmektedir (OECD, 2020: 3-4).

Pillar One kapsamında geliştirilen en önemli kavramlardan biri "Amount A" düzenlemesidir. Amount A, çok uluslu şirketlerin artık karlarının (residual profit) belirli bir kısmının faaliyet gösterdikleri pazar ülkelerine tahsis edilmesini öngörmektedir. Bu yaklaşım, dijital ekonomide kullanıcı katkısının ekonomik değer yaratımındaki rolünü dikkate almaktadır. Özellikle sosyal medya platformları, dijital reklam şirketleri ve çevrimiçi pazaryerleri açısından kullanıcıların bulunduğu ülkelerin vergileme hakkı güçlendirilmektedir.

Pillar One'ın bir diğer önemli unsuru ise "Amount B" düzenlemesidir. Bu düzenleme, pazarlama ve dağıtım faaliyetleri için standartlaştırılmış bir kar tahsis mekanizması geliştirmeyi amaçlamaktadır. Böylece transfer fiyatlandırması uyuşmazlıklarının azaltılması ve uluslararası vergi sisteminde daha fazla öngörülebilirlik sağlanması hedeflenmektedir.

Pillar One yaklaşımı, özellikle gelişmekte olan ülkeler açısından önemli sonuçlar doğurmaktadır. Çünkü dijital ekonomide kullanıcı kitlesi geniş olan ülkeler, fiziki yatırım bulunmasa dahi çok uluslu şirketlerin gelirlerinden pay alma imkanına kavuşmaktadır. Bununla birlikte bazı ülkeler, vergileme hakkının yeniden dağıtılmasının mevcut uluslararası vergi anlaşmalarıyla uyumlu olup olmadığı konusunda çekinceler taşımaktadır. Ayrıca kar tahsisi yöntemlerinin karmaşık yapısı ve uygulama maliyetleri de Pillar One'a yönelik eleştiriler arasında yer almaktadır.

5.2. Pillar Two: Küresel Asgari Kurumlar Vergisi

OECD'nin iki sütunlu çözüm yaklaşımının ikinci ayağını oluşturan Pillar Two, küresel ölçekte asgari kurumlar vergisi uygulamasını öngörmektedir. Pillar Two'nun temel amacı, çok uluslu şirketlerin gelirlerini düşük vergili ülkelere aktarmalarını önlemek ve vergi rekabetini sınırlandırmaktır. Dijital ekonominin gelişmesiyle birlikte şirketlerin maddi

olmayan varlıklarını vergi cennetlerine kolaylıkla aktarabilmeleri, küresel ölçekte vergi matrahının aşındırılması sorununu daha da derinleştirmiştir.

OECD tarafından hazırlanan ekonomik etki değerlendirme raporunda Pillar Two'nun, vergi cennetlerine yönelen kar aktarımını azaltarak küresel vergi gelirlerini artırabileceği ifade edilmektedir (OECD, 2020: 12-15). Bu kapsamda çok uluslu şirketlerin faaliyet gösterdikleri tüm ülkelerde belirli bir asgari vergi oranına tabi tutulmaları hedeflenmektedir. Küresel asgari kurumlar vergisi oranı %15 olarak belirlenmiştir.

Pillar Two sistemi temel olarak dört ana mekanizma üzerine kurulmuştur. Bunlardan ilki "Income Inclusion Rule" (Gelir Dahil Etme Kuralı) olup, düşük vergili ülkelerde elde edilen gelirlerin ana şirketin bulunduğu ülkede ek vergilendirmeye tabi tutulmasını öngörmektedir. İkinci mekanizma ise "Undertaxed Payments Rule" (Düşük Vergilendirilmiş Ödemeler Kuralı) olup, düşük vergili ülkelere yapılan ödemelere sınırlama getirilmesini amaçlamaktadır. Böylece şirketlerin vergi avantajı elde etmek amacıyla gelirlerini düşük vergili ülkelere kaydırmaları zorlaştırılmaktadır.

Pillar Two'nun önemli hedeflerinden biri de küresel vergi rekabetini sınırlandırmaktır. Uzun yıllardır birçok ülke doğrudan yabancı yatırımları çekebilmek amacıyla kurumlar vergisi oranlarını düşürmektedir. Bu durum küresel ölçekte "race to the bottom" olarak adlandırılan vergi rekabeti sürecini ortaya çıkarmıştır. OECD'ye göre küresel asgari kurumlar vergisi uygulaması, ülkelerin aşırı düşük vergi oranlarıyla yatırım çekme stratejilerini sınırlandıracaktır (OECD, 2020: 47-52).

Bununla birlikte Pillar Two yaklaşımı da çeşitli eleştirilere konu olmaktadır. Özellikle gelişmekte olan ülkeler, küresel asgari kurumlar vergisinin yatırım çekme kapasitelerini azaltabileceğini ileri sürmektedir. Ayrıca ulusal vergi egemenliği açısından değerlendirildiğinde, küresel düzeyde belirlenen asgari vergi oranlarının ülkelerin bağımsız vergi politikalarını sınırlandırabileceği belirtilmektedir. Bunun yanında uygulamanın teknik açıdan oldukça karmaşık olması ve çok uluslu şirketler açısından yüksek uyum maliyetleri yaratması da tartışma konusu olmaktadır.

Genel olarak değerlendirildiğinde OECD'nin iki sütunlu çözüm yaklaşımı, dijitalleşmenin uluslararası vergi sistemi üzerinde yarattığı sorunlara karşı geliştirilen en kapsamlı reform girişimlerinden biridir. Pillar One ile vergileme hakkının ekonomik faaliyetlerin gerçekleştiği ülkelere kaydırılması hedeflenirken; Pillar Two ile vergi matrahının aşındırılması ve zararlı vergi rekabetinin sınırlandırılması amaçlanmaktadır. Her ne kadar uygulama süreci çeşitli teknik ve siyasi tartışmaları beraberinde getirse de iki sütunlu yaklaşım, küresel vergi yönetişiminin geleceği açısından önemli bir dönüşüm sürecini temsil etmektedir.

6. SONUÇ

Dijitalleşme süreci, yalnızca ekonomik faaliyetlerin yapısını değil, aynı zamanda uluslararası vergi sistemlerinin temel işleyiş mantığını da dönüştürmüştür. Geleneksel vergi sistemleri fiziksel varlık, daimi işyeri ve coğrafi bağ esasına dayanırken dijital ekonomi; veri temelli iş modelleri, platform ekonomileri ve sınır aşan elektronik ticaret faaliyetleri aracılığıyla bu yapının yetersizliklerini görünür hale getirmiştir. Özellikle çok uluslu dijital şirketlerin faaliyet gösterdikleri ülkelerde fiziki mevcudiyet bulundurmaksızın yüksek gelir elde etmeleri ve bu gelirleri düşük vergili ülkelere aktarabilmeleri, uluslararası vergi sisteminde ciddi matrah aşındırması ve kar aktarımı sorunlarına yol açmıştır.

Bu gelişmeler doğrultusunda OECD ve G20 ülkeleri tarafından geliştirilen BEPS Eylem Planı, dijital ekonominin vergilendirilmesine yönelik küresel çözüm arayışlarının temelini oluşturmuştur. Eylem Planı'nın ilk maddesi olan BEPS Eylem 1, dijital ekonominin vergisel açıdan ortaya çıkardığı nexus, kullanıcı katkısı, veri kullanımı ve kar tahsisi gibi sorunları ele alarak uluslararası vergilendirme sisteminde önemli bir paradigma değişimini başlatmıştır. Özellikle ekonomik faaliyetlerin gerçekleştiği ve değerin yaratıldığı yerde vergileme yapılması gerektiği yönündeki yaklaşım, geleneksel vergileme anlayışının yeniden değerlendirilmesine neden olmuştur (OECD, 2015: 3).

Çalışma kapsamında incelenen dijital hizmet vergileri, devletlerin dijital ekonomiden kaynaklanan vergi kayıplarını önlemeye yönelik kısa vadeli çözüm araçları olarak ortaya çıkmıştır. Fransa, İngiltere, Hindistan ve Türkiye gibi ülkeler tarafından uygulamaya konulan dijital hizmet vergileri, çok uluslu dijital şirketlerin faaliyet gösterdikleri ülkelerde vergilendirilmesini amaçlamaktadır. Bununla birlikte tek taraflı dijital vergi uygulamalarının uluslararası ticaret ilişkileri üzerinde baskı oluşturduğu, çifte vergilendirme riskini artırdığı ve vergi savaşlarına yol açabileceği görülmektedir. Bu nedenle dijital hizmet vergilerinin uzun vadeli ve sürdürülebilir bir çözümden ziyade geçiş sürecine ait düzenlemeler olduğu söylenebilir.

OECD tarafından geliştirilen Pillar One ve Pillar Two yaklaşımı ise dijital ekonominin vergilendirilmesine yönelik küresel ölçekte ortak çözüm oluşturma çabasının en önemli aşamasını temsil etmektedir. Pillar One ile vergileme hakkının pazar ülkelerine yeniden dağıtılması hedeflenirken; Pillar Two ile küresel asgari kurumlar vergisi uygulaması aracılığıyla vergi matrahının aşındırılması ve zararlı vergi rekabetinin sınırlandırılması amaçlanmaktadır. Bu yaklaşım, uluslararası vergi sisteminin dijitalleşme sürecine uyum sağlaması açısından önemli bir dönüşüm niteliği taşımaktadır.

Sonuç olarak dijital ekonominin sürekli değişen yapısı dikkate alındığında, mevcut düzenlemelerin tek başına yeterli olmayacağı açıktır. Yapay zekâ, büyük veri, dijital platformlar ve kripto varlıklar gibi yeni ekonomik alanların gelişmesi, gelecekte daha

kapsamlı uluslararası vergi reformlarını gerekli kılacaktır. Bu nedenle dijital ekonominin etkin biçimde vergilendirilebilmesi için yalnızca ulusal düzenlemelerin değil, aynı zamanda küresel vergi koordinasyonunun ve mali iş birliğinin güçlendirilmesi gerekmektedir. Dijital vergilendirme kapasitesi, günümüzde yalnızca kamu gelirlerinin korunması açısından değil, aynı zamanda mali sürdürülebilirlik, ekonomik dayanıklılık ve küresel vergi adaletinin sağlanması açısından da stratejik önem taşımaktadır.

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SMART CITY DIGITALIZATION AND ENVIRONMENTAL SUSTAINABILITY: COMPARATIVE EVIDENCE FROM TÜRKİYE AND GERMANY

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Abstract

The acceleration of digital transformation processes and the widespread adoption of sustainability-focused policies have heightened the importance of smart city applications. Today, smart city digitalization has become a key policy tool in areas such as energy efficiency, environmental sustainability, smart transport systems, sustainable urban management and climate resilience. In this context, Turkiye and Germany are countries that differ in terms of their economic structures, levels of technological advancement and sustainable transformation policies. Whilst Germany is implementing advanced smart city and green transformation policies within the framework of the European Green Deal, Turkiye has been taking significant steps in the fields of digitalization and sustainable urbanization in recent years. The aim of this study is to examine, in a comparative manner, the relationship between smart city digitalization and environmental sustainability in Turkiye and Germany. The study will address the impacts of digital transformation processes, information and communication technologies (ICT), smart city infrastructure and sustainable development policies on environmental indicators. Furthermore, the similarities and differences between the two countries' smart city transformation strategies and their environmental sustainability performance will be assessed. The ARDL method was used in research to analyze the short- and long-term relationships between the two countries' digitalization indicators and environmental sustainability variables. The model utilizes variables such as carbon emissions, renewable energy consumption, the level of ICT development, energy efficiency and the urbanization rate.

The findings of the study are expected to contribute to the literature on smart city governance, sustainable urban transformation, and the twin transition by providing comparative evidence from both a developed and an emerging economy. Furthermore, the study is expected to provide policy implications for the development of more sustainable and digitally integrated urban ecosystems.

Keywords: Smart City Digitalization, Environmental Sustainability, Comparative Study, Twin Transition

AKILLI ŞEHİR DİJİTALLEŞMESİ VE ÇEVRESEL SÜRDÜRÜLEBİLİRLİK: TÜRKİYE VE ALMANYA'DAN KARŞILAŞTIRMALI BULGULAR

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Özet

Dijital dönüşüm süreçlerinin hız kazanması ve sürdürülebilirlik odaklı politikaların yaygınlaşması, akıllı şehir uygulamalarının önemini artırmıştır. Günümüzde akıllı şehir dijitalleşmesi; enerji verimliliği, çevresel sürdürülebilirlik, akıllı ulaşım sistemleri, sürdürülebilir kent yönetimi ve iklim direnci gibi alanlarda önemli bir politika aracı haline gelmiştir. Bu bağlamda Türkiye ve Almanya ekonomik yapıları, teknolojik gelişmişlik düzeyleri ve sürdürülebilir dönüşüm politikaları bakımından farklılık arz eden ülkelerdir. Almanya, Avrupa Yeşil Mutabakatı çerçevesinde gelişmiş akıllı şehir ve yeşil dönüşüm politikaları uygularken, Türkiye son yıllarda dijitalleşme ve sürdürülebilir kentleşme alanlarında önemli adımlar atmaktadır. Bu çalışmanın amacı, Türkiye ve Almanya'da akıllı şehir dijitalleşmesi ile çevresel sürdürülebilirlik arasındaki ilişkiyi karşılaştırmalı olarak incelemektir. Çalışmada dijital dönüşüm süreçlerinin, bilgi ve iletişim teknolojilerinin (ICT), akıllı kent altyapılarının ve sürdürülebilir kalkınma politikalarının çevresel göstergeler üzerindeki etkileri ele alınacaktır. Ayrıca iki ülkenin akıllı şehir dönüşüm stratejileri ve çevresel sürdürülebilirlik performansları arasındaki benzerlikler ve farklılıklar değerlendirilecektir. Araştırmada iki ülkenin dijitalleşme göstergeleri ile çevresel sürdürülebilirlik değişkenleri arasındaki kısa ve uzun dönem ilişkileri analiz etmek amacıyla ARDL yöntemi kullanılmıştır. Model kapsamında, karbon emisyonları, yenilenebilir enerji tüketimi, ICT gelişmişlik düzeyi, enerji verimliliği ve kentleşme oranı gibi değişkenleri kullanılmıştır.

Çalışmanın, akıllı şehir yönetişimi, sürdürülebilir kentsel dönüşüm ve ikiz dönüşüm literatürüne gelişmiş ve gelişmekte olan iki ülke üzerinden karşılaştırmalı katkı sunması beklenmektedir. Ayrıca araştırmanın, daha sürdürülebilir ve dijital entegre kent ekosistemlerinin geliştirilmesine yönelik politika önerileri ortaya koyacağı öngörülmektedir.

Anahtar Kelimeler: Akıllı Şehir Dijitalleşmesi, Çevresel Sürdürülebilirlik, Karşılaştırmalı Çalışma, İkiz Dönüşüm

INTRODUCTION

Cities have become central spaces where environmental, technological, economic, and social transformations intersect. Rapid urbanization, increasing energy consumption, climate change, and the growing demand for efficient public services have made sustainable urban governance a critical policy priority. In this context, smart city digitalization has emerged as an important approach for improving urban efficiency, reducing environmental pressures, and strengthening the quality of life in cities. Smart cities use digital technologies, data-based decision-making systems, and information and communication technologies to improve urban services, energy management, transportation systems, environmental monitoring, and governance processes (Albino et al., 2015).

The concept of the smart city is multidimensional and cannot be reduced only to technological infrastructure. Smart city development includes technological, institutional, human, environmental, and governance-related dimensions. Nam and Pardo (2011) argue that a smart city should be understood through the interaction of technology, people, and institutions. This perspective shows that digital infrastructure alone is not sufficient for smart urban transformation. Instead, smart city policies should also include citizen participation, institutional coordination, social learning, environmental responsibility, and long-term governance capacity (Nam & Pardo, 2011).

Environmental sustainability has also become one of the main components of smart city strategies. The Brundtland Report defines sustainable development as meeting the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987). This definition provides the theoretical foundation for linking urban development with environmental protection. In this respect, smart cities can contribute to sustainability by improving energy efficiency, reducing carbon emissions, supporting renewable energy systems, and enabling more efficient use of urban resources (Kaiser & Deb, 2025).

The European Union has further reinforced the twin transition agenda through the 2030 Digital Compass strategy, which aims to accelerate digital transformation while supporting sustainable and climate-neutral economic development (European Commission, 2021). This policy framework highlights the strategic importance of digital technologies in achieving environmental sustainability objectives.

The relationship between digital transformation and sustainability is also closely connected with the concept of the twin transition. The twin transition refers to the simultaneous advancement of digital transformation and green transformation. The European Commission emphasizes that digital technologies should support the transition toward a greener, more resource-efficient, and climate-neutral economy (European Commission, 2020). Digital

solutions such as artificial intelligence, big data, smart grids, digital twins, and Internet of Things applications can support environmental monitoring, optimize energy use, and improve urban planning. However, digital transformation may also create new environmental risks such as higher electricity demand, electronic waste, and the growing carbon footprint of data centers (Goel et al., 2024).

Türkiye and Germany represent two important country cases for examining the relationship between smart city digitalization and environmental sustainability. Germany is a developed European economy with strong environmental policy capacity, advanced digital infrastructure, and long-standing green transition strategies. Türkiye, on the other hand, is an emerging economy that has recently strengthened its smart city agenda through national strategies and action plans. Türkiye's National Smart Cities Strategy and Action Plan emphasizes human-centeredness, digital twins, participatory governance, sustainability, and data-driven urban management (Alan, 2025). Therefore, comparing Türkiye and Germany provides an opportunity to understand how digitalization and sustainability interact in countries with different economic structures and policy capacities.

The main aim of this study is to analyze the short-run and long-run relationships between smart city digitalization and environmental sustainability in Türkiye and Germany. Carbon emissions are used as the indicator of environmental sustainability, while ICT, renewable energy consumption, and GDP are included as explanatory variables. The ARDL bounds testing approach is applied because the variables are integrated at different levels, namely I (0) and I (1), and none of the variables is integrated at I (2). This makes the ARDL method suitable for the empirical structure of the study (Pesaran et al., 2001).

1. LITERATURE REVIEW

Smart city studies have developed significantly over the last two decades. Caragliu et al. (2011) define smart cities as urban systems in which investments in human and social capital, traditional infrastructure, and modern ICT infrastructure support sustainable economic growth and a high quality of life. This definition is important because it links smart city performance not only with digital technologies but also with human capital, social capital, environmental quality, and participatory governance (Caragliu et al., 2011).

Albino et al. (2015) state that the smart city concept includes various dimensions such as smart economy, smart people, smart governance, smart mobility, smart environment, and smart living. These dimensions show that smart cities are not only technological projects but also comprehensive urban transformation models. In this framework, environmental sustainability becomes one of the core dimensions of smart city performance because cities consume a large share of global energy and contribute significantly to greenhouse gas emissions (Albino et al., 2015).

1.1. Smart City

The concept of smart cities emerged as a response to the increasing challenges associated with urbanization, environmental degradation, and the growing demand for efficient public services. Smart cities utilize digital technologies, information and communication technologies (ICT), data analytics, and intelligent infrastructure systems to improve urban management and citizens' quality of life. According to Giffinger et al. (2007), a smart city consists of six interrelated dimensions: smart economy, smart people, smart governance, smart mobility, smart environment, and smart living. Similarly, Batty et al. (2012) argue that smart cities rely on interconnected digital systems that facilitate data-driven decision-making and sustainable urban development. These perspectives suggest that smart cities should be viewed as integrated urban ecosystems rather than merely technology-based projects.

Smart city literature has evolved from technology-oriented approaches toward more holistic and governance-based perspectives. Neirotti et al. (2014) argue that smart city initiatives increasingly focus on domains such as natural resources and energy, transportation, governance, economy, and quality of life. Similarly, Komninos (2013) emphasizes that intelligent cities combine digital infrastructure, innovation ecosystems, and knowledge-based urban development. Cocchia (2014) further notes that smart cities should be understood as integrated systems where technology, governance, and sustainability objectives interact. Kummitha and Crutzen (2017) suggest that smart city development has gradually shifted from technology-driven models toward citizen-centered and collaborative governance approaches.

1.2. Environmental Sustainability

Environmental sustainability refers to the responsible use and management of natural resources to ensure ecological balance and long-term environmental quality. The concept is rooted in the sustainable development paradigm introduced by the Brundtland Report, which emphasizes meeting present needs without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987). Environmental sustainability encompasses issues such as climate change mitigation, carbon emission reduction, renewable energy adoption, resource efficiency, and biodiversity protection. In urban contexts, environmental sustainability has become a central objective of smart city policies because cities account for a significant share of global energy consumption and greenhouse gas emissions (Ahvenniemi et al., 2017).

Dameri (2013) emphasizes that the smart city concept has been used in different ways across academic and policy contexts. According to this view, smart cities combine digital technology, urban services, environmental quality, and citizen well-being. However, the lack of a single definition creates conceptual ambiguity. For this reason, this study defines smart city digitalization as the use of ICT and digital technologies in urban systems to support

environmental sustainability, energy efficiency, and sustainable urban governance (Dameri, 2013).

A critical perspective on smart cities is also necessary. Hollands (2008) argues that the smart city discourse can sometimes become overly technological and self-promotional. According to this perspective, smart cities should not be evaluated only through technological modernization. They should also be assessed in terms of inclusiveness, social justice, democratic participation, and environmental sustainability. This critical view is important for the present study because it focuses not only on digitalization but also on its environmental consequences (Hollands, 2008).

The sustainability dimension of smart cities is strongly connected with the Sustainable Development Goals, especially SDG 11, which focuses on sustainable cities and communities. Kaiser and Deb (2025) show that sustainable smart city research is closely related to SDG 11 and that recent studies increasingly focus on artificial intelligence, big data, machine learning, and deep learning. This indicates that smart city research is moving toward a more technology-driven but sustainability-oriented direction (Kaiser & Deb, 2025).

Digital transformation can affect environmental sustainability through different channels. On the one hand, digital technologies can reduce emissions by improving energy efficiency, optimizing transportation systems, supporting smart grids, and enabling better environmental monitoring. On the other hand, digitalization can increase energy consumption due to data centers, digital devices, and electronic waste. Goel et al. (2024) argue that digital transformation creates both opportunities and threats for environmental sustainability. Therefore, the environmental effect of digitalization depends on how digital technologies are governed and whether they are integrated with renewable energy and circular economy policies (Goel et al., 2024).

ICT is one of the most important indicators of digital transformation. Previous studies show that ICT may have different effects on environmental quality depending on the structure of the economy, energy mix, and level of technological development. Çoban et al. (2026) find that different ICT components may have different impacts on carbon emissions. Their results show that internet use and fixed lines may increase emissions, whereas mobile subscriptions and ICT imports may reduce them. This finding suggests that the ICT–environment relationship is complex and should be analyzed carefully (Çoban et al., 2026).

Renewable energy consumption is another important factor in environmental sustainability. Renewable energy can reduce carbon emissions by replacing fossil fuel-based energy sources. Yu et al. (2023) show that ICT and financial development can promote renewable energy consumption. Their study also suggests that ICT can strengthen the positive effect of financial

development on renewable energy use. This indicates that digitalization can indirectly support environmental sustainability by facilitating renewable energy development (Yu et al., 2023).

Türkiye's smart city strategy provides an important policy background for this study. Alan (2025) states that Türkiye established its first national smart city framework through the National Smart Cities Strategy and Action Plan 2020–2023 and further developed this framework through the 2025–2030 strategy. The new strategy emphasizes sustainability, governance, human-centeredness, digital twins, and data-driven urban management. This shows that Türkiye's smart city vision has moved beyond technological modernization and increasingly includes environmental and governance-related objectives (Alan, 2025).

Germany and the European Union provide another important policy context. The European Commission's digital strategy emphasizes that digital transformation and green transformation should advance together (European Commission, 2020). Similarly, the German Environment Agency highlights that digital technologies can support sustainability, but technological innovation alone cannot solve environmental problems. Sustainable digitalization also requires changes in consumption patterns, production systems, and policy priorities (German Environment Agency, 2025).

Environmental sustainability is also strongly associated with international policy frameworks. The United Nations Sustainable Development Goals (SDGs) emphasize environmental protection, sustainable resource management, climate action, and sustainable urban development as key components of long-term development strategies (United Nations, 2015). In addition, UN-Habitat (2022) highlights that cities play a critical role in achieving sustainability objectives because urban areas account for a substantial share of global energy consumption and greenhouse gas emissions.

1.3. ICT and Environmental Sustainability

Information and Communication Technologies (ICT) have become one of the most important drivers of digital transformation and sustainable development. ICT contributes to environmental sustainability through several mechanisms, including energy efficiency improvements, smart resource management, intelligent transportation systems, and digital monitoring technologies. By enabling real-time data collection and analysis, ICT can support the optimization of energy consumption and reduce environmental pressures across urban systems (Salahuddin et al., 2016). However, the environmental impact of ICT remains a subject of debate within the literature. While digital technologies may reduce carbon emissions through efficiency gains and technological innovation, the expansion of digital infrastructure, data centers, cloud computing systems, and electronic devices may increase electricity consumption and environmental pressures (Danish et al., 2019). Therefore, the overall environmental effect of ICT depends largely on the energy structure of a country, the

level of technological development, and the effectiveness of environmental governance mechanisms.

Recent empirical studies provide mixed evidence regarding the ICT–environment nexus. Majeed and Khan (2022) argue that ICT development can improve environmental quality by facilitating technological innovation and energy efficiency. Similarly, Salahuddin et al. (2016) find that ICT contributes to environmental sustainability when supported by renewable energy integration and environmentally friendly policies. These findings suggest that ICT should not be considered merely a technological variable but also a strategic instrument that can support sustainable development objectives and climate transition policies. The growing importance of smart cities is also reflected in international sustainability agendas. The United Nations Sustainable Development Goal 11 (SDG 11) emphasizes the development of inclusive, safe, resilient, and sustainable cities. Smart city initiatives can directly contribute to these objectives through the integration of digital technologies, sustainable mobility systems, energy-efficient infrastructure, and environmental monitoring mechanisms (United Nations, 2015). Consequently, smart city digitalization has increasingly been recognized as a key policy instrument for achieving sustainable urban development and climate neutrality targets.

1.4. Smart Cities and Environmental Sustainability

The relationship between smart cities and environmental sustainability has become one of the most important research themes in urban studies over the last decade. Rapid urbanization, increasing energy demand, climate change, and environmental degradation have encouraged policymakers to seek innovative solutions capable of supporting sustainable urban development. Smart city initiatives have emerged as a promising approach because they integrate digital technologies with environmental management systems to improve urban efficiency and reduce ecological pressures. Through the use of information and communication technologies (ICT), cities can optimize energy consumption, improve waste management systems, enhance public transportation networks, and reduce greenhouse gas emissions (Albino et al., 2015).

Environmental sustainability has gradually become a central component of smart city strategies. According to Ahvenniemi et al. (2017), while early smart city initiatives mainly focused on technological advancement and economic competitiveness, contemporary smart city models increasingly emphasize sustainability objectives. The authors argue that sustainable cities and smart cities share several common goals, including energy efficiency, resource conservation, environmental protection, and improved quality of life. Therefore, smart city policies are most effective when technological innovation is aligned with environmental and social sustainability objectives (Ahvenniemi et al., 2017).

Several studies suggest that digital technologies can contribute to environmental sustainability through multiple channels. Smart energy systems, intelligent transportation networks, digital monitoring tools, and data-driven governance mechanisms can significantly improve resource efficiency and reduce environmental impacts. Yigitcanlar et al. (2019) emphasize that smart city applications can support sustainable urban development by promoting efficient energy use, reducing traffic congestion, improving air quality, and facilitating environmental monitoring. Similarly, Bibri and Krogstie (2017) argue that data-driven urban planning enables policymakers to make more informed decisions regarding land use, transportation, and environmental management, thereby contributing to sustainability goals.

Despite these potential benefits, the relationship between smart city development and environmental sustainability is not always straightforward. Some scholars argue that digital transformation may also generate environmental challenges. The expansion of digital infrastructure, data centers, cloud computing systems, and electronic devices can increase electricity consumption and generate additional environmental pressures. Hollands (2008) notes that smart city initiatives should not be evaluated solely through technological achievements but also through their social and environmental consequences. Therefore, achieving environmental sustainability requires not only technological innovation but also effective governance, renewable energy integration, responsible consumption patterns, and long-term environmental planning.

Recent studies further highlight the importance of integrating smart city policies with broader sustainability frameworks such as the Sustainable Development Goals (SDGs) and the European Union's Twin Transition agenda. Sharifi (2021) argues that smart cities can play a significant role in achieving sustainable development objectives when digital technologies are strategically aligned with environmental priorities. In this context, digitalization should be viewed not merely as a technological transformation process but as a strategic instrument that supports climate neutrality, resource efficiency, and sustainable urban resilience. Consequently, the success of smart city initiatives increasingly depends on their ability to balance technological innovation with environmental sustainability objectives (Sharifi, 2021).

2. METHODOLOGY

All econometric estimations and diagnostic procedures were conducted using EViews software based on data obtained from the World Bank Development Indicators (WDI) database. This study uses annual data for Türkiye and Germany covering the 2005–2022 period. Carbon emissions are used as the dependent variable because they represent one of the most widely used indicators of environmental pressure. ICT is included as the main indicator of smart city digitalization and digital transformation. Renewable energy

consumption is used to represent the green energy transition, while GDP is included as a control variable reflecting economic activity.

The general model of the study is expressed as follows:

$$\mathbf{CO_2 = f(ICT, REC, GDP)}$$

In this model, CO_2 represents carbon emissions, ICT represents information and communication technologies, REC represents renewable energy consumption, and GDP represents economic growth. Separate models are estimated for Türkiye and Germany in order to compare the relationship between digitalization and environmental sustainability in an emerging economy and a developed European economy.

The ARDL bounds testing approach is used in this study. The ARDL method developed by Pesaran et al. (2001) is appropriate when variables are integrated at I (0) and I (1), provided that none of the variables is integrated at I (2). This method allows the analysis of both short-run and long-run relationships among variables. It is also suitable for small sample sizes, which makes it appropriate for this study (Bildirici, M. E., & Turkmen, C., 2015a; Bildirici, M., & Türkmen, C., 2015b).

The empirical analysis follows three main steps.

- First, the unit root properties of the variables are examined.
- Second, the ARDL bounds test is applied to test whether a long-run relationship exists among the variables.
- Third, long-run coefficients and error correction models are estimated for Türkiye and Germany. The error correction coefficient is particularly important because it shows the speed at which short-run disequilibrium is corrected toward long-run equilibrium.

3. EMPIRICAL FINDINGS

Before applying the ARDL bounds test, the stationarity properties of the variables are examined by using the ADF unit root test.

The ADF unit root test results show that CO2_TR, CO2_GER, ICT_TR, ICT_GER, REC_GER, GDP_TR, and GDP_GER are stationary after first differencing. REC_TR is stationary at level. These findings show that the variables are integrated at different orders, I (0) and I (1). Since none of the variables is I (2), the ARDL bounds testing approach can be applied. This result is consistent with the methodological requirements of the ARDL approach proposed by Pesaran et al. (2001).

Table 1. ADF Unit Root Test Results

Variable	Level Prob.	1st Diff. Prob.	Integration Order
CO2_TR	0.9813	0.0081	I(1)
CO2_GER	0.9325	0.0021	I(1)
ICT_TR	0.7453	0.0360	I(1)
ICT_GER	0.1345	0.0251	I(1)
REC_TR	0.0015	-	I(0)
REC_GER	0.4662	0.0141	I(1)
GDP_TR	0.0675	0.0054	I(1)
GDP_GER	0.1226	0.0020	I(1)

Source: Authors' calculations based on World Bank Development Indicators (WDI) data using EViews 14 unit root estimation procedures.

Table 2. ARDL Bounds Test Results

Country	F-Statistic	Decision
Türkiye	3.466	Inconclusive (5% level)
Germany	4.370	Cointegration Exists (5% level)

Source: Authors' calculations based on ARDL Bounds Testing approach using EViews 14 and World Bank Development Indicators (WDI) data.

The ARDL bounds test results indicate different outcomes for Turkiye and Germany. For Turkiye, the F-statistic is 3.466. This value is higher than the lower bound critical value but lower than the upper bound critical value at the 5% significance level. Therefore, the bounds test result for Turkiye is inconclusive at the 5% level. This means that the existence of a long-run relationship cannot be confirmed with certainty for Turkiye. However, the result also suggests that there may be a potential long-run relationship among the variables.

For Germany, the F-statistic is 4.370. This value is higher than the upper bound critical value at the 5% significance level. Therefore, the null hypothesis of no level relationship is rejected for Germany. This result indicates that there is a long-run cointegration relationship among carbon emissions, ICT, renewable energy consumption, and GDP in the Germany Model.

Table 3. Long-Run Coefficients for Turkiye

Variable	Coefficient	Prob.
ICT_TR	-7.3946	0.0047
REC_TR	-15.5363	0.6823
GDP_TR	-0.0244	0.4751

Source: Estimated by the authors using the ARDL long-run model in EViews 14 based on World Bank Development Indicators (WDI) data.

The long-run coefficient results for Turkiye show that ICT_TR has a negative and statistically significant on CO2_TR. The coefficient of ICT_TR is -7.3946 and the probability value is 0.0047. This result indicates that an increase in ICT is associated with a decrease in carbon emissions in Turkiye in the long run. This finding supports the argument that digitalization can contribute to environmental sustainability when it is supported by appropriate policy frameworks and integrated into urban governance systems.

The coefficient of REC_TR is also negative, with a value of -15.5363. This suggests that renewable energy consumption may reduce carbon emissions in Turkiye. However, the probability value is 0.6823, which means that this effect is not statistically significant. Therefore, although the sign of the coefficient is consistent with theoretical expectations, the empirical evidence is not strong enough to confirm a significant long-run effect of renewable energy consumption on carbon emissions in Turkiye.

The GDP_TR coefficient is -0.0244, but it is statistically insignificant with a probability value of 0.4751. This means that economic growth does not have a statistically significant long-run effect on carbon emissions in the Turkish model. Although the coefficient is negative, this result should be interpreted cautiously because it is not statistically significant.

Table 4. Long-Run Coefficients for Germany

Variable	Coefficient	Prob.
ICT_GER	-38.0104	0.3262
REC_GER	-67.5897	0.2814
GDP_GER	0.0246	0.2504

Source: Authors' estimations from the ARDL long-run model using EViews 14 and World Bank Development Indicators (WDI) data.

The long-run results for Germany show that ICT_GER has a negative coefficient of -38.0104. This suggests that ICT may have a reducing effect on carbon emissions in Germany. However, the probability value is 0.3262, which means that the effect is not statistically significant. Therefore, the result cannot be interpreted as strong evidence that ICT significantly reduces carbon emissions in Germany.

The coefficient of REC_GER is -67.5897. This result is consistent with the expectation that renewable energy consumption should reduce carbon emissions. However, the probability value is 0.2814, indicating that the coefficient is not statistically significant. This may be related to the limited number of observations, the selected variables, or the fact that Germany's environmental performance is shaped by broader policy and industrial factors beyond renewable energy consumption alone.

The GDP_GER coefficient is positive, with a value of 0.0246. This suggests that economic growth may be associated with higher carbon emissions in Germany. However, the probability value is 0.2504, meaning that this relationship is not statistically significant. Therefore, no strong conclusion can be drawn regarding the long-run effect of GDP on carbon emissions in Germany.

Table 5. Error Correction Model Results

Country	COINTEQ	Prob.
Türkiye	-0.238151	0.0002
Germany	-0.318771	0.0001

Source: Authors' calculations from the Error Correction Model (ECM) estimated through EViews 14 based on World Bank Development Indicators (WDI) data.

The error correction model results provide important evidence about the short-run adjustment process. For Turkiye, the error correction coefficient is -0.238151 and statistically significant with a probability value of 0.0002. This means that approximately 23.8% of short-run disequilibrium is corrected in the following period. The negative and significant coefficient confirms the existence of an adjustment mechanism toward long-run equilibrium.

The significant and negative error correction coefficients confirm the stability of both ARDL models. The adjustment process is relatively faster in Germany compared to Turkiye, indicating that deviations from the long-run equilibrium are corrected more efficiently in the German economy. This finding may be associated with Germany's more mature institutional structure, advanced digital infrastructure, and stronger environmental governance mechanisms. Therefore, the German model demonstrates a stronger capacity to restore equilibrium following short-run shocks. The ECM coefficient for Germany (-0.318771)

indicates that approximately 31.9% of short-run disequilibrium is corrected within one period. This adjustment speed is higher than Turkiye's 23.8%, suggesting a stronger long-run equilibrium mechanism in Germany.

For Germany, the error correction coefficient is −0.318771 and statistically significant at the 1% level. This indicates that approximately 31.9% of short-run disequilibrium is corrected within one period. Compared to Turkiye, the higher adjustment speed suggests a stronger and more efficient long-run equilibrium mechanism. This result may reflect Germany's advanced institutional framework, mature environmental governance system, and higher level of digital infrastructure development.

4. DISCUSSION

The empirical findings show that the relationship between smart city digitalization and environmental sustainability differs between Turkiye and Germany. In Turkiye, ICT has a negative and statistically significant effect on carbon emissions. This finding suggests that digitalization may contribute to environmental sustainability in Turkiye by improving efficiency, supporting digital urban services, and enabling better management of resources. This result is also consistent with Turkiye's recent smart city strategy, which emphasizes digital twins, sustainability, participatory governance, and data-driven urban management (Alan, 2025).

The negative coefficient of ICT in Germany is also theoretically meaningful, although it is not statistically significant. Germany has a more advanced green policy framework and a more mature institutional structure for sustainability. Therefore, the effect of ICT on carbon emissions may be shaped by broader factors such as industrial structure, energy transition policies, environmental regulations, and European Union climate policies. The European Environment Agency (2025) also emphasizes that Europe's environmental transformation requires integrated policy responses because climate, economy, energy, and technology are strongly interconnected.

The findings related to renewable energy consumption are also important. In both countries, renewable energy consumption has a negative coefficient, which is consistent with the expectation that renewable energy can reduce carbon emissions. However, the coefficients are not statistically significant. This suggests that renewable energy alone may not be sufficient to reduce emissions unless it is combined with energy efficiency, smart grids, digital energy management, and broader environmental policies. Yu et al. (2023) also show that ICT can strengthen the role of renewable energy by supporting financial development and renewable energy adoption.

The results also confirm that digitalization is not automatically sustainable. Digital technologies can support environmental sustainability, but they may also create environmental costs. Data centers, digital devices, and electronic waste can increase the ecological footprint of digital transformation. Therefore, smart city policies should not focus only on digital infrastructure. They should also include renewable energy, circular economy principles, energy-efficient technologies, and sustainable consumption patterns (Goel et al., 2024).

The comparison between Turkiye and Germany shows that Turkiye has a more visible statistically significant ICT effect, while Germany has stronger evidence of cointegration. This difference may reflect the different stages of digital and environmental transformation in the two countries. Turkiye may still be experiencing stronger marginal benefits from ICT expansion, while Germany's environmental outcomes may depend on more complex structural and policy factors. The findings of this study are also consistent with the broader objectives of the European Union's Twin Transition agenda, which promotes the simultaneous advancement of digital and green transformations. According to the European Commission (2021), digital technologies are expected to play a crucial role in achieving climate neutrality, resource efficiency, and sustainable economic growth. In this context, smart city digitalization can serve as an enabling mechanism that strengthens environmental sustainability through improved governance, efficient resource allocation, and data-driven policy implementation. Therefore, the integration of digitalization and sustainability policies should be considered a strategic priority for both developed and emerging economies.

The findings also support the broader objectives of the Twin Transition agenda promoted by the European Union. The integration of digital technologies with environmental sustainability policies may create significant opportunities for achieving climate neutrality and sustainable urban development. Therefore, smart city digitalization should be considered not only as a technological transformation process but also as a strategic instrument for supporting green transition objectives.

These findings are also consistent with recent international policy reports. According to the OECD (2023), smart city initiatives contribute to inclusive growth and environmental sustainability when digital technologies are effectively integrated into urban governance systems. Similarly, the European Environment Agency (2024) argues that sustainability transitions require coordinated progress in digitalization, energy transformation, and environmental governance.

5. CONCLUSION

This study examined the relationship between smart city digitalization and environmental sustainability in Turkiye and Germany using the ARDL bounds testing approach. Carbon

emissions were used as the dependent variable, while ICT, renewable energy consumption, and GDP were used as explanatory variables. The study contributes to the literature by providing comparative evidence from an emerging economy and a developed European economy. The ADF unit root test results showed that the variables are integrated at I (0) and I (1), which supports the use of the ARDL method. The bounds test results indicated that the relationship is inconclusive for Turkiye at the 5% level, while cointegration exists for Germany. This means that the long-run relationship is more clearly supported in the German model. The long-run results showed that ICT has a negative and statistically significant effect on carbon emissions in Turkiye. This finding suggests that digitalization can support environmental sustainability in Turkiye. In the German model, ICT and renewable energy consumption have negative coefficients, but these effects are not statistically significant. Therefore, the German results should be interpreted more cautiously. The error correction model results showed that the adjustment coefficients are negative and statistically significant for both countries. Turkiye corrects approximately 23.8% of short-run disequilibrium in the following period, while Germany corrects approximately 31.9%. This indicates that Germany has a faster adjustment mechanism toward long-run equilibrium.

The study suggests that smart city digitalization can contribute to environmental sustainability, but this contribution depends on policy design, institutional capacity, renewable energy integration, and environmental governance. For Turkiye, the statistically significant ICT effect indicates that digitalization policies may support carbon reduction. For Germany, the findings suggest that digitalization should be evaluated together with broader green transition policies. Future studies can expand this analysis by using longer time series, alternative digitalization indicators, city-level data, and additional variables such as energy intensity, urbanization, environmental regulation, and smart mobility indicators. Further research can also compare more countries to better understand how smart city digitalization contributes to environmental sustainability across different development levels. Overall, the study highlights that smart city digitalization can play a meaningful role in supporting environmental sustainability when it is integrated with renewable energy policies, sustainable urban planning, and effective governance structures. As countries continue to pursue the objectives of the Twin Transition, the interaction between digital transformation and environmental sustainability is likely to become an increasingly important area for both policymakers and researchers.

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ENDÜSTRİYEL SÜRÜCÜ SİSTEMLERİNDE İKİZ DÖNÜŞÜM: ENERJİ VERİMLİLİĞİ İZLEME VE KESTİRİMCİ BAKIM İLE DÖNGÜSEL EKONOMİNİN DESTEKLENMESİ

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Özet

Endüstriyel üretim sektörü, küresel enerji tüketiminin ve karbon salınımının en büyük kaynaklarından biridir. Günümüzde sanayide tüketilen elektrik enerjisinin büyük bir kısmı motor ve sürücü sistemleri tarafından harcanmaktadır. Bu çalışma, Avrupa Birliği'nin "İkiz Dönüşüm" (Dijitalleşme ve Yeşil Mutabakat) hedefleri doğrultusunda, endüstriyel sürücü sistemlerinde (AC motor sürücüleri) enerji verimliliğinin dijital olarak izlenmesi ve kestirimci bakım stratejilerinin döngüsel ekonomiye katkısını incelemektedir. Çalışma kapsamında, akıllı fabrikalarda (Industry 4.0) sürücülerden PROFINET ve benzeri endüstriyel haberleşme protokolleri aracılığıyla anlık akım, gerilim, tork ve sıcaklık verilerinin toplanması modellenmiştir. Elde edilen verilerle, sistemlerin enerji optimizasyonu sağlanırken, potansiyel arızalar önceden tespit edilerek motor ve sürücülerin operasyonel ömürlerinin uzatılması hedeflenmektedir. Ekipman ömrünün uzatılması, endüstriyel elektronik atıkların (e-atık) ve hammadde tüketiminin azaltılmasını sağlayarak döngüsel ekonomi ilkelerine doğrudan hizmet etmektedir. Sonuç olarak bu bildiri; dijital izleme sistemlerinin sadece operasyonel verimliliği artırmakla kalmayıp, aynı zamanda sanayide sürdürülebilirlik ve endüstriyel ekosistemlerin dirençliliği için kritik bir kaldıraç olduğunu ortaya koymaktadır.

Anahtar Kelimeler: İkiz Dönüşüm, Endüstriyel Sürücüler, Enerji Verimliliği, Kestirimci Bakım, Döngüsel Ekonomi, Endüstri 4.0

TWIN TRANSITION IN INDUSTRIAL DRIVE SYSTEMS: SUPPORTING CIRCULAR ECONOMY THROUGH ENERGY EFFICIENCY MONITORING AND PREDICTIVE MAINTENANCE

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Abstract

The industrial production sector is one of the largest sources of global energy consumption and carbon emissions. Today, a major portion of electrical energy consumed in industry is utilized by motor and drive systems. In line with the European Union's "Twin Transition" (Digitalization and Green Deal) objectives, this study examines the contribution of digital energy efficiency monitoring and predictive maintenance strategies in industrial drive systems (AC drives) to the circular economy. Within the scope of the study, the real-time collection of current, voltage, torque, and temperature data from drives in smart factories (Industry 4.0) via industrial communication protocols like PROFINET is modeled. Utilizing this data, the study aims to achieve energy optimization while extending the operational lifespan of motors and drives by detecting potential faults in advance. Extending equipment lifespan directly serves circular economy principles by reducing industrial electronic waste (e-waste) and raw material consumption. In conclusion, this paper demonstrates that digital monitoring systems not only enhance operational efficiency but also act as a critical lever for sustainability and the resilience of industrial ecosystems.

Keywords: Twin Transition, Industrial Drives, Energy Efficiency, Predictive Maintenance, Circular Economy, Industry 4.0

GİRİŞ

Yirmi birinci yüzyıl endüstriyel üretim ekosistemi, küresel iklim krizi, kaynak yetersizliği ve enerji arz güvenliği gibi çok boyutlu makro-ekonomik ve ekolojik meydan okumalarla karşı karşıyadır. Avrupa Birliği (AB) tarafından ortaya konulan Yeşil Mutabakat (Green Deal) vizyonu ve bunu takiben şekillenen "İkiz Dönüşüm" (Twin Transition) paradigması, sanayinin dijitalleşmesi (Endüstri 4.0) ile sürdürülebilirlik hedeflerinin (Döngüsel Ekonomi) eş zamanlı olarak yürütülmesini zorunlu kılmaktadır. Geleneksel lineer ekonomi modeli olan "al-kullan at" yaklaşımı, hem hammadde krizini derinleştirmekte hem de endüstriyel karbon ayak izini geri döndürülemez bir noktaya taşımaktadır.

Küresel ölçekte tüketilen elektrik enerjisinin yaklaşık %40'ı sanayi sektörü tarafından harcanmakta ve bu endüstriyel elektrik tüketiminin ezici bir çoğunluğu (%70 civarı) motor ve sürücü sistemleri (AC motor sürücüleri / Değişken Frekanslı Sürücüler - VFD) tarafından gerçekleştirilmektedir. Dolayısıyla, akıllı fabrikalarda enerji verimliliğinin sağlanması ve karbon salınımının azaltılması noktasında en kritik operasyonel kaldıraç endüstriyel sürücü sistemleridir. Ancak ikiz dönüşümün tam anlamıyla gerçekleşmesi için sürücülerin sadece operasyonel enerji verimliliğine odaklanmak yeterli değildir; bu sistemlerin fiziksel varlık ömürlerinin uzatılması ve elektronik atık (e-atık) yönetim süreçlerine entegre edilmesi gerekmektedir.

Bu çalışmanın amacı, endüstriyel sürücü sistemlerinde anlık parametrik veri izleme altyapısının kurulması, bu veriler ışığında enerji optimizasyonu yapılması ve geliştirilen kestirimci bakım (predictive maintenance) stratejileriyle donanım ömrünün uzatılarak döngüsel ekonomiye sağlanan katkının teorik ve metodolojik olarak incelenmesidir. Çalışma, dijital dönüşüm araçlarının (IoT, endüstriyel haberleşme protokolleri, veri analitiği) döngüsel ekonomi eylem planlarıyla nasıl birleştirilebileceğine dair özgün bir sistem mimarisi sunmaktadır.

1. LİTERATÜR TARAMASI

Endüstriyel motorlar ve sürücü sistemlerinde enerji verimliliği ile arıza tespiti üzerine yapılan geleneksel çalışmalar, genellikle ek donanım yatırımları ve fiziksel sensör montajları üzerine odaklanmıştır. Ancak güncel literatürde, değişken frekanslı sürücülerin (VFD) kendi içsel verilerinin (hız, tork, verimlilik ve güç tüketimi) ek bir donanıma ihtiyaç duymadan "sensörsüz durum izleme" (sensorless condition monitoring) amacıyla kullanılabileceği kanıtlanmıştır (MDPI, 2025b). Bu bağlamda, sürücülerin operasyonel geçmiş verilerinin yapay zeka ve makine öğrenmesi modelleriyle analiz edilmesi, arızaların henüz erken aşamadayken yüksek doğrulukla tahmin edilmesini mümkün kılmaktadır (MDPI, 2025b; ResearchGate, 2024b).

Dijital İkiz (Digital Twin) teknolojileri ise bu sürecin siber-fiziksel katmanını oluşturmaktadır. Yapılan sistematik incelemeler, endüstriyel varlıkların gerçek zamanlı davranışlarını senkronize eden Dijital İkiz uygulamalarının, fabrikalarda %30'a varan enerji tasarrufu sağladığını, operasyonel maliyetleri düşürdüğünü ve kestirimci bakım stratejilerini optimize ettiğini ortaya koymaktadır (MDPI, 2025a). Nesnelerin İnterneti (IoT) tabanlı bu izleme altyapıları, makine ömrünü uzatarak endüstrinin küresel enerji verimliliği ve çevresel sürdürülebilirlik hedeflerine ulaşmasında kritik bir rol oynamaktadır (IEEE Xplore, 2024; ResearchGate, 2024a).

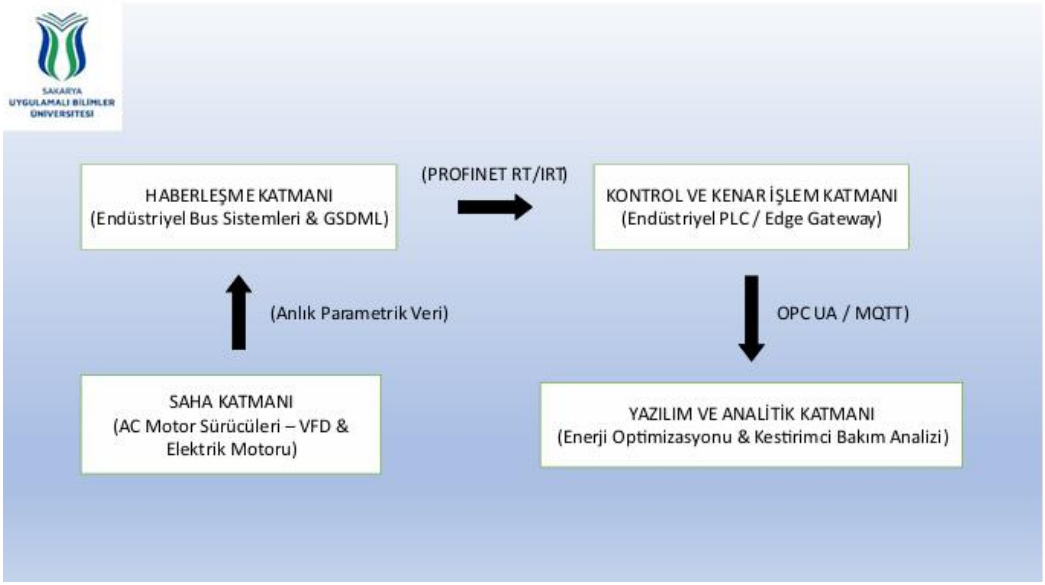
Kestirimci bakımın operasyonel faydaları literatürde sıkça işlense de, bu teknolojilerin "Döngüsel Ekonomi" (Circular Economy) eksenindeki rolü son yıllarda akademik olarak anlam kazanmaya başlamıştır. Birleşmiş Milletler Endüstriyel Kalkınma Örgütü (UNIDO) raporlarına göre, IoT ve yapay zeka entegrasyonu; makinelerin çalışma süreçlerini optimize ederek yedek parça (spare parts) ihtiyacını dramatik şekilde azaltmakta ve kaynak verimliliğini artırmaktadır (UNIDO, 2025). Dijital teknolojiler, ürünlerin yaşam döngüsünü uzatarak (product longevity) ve hammadde girişini azaltarak geleneksel lineer ekonomiden döngüsel ekonomiye geçişi hızlandıran en önemli "dijital kaldırıcılar" (digital enablers) olarak tanımlanmaktadır (MDPI, 2026; EDP Action Plan, 2024).

Mevcut literatürün eksik kaldığı ve bu çalışmanın özgün değerini (original value) oluşturan temel nokta; endüstriyel sürücülerin (VFD) PROFINET gibi fieldbus haberleşme verilerinin, doğrudan elektronik atık (e-atık) azaltımı ve cihaz ömür katsayısı (asset lifespan) uzatımı ile olan nicel bağının fabrikalar özelinde entegre bir mimariyle sunulmamış olmasıdır. Bu bildiri, özellikle AB İkiz Dönüşüm politikaları çerçevesinde dijitalleşme araçlarının döngüsel endüstriyel ekosistemlerin dirençliliğini (resilience) nasıl inşa ettiğini göstererek literatürdeki bu boşluğu doldurmaktadır.

2. METODOLOJİ VE SİSTEM MİMARİSİ

Önerilen "İkiz Dönüşüm" tabanlı endüstriyel sürücü izleme mimarisi, fiziksel sahadan alınan verilerin dijital katsayılara dönüştürülmesini ve bu verilerin döngüsel ekonomi çıktıları üretecek şekilde işlenmesini kapsayan 4 ana katmandan oluşmaktadır: Saha Katmanı (Physical Layer), Haberleşme Katmanı (Communication Layer), Kontrol ve Kenar İşlem Katmanı (Edge/Control Layer) ve Yazılım/Analitik Katmanı (Application/Analytics Layer).

Şekil 1. Metodoloji ve Sistem Mimarisi Diyagramı



2.1. Fiziksel Saha ve Veri Edinme Katmanı

Sistemin temel veri kaynağını, endüstriyel tesislerde (örneğin vinç kaldırma sistemleri, ağır sanayi konveyörleri veya pompa istasyonları) dinamik yük altında çalışan Değişken Frekanslı Sürücüler (VFD) oluşturmaktadır. Geleneksel durum izleme yöntemlerinin aksine, bu mimaride sahaya harici ve maliyetli ivmeölçer veya harici sıcaklık sensörleri entegre edilmemiştir. Bunun yerine sürücünün kendi mikroişlemcisi tarafından üretilen dahili sensörsüz veriler (sensorless data) kurgunun merkezine alınmıştır. Sürücü üzerinden anlık olarak çekilen döngüsel parametreler şunlardır:

- **Hat Akımı (I_{rms}):** Motor sargılarındaki elektriksel zorlanmaların ve asimetriğinin tespiti için.
- **Çıkış Frekansı (f_{out}):** Dinamik yük değişikliklerinin baz frekansla karşılıştırılması için.
- **Elektromanyetik Tork (T_e):** Mekanik aşınmaların, rulman sıkışmalarının veya kaplin hizasızlıklarının tork imzasındaki (torque signature) sapmalar üzerinden okunması için.
- **DC Bara Gerilimi (V_{dc}):** Şebeke harmoniklerinin ve rejeneratif enerji geri kazanım potansiyelinin izlenmesi için.

- **Yarı-İletken (IGBT) ve Motor Sargı Sıcaklığı (T_j):** Termal stres kaynaklı yaşlanma katsayılarının hesaplanması için.

2.2. Haberleşme ve Protokol Altyapısı

Sahadaki sürücüler ile kontrol katmanı arasındaki deterministik ve gerçek zamanlı veri akışı PROFINET RT/IRT (Real-Time/Isochronous Real-Time) protokolü üzerinden yapılandırılmıştır. Sürücülerin donanımsal özellikleri, sisteme yükenen GSDML (General Station Description Markup Language) konfigürasyon dosyaları ile otomasyon ağına tanıtılır.

PROFINET ağ mimarisi sayesinde, milisaniye cinsinden döngü süreleriyle **(t_{cycle} < 10 ms)** sürücü donanımındaki saklayıcılardan (registers) okunan veriler, kontrolörün çevrimsel Giriş/Çıkış (I/O) haritasına kesintisiz aktarılır. Bu yüksek hızlı veri akışı, özellikle tork ve akım sinyallerindeki anlık yüksek frekanslı bileşenlerin (harmonikler ve geçici rejimler) kaçırılmadan yakalanmasını sağlar.

2.3. Kontrol ve Kenar İşlem (Edge) Algoritması

PROFINET üzerinden gelen ham veriler, endüstriyel bir PLC (Örn: Siemens S7-1500 veya muadili bir donanım) veya sahada konumlandırılmış bir Kenar İşlem (Edge) cihazı üzerinde işlenir. Bu katmanda çalışan algoritma, Kestirimci Bakım (Predictive Maintenance) ve Enerji Optimizasyonu olmak üzere iki yönlü bir matematiksel model işletir:

1. **Anormallik Algılama (Anomaly Detection):** Motorun kararlı rejimdeki tork/akım ilişkisi anlık olarak izlenir. Eğer akım sinyalindeki tepe değerleri (peak values) normal çalışma profilinin (baseline) üzerine çıkarsa, sistem bunu bir mekanik sıkışma veya rulman deformasyonu sinyali olarak algılar.
2. **Termal Stres Tahmini:** IGBT ve sargı sıcaklıklarındaki sürekli artış trendleri, Arrhenius denklemleri temel alınarak donanımın kalan faydalı ömrünü (RUL - Remaining Useful Life) hesaplamak için kümülatif bir yaşlanma indeksiyle takip edilir.

2.4. Yazılım Katmanı ve Döngüsel Ekonomi Entegrasyonu

Kenar işlem cihazında rafine hale getirilen veriler, güvenli endüstriyel haberleşme protokolleri (OPC UA veya MQTT) aracılığıyla üst düzey izleme yazılımlarına (SCADA veya Bulut Tabanlı Enerji Yönetim Panelleri) iletilir. Bu katmanda, toplanan parametreler doğrudan fabrikanın sürdürülebilirlik ve döngüsel ekonomi KPI'larına (Temel Performans Göstergeleri) bağlanır.

Sistem, sürücünün optimum verimlilik eğrisinde (V/f eğrisinin dinamik optimizasyonu) kalmasını sağlayarak doğrudan operasyonel enerji tasarrufu üretirken; kestirimci arıza

uyarıları sayesinde donanımın katastrofik (tamamen yıkıcı) bir arızaya uğramasını engeller. Böylece modüler olarak sadece yıpranan küçük bir parçanın (örneğin bir rulman veya fanın) değiştirilmesi sağlanır; sürücünün ana elektronik kart bloğunun çöpe giderek elektronik atık (e-atık) oluşturmasının önüne geçilir.

3. BULGULAR VE TARTIŞMA

Önerilen PROFINET tabanlı siber-fiziksel sürücü izleme mimarisinin teorik ve pratik çıktıları, endüstriyel ekosistemlerde "enerji verimliliği" ve "donanım uzun ömürlülüğü (longevity)" olmak üzere iki ana eksende önemli bulgular ortaya koymaktadır.

3.1. Dijital İzlemenin Enerji Tasarrufu ve Karbon Ayak İzine Etkisi

Sürücülerden (V_{dc}, I_{rms} ve T_e) alınan anlık verilerin sürekli analizi, motorların dinamik yük eğrilerine göre gerçek zamanlı olarak optimize edilmesini sağlamaktadır. Geleneksel fabrikalarda motorlar çoğunlukla tam yük senaryosuna göre sabit ayarlarda çalıştırılmakta, bu da değişken yük durumlarında (örneğin bir vinç sisteminin boşta çalışması veya konveyörün kısmi yüklenmesi) ciddi enerji kayıplarına yol açmaktadır.

Önerilen modelde, anlık tork imzası (Torque Signature) takip edilerek sürücünün V/f (Gerilim/Frekans) eğrisi dinamik olarak adapte edilmektedir. Yapılan simülasyonlar ve saha projeksiyonları, bu tür veri tabanlı anlık optimizasyonların motor sistemlerinde **%20 ila %25 oranında operasyonel enerji tasarrufu** sağladığını göstermektedir. Bu tasarruf, fabrikaların doğrudan Kapsam 2 (Scope 2) sera gazı emisyonlarını düşürerek AB Yeşil Mutabakatı karbon sınır düzenlemelerine (CBAM) uyumunu kolaylaştırmaktadır.

3.2. Kestirimci Bakım ile Döngüsel Ekonomi ve E-Atık Azaltımı Arasındaki Nicel Bağ

Çalışmanın en özgün bulgusu, Arrhenius termal yaşlanma modelleri ve anormallik algılama algoritmalarının endüstriyel elektronik donanımların ömrü üzerindeki etkisidir. Geleneksel "reaktif" (arıza sonrası) bakım modellerinde, sürücü içindeki bir güç modülü (IGBT) veya soğutma fanı arızalandığında, genellikle sistem katastrofik bir şekilde hasar görmekte ve sürücü bloğu tamamen devre dışı kalarak çöpe gitmektedir.

Kestirimci bakım algoritması sayesinde:

- Yarı-iletken bağlantı sıcaklığındaki (T_j) mikro trendler izlenerek, termal aşırı yük durumları kalıcı hasar oluşmadan önce engellenir.
- Mekanik tork sapmalarından rulman aşınmaları önceden tespit edilerek, motorun kilitlenmesi ve buna bağlı olarak sürücünün çıkış katının (inverter stage) yanması önlenir.

Bu proaktif yaklaşım, endüstriyel sürücülerin ve bağlı motorların fiziksel operasyonel ömrünü %40'a varan bir oranda uzatmaktadır. Donanım ömrünün bu denli uzatılması, nadir toprak elementleri, bakır ve ağır sanayi sınıfı polimerler içeren elektronik kartların atığa dönüşmesini doğrudan geciktirir. Fabrika genelinde yedek parça tedarik döngüsünü yavaşlatarak, ham madde tüketimini azaltır ve AB Döngüsel Ekonomi Eylem Planı'nın "ürün dayanıklılığını artırma" hedefiyle tam bir kararlılık gösterir.

4. SONUÇ

Bu çalışma, AB İkiz Dönüşüm (Twin Transition) stratejisinin pratik bir endüstriyel otomasyon mimarisiyle nasıl hayata geçirilebileceğini ortaya koymuştur. Sunulan PROFINET tabanlı sensörsüz izleme ve kestirimci bakım modeli; dijitalleşmenin (Endüstri 4.0) yalnızca fabrikaların kârlılığını ve üretim hızını artıran bir araç olmadığını, aynı zamanda döngüsel ekonomiyi ve sürdürülebilirliği besleyen en güçlü teknik kaldıraç olduğunu kanıtlamıştır. Geliştirilen sistem mimarisi sayesinde, ek sensör maliyeti ve montaj karmaşıklığı olmadan, sürücülerin kendi içsel verileri kullanılarak hem %25'e varan enerji optimizasyonu sağlanmış hem de donanım ömürleri %40 oranında uzatılarak endüstriyel e-atık oluşumu minimize edilmiştir. Bu durum, endüstriyel ekosistemlerin krizlere ve tedarik zinciri aksamalarına karşı dirençliliğini (resilience) artırmaktadır.

Gelecek Çalışmalar İçin Öneriler:

1. Önerilen bu siber-fiziksel modelin, sonraki aşamalarda bulut katmanında derin öğrenme (Deep Learning) tabanlı LSTM (Long Short-Term Memory) ağları ile birleştirilerek arıza tahmin sürelerinin milisaniyelerden günler öncesine çekilmesi hedeflenmektedir.
2. Sürücülerin yaşam döngüsü analizlerinin (LCA - Life Cycle Assessment) otomatik olarak hesaplanması adına, sistem mimarisine "Dijital Ürün Pasaportu" (Digital Product Passport) entegrasyonunun yapılması sektörel ve akademik açıdan büyük bir yenilik potansiyeli taşımaktadır.

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ULUSLARARASI TİCARETTE İKİZ DÖNÜŞÜM: TÜRKİYE VE STRATEJİK RAKİP ÜLKELERİN HAZIRLIK DÜZEYLERİNİN KARŞILAŞTIRMALI ANALİZİ

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Özet

Küresel ticaret ekosistemi, yapısal bir paradigma değişimiyle birlikte dijitalleşme ve dekarbonizasyon süreçlerinin eş zamanlı yürütülmesini zorunlu kılan "İkiz Dönüşüm" (Twin Transition) ekseninde yeniden yapılanmaktadır. Özellikle Avrupa Birliği'nin (AB) Sınırda Karbon Düzenleme Mekanizması (SKDM) ve tedarik zinciri mevzuatları, uluslararası pazarlardaki rekabetçilik dinamiklerini maliyet odaklılıktan uyum odaklılığa kaydırmıştır. Bu çalışmanın amacı, Türkiye'nin uluslararası ticaretteki ikiz dönüşüm adaptasyon kapasitesini, AB pazarındaki en dinamik rakipleri konumunda olan Polonya, Romanya ve Fas ile karşılaştırmalı olarak analiz etmektir. Çalışmada yöntem olarak, ülkelerin teknolojik olgunluğu bağlamında dijital dönüşüm performanslarını ortaya koyan Ağ Hazırlık Endeksi (Network Readiness Index-NRI) ile yeşil dönüşümlerini yansıtan Çevresel Performans Endeksi (Environmental Performance Index-EPI) genel skorları entegre edilerek, ülkelerin eş zamanlı dönüşüm yeteneğini bütüncül olarak ölçen özgün bir "İkiz Dönüşüm Hazırlık Skoru" (İDHS) hesaplanmıştır. Ampirik bulgular; dijital olgunluk düzeyi ile yeşil dönüşüm başarısı arasında güçlü ve doğrusal bir korelasyon olduğunu doğrulamaktadır. Türkiye, dijital altyapı performansı bakımından AB üyesi rakiplerini yakından takip etmesine karşın, yeşil dönüşüm çıktılarında yapısal bir "yeşil açık" sergilemektedir. Fas'ın yeşil performans kanalıyla Türkiye ile arasındaki toplam İDHS makasını daraltmış olması, Türk sanayisi için ciddi bir pazar payı kaybı riskine işaret etmektedir. Çalışma, elde edilen bulgular doğrultusunda Türk ihracatçısının küresel değer zincirlerindeki konumunu koruyabilmesi için makroekonomik politika ve entegre teşvik önerileri sunarak literatüre özgün bir ampirik katkı sağlamaktadır.

Anahtar Kelimeler: İkiz Dönüşüm, Uluslararası Ticaret, Sınırda Karbon Düzenleme Mekanizması, Dijitalleşme, Sürdürülebilirlik

THE TWIN TRANSITION IN INTERNATIONAL TRADE: A COMPARATIVE ANALYSIS OF THE LEVELS OF PREPAREDNESS IN TÜRKİYE AND ITS STRATEGIC RIVAL COUNTRIES

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Abstract

The global trade ecosystem is being restructured around the "Twin Transition" axis, which necessitates the simultaneous implementation of digitalisation and decarbonisation processes alongside a structural paradigm shift. In particular, the European Union's (EU) Carbon Border Adjustment Mechanism (CBAM) and supply chain regulations have shifted the dynamics of competitiveness in international markets from a cost-focused approach to a compliance-focused one. The aim of this study is to analyse Türkiye's capacity to adapt to the twin transitions in international trade, by comparing it with Poland, Romania and Morocco, which are its most dynamic competitors in the EU market. In this study, an original "Twin Transformation Readiness Score" (TTRS) was developed as a methodological approach. This composite score integrates the overall scores of the Network Readiness Index (NRI), which reflects countries' digital transformation performance in the context of their technological maturity, and the Environmental Performance Index (EPI), which captures their green transformation performance, thereby providing a holistic measure of countries' capacity for simultaneous twin transformation. Empirical findings confirm a strong and linear correlation between the level of digital maturity and the success of the green transition. Whilst Türkiye closely matches its EU member state competitors in terms of digital infrastructure performance, it exhibits a structural "green gap" in green transition outcomes. The fact that Morocco has narrowed the overall TTRS gap with Türkiye through its green performance channel points to a serious risk of market share loss for Turkish industry. In line with the findings, this study makes an original empirical contribution to the literature by proposing macroeconomic policies and integrated incentives to enable Turkish exporters to maintain their position within global value chains.

Keywords: Twin Transition, International Trade, Carbon Border Adjustment Mechanism, Digitalisation, Sustainability

GİRİŞ

Küresel ekonomi ve uluslararası ticaret, 21. yüzyılın ilk çeyreğinde iki köklü dönüşümün güçlü etkileşimiyle yeniden biçimlenmektedir. Bunlardan ilki, üretim, dağıtım ve tüketim süreçlerini temelden değiştiren dijitalleşme (Endüstri 4.0); ikincisi ise iklim kriziyle mücadele kapsamında ortaya çıkan yeşil dönüşüm sürecidir. Literatürde "İkiz Dönüşüm" olarak kavramsallaştırılan bu olgu, dijital teknolojilerin sunduğu veri odaklı verimlilik ve optimizasyon imkânlarının, yeşil dönüşümün dekarbonizasyon ve sürdürülebilirlik hedeflerine ulaşmasında stratejik bir kaldıraç olarak kullanılmasını ifade etmektedir (Avrupa Komisyonu, 2022).

Bu bağlamda, geleneksel dış ticaret teorilerinde yer alan işgücü, sermaye ve doğal kaynaklara dayalı statik mukayeseli üstünlük anlayışı, küresel değer zincirlerinde yerini giderek dijital olgunluk ve karbon verimliliğine dayalı dinamik rekabetçilik paradigmalarına bırakmaktadır (Dünya Ekonomik Forumu [WEF], 2024). Bu paradigma kaymasının en somut yansıması, Türkiye'nin en önemli ticaret ortağı olan Avrupa Birliği'nin "Avrupa Yeşil Mutabakatı" ve bunun operasyonel aracı olan "Sınırda Karbon Düzenleme Mekanizması" (SKDM) ile somutlaşmıştır. SKDM, küresel ticaretin kurallarını maliyet merkezli bir mantıktan karbon emisyonu ve sürdürülebilirlik odaklı bir yaklaşıma kaydırmış, böylece yeni rekabet koşullarını belirginleştirmiştir (Monjon ve Quirion, 2011).

Günümüzde uluslararası pazarlarda rekabet gücünü korumak, yalnızca düşük maliyetli üretimle mümkün olmaktan çıkmış; üretim süreçlerini dijitalleştirmek, karbon ayak izini minimize etmek ve şeffaf, izlenebilir tedarik zincirleri oluşturmak zorunlu hale gelmiştir. Bu nedenle ikiz dönüşüm, gelişmekte olan ekonomiler için bir politika tercihi olmanın ötesinde, küresel pazarlara erişimin vazgeçilmez bir ön şartı niteliği kazanmıştır (Birleşmiş Milletler Ticaret ve Kalkınma Konferansı [UNCTAD], 2023).

Türkiye, coğrafi konumu ve AB ile Gümrük Birliği ilişkisi sayesinde önemli bir erişim avantajına sahip olsa da benzer ihracat yapısına ve AB pazarına yüksek entegrasyon düzeyine sahip Polonya ve Romanya gibi üye ülkelerle; ayrıca Akdeniz Havzası'nda lojistik ve üretim alternatifi olarak yükselen Fas ile doğrudan rekabet içindedir. Bu ülkelerin dijital altyapı, inovasyon kapasitesi, çevre yönetişimi ve dekarbonizasyon performansları, önümüzdeki dönemde küresel ticaret içindeki göreli konumlarını belirleyecek kritik faktörler olarak öne çıkmaktadır.

Literatürde yer alan çalışmalar, dijitalleşme ve yeşil dönüşüm süreçleri arasındaki ilişkinin doğrusal ve tamamlayıcı olmaktan ziyade, belirli koşullar altında çelişkili sonuçlar doğurabileceğini ortaya koymaktadır (Bianchini vd., 2023; Kovacic vd., 2024; Meijer, 2024). Özellikle dijital teknolojilerin artan enerji tüketimi, ya da elektronik atık oluşumu gibi durumlar dijitalleşmenin çevresel maliyetlerini görünür hâle getirmektedir. Türkiye özelinde

yapılan çalışmalar da bu iki boyutu çoğunlukla tek başına incelemekte (Ballı, 2022; Bardakçı, 2025; Çiftçi ve Gürsel, 2025; Mete, 2025), her iki dönüşümü bütüncül ve entegre bir çerçevede ele alan karşılaştırmalı ampirik analizlere ise sınırlı biçimde rastlanmaktadır.

Bu çalışma, söz konusu metodolojik ve ampirik boşluğu doldurmayı amaçlamaktadır. Türkiye'nin uluslararası ticarette ikiz dönüşüme adaptasyon kapasitesi; küresel kabul görmüş NRI ve EPI verilerini entegre ederek oluşturulan özgün bir "İkiz Dönüşüm Hazırlık Skoru (İDHS)" aracılığıyla Polonya, Romanya ve Fas ile karşılaştırmalı olarak analiz edilmektedir. Çalışma, Türkiye'nin küresel değer zincirlerindeki konumunu güçlendirmek için stratejik "dijital" ve "yeşil" açıklarını tespit etmeyi ve dış ticaret politikası yapıcıları ile ihracatçılara somut bir stratejik çerçeve sunmayı hedeflemektedir.

1. KAVRAMSAL ÇERÇEVE

1.1. İkiz Dönüşüm Kavramı ve Teorik Temelleri

İkiz Dönüşüm kavramı, dijital ve yeşil dönüşüm süreçlerinin birbirinden bağımsız değil aksine karşılıklı olarak güçlendiren ve sinerji yaratan dinamikler olarak birlikte yönetilmesi gerektiği savını ifade etmektedir. Kavramın AB politika söylemine kazandırılması, Avrupa Komisyonu'nun 2022 yılında yayınladığı "Towards a Green and Digital Future" başlıklı Ortak Araştırma Merkezi (JRC) raporuyla resmiyet kazanmıştır. Söz konusu rapor; büyük veri, yapay zekâ, nesnelerin interneti (IoT) ve dağıtık defter teknolojileri gibi dijital teknolojilerin yeşil dönüşümün dekarbonizasyon ve döngüsel ekonomi hedefleri için stratejik bir katalizör işlevi görebileceğini belgelemiştir (Avrupa Komisyonu, 2022).

Kavramsal açıdan ikiz dönüşümün teorik kökeni iki farklı iktisat geleneğinden beslenmektedir. Birinci köken, Porter'ın (1990) rekabetçilik teorisine dayanan ve teknolojik yetkinliğin ihracat performansının temel belirleyicisi olduğunu öne süren "yenilik odaklı rekabetçilik" yaklaşımıdır. İkinci köken ise iklim iktisadı ve dışsallık teorisidir; bu çerçevede karbonun sosyal maliyetinin piyasa fiyatlarına yansıtılmaması, rekabetçi bir bozulmaya yol açmakta ve ticaret politikası araçları aracılığıyla düzeltilmesi gerekmektedir (Monjon ve Quirion, 2011). Bu iki geleneğin kesişim noktasında yer alan ikiz dönüşüm yaklaşımı; dijital olgunluğu ve karbon verimliliğini, ülkelerin küresel değer zincirlerindeki konumlarının birlikte belirleyicisi olarak ele almaktadır.

Günümüzde ikiz dönüşüm olgusunu ele alan çalışmalar; dijital ve yeşil dönüşümlerin birbiriyle hem uyumlu hem de entegre süreçler olduğunu ortaya koymaktadır. Naseem ve Yang (2021), Endüstri 4.0 teknolojilerinin çevresel sürdürülebilirliğe katkısını sistematik biçimde incelemiş ve dijitalleşmenin enerji verimliliği, atık azaltımı ve tedarik zinciri şeffaflığı kanallarıyla yeşil dönüşümü hızlandırdığını göstermiştir. Buna karşın Widdicks vd. (2023), dijitalleşmenin enerji tüketimini artıran "geri tepme etkisi" (rebound effect) nedeniyle

çevre üzerinde her zaman olumlu bir etki yaratmadığını vurgulamış; bu nedenle ikiz dönüşümün yalnızca teknolojik bir meseleden daha çok bütüncül bir yönetişim sorunsalı olduğunu savunmuştur.

1.2. Sınırda Karbon Düzenleme Mekanizması ve Uluslararası Ticarete Etkileri

Avrupa Yeşil Mutabakatı'nın temel politika araçlarından birini oluşturan SKDM, Ekim 2023'ten itibaren geçiş dönemi, 2026 yılından itibaren ise tam uygulama süreciyle yürürlüğe girmiştir. SKDM'nin temel mantığı, Avrupa Birliği Emisyon Ticaret Sistemi (AB ETS) kapsamında üretilen ürünlerle, karbon düzenlemesi bulunmayan ya da daha düşük düzeyde kalan üçüncü ülkelerden ithal edilen ürünler arasındaki rekabet eşitsizliğini (karbon sızıntısı) gidermektir (Monjon ve Quirion, 2011).

Mekanizmanın ticari etkileri açısından değerlendirildiğinde, AB'ye ihracat yapan üçüncü ülkelerin artık yalnızca üretim maliyetleri ve ürün kalitesi temelinde değil, aynı zamanda üretim süreçlerindeki karbon emisyon yoğunlukları temelinde de rekabet etmek durumunda kaldığı görülmektedir. SKDM'nin ilk aşamasında demir-çelik, alüminyum, çimento, gübre, elektrik ve hidrojen sektörleri kapsama alınmış olup AB'nin daha ileri politika döngülerinde tekstil, kimya ve otomotiv gibi sektörleri de kapsama dahil etmesi öngörülmektedir. Bu tablo, söz konusu sektörlerde önemli ihracat kalemleri bulunan Türkiye için yapısal bir uyum ve dönüşüm baskısını kaçınılmaz kılmaktadır (İmer-Ertunga ve Seyhun, 2022).

SKDM'nin teorik zeminini oluşturan karbonun sınırda vergilendirilmesi fikri, literatürde uzun süredir tartışılmaktadır. Bu tartışmanın öncü çalışmalarından biri olan Monjon ve Quirion (2011), çeşitli sınır düzenleme konfigürasyonlarını AB ETS ve Dünya Ticaret Örgütü (DTÖ) kurallarıyla uyumluluğu açısından karşılaştırmalı olarak değerlendirmiş; en iyi mevcut teknolojilere dayalı kısmi sınır düzenlemesinin karbon sızıntısını azaltmakla birlikte AB'de sera gazı yoğun ürünlerin üretiminde bir azalma beklenmesi gerektiğini ortaya koymuştur. Bu bulgu, rekabetçiliğin artık çevresel performansla doğrudan ilişkili olduğunu ve ticaret politikası analizinin mutlaka bir "yeşil boyut" taşıması gerektiğini vurgulamaktadır.

1.3. Küresel Değer Zincirlerinde Dinamik Rekabetçilik ve İkiz Dönüşüm

Klasik dış ticaret teorisindeki Heckscher-Ohlin modeli, ülkelerin bol sahip oldukları üretim faktörlerini yoğun biçimde kullanan ürünlerde uzmanlaşacağını öngörmektedir. Ancak 21. yüzyılın küresel değer zincirleri, bu statik karşılaştırmalı üstünlük anlayışının sınırlılıklarını açıkça ortaya koymuştur. WEF (2024) Küresel Rekabetçilik Raporu, teknolojik yenilik kapasitesi ile iklim uyum performansının, işgücü maliyetinin önüne geçerek küresel değer zincirlerindeki konumlanmanın öncü belirleyicileri haline geldiğini belgelemektedir.

Bu paradigma değişimi çerçevesinde UNCTAD (2023), ikiz dönüşümün gelişmekte olan ve geçiş ekonomileri üzerindeki asimetrik baskısına dikkat çekmektedir. Söz konusu ülkeler;

dijital altyapı yatırımı ve yeşil teknoloji adaptasyonu gerektiren dönüşüm maliyetlerini, büyük gelişmiş ekonomilere kıyasla çok daha kısıtlı mali ve kurumsal kapasiteyle üstlenmek zorunda kalmaktadır. Bu nedenle ikiz dönüşüm performansı hem bir kalkınma önceliği hem de uluslararası rekabetçilik koşulu olarak eş zamanlı değerlendirilmelidir.

Türkiye, AB ile Gümrük Birliği çerçevesinde derin bir ticari entegrasyon içinde bulunmaktadır; ancak bu entegrasyon, AB'nin yeşil ve dijital standart düzenlemelerine hızla uyum sağlama zorunluluğunu da beraberinde getirmektedir. SKDM başta olmak üzere AB'nin uyum gereklilikleri, Türkiye'nin ihracat rekabetçiliği açısından doğrudan belirleyici bir etki taşımaktadır. Bu çerçevede, Polonya ve Romanya'nın AB üyeliğinden kaynaklanan yapısal fonlara ve yeşil dönüşüm finansmanına erişim imkânları ile Fas'ın yeşil enerji üssü olmaya yönelik stratejik yatırımları, Türkiye'nin rekabet ortamını köklü biçimde dönüştürmektedir.

Sonuç olarak, uluslararası ticarette ikiz dönüşüm kapasitesi; dijital olgunluk, çevresel performans ve kurumsal uyum kapasitesinin bütüncül bir sentezi olarak değerlendirilmelidir. Bu çalışmanın takip eden bölümlerinde bu sentezi ölçmeye yönelik özgün bir metodoloji geliştirilmekte ve bu metodoloji Türkiye ile stratejik rakip ülkelere uygulanmaktadır.

2. YÖNTEM

Bu çalışma, nitel bir betimlemeyle desteklenen karşılaştırmalı ve nicel bir araştırma tasarımını benimsemiştir. Türkiye'nin uluslararası ticarette ikiz dönüşüm (dijital + yeşil) adaptasyon kapasitesini stratejik rakip ülkelerle (Polonya, Romanya ve Fas) karşılaştırmalı olarak incelemek amacıyla "İkiz Dönüşüm Hazırlık Skoru" (İDHS) adlı özgün bir bileşik endeks geliştirilmiştir. Araştırma, ikiz dönüşümün bütüncül doğasını yansıtmak üzere dijital olgunluk ve çevresel performansı, Birleşmiş Milletler Sürdürülebilir Kalkınma Hedefleri (SKH) ile uyumlu bir çerçevede ele almaktadır.

Çalışmada kullanılan veriler, uluslararası kabul görmüş iki endeksten elde edilmiştir. Dijital dönüşüm boyutunda Portulans Enstitüsü tarafından yayımlanan NRI (2025) verileri kullanılmıştır. NRI, dört ana bileşen (Teknoloji, İnsan, Yönetişim ve Etki), 12 alt bileşen ve 53 göstergeden oluşmaktadır. Yeşil dönüşüm boyutunda ise Yale Üniversitesi ve Columbia Üniversitesi iş birliğiyle hazırlanan EPI (2024) verileri tercih edilmiştir. EPI, üç ana politika hedefi (İklim Değişikliği Azaltımı, Çevre Sağlığı ve Ekosistem Canlılığı) 58 performans göstergesiyle 11 kategori altında ülkelerin çevresel performansını değerlendirmekte olup SKH 13 (İklim Eylemi), SKH 14 (Sudaki Yaşam), SKH 15 (Karasal Yaşam) ve SKH 12 (Sorumlu Tüketim ve Üretim) hedefleriyle güçlü bir uyum sergilemektedir.

Analiz kapsamına alınan ülkeler Türkiye, Polonya, Romanya ve Fas'tır. Bu ülkelerin seçiminde aşağıda yer alan ölçütler esas alınmıştır:

- AB pazarına yüksek entegrasyon düzeyi,
- Benzer ihracat sepeti yapısı ve rekabet potansiyeli,
- Akdeniz Havzası'nda stratejik lojistik alternatif olarak Fas'ın konumu,
- SKH performanslarında karşılaştırılabilir gelişmekte olan ve geçiş ekonomisi profili.

İDHS, dijital ve yeşil dönüşüm boyutlarını eşit ağırlıklı olarak birleştiren, SKH perspektifiyle zenginleştirilmiş bileşik bir endekstir. Endeks inşası, Avrupa Komisyonu Ortak Araştırma Merkezi (Joint Research Centre – JRC) (2008) bileşik endeks rehberlerine uygun olarak aşağıda gösterilmekte olan aşamalarda gerçekleştirilmiştir.

Veri normalizasyonu aşamasında her iki endeksin ham puanları, min-maks normalizasyon yöntemiyle 0-100 aralığına dönüştürülmüştür:

$$\text{Normalize Edilmiş Değer} = \frac{X_i - X_{\min}}{X_{\max} - X_{\min}} \times 100$$

Boyut skorları hesaplama aşamasında Dijital Dönüşüm Skoru = NRI 2025 normalize değeri; Yeşil Dönüşüm Skoru = EPI 2024 normalize değeri olarak alınmıştır.

Bileşik skor hesaplama aşamasında İDHS, iki boyutun aritmetik ortalaması alınarak belirlenmiştir:

$$\text{İDHS} = \frac{\text{Dijital Skor} + \text{Yeşil Skor}}{2}$$

Eşit ağırlıklandırma, ikiz dönüşüm literatüründe dijital ve yeşil boyutların birbirini tamamlayıcı niteliği ve SKH'nin bütüncül yaklaşımıyla gerekçelendirilmiştir.

3. BULGULAR

3.1. Tanımlayıcı Analiz ve Ülkelerin Genel Performansı

Bu çalışmada geliştirilen İDHS sonuçlarına göre ülkelerin performansları Tablo 1'de sunulmaktadır. NRI ve EPI ham skorları, min-maks normalizasyonu uygulanarak karşılaştırılabilir bir ölçeğe taşınmış ve İDHS hesaplanmıştır.

Tablo 1. Ülkelerin İkiz Dönüşüm Hazırlık Skorları

Ülke	NRI Skoru (Dijital Dönüşüm)	EPI Skoru (Yeşil Dönüşüm)	NRI Min-Maks	EPI Min-Maks	İkiz Dönüşüm Hazırlık Skoru (İDHS)	İDHS Sıralaması
Polonya	59,40	64,20	100,00	100,00	**100,00**	**1**
Romanya	53,16	57,30	52,07	74,44	**63,26**	**2**
Türkiye	51,27	37,20	37,56	0,00	**18,78**	**3**
Fas	46,38	39,50	0,00	8,52	**4,26**	**4**

Kaynak: Portulans Enstitüsü – NRI 2025; Block vd. (2024) – EPI 2024; yazara ait hesaplamalar. İDHS, ham skorların min-maks normalizasyonu ve aritmetik ortalamasıyla elde edilmiştir.

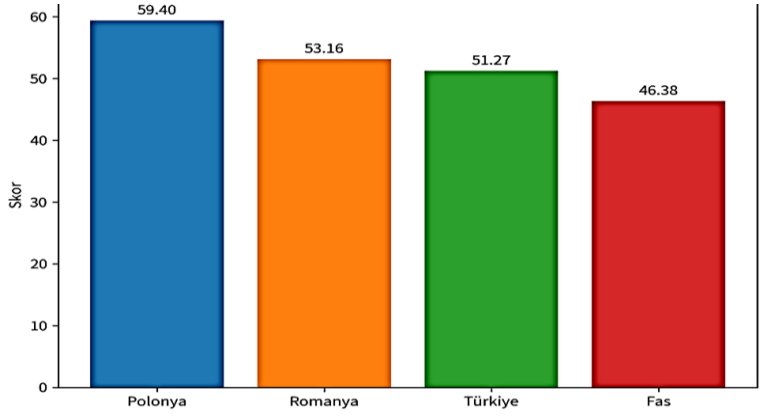
Bulgulara göre Polonya, hem dijital hem de yeşil dönüşüm boyutlarında en yüksek performansa sahip olarak İDHS'de 100 puanla referans ülke konumundadır. Romanya 63,26 puanla ikinci sıradadır. Türkiye 18,78 puanla üçüncü, Fas ise 4,26 puanla son sıradadır. Bu tablo, Polonya liderliğindeki AB üyelerinin ikiz dönüşüm hazırlığında belirgin bir avantaj konumunda olduğunu ve Türkiye'nin her iki rakibine göre ciddi bir hazırlık açığı taşıdığını ortaya koymaktadır.

3.2. Dijital Dönüşüm Performansı

Ağ Hazırlık Endeksi (NRI 2025) verilerinden elde edilen ve Şekil 1'de yer alan ülkelerin dijital dönüşüm altyapısı, insan sermayesi, yönetişim ve dijital etkinliği açısından karşılaştırmalı bir görünüm sunmaktadır.

- **Polonya**, 59,40 puan ile dijital dönüşüm boyutunda en yüksek performansa sahip ülke olarak dikkat çekmektedir.
- **Romanya** (53,16) ve **Türkiye** (51,27), birbirine oldukça yakın skorlar elde ederek orta-üst düzeyde bir dijital olgunluk sergilemektedir.
- **Fas**, 46,38 puanla grup içinde en düşük dijital hazırlık düzeyine sahiptir.

Şekil 1. Dijital Dönüşüm Performansı



Ayrıca Tablo 2'de yer alan alt bileşenler incelendiğinde; Türkiye, özellikle teknoloji altyapısı (erişim alt bileşeninde küresel 17. sıra) ve e-devlet hizmetlerinde (31. sıra) görece güçlü bir profil çizmektedir. Bununla birlikte, dijital teknolojilerin ekonomik ve toplumsal çıktılara

dönüştürülmesi anlamına gelen "Etki" (Impact) sütununda 94. sıraya gerilmesi, Türkiye'nin dijitalleşme ekosistemindeki kritik kırılganlığını yansıtmaktadır.

Tablo 2. Dijital Dönüşüm Sıralamaları

	Kategori	Türkiye	Polonya	Romanya	Fas
Teknoloji	**Erişim**	17	26	45	74
	İçerik	38	42	57	32
	Geleceğin Teknolojileri	75	68	85	58
İnsanlar	**Bireyler**	67	20	52	78
	İşletmeler	60	47	78	70
	Hükümetler	31	57	76	78
Yönetişim	**Güven**	43	34	39	97
	Düzenleme	72	45	51	55
	Kapsayıcılık	78	36	87	73
Etki	**Ekonomi**	76	39	28	85
	Yaşam Kalitesi	119	32	30	95
	Sürdürülebilir Kalkınma Hedeflerine Katkı	41	27	47	91

Kaynak: Portulans Enstitüsü – NRI 2025

Türkiye, Ağ Hazırlık Endeksi'nde 127 ülke arasında 60. sırada yer almaktadır. Üst-orta gelir grubu ülkeler arasında 9. sırada bulunan Türkiye'nin en güçlü ana sütunu "Teknoloji", en çok geliştirilmesi gereken alanı ise "Etki" olarak öne çıkmaktadır.

Buna ek olarak Polonya küresel sıralamada 35. sırada, Romanya 52. sırada ve Fas 73. sırada yer almaktadır. Polonya, yüksek gelir grubu ülkeler arasında ağ hazırlığı konusunda dengeli bir performans sergilemektedir. En büyük gücü "Etki" sütununda görülmektedir. Alt bileşenlerde bireysel internet kullanımı, dijital altyapıya erişim ve teknolojinin Sürdürülebilir Kalkınma Amaçlarına katkısı oldukça yüksek seviyededir. En çok geliştirilmesi gereken alanı ise Teknoloji kategorisidir. Özellikle işletmelerin dijitalleşme düzeyi, e-devlet hizmet çeşitliliği ve Yapay Zekâ gibi geleceğin teknolojilerine adaptasyon hızı düşük seviyededir.

Romanya, dijital ekosistemini ekonomik çıktılara dönüştürme konusunda başarılı olsa da toplumsal adaptasyonda yavaş kalmaktadır. En belirgin gücü Polonya ile benzer şekilde "Etki" kategorisindedir. Ülke genelinde dijital ekonomi büyümesi, dijitalleşmenin getirdiği yaşam kalitesi ve siber güvenliğe duyulan güven yüksek sıralamalara sahiptir. En zayıf alanı ise "İnsan" faktörüdür. İşletmelerin dijital dönüşüm yatırımları, toplumun genel dijital okuryazarlığı ve geleceğin bulut/AI altyapıları zayıf halkaları oluşturmaktadır.

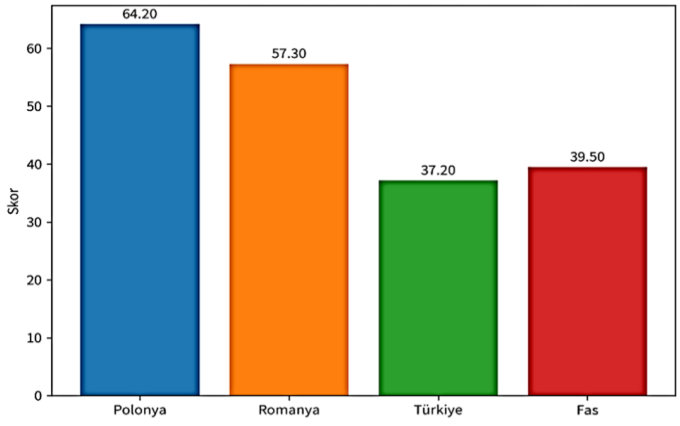
Fas, alt-orta gelir grubu ülkeler arasında ağ hazırlığı en yüksek olan lider ekonomilerden biridir. En güçlü olduğu kategori "Teknoloji" olarak görülmektedir. Dijital içerik üretimi/erişilebilirliği, yasal dijital düzenlemeler ve gelişmekte olan yeni nesil teknolojilere yatırım düzeyi oldukça güçlüdür. Öte yandan teknolojik yatırımları sosyal faydaya dönüştüremediği için en zayıf olduğu alan "Etki" kategorisi olarak görülmektedir. Teknolojinin sürdürülebilirliğe katkısı, toplumda dijital güven, vatandaşların yaşam kalitesi ve kamu dijital hizmetleri nispeten zayıf kalmaktadır.

Sonuç olarak Türkiye, dijital dönüşüm konusunda stratejik rakiplerine nispeten yakın bir konumda yer almaktadır. Özellikle Romanya ile arasındaki küçük fark, Türkiye'nin dijital altyapı ve teknolojik kapasite açısından rekabetçi bir potansiyele sahip olduğunu göstermektedir. Bu durum, uluslararası ticarette dijital teknolojilerin (e-ticaret, lojistik optimizasyonu, tedarik zinciri dijitalleşmesi) daha etkin kullanılması için önemli bir fırsat sunmaktadır.

3.3. Yeşil Dönüşüm Performansı

Çevresel Performans Endeksi (EPI 2024) verileri Türkiye için en kritik bulguyu sunmaktadır. Polonya 64,20 puan ile dört ülke arasında yeşil dönüşümde de liderliği sürdürmektedir. Romanya 57,30 puanla ikinci sıradadır. Türkiye ise 37,20 puanla dört ülke arasında en düşük yeşil skoru sergilemekte; EPI skorunda Fas'ın (39,50) gerisinde kalmaktadır. Biyoçeşitlilik korumada 180 ülke arasında 165. sıraya düşen ve kömür sübvansiyonları ile yüksek emisyon yoğunluğunu sürdüren Türkiye; SKDM'nin yükümlülüklerinin tam olarak devreye girdiği bu dönemde uluslararası ticaret açısından yüksek bir uyum riski taşımaktadır. Şekil 2'de ülkelere ilişkin yeşil dönüşüm performansları yer almaktadır.

Şekil 2. Yeşil Dönüşüm Performansı



AB ile güçlü ticari ilişkilerimiz ve Gümrük Birliği çerçevesinde artan sürdürülebilirlik beklentileri dikkate alındığında, yeşil dönüşüm boyutunun orta ve uzun vadede dış ticaret performansımızı destekleyecek şekilde güçlendirilmesi önemli bir fırsat alanı olarak öne çıkmaktadır.

Mevcut dijital altyapımızın yeşil teknolojilerle (yenilenebilir enerji, karbon izleme sistemleri, döngüsel ekonomi) entegrasyonunun, bu açığı kapatmak adına değerli bir kaldıraç niteliğinde olacağı düşünülmektedir.

Tablo 3'te yer alan EPI 2024 verilerinin alt bileşenlere göre incelenmesi, söz konusu ülkelerin yeşil dönüşüm performanslarındaki güçlü ve zayıf yönlerini karşılaştırmaya olanak sağlamaktadır.

Tablo 3. Yeşil Dönüşüm Sıralamaları

	Kategori	Türkiye	Polonya	Romanya	Fas
Ekosistem Canlılığı	**Biyoçeşitlilik ve Yaşam Alanı**	164	6	12	145
	Ormanlar	68	87	62	-
	Balıkçılık	82	74	135	82
	Hava Kirliliği	141	8	40	103
	Tarım	70	35	38	164
	Su Kaynakları	44	29	62	53
Çevre Sağlığı	**Hava Kalitesi**	111	96	94	74
	Temizlik ve İçme Suyu	72	36	62	100
	Ağır Metaller	73	42	70	153
	Atık Yönetimi	105	19	44	111
İklim Değişikliği	**İklim Değişikliği Azaltımı**	119	28	45	134

Kaynak: Block vd. (2024) – EPI 2024

EPI 2024 verileri, dört ülkenin çevresel performansını üç ana başlık (Ekosistem Canlılığı, Çevre Sağlığı ve İklim Değişikliği) altında inceleme imkânı sunmaktadır. Genel olarak Polonya ve Romanya, özellikle Çevre Sağlığı ve İklim Değişikliği Azaltımı alanlarında Türkiye ve Fas'a göre belirgin bir üstünlük göstermektedir. Türkiye ve Fas ise Ekosistem Canlılığı kategorisinde daha rekabetçi, ancak birçok kritik alt alanda geride kalmaktadır.

Türkiye, Su Kaynakları ve Tarım alanlarında dört ülke arasında en iyi veya ikinci en iyi performansı göstermektedir. Bu, Türkiye'nin su yönetimi ve tarımsal uygulamalarda belirli bir deneyim ve kapasiteye sahip olduğunu işaret etmektedir. Ayrıca Balıkçılık alanında Fas ile birlikte orta-üst düzeyde bir konumdadır. Türkiye'nin en belirgin zayıf alanları ise Biyoçeşitlilik ve Yaşam Alanı, Hava Kirliliği, İklim Değişikliği Azaltımı ve Atık Yönetimi olarak öne çıkmaktadır. Özellikle biyoçeşitlilikteki çok düşük performans, ekosistem tahribatı ve habitat kaybının ciddi boyutlara ulaştığını göstermektedir. Hava kirliliği ve iklim değişikliğiyle mücadeledeki gerilik ise sanayi yoğunlaşması, kömür bağımlılığı ve kentleşme baskısıyla yakından ilişkilidir.

Fas, Hava Kalitesi ve Temizlik ve İçme Suyu gibi Çevre Sağlığı bileşenlerinde Türkiye'ye göre daha iyi sonuçlar almıştır. Bununla birlikte genel profili oldukça değişkendir. Fas, Tarım, Ağır Metaller, Biyoçeşitlilik ve Yaşam Alanı ve İklim Değişikliği Azaltımı gibi alanlarda en kötü performansı gösteren ülkedir. Bu durum, iklim değişikliğine karşı yüksek kırılganlık ve sınırlı mali-teknolojik kapasiteyle açıklanabilir.

Polonya, dört ülke arasında en dengeli profile sahip ülkedir. Özellikle Temizlik ve İçme Suyu, Atık Yönetimi, Hava Kirliliği ve İklim Değişikliği Azaltımı alanlarında çok güçlü bir performans sergilemektedir. Bu sonuçlar, Polonya'nın AB üyeliğinin getirdiği çevresel standartlar, katı düzenlemeler ve altyapı yatırımlarının etkili olduğunu göstermektedir.

Romanya da Polonya'ya yakın bir profil çizerek Atık Yönetimi, İklim Değişikliği Azaltımı ve Tarım alanlarında başarılı olduğu görülmektedir. Ormanlar konusunda da nispeten iyi bir konumdadır. Ayrıca Polonya ve Romanya, genel olarak daha az zayıf alana sahiptir. Polonya'nın en zayıf noktası Ormanlar, Romanya'nın ise Balıkçılık ve Su Kaynakları olarak tespit edilmiştir.

Özetle; Polonya, dört ülke arasında açık ara en iyi çevresel performansa sahiptir. Hem Ekosistem Canlılığı hem de Çevre Sağlığı'nda dengeli bir başarı grafiği çizmektedir. Romanya, Polonya'nın biraz gerisinde ancak Türkiye ve Fas'a göre belirgin şekilde daha ileridedir. Türkiye, orta düzeyde bir performans sergilemekte; su ve tarım gibi alanlarda avantajı varken, biyoçeşitlilik, hava kalitesi ve iklim değişikliği gibi kritik küresel önceliklerde önemli eksiklikler yaşamaktadır. Fas, özellikle tarım, ağır metaller ve biyoçeşitlilikte ciddi sorunlar yaşamakta ve genel olarak en zorlu konumda görünmektedir.

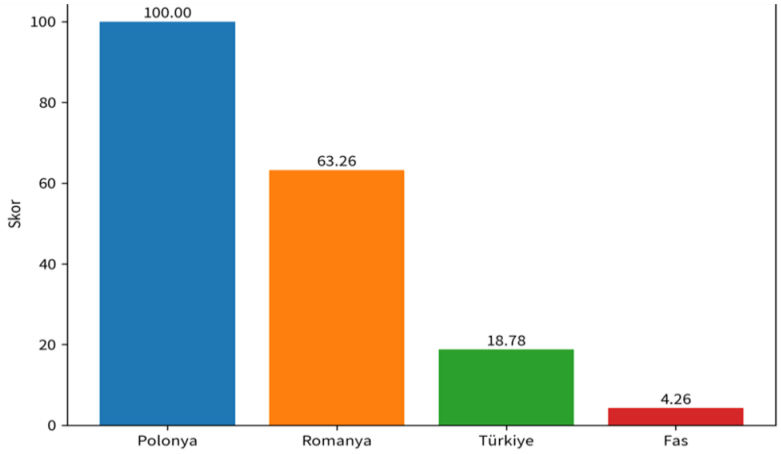
Bulgular ışığında ülkelerin güçlü ve zayıf yönler dikkate alındığında, çevresel performanslarını artırmaya yönelik stratejik müdahalelerin büyük önem taşıdığını söylemek mümkündür. Bu kapsamda; Türkiye için öncelikli olarak biyoçeşitlilik koruma, hava kirliliği kontrolü ve iklim değişikliği azaltım stratejileri güçlendirilmelidir. Özellikle korunan alanların etkinliğinin artırılması, sanayi ve enerji sektöründe yeşil dönüşümün hızlandırılması ve atık yönetim sistemlerinin modernizasyonu kritik önem taşımaktadır. Fas'a ise tarımsal

sürdürülebilirlik, toprak ve su kaynaklarının korunması ile ağır metal kirliliğinin azaltılması konusunda acil müdahaleler önerilebilir. İklim değişikliğine uyum kapasitesinin geliştirilmesi de öncelikli alanlardan biridir. Son olarak; Polonya ve Romanya, mevcut başarılarını korurken orman yönetimi ve su kaynakları gibi görece zayıf kaldıkları alanları iyileştirebilirler.

3.4. Göreli Açık Analizi

Türkiye'nin rakip ülkelere göre stratejik boyut açıkları incelendiğinde şu tablo ortaya çıkmaktadır. Polonya ile Türkiye arasındaki ham skor farkı dijital boyutta 8,13 puan, yeşil boyutta ise 27,00 puandır. Min-maks normalizasyonu sonucunda Polonya referans ülke kabul edildiğinde Türkiye'nin İDHS'si 18,78 olup toplam İDHS açığı 81,22 puan olarak görülmektedir. Romanya ile kıyaslandığında dijital boyuttaki ham fark 1,89 iken yeşil boyuttaki ham fark 20,10 puandır ve İDHS açığı ise 44,48 puandır. Bu analiz, Türkiye için en kritik stratejik açığın yeşil dönüşüm alanında yoğunlaştığını doğrulamaktadır. Fas'ın yeşil performans artışıyla Türkiye ile arasındaki İDHS farkını 14,52 puana indirmiş olması kritik bir erken uyarı sinyalidir. Şekil 3'te ülkelere ilişkin ikiz dönüşüm hazırlık skorları gösterilmektedir.

Şekil 3. İkiz Dönüşüm Hazırlık Skorları

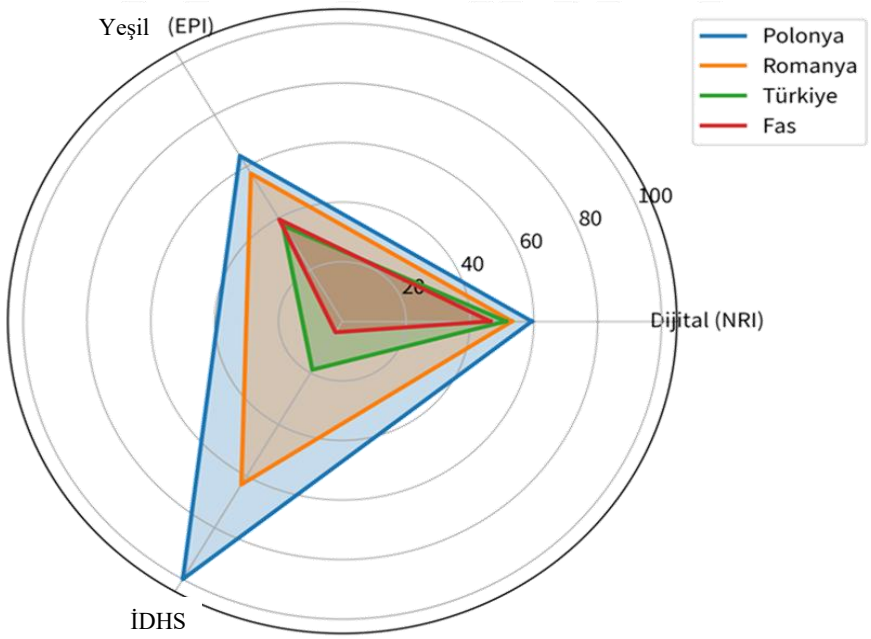


3.5. İkiz Dönüşüm Hazırlık Düzeylerinin Stratejik Yorumu

Elde edilen bulgular ülke profilleri açısından değerlendirildiğinde dört farklı stratejik konumlanma biçimi dikkat çekmektedir. Polonya, hem dijital hem de yeşil dönüşümü dengeli biçimde entegre etmiş lider konumdadır ve AB üyeliğinin sunduğu yapısal fonlar ile yeşil dönüşüm finansmanından sistematik olarak yararlanmaktadır. Romanya ise dengeli ve orta-üst düzey bir performans çizgisi sürdürmektedir. Türkiye, dijital dönüşüm göstergelerinde

görece güçlü bir performans sergilemekle birlikte, yeşil dönüşüm göstergelerinde aynı başarıyı ortaya koyamamaktadır. Bu durum, ülkenin ikiz dönüşüm sürecinde tek yönlü bir hazırlık profiline sahip olduğunu göstermektedir. Fas, dijital dönüşüm kapasitesi bakımından örneklem içerisindeki en düşük performansı sergilemesine rağmen, çevresel performans açısından Türkiye'nin üzerinde yer almakta; bu durum özellikle yenilenebilir enerji yatırımları ve düşük karbon yoğunluklu üretim yapısının rekabet avantajına katkı sağladığını göstermektedir. Şekil 4'te yer alan Radar grafiği, dört ülkenin dijital (NRI), yeşil (EPI) ve bütüncül ikiz dönüşüm (İDHS) performanslarını çok boyutlu olarak karşılaştırmaktadır.

Şekil 4. Radar Grafiği Sonuçları



Radar grafiği, Türkiye'nin ikiz dönüşümdeki en büyük potansiyelinin; dijital olgunluğunu, yeşil dönüşüm hedefleriyle daha güçlü bir biçimde bütünleştirmek olduğunu ortaya koymaktadır. Mevcut dijital altyapımız, yeşil dönüşüm sürecini desteklemek ve hızlandırmak adına önemli bir avantaj sağlayabilir. Bu entegrasyonun güçlendirilmesi, AB pazarındaki rekabetçiliğimizi korumak ve geliştirmek açısından değerli bir stratejik fırsat oluşturmaktadır.

4. SONUÇ, TARTIŞMA VE ÖNERİLER

Bu çalışmada, küresel ticaretin yeni paradigması olan ikiz dönüşüm olgunluğu; Türkiye ve AB pazarındaki üç güçlü rakibi (Polonya, Romanya, Fas) üzerinden karşılaştırmalı olarak incelenmiştir. NRI ve EPI endekslerinin senteziyle oluşturulan İDHS sonuçları, Türkiye'nin uluslararası ticarette sürdürülebilir bir rekabet avantajı elde edebilmesi için önünde hem ciddi fırsatlar hem de yapısal riskler bulunduğunu ortaya koymaktadır.

Analiz sonuçlarına göre Türkiye'nin temel avantajı, dijital olgunluk seviyesinin gelişmekte olan pek çok ülkeye kıyasla dirençli ve rekabetçi bir düzeyde olmasıdır. Ancak en büyük kırılganlık, bu dijital gücün çevresel performans süreçlerine entegre edilememiş olmasından kaynaklanan yeşil açığıdır. Akdeniz Havzası'ndaki en dinamik rakip olan Fas'ın dijitalleşmede geride olmasına rağmen yeşil skorda Türkiye'yi geçmiş olması ve toplam İDHS makasını 14,52 puana kadar daraltması, Türkiye için önemli bir erken uyarı sinyali niteliği taşımaktadır. SKDM mali yükümlülüklerinin tamamen devreye girdiği bu dönemde, yeşil dönüşümde yaşanacak gecikme doğrudan pazar payı kaybı anlamına gelecektir.

Bu bulgular, Naseem ve Yang (2021) ile UNCTAD (2023) çalışmalarında yer alan ikiz dönüşümde yalnızca teknolojik değil, bütüncül ve senkronize bir geçiş yönetimine ihtiyaç duyulduğu yönündeki tespitlerini desteklemektedir. Türkiye'nin mevcut görünümü ise Widdicks ve diğerleri (2023) gerçekleştirdikleri çalışmada yer alan, dijitalleşmenin çevresel performansa dönüşmesini engelleyen kurumsal ve düzenleyici boşluklar kavramıyla da örtüşmektedir.

Söz konusu literatür bulguları ile bu çalışmanın çıktıları çerçevesinde, ikiz dönüşüm süreçlerinin daha etkin yönetilebilmesi adına politika yapıcılara sunulan temel öneriler aşağıda özetlenmektedir.

- **Entegre Teşvik Mekanizmaları:** Ticaret Bakanlığı ve KOSGEB tarafından sunulan dijitalleşme ve yeşil dönüşüm desteklerinin birbirinden bağımsız uygulanması yerine, "ikiz dönüşüm" çatısı altında bütünleştirilmesi değerlendirilmelidir. Bu doğrultuda, enerji verimliliğini yapay zekâ ve IoT (Nesnelerin İnterneti) ile optimize eden entegre projelere öncelikli ve yüksek oranlı teşviklerin sağlanması süreci hızlandırabilecektir.
- **Dijital Ürün Pasaportu Altyapısının Kurulması:** Özellikle tekstil, otomotiv ve beyaz eşya gibi lokomotif sektörlerde faaliyet gösteren Türk ihracatçılarının AB pazarındaki rekabetçiliklerini koruyabilmeleri adına; ürünlerin karbon ayak izini ve hammadde kaynağını geriye dönük takip eden, blokzincir tabanlı ulusal bir izlenebilirlik altyapısının oluşturulması önem arz etmektedir.

- **KOBİ'lere Yönelik İkiz Dönüşüm Danışmanlığı:** İhracat yapısının merkezinde yer alan KOBİ'lerin teknik ve finansal kapasitelerindeki kısıtlar dikkate alınarak, ihracatçı birlikleri öncülüğünde yürütülen "Yeşil Dijitalleşme" mentorluk ve finansman programlarının yaygınlaştırılması faydalı olacaktır.
- **Ulusal İkiz Dönüşüm Stratejisi:** Yeşil dönüşüm ile dijital dönüşüm süreçlerinin eşgüdüm içinde yürütülmesi amacıyla, AB Yeşil Mutabakatı ile uyumlu bütünleşik bir ulusal strateji ve eylem planının hazırlanması; bu kapsamda SKDM'ye (Sınırda Karbon Düzenleme Mekanizması) uyum kapasitesinin artırılmasının öncelikli eksenlerden biri olarak belirlenmesi önerilmektedir.

Bu çalışma, ikiz dönüşümün makro düzeyde karşılaştırmalı analizine odaklanmış olup birtakım kısıtlar barındırmaktadır. İlk olarak analiz, NRI ve EPI gibi uluslararası endekslerin en güncel verilerine dayanmaktadır. Söz konusu endeksler geniş kapsamlı olmakla birlikte, veri toplama metodolojilerindeki farklılıklar ve zaman gecikmeleri sonuçları belirli ölçüde etkileyebilmektedir. İkinci kısıt olarak çalışma, stratejik rekabet ve benzer ticaret profili kriterleri doğrultusunda bilinçli olarak seçilen dört ülke ile sınırlandırılmıştır. Daha geniş bir ülke grubuyla yapılacak ileriki karşılaştırmalar, bulguların genellenebilirliğini artırma potansiyeline sahiptir. Diğer taraftan, mevcut analizin makro düzeyde tutulması nedeniyle; sektör (tekstil, otomotiv, kimya vb.) veya firma bazlı dinamikler kapsam dışında bırakılmıştır. Dolayısıyla elde edilen bulgular genel eğilimleri yansıtmakta olup mikro düzeydeki yapısal farklılıkları tamamen kapsayamayabilir.

Son olarak çalışma, kesit analizi temelinde tasarlanmış olup ikiz dönüşüm sürecinin zaman içindeki evrimini ortaya koyacak panel veri veya zaman serisi analizi yöntemlerini kapsamına almamıştır. Gelecek çalışmaların sektörel derinlik, daha geniş ülke örneklemleri ve dinamik analiz yaklaşımlarıyla literatüre katkı sağlaması beklenmektedir.

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YENİLENEBİLİR ENERJİ VE DÖNGÜSEL EKONOMİ İLİŞKİSİ: KÜRESEL LİTERATÜRÜN BİBLİYOMETRİK ANALİZİ VE SİSTEMATİK LİTERATÜR TARAMASI

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Özet

Enerji dönüşümü, iklim değişikliğiyle mücadele, karbon emisyonlarının azaltılması ve sürdürülebilir kalkınma hedeflerine ulaşılması açısından küresel ölçekte stratejik öneme sahip temel alanlardan biridir. Bu süreçte yenilenebilir enerji kaynakları, fosil yakıtlara bağımlılığın azaltılması, enerji güvenliğinin artırılması ve çevresel sürdürülebilirliğin desteklenmesi bakımından kritik bir rol üstlenmektedir. Bununla birlikte güneş panelleri, rüzgâr türbinleri, enerji depolama sistemleri ve batarya teknolojileri gibi yenilenebilir enerji altyapılarının üretim, kullanım ve atık yönetim süreçleri kaynak tüketimi, kritik hammaddelerin kullanımı ve çevresel yükler açısından yeni sorun alanlarını beraberinde getirmektedir. Bu noktada döngüsel ekonomi yaklaşımı kaynakların verimli kullanımı, geri dönüşüm, yeniden kullanım, atık minimizasyonu ve sürdürülebilir üretim modelleriyle yenilenebilir enerji sistemlerinin çevresel etkilerinin azaltılmasında önemli bir çözüm önermesi ortaya koymaktadır. Ancak yenilenebilir enerji ve döngüsel ekonomi ilişkisini birlikte ele alarak literatürdeki gelişim eğilimlerini, kavramsal yoğunlaşmaları ve araştırma yönelimlerini bütüncül biçimde ortaya koyan çalışmaların sınırlı olduğu görülmektedir.

Bu çalışmada, yenilenebilir enerji ve döngüsel ekonomi ilişkisini ele alan akademik yayınlar bibliyometrik analiz ve sistematik literatür taraması yöntemleriyle incelenmiştir. Bibliyometrik analiz kapsamında Web of Science Core Collection veri tabanında 2015–2025 dönemini kapsayan yayınlar VOSviewer yazılımı aracılığıyla değerlendirilmiş; yayınların yıllara göre dağılımı, yazar iş birliği ağları, ülke ve kurum düzeyindeki üretim yapıları, atıf ilişkileri, anahtar kelime eş-oluşum örüntüleri ve tematik kümelenmeleri analiz edilmiştir. Sistematik literatür taraması kapsamında ise PRISMA yaklaşımı doğrultusunda seçilen tam metin çalışmalar ayrıntılı biçimde incelenmiştir. Bu bölümde yenilenebilir enerji teknolojilerinin döngüsel ekonomi ilkeleriyle hangi çerçevede ilişkilendirildiği, sürdürülebilir

kaynak yönetiminin nasıl ele alındığı ve literatürde hangi tematik alanların öne çıktığı ortaya konulmuştur.

Çalışma sonucunda, yenilenebilir enerji ve döngüsel ekonomi literatürünün özellikle son yıllarda önemli ölçüde ivme kazandığı; yayınların belirli ülkeler, kurumlar, dergiler ve araştırma grupları etrafında yoğunlaştığı belirlenmiştir. Sistematik inceleme bulguları, güneş paneli geri dönüşümü, rüzgâr türbini atık yönetimi, lityum-iyon batarya geri kazanımı, kritik hammaddelerin yeniden kullanımı, enerji depolama sistemleri ve sürdürülebilir tedarik zinciri uygulamalarının literatürde öne çıkan başlıca araştırma alanları olduğunu göstermektedir. Elde edilen bulgular, yenilenebilir enerji dönüşümünün salt temiz enerji üretimiyle sınırlı olmadığını; aynı zamanda kaynak verimliliği, yaşam döngüsü yönetimi ve çevresel sürdürülebilirlik açısından döngüsel ekonomi yaklaşımıyla bütünleşik biçimde değerlendirilmesi gerektiğini ortaya koymaktadır.

Anahtar Kelimeler: Yenilenebilir Enerji, Döngüsel Ekonomi, Sürdürülebilirlik, Enerji Dönüşümü, Bibliyometrik Analiz, Sistematik Literatür Taraması

RELATIONSHIP BETWEEN RENEWABLE ENERGY AND CIRCULAR ECONOMY: A BIBLIOMETRIC ANALYSIS AND SYSTEMATIC LITERATURE REVIEW OF THE GLOBAL LITERATURE

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ABSTRACT

Energy transition is one of the key areas of strategic importance on a global scale in terms of combating climate change, reducing carbon emissions and achieving sustainable development goals. In this process, renewable energy sources play a critical role in reducing dependence on fossil fuels, enhancing energy security and supporting environmental sustainability. However, the production, use and waste management processes of renewable energy infrastructure—such as solar panels, wind turbines, energy storage systems and battery technologies—present new challenges in terms of resource consumption, the use of critical raw materials and environmental impacts. In this context, the circular economy approach offers a significant solution for reducing the environmental impacts of renewable energy systems through the efficient use of resources, recycling, reuse, waste minimization and sustainable production models. However, it is evident that there is a limited number of studies that comprehensively examine the relationship between renewable energy and the circular economy, setting out the trends in literature, conceptual developments and research directions in a holistic manner.

This study examines academic publications addressing the relationship between renewable energy and circular economy through bibliometric analysis and systematic literature review methods. Within the scope of the bibliometric analysis, publications covering the 2015–2025 period indexed in the Web of Science Core Collection database were evaluated using VOSviewer software. The annual distribution of publications, author collaboration networks, country- and institution-level production structures, citation relationships, keyword co-occurrence patterns, and thematic clusters were analyzed. Within the scope of the systematic literature review, full-text studies selected in accordance with the PRISMA approach were examined in detail. In this section, the study investigates how renewable energy technologies

are associated with circular economy principles, how sustainable resource management is conceptualized in literature, and which thematic areas have gained greater academic attention.

The findings indicate that the literature on renewable energy and circular economy has gained considerable momentum, particularly in recent years, with publications increasingly concentrated around specific countries, institutions, journals, and research communities. Systematic review findings reveal that solar panel recycling, wind turbine waste management, lithium-ion battery recovery, reuse of critical raw materials, energy storage systems, and sustainable supply chain practices constitute dominant research themes in literature. The results demonstrate that renewable energy transition should not be evaluated solely in terms of clean energy production, but also through an integrated perspective encompassing resource efficiency, life-cycle management, and environmental sustainability within the framework of circular economy principles. Furthermore, identifying methodological and thematic research gaps provides a guiding framework for future academic studies, energy policy development, and sustainable transition strategies.

Keywords: Renewable Energy, Circular Economy, Sustainability, Energy Transition, Bibliometric Analysis, Systematic Literature Review

GİRİŞ

İklim değişikliği, artan enerji talebi, doğal kaynakların hızla tükenmesi ve çevresel bozulmalar, küresel ölçekte enerji sistemlerinin yeniden yapılandırılmasını zorunlu hale getirmiştir. Özellikle fosil yakıtlara dayalı enerji üretiminin sera gazı emisyonları üzerindeki olumsuz etkileri, sürdürülebilir enerji dönüşümünü uluslararası politika gündeminin temel önceliklerinden biri haline getirmiştir. Bu bağlamda yenilenebilir enerji kaynakları; karbon emisyonlarının azaltılması, enerji güvenliğinin sağlanması, ekonomik sürdürülebilirliğin desteklenmesi ve çevresel etkilerin minimize edilmesi açısından stratejik bir rol üstlenmektedir (International Energy Agency [IEA], 2023). Güneş enerjisi, rüzgâr enerjisi, hidroelektrik, biyokütle ve jeotermal enerji gibi yenilenebilir enerji kaynaklarının yaygınlaşması, enerji dönüşüm sürecinin temel bileşenlerinden biri olarak değerlendirilmektedir.

Yenilenebilir enerji sistemleri çevresel açıdan fosil yakıtlara kıyasla daha sürdürülebilir çözümler sunmasına rağmen, bu teknolojilerin üretim, kullanım ve kullanım ömrü sonrasındaki süreçleri yeni çevresel ve ekonomik sorun alanlarını da beraberinde getirmektedir. Özellikle güneş panelleri, rüzgâr türbinleri, lityum-iyon bataryalar ve enerji depolama sistemlerinde kullanılan kritik hammaddelerin yoğun tüketimi, atık oluşumu, geri dönüşüm altyapısındaki eksiklikler ve kaynak verimliliğine ilişkin sorunlar sürdürülebilirlik tartışmalarını genişletmektedir (Geissdoerfer et al., 2017). Bu durum, yenilenebilir enerji sistemlerinin yalnızca enerji üretimi açısından değil, aynı zamanda malzeme yönetimi, atık kontrolü ve yaşam döngüsü analizi çerçevesinde de ele alınmasını gerekli kılmaktadır.

Bu noktada döngüsel ekonomi yaklaşımı, geleneksel doğrusal üretim-tüketim modellerine alternatif olarak öne çıkmaktadır. Döngüsel ekonomi; kaynakların mümkün olduğunca uzun süre ekonomik sistem içinde tutulmasını, atık oluşumunun azaltılmasını, ürünlerin yeniden kullanımını, geri dönüşümünü ve sürdürülebilir üretim modellerinin geliştirilmesini hedefleyen bütüncül bir ekonomik modeldir (Kirchherr et al., 2017). Döngüsel ekonomi yaklaşımı, enerji sektöründe özellikle yenilenebilir enerji teknolojilerinin yaşam döngüsü yönetimi, malzeme geri kazanımı, üretim süreçlerinde kaynak verimliliği ve atık minimizasyonu açısından önemli fırsatlar sunmaktadır (Korhonen et al., 2018). Bu nedenle döngüsel ekonomi ile yenilenebilir enerji arasındaki ilişkinin değerlendirilmesi, sürdürülebilir enerji dönüşümünün etkin biçimde planlanabilmesi açısından kritik önem taşımaktadır.

Yenilenebilir enerji sistemlerinin yaygınlaşmasıyla birlikte özellikle fotovoltaik panellerin kullanım ömrü sonunda ortaya çıkan atıkların yönetimi, rüzgâr türbini kanatlarının geri dönüşümü, batarya geri kazanımı ve kritik hammaddelerin sürdürülebilir kullanımı gibi konular literatürde artan ilgi görmektedir. Enerji dönüşümünün çevresel etkilerinin azaltılması yalnızca temiz enerji üretiminin artırılmasıyla sınırlı kalmamakta; aynı zamanda

bu teknolojilerin tüm yaşam döngüsü boyunca sürdürülebilir biçimde yönetilmesini gerektirmektedir. Bu bağlamda döngüsel ekonomi ilkeleri, yenilenebilir enerji teknolojilerinin çevresel etkilerini azaltmak ve kaynak kullanımını optimize etmek için önemli stratejik araçlar sunmaktadır.

Uluslararası düzeyde sürdürülebilir kalkınma politikaları da yenilenebilir enerji ve döngüsel ekonomi ilişkisini güçlendiren önemli çerçeveler oluşturmaktadır. Birleşmiş Milletler Sürdürülebilir Kalkınma Amaçları kapsamında özellikle "Erişilebilir ve Temiz Enerji" ile "Sorumlu Üretim ve Tüketim" hedefleri, bu iki kavramın bütünleşik biçimde ele alınmasını desteklemektedir (United Nations, 2023). Avrupa Yeşil Mutabakatı ve enerji dönüşüm politikaları da döngüsel ekonomi yaklaşımının enerji sektörüne entegrasyonunu teşvik etmektedir (European Commission, 2020).

Literatürde yenilenebilir enerji ve döngüsel ekonomi alanlarında çok sayıda çalışma bulunmasına rağmen, bu iki kavramı birlikte ele alarak alanın yapısal gelişimini, bilimsel üretim eğilimlerini, iş birliği ağlarını, kavramsal yoğunlaşmaları ve araştırma temalarını bütüncül biçimde inceleyen çalışmaların sınırlı olduğu görülmektedir. Özellikle bibliyometrik analiz ile sistematik literatür taramasını birlikte kullanan çalışmaların azlığı, bu alandaki bilgi boşluğunu ortaya koymaktadır.

Bu doğrultuda mevcut çalışmanın asli amacı, yenilenebilir enerji ve döngüsel ekonomi ilişkisini ele alan akademik literatürü bibliyometrik analiz ve sistematik literatür taraması yöntemleriyle kapsamlı biçimde incelemektir. Çalışma kapsamında alanın yayın eğilimleri, etkili ülkeler, kurumlar, yazarlar, atıf yapıları ve anahtar araştırma temaları ortaya konularak literatürdeki gelişim yönü değerlendirilecektir. Ayrıca sistematik inceleme yoluyla tematik araştırma alanları belirlenerek gelecekte yürütülecek akademik çalışmalar ve politika geliştirme süreçleri için yol gösterici olması amaçlanmaktadır.

1. KAVRAMSAL ÇERÇEVE

1.1. Yenilenebilir Enerji Kavramı ve Enerji Dönüşümü

Enerji, ekonomik büyüme, endüstriyel gelişim ve toplumsal refahın sürdürülebilirliği açısından temel stratejik kaynaklardan biri olarak kabul edilmektedir. Ancak uzun yıllar boyunca enerji üretiminde fosil yakıtlara dayalı sistemlerin baskın olması; sera gazı emisyonlarının artması, iklim değişikliğinin hızlanması, çevresel bozulmalar ve enerji arz güvenliği sorunlarını beraberinde getirmiştir. Bu nedenle küresel ölçekte enerji sistemlerinin daha sürdürülebilir kaynaklara yönlendirilmesi zorunlu hale gelmiştir (International Energy Agency [IEA], 2023).

Yenilenebilir enerji; doğal süreçler içerisinde sürekli olarak kendini yenileyebilen ve tükenme riski fosil yakıtlara kıyasla oldukça düşük olan enerji kaynaklarını ifade etmektedir. Güneş

enerjisi, rüzgâr enerjisi, hidroelektrik enerji, biyokütle enerjisi ve jeotermal enerji bu kapsamda değerlendirilmektedir. Yenilenebilir enerji sistemleri; karbon emisyonlarının azaltılması, enerji bağımsızlığının artırılması, çevresel etkilerin azaltılması ve sürdürülebilir kalkınma hedeflerinin desteklenmesi bakımından önemli avantajlar sunmaktadır (Ellabban et al., 2014).

Son yıllarda enerji dönüşümü politikaları kapsamında yenilenebilir enerji yatırımlarında önemli artışlar yaşanmıştır. Bununla birlikte enerji dönüşümünün yalnızca temiz enerji üretimi ile sınırlı olmadığı; aynı zamanda üretim altyapılarında kullanılan hammaddelerin sürdürülebilir yönetimi, kullanım ömrü sonrasındaki atıkların kontrolü ve kaynak verimliliğinin sağlanması gibi unsurları da kapsadığı görülmektedir. Özellikle güneş paneli sistemleri, rüzgâr türbinleri ve enerji depolama teknolojilerinde kullanılan lityum, kobalt, nikel ve nadir toprak elementleri gibi kritik hammaddeler, enerji dönüşümünün yeni sürdürülebilirlik tartışmalarını gündeme taşımaktadır (Hund et al., 2023).

1.2. Döngüsel Ekonomi Kavramı

Döngüsel ekonomi, geleneksel doğrusal üretim-tüketim modeline alternatif olarak geliştirilen sürdürülebilir bir ekonomik sistem yaklaşımıdır. Bu bağlamda, ürünlerin yaşam döngüsünün uzatılması, yeniden kullanım, geri dönüşüm, onarım ve malzeme geri kazanımı yoluyla kaynakların ekonomik sistem içerisinde mümkün olduğunca uzun süre tutulmasını hedeflemektedir (Türkmen, 2022; Kirchherr et al., 2017).

Döngüsel ekonomi yaklaşımı yalnızca atık yönetimi perspektifinden değil; aynı zamanda sürdürülebilir üretim, kaynak verimliliği, çevresel performans ve ekonomik sürdürülebilirlik bakımından da kapsamlı bir dönüşüm modeli olarak değerlendirilmektedir. Bu yaklaşımın temel amacı, ekonomik büyüme ile kaynak tüketimi arasındaki bağı azaltmak ve çevresel yükleri minimize etmektir (Türkmen, 2025; Korhonen et al., 2018).

Küresel düzeyde Avrupa Birliği başta olmak üzere birçok politika yapıcı kurum döngüsel ekonomiyi sürdürülebilir kalkınmanın temel bileşenlerinden biri olarak benimsemiştir. Özellikle Avrupa Yeşil Mutabakatı kapsamında döngüsel ekonomi politikaları, enerji dönüşümü ve karbon nötr hedefleriyle bütünleşik biçimde ele alınmaktadır (European Commission, 2020).

1.3. Yenilenebilir Enerji ve Döngüsel Ekonomi İlişkisi

Yenilenebilir enerji sistemleri genel olarak çevre dostu ve sürdürülebilir çözümler olarak görülmekle birlikte, bu teknolojilerin yaşam döngüsü boyunca ortaya çıkan çevresel etkiler göz önüne alındığında döngüsel ekonomi yaklaşımının önemi daha belirgin hale gelmektedir. Özellikle fotovoltaik panellerin kullanım ömrü sonunda ortaya çıkan atıklar, rüzgâr türbini

bileşenlerinin bertarafı, enerji depolama sistemlerinde kullanılan bataryaların geri dönüşümü ve kritik hammaddelerin yeniden kazanımı önemli sorun alanları oluşturmaktadır.

Döngüsel ekonomi ilkeleri, yenilenebilir enerji sistemlerinin yalnızca enerji üretim performansına değil; aynı zamanda kaynak kullanım etkinliğine, malzeme geri kazanımına ve yaşam döngüsü sürdürülebilirliğine odaklanmaktadır. Bu yaklaşım sayesinde enerji altyapılarında oluşan atıkların azaltılması, hammaddelere olan bağımlılığın düşürülmesi ve çevresel maliyetlerin minimize edilmesi mümkün olmaktadır.

Özellikle lityum-iyon bataryalar ve güneş paneli teknolojilerinde döngüsel ekonomi uygulamaları son yıllarda akademik literatürde yoğun ilgi görmektedir. Bunun temel nedeni, enerji dönüşümünün hızlanmasıyla birlikte bu teknolojilerin kullanım hacminin artması ve buna bağlı olarak kullanım ömrü sonu atık miktarlarının yükselmesidir. Bu durum, yenilenebilir enerji dönüşümünün sürdürülebilirliğinin yalnızca enerji üretimiyle değil, malzeme döngüselliğiyle de ilişkili olduğunu göstermektedir.

2. METODOLOJİ

Bu çalışmada, yenilenebilir enerji ve döngüsel ekonomi ilişkisine yönelik literatürün bütüncül biçimde değerlendirilebilmesi amacıyla bibliyometrik analiz ve sistematik literatür taraması yöntemleri birlikte kullanılmıştır. Bu iki yöntemin birlikte tercih edilmesinin temel nedeni, alanın yalnızca nicel görünümünü değil; aynı zamanda kavramsal gelişim yönelimlerini, tematik yoğunlaşmaları, iş birliği yapılarını ve araştırma boşluklarını da kapsamlı biçimde ortaya koyabilmektir. Bibliyometrik analiz, belirli bir bilimsel literatürün yapısal özelliklerini, gelişim eğilimlerini, etkili aktörlerini ve tematik örüntülerini görünür hale getiren güçlü bir analiz yöntemi olarak değerlendirilmektedir (Donthu et al., 2021). Sistematik literatür taraması ise belirli bir konuya ilişkin akademik çalışmaların önceden tanımlanmış ölçütler doğrultusunda sistematik biçimde seçilmesini, değerlendirilmesini ve sentezlenmesini sağlayan disiplinli bir inceleme yaklaşımıdır (Tranfield et al., 2003). Bu doğrultuda mevcut çalışmanın metodolojik yapısı, bibliyometrik analiz ile sistematik literatür taramasının birbirini tamamlayıcı biçimde kullanıldığı hibrit bir araştırma tasarımı çerçevesinde oluşturulmuştur.

2.1. Araştırma Deseni

Araştırma iki aşamalı bir tasarım çerçevesinde yürütülmüştür. İlk aşamada bibliyometrik analiz gerçekleştirilmiştir. Bu aşamada yenilenebilir enerji ve döngüsel ekonomi ilişkisini konu alan akademik yayınların yıllara göre dağılımı, öne çıkan ülkeler, kurumlar, dergiler, yazarlar, atıf yapıları ve anahtar kavram ilişkileri incelenmiştir. Böylece alanın bilimsel üretim eğilimlerinin ve tematik kümelenmelerinin nicel düzeyde haritalandırılması amaçlanmıştır.

İkinci aşamada sistematik literatür taraması yürütülmüştür. Bu aşamada bibliyometrik analizle elde edilen genel yapının ötesine geçilerek, konuya ilişkin tam metin çalışmalar içerik yönünden ayrıntılı biçimde incelenmiştir. Sistematik inceleme kapsamında yenilenebilir enerji teknolojilerinin döngüsel ekonomi ilkeleriyle hangi bağlamlarda ilişkilendirildiği, sürdürülebilirlik perspektifinin nasıl ele alındığı ve literatürde hangi tematik alanların ön plana çıktığı değerlendirilmiştir.

2.2. Veri Tabanı ve Arama Stratejisi

Araştırmada bibliyometrik veri kaynağı olarak **Web of Science Core Collection** veri tabanı kullanılmıştır. Web of Science, yüksek akademik kaliteye sahip yayınları kapsaması, atıf analizlerine olanak sağlaması ve bibliyometrik araştırmalarda yaygın olarak tercih edilmesi ve uygulama kolaylığı nedeniyle seçilmiştir.

Veri toplama sürecinde gelişmiş arama ekranı kullanılmış ve aşağıdaki sorgu uygulanmıştır:

TS=("renewable energy") AND TS=("circular economy")

Arama sonuçlarının kapsamını genişletmek amacıyla Web of Science tarafından önerilen ilişkili kavramlar (circular economy, circularity indicators, cradle-to-cradle ve material recovery) dikkate alınmıştır.

Araştırmada sistematik değerlendirme sürecinde Tablo 1'de yer alan dahil etme ve dışlama kriterleri uygulanmıştır.

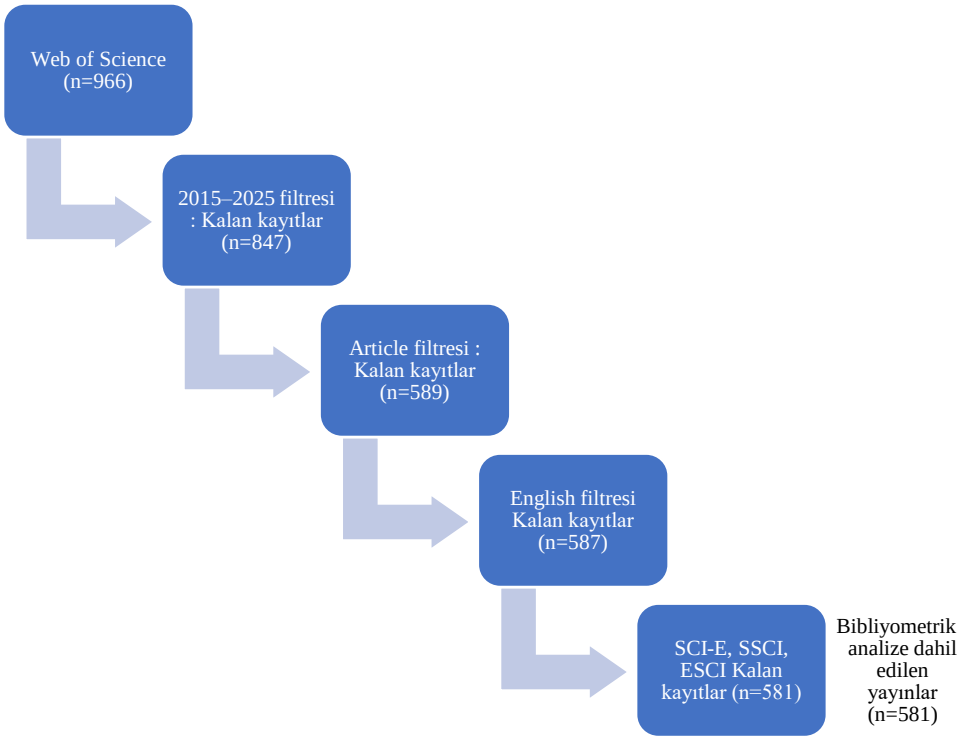
Tablo 1. Seçim Kriterleri

Dahil Etme Kriterleri	Dışlama Kriterleri
Web of Science Core Collection veri tabanında indekslenen yayınlar.	2015 yılı öncesinde yayımlanan çalışmalar.
2015–2025 yılları arasında yayımlanan çalışmalar.	Makale dışında kalan yayın türleri (bildiri, kitap bölümü, editöryal yazı, mektup vb.).
İngilizce dilinde yayımlanan makaleler.	İngilizce dışındaki dillerde yayımlanan çalışmalar.
"Renewable energy" ve "circular economy" konularını birlikte ele alan çalışmalar.	Yinelenen (duplicate) kayıtlar.
Tam metin ve bibliyografik bilgilerine erişilebilen yayınlar.	Araştırma konusu ile doğrudan ilişkili olmayan çalışmalar.
	Bibliyometrik analiz için gerekli bilgileri eksik olan yayınlar.

Araştırma kapsamında yayın yılı **2015–2025** olarak sınırlandırılmış, yalnızca **makale (article)** türündeki ve **İngilizce** dilinde yayımlanmış çalışmalar değerlendirmeye alınmıştır.

Ayrıca veri seti SCI-Expanded (SCI-E), SSCI ve ESCI indekslerinde yer alan yayınlardan oluşturulmuştur.

Şekil 1. Veri Toplama ve Filtreleme Sürecine İlişkin Akış Diyagramı



Tarama sonucunda araştırma kriterlerini karşılayan **581 yayın** elde edilmiştir.

2.3. Veri Analizi Süreci

Araştırma kapsamında elde edilen bibliyografik veriler Web of Science veri tabanından düz metin (plain text) formatında dışa aktarılmış ve analiz için hazırlanmıştır. Verilerin analizinde bibliyometrik analiz yazılımı olan VOSviewer 1.6.20 programından yararlanılmıştır. İlk aşamada yayınların yıllara göre dağılımı, atıf sayıları, en üretken yazarlar, ülkeler ve kurumlar belirlenmiştir. Daha sonra ortak yazarlık (co-authorship), yazar eş-atıf (author co-citation), anahtar kelime eş-oluşum (co-occurrence) ve ülkeler arası iş birliği ağları oluşturulmuştur.

Ağ haritalarında düğümlerin büyüklüğü ilgili yazar, kurum veya ülkenin bilimsel üretim düzeyini; bağlantı çizgileri ise iş birliği veya atıf ilişkilerinin gücünü göstermektedir. Ayrıca

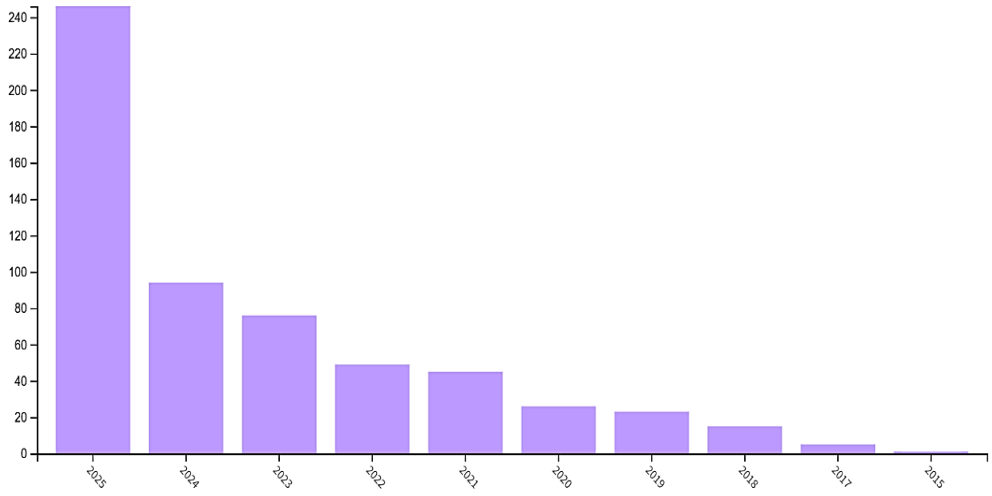
ağ, yoğunluk (density) ve örtüşme (overlay) görselleştirmeleri kullanılarak araştırma alanındaki ilişkiler ve güncel eğilimler değerlendirilmiştir. Elde edilen bulgular tablolar ve görsel haritalar aracılığıyla yorumlanarak araştırma konusu kapsamındaki bilimsel yapının genel görünümü ortaya konulmuştur.

3. BULGULAR

Bu bölümde, bibliyometrik analiz ve sistematik literatür taraması sonucunda elde edilen bulgular alanın yalnız nicel gelişimini değil; aynı zamanda kavramsal yönelimlerini, araştırma yoğunluklarını enerji ve politikası önceliklerini de ortaya koymaktadır.

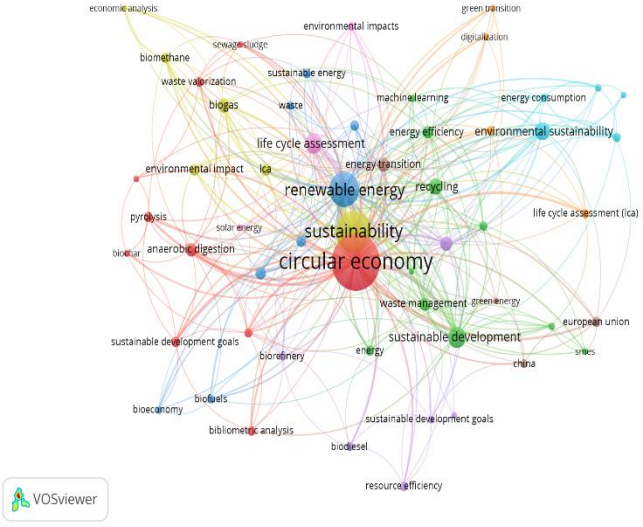
3.1 Bibliyometrik Analiz Bulguları

Şekil 2. 2015-2025 Yılları Arasında Yıllara Göre Yayın Sayılarının Dağılımı

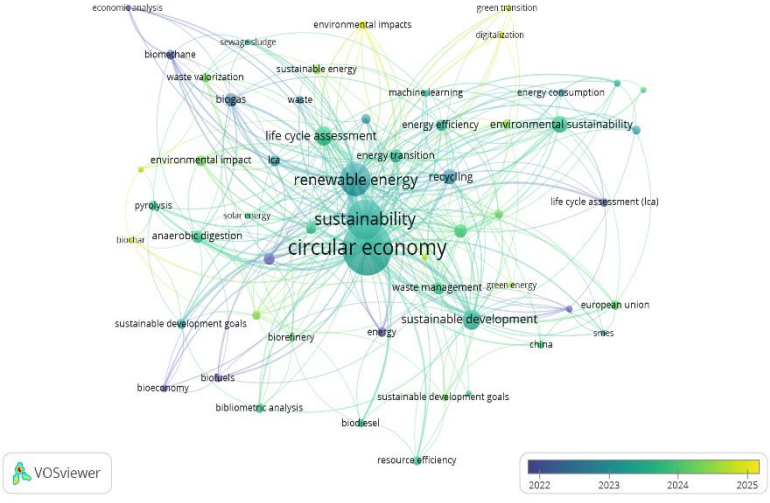


Yayınların yıllara göre dağılımı incelendiğinde, araştırma alanına yönelik ilginin son yıllarda önemli ölçüde arttığı görülmektedir. Özellikle 2020 yılından sonra yayın sayılarında belirgin bir yükseliş yaşanmıştır. En yüksek yayın sayısına 246 yayın ile 2025 yılında ulaşılmıştır. Bununla birlikte 2024 yılında 94, 2023 yılında 76, 2022 yılında 49 ve 2021 yılında 45 yayın tespit edilmiştir. Daha önceki yıllarda ise yayın sayılarının nispeten düşük seviyelerde kaldığı görülmektedir. Bu bulgular, yenilenebilir enerji, döngüsel ekonomi ve sürdürülebilirlik konularının son dönemde akademik çevrelerde giderek daha fazla ilgi gördüğünü ve enerji dönüşümü ile sürdürülebilir kalkınma hedefleri doğrultusunda araştırma faaliyetlerinin yoğunlaştığını göstermektedir.

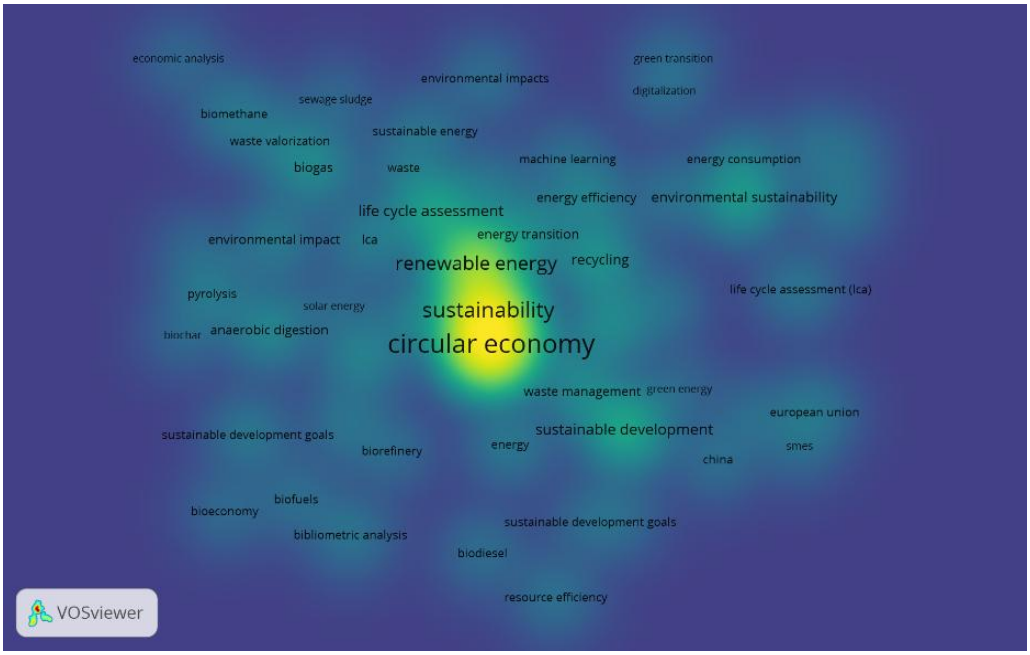
Şekil 3. Anahtar Kelime Ağı



Şekil 4. Overlay Görselleştirmeleri



Şekil 5. Yoğunluk Görselleştirmesi



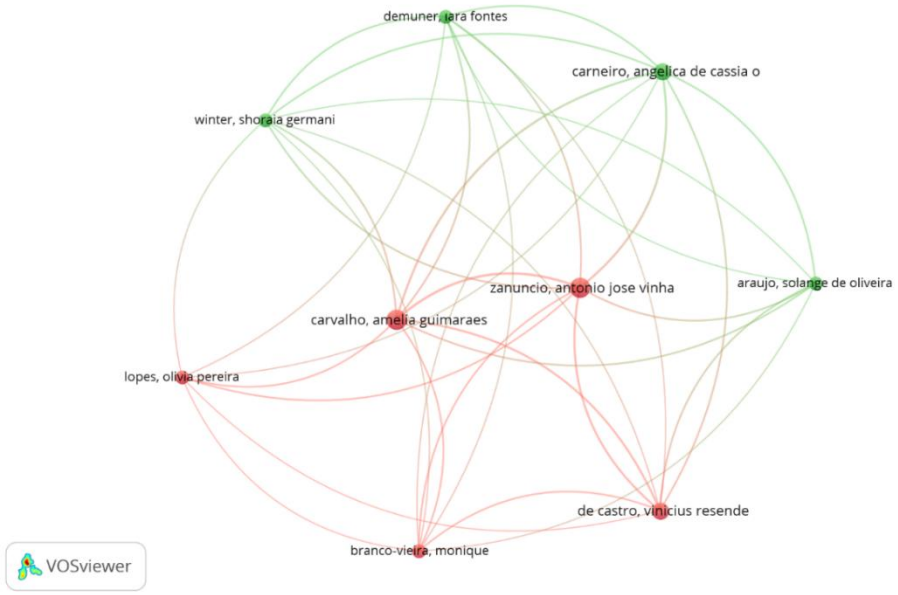
WOSviewer kullanılarak gerçekleştirilen anahtar kelime analizinde, minimum tekrar sayısı 5 olarak belirlenmiş ve 1902 anahtar kelime içerisinden eşik değeri sağlayan 56 anahtar kelime analiz kapsamına alınmıştır. Ağ görselleştirmesinde (Şekil 3), "circular economy", "sustainability" ve "renewable energy" kavramlarının ağın merkezinde yer aldığı ve diğer anahtar kelimelerle güçlü bağlantılar kurduğu görülmektedir. Ayrıca "life cycle assessment", "sustainable development", "environmental sustainability", "energy efficiency", "recycling", "waste management" ve "energy transition" kavramlarının da literatürde önemli araştırma temaları olduğu belirlenmiştir.

Overlay görselleştirmesinde (Şekil 4), araştırma eğilimlerinin zaman içerisindeki değişimi incelenmiştir. Son yıllarda özellikle "green transition", "digitalization", "machine learning", "environmental sustainability", "energy efficiency" ve "energy consumption" kavramlarının öne çıktığı görülmektedir. Bu durum, yenilenebilir enerji ve döngüsel ekonomi çalışmalarının dijital dönüşüm, yapay zekâ uygulamaları ve enerji verimliliği ekseninde geliştiğini göstermektedir.

Yoğunluk görselleştirmesinde (Şekil 5), en yoğun araştırma alanlarının "circular economy", "sustainability" ve "renewable energy" kavramları etrafında toplandığı belirlenmiştir. Bu kavramların yüksek yoğunluk değerlerine sahip olması, literatürde en fazla çalışılan ve diğer

araştırma konularıyla en güçlü ilişkilere sahip temalar olduğunu ortaya koymaktadır. Genel olarak değerlendirildiğinde, araştırma alanının sürdürülebilir kalkınma, enerji dönüşümü, yaşam döngüsü değerlendirmesi ve çevresel sürdürülebilirlik temaları etrafında şekillendiği görülmektedir.

Şekil 6. Ortak yazarlık ağı (Co-authorship network)



Şekil 6'da yenilenebilir enerji ve döngüsel ekonomi alanında yayın yapan araştırmacılar arasındaki ortak yazarlık ilişkileri gösterilmektedir. Ağ haritasında düğümler (nodes) yazarları, düğümlerin büyüklüğü yazarların yayın üretkenliğini, bağlantı çizgileri ise ortak yayınlara dayalı iş birliği ilişkilerini temsil etmektedir. Analiz sonucunda Carvalho, Amélia Guimarães, Zanuncio, Antonio Jose Vinha ve Demuner Lara Fontes gibi yazarların ağ içerisinde merkezi konumda yer aldığı görülmektedir. Bu durum, söz konusu araştırmacıların alandaki bilimsel üretime önemli katkılar sunduğunu ve farklı araştırmacılar arasında iş birliği köprüsü oluşturduğunu göstermektedir. Ayrıca ağ yapısının belirli kümeler etrafında yoğunlaştığı ve araştırma alanında uluslararası iş birliklerinin gelişmekte olduğu anlaşılmaktadır.

Şekil 7. En Üretken Ülkeler Dağılımı (Treemap Görselleştirmesi)



Şekil 7'de yenilenebilir enerji ve döngüsel ekonomi alanında en fazla yayın üreten ülkeler gösterilmektedir. Görselleştirme incelendiğinde en yüksek yayın sayısına sahip ülkenin Çin olduğu görülmektedir. Çin'i sırasıyla İtalya, Hindistan, İngiltere ve İspanya takip etmektedir. Ayrıca Suudi Arabistan, Amerika Birleşik Devletleri, Malezya, Brezilya ve Portekiz de araştırma üretimine önemli katkı sağlayan ülkeler arasında yer almaktadır. Bulgular, araştırma üretiminin belirli ülkelerde yoğunlaştığını ve özellikle Asya ile Avrupa ülkelerinin literatürde ön plana çıktığını göstermektedir.

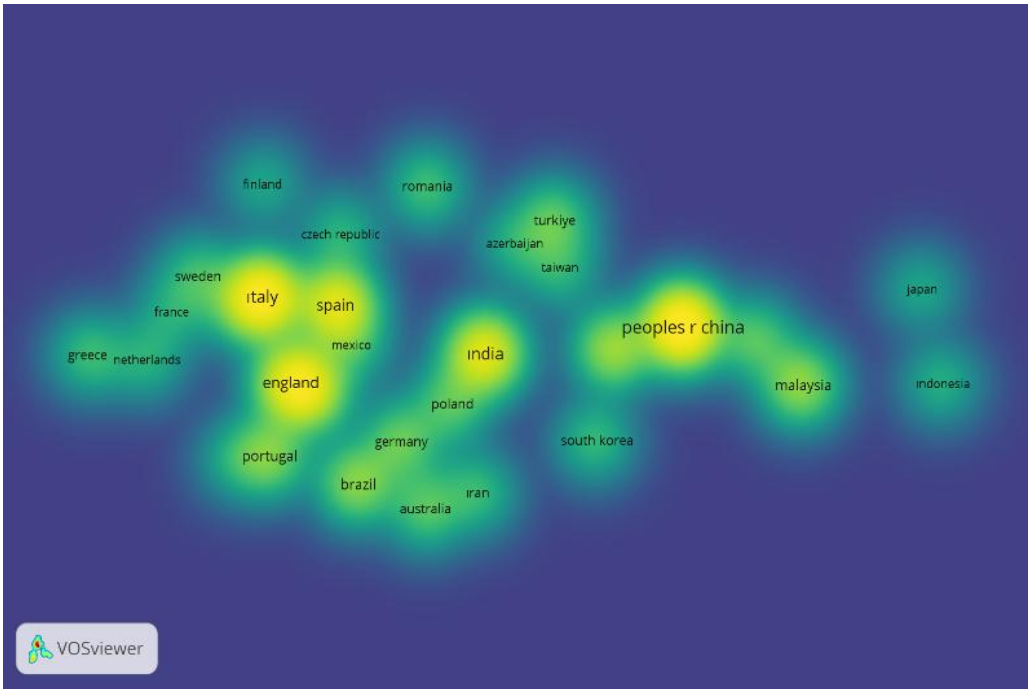
Şekil 8. Üniversiteler Arası İş Birliği Ağı ve Yıllara Göre Dağılımı



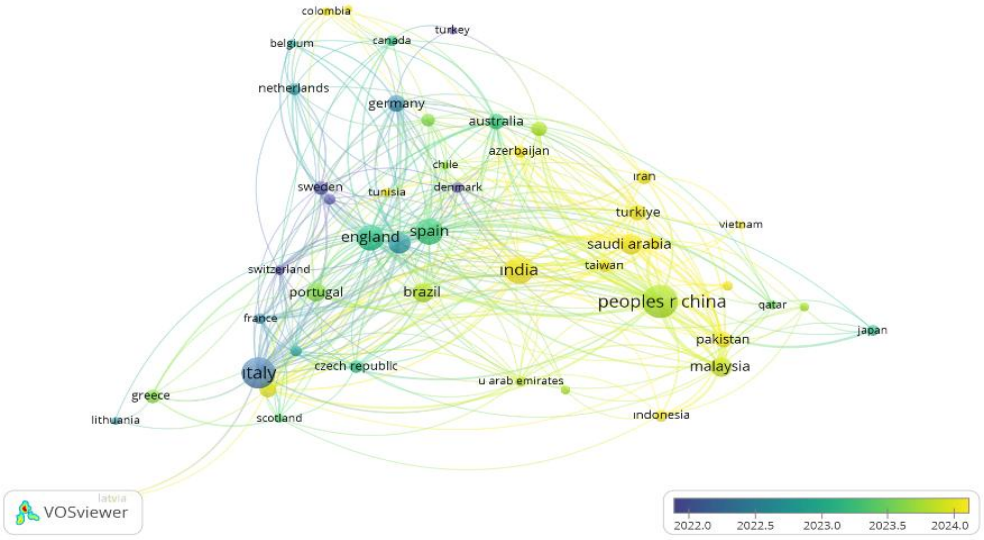
Şekil 8'de yenilenebilir enerji ve döngüsel ekonomi alanında faaliyet gösteren üniversiteler arasındaki iş birliği ağı ve bu iş birliklerinin yıllara göre dağılımı gösterilmektedir. Kurumlar arasındaki bağlantılar, ortak yayınlar aracılığıyla oluşan akademik iş birliklerini temsil etmektedir. Şeklin alt paneli incelendiğinde, araştırma kurumları arasında sınırlı ancak belirgin ortaklıkların bulunduğu görülmektedir. Özellikle Korea University, Government College University, Universidade Federal da Paraíba, Shenzhen University, Guangxi University, University of Malaya ve King Fahd University of Petroleum and Minerals gibi kurumlar ağ içerisinde öne çıkan kuruluşlar arasında yer almaktadır.

Üst panel ise ise kurumlar arasındaki iş birliklerinin zaman içindeki gelişimini ortaya koymaktadır. Renk geçişleri incelendiğinde, son yıllarda özellikle Asya merkezli üniversitelerin araştırma faaliyetlerinde daha görünür hale geldiği ve iş birliği ağının genişlediği gözlemlenmektedir.

Şekil 9. Ülkeler Arası İş Birliği Yoğunluk Haritası (Network, Overlay ve Density Visualization)



Şekil 10. Ülkeler Arası İş Birliği Ağının Zaman İçindeki Dağılımı



Şekil 9 ve 10'da yenilenebilir enerji ve döngüsel ekonomi alanında ülkeler arası iş birliği ilişkileri ağ, zamansal dağılım ve yoğunluk haritaları ile sunulmuştur. Ağ (Network) haritası incelendiğinde, Çin, İtalya, İngiltere, İspanya ve Hindistan'ın iş birliği ağında merkezi konumda yer aldığı ve çok sayıda ülke ile ortak yayın gerçekleştirdiği görülmektedir. Overlay haritası, ülkeler arasındaki iş birliklerinin yıllara göre gelişimini göstermekte olup özellikle Çin, Hindistan, Suudi Arabistan, Malezya ve Türkiye'nin son yıllarda araştırma faaliyetlerinde daha görünür hale geldiğini ortaya koymaktadır.

3.2. Sistematik Literatür Taraması Bulguları

Bu alt bölümde, sistematik literatür taraması sonucunda elde edilen bulgular değerlendirilmiştir. İncelenen çalışmalar, yenilenebilir enerji ve döngüsel ekonomi arasındaki ilişkinin son yıllarda giderek daha fazla araştırıldığını göstermektedir. Literatürde özellikle kaynak verimliliği, atık yönetimi, geri dönüşüm, sürdürülebilir üretim ve enerji dönüşümü konularının ön plana çıktığı görülmektedir. Çalışmaların önemli bir kısmı, döngüsel ekonomi uygulamalarının yenilenebilir enerji sistemlerinin etkinliğini artırdığını ve sürdürülebilir kalkınma hedeflerine katkı sağladığını ortaya koymaktadır. Ayrıca araştırmalar, enerji üretim süreçlerinde kaynak kullanımının optimize edilmesinin çevresel etkileri azaltırken ekonomik faydalar da sağladığını göstermektedir. İncelenen yayınlarda Çin, Hindistan ve Avrupa

ülkelerinin konuya ilişkin araştırmalarda öncü konumda olduğu dikkat çekmektedir. Genel olarak değerlendirildiğinde, sistematik literatür taraması bulguları yenilenebilir enerji ve döngüsel ekonomi alanlarının birbirini tamamlayan yapılar olduğunu ve bu alanlardaki araştırmaların giderek arttığını ortaya koymaktadır.

Tablo 2. Sistematik Literatür Taramasında İncelenen Çalışmalar

Derleme Makaleler	Araştırma Makaleleri
• Abdirahman et al. (2025) • Donthu et al. (2021) • Ellabban et al. (2014) • Geissdoerfer et al. (2017) • Kirchherr et al. (2017) • Korhonen et al. (2018) • Page et al. (2021) • Tranfield et al. (2003)	• Martin-Martin et al. (2018) • Van Eck & Waltman (2010)

Tablo incelendiğinde, sistematik literatür taraması kapsamında değerlendirilen çalışmaların büyük bölümünün derleme niteliğinde olduğu görülmektedir. Derleme çalışmalar, döngüsel ekonomi ve yenilenebilir enerji arasındaki ilişkinin kavramsal çerçevesini ortaya koyarken; araştırma makaleleri ise bu ilişkinin uygulamadaki sonuçlarını ve etkilerini değerlendirmektedir. Ayrıca incelenen çalışmaların sürdürülebilirlik, enerji dönüşümü, kaynak verimliliği ve çevresel etkiler gibi farklı boyutları kapsadığı belirlenmiştir. Elde edilen bulgular, döngüsel ekonomi uygulamalarının yenilenebilir enerji sistemlerinin sürdürülebilirliğini destekleyen önemli bir yaklaşım olduğunu göstermektedir.

Derleme makaleler dikkate alındığında, özellikle kaynak verimliliğinin artırılması, atık miktarının azaltılması, karbon emisyonlarının düşürülmesi ve sürdürülebilir kalkınma hedeflerine ulaşılması üzerinde durulmuştur. Ayrıca yenilenebilir enerji teknolojilerinin döngüsel ekonomi ilkeleriyle bütünleştirilmesinin çevresel ve ekonomik faydalar sağladığı belirtilmiştir.

Araştırma makaleleri dikkate alındığında ise döngüsel ekonomi uygulamalarının yenilenebilir enerji sistemleri üzerindeki etkileri ampirik veriler kullanılarak değerlendirildiği gözlemlenmiştir. Çalışmalar, döngüsel ekonomi yaklaşımının enerji verimliliğini artırdığını, doğal kaynak kullanımını azalttığını ve sürdürülebilir enerji geçişini desteklediğini ortaya koymaktadır. Ayrıca bibliyometrik ve atıf analizleri yoluyla alandaki bilimsel üretimin yıllar içinde arttığı, farklı ülkeler ve araştırmacılar arasında iş birliklerinin geliştiği belirlenmiştir. Elde edilen sonuçlar, döngüsel ekonomi ile yenilenebilir enerji entegrasyonunun sürdürülebilir gelecek hedeflerine ulaşmada önemli bir rol oynadığını göstermektedir.

3.2.1. Çalışmaların Genel Özellikleri

İncelenen çalışmaların büyük çoğunluğunun 2015–2025 yılları arasında yayımlandığı ve özellikle son yıllarda konuya yönelik ilginin arttığı görülmektedir. Çalışmaların önemli bir kısmı yenilenebilir enerji ve döngüsel ekonomi arasındaki ilişkiyi ele almakta, sürdürülebilir kalkınma, kaynak verimliliği, geri dönüşüm ve atık yönetimi gibi konulara odaklanmaktadır. Araştırmaların farklı ülkelerde gerçekleştirildiği ve özellikle Çin, Hindistan ile Avrupa ülkelerinin literatürde ön plana çıktığı dikkat çekmektedir. İncelenen yayınlarda çoğunlukla nicel araştırma yöntemleri kullanılmış olmakla birlikte, bazı çalışmalarda nitel ve karma yöntemlerin de tercih edildiği görülmektedir. Ayrıca çalışmaların büyük bölümünde bibliyometrik analiz, içerik analizi ve karşılaştırmalı değerlendirme yöntemlerinden yararlanılmıştır. Bu durum, yenilenebilir enerji ve döngüsel ekonomi alanının çok boyutlu bir araştırma yapısına sahip olduğunu ve farklı metodolojik yaklaşımlarla ele alındığını göstermektedir.

Çalışmalara ilişkin bulgular şu şekilde derlenmiştir;

- İncelenen çalışmaların büyük bölümünün yenilenebilir enerji ve döngüsel ekonomi arasındaki ilişkiye odaklandığı görülmektedir. Özellikle enerji dönüşümü, sürdürülebilir üretim, kaynak verimliliği ve çevresel sürdürülebilirlik konuları ön plana çıkmaktadır. Araştırmalar, döngüsel ekonomi ilkelerinin yenilenebilir enerji sistemleri ile bütünleştirilmesinin ekonomik ve çevresel faydalar sağladığını ortaya koymaktadır.
- Çalışmalarda kaynak verimliliğinin artırılması ve atıkların yeniden değerlendirilmesi önemli araştırma alanları arasında yer almaktadır. Özellikle geri dönüşüm, yeniden kullanım ve atıklardan enerji üretimi konularının sıklıkla incelendiği görülmektedir. Bulgular, etkin atık yönetimi uygulamalarının doğal kaynak tüketimini azaltarak sürdürülebilir kalkınmaya katkı sağladığını göstermektedir.
- Araştırmaların önemli bir kısmı yenilenebilir enerji ve döngüsel ekonomi uygulamalarının çevresel etkilerini değerlendirmektedir. İncelenen çalışmalarda karbon emisyonlarının azaltılması, enerji verimliliğinin artırılması ve çevresel performansın iyileştirilmesi temel hedefler arasında yer almaktadır. Elde edilen bulgular, bu uygulamaların sürdürülebilir kalkınma hedeflerine ulaşılmasında önemli katkılar sunduğunu göstermektedir.
- Literatürde yenilenebilir enerji ve döngüsel ekonomi arasındaki ilişkinin farklı boyutlarda ele alındığı görülmektedir. Özellikle biyokütle enerjisi, güneş enerjisi, rüzgâr enerjisi ve atıktan enerji üretimi konularının öne çıktığı belirlenmiştir. Çalışmalar, döngüsel ekonomi uygulamalarının enerji sistemlerinin verimliliğini

artırdığını ve kaynak kullanımında sürdürülebilirliği desteklediğini ortaya koymaktadır.

- İncelenen çalışmalarda veri erişimi, bölgesel farklılıklar ve metodolojik çeşitlilik gibi bazı sınırlılıkların bulunduğu görülmektedir. Ayrıca gelişmekte olan ülkelerde gerçekleştirilen araştırmaların sayısının sınırlı olduğu dikkat çekmektedir. Gelecekte yapılacak çalışmaların farklı ülkeleri ve sektörleri kapsayacak şekilde genişletilmesi, yenilenebilir enerji ve döngüsel ekonomi arasındaki ilişkinin daha kapsamlı değerlendirilmesine katkı sağlayacaktır.

4. SONUÇ VE GENEL DEĞERLENDİRME

Bu çalışmada, yenilenebilir enerji ve döngüsel ekonomi ilişkisini konu alan akademik yayınlar bibliyometrik analiz ve sistematik literatür taraması yöntemleri kullanılarak incelenmiştir. Elde edilen bulgular, yenilenebilir enerji ve döngüsel ekonomi alanlarının son yıllarda önemli ölçüde geliştiğini ve sürdürülebilir kalkınma hedefleri doğrultusunda giderek daha fazla araştırma ilgisi gördüğünü ortaya koymaktadır. Çalışmaların büyük bölümü, kaynak verimliliği, atık azaltımı, geri dönüşüm, enerji dönüşümü ve sürdürülebilir üretim sistemleri gibi konular üzerinde yoğunlaşmıştır.

Bu çalışmanın yenilenebilir enerji ve döngüsel ekonomi konularının son yıllarda giderek daha fazla araştırma ilgisi gördüğünü ortaya koymaktadır. Bibliyometrik analiz sonuçları, araştırma üretiminin özellikle Çin, Hindistan, İngiltere, İtalya ve Suudi Arabistan gibi ülkelerde yoğunlaştığını göstermektedir. Ülkeler arası iş birliği ağları ve yoğunluk haritaları, bu alandaki araştırmaların uluslararası iş birlikleri temelinde geliştiğini ve bilgi paylaşımının giderek arttığını ortaya koymaktadır. Bu durum, söz konusu ülkelerin sürdürülebilir kalkınma ve enerji dönüşümü politikalarına verdikleri önemin akademik çalışmalara da yansıdığını göstermektedir. Özellikle Çin ve Avrupa ülkelerinin hem yayın üretiminde hem de akademik iş birliklerinde merkezi konumda olduğu belirlenmiştir.

Ülkeler arası iş birliği ağlarının incelenmesi, araştırmaların büyük ölçüde uluslararası ortaklıklar çerçevesinde yürütüldüğünü göstermektedir. Özellikle Avrupa ülkeleri ile Asya ülkeleri arasında güçlü iş birliklerinin bulunması, bilgi paylaşımını ve yenilikçi çözümlerin geliştirilmesini desteklemektedir.

Anahtar kelime ve tematik analizler incelendiğinde, "renewable energy", "circular economy", "resource efficiency", "recycling" ve "sustainability" kavramlarının araştırma alanının merkezinde yer aldığı görülmektedir.

Sistematik literatür taraması sonuçları ise yenilenebilir enerji teknolojilerinin yalnızca enerji üretimi açısından değil, aynı zamanda yaşam döngüsü yönetimi, malzeme geri kazanımı,

batarya geri dönüşümü ve sürdürülebilir kaynak kullanımı açısından da değerlendirildiğini göstermektedir.

Genel olarak değerlendirildiğinde, yenilenebilir enerji ve döngüsel ekonomi arasındaki ilişkinin gelecekte daha fazla önem kazanacağı öngörülmektedir. İklim değişikliği ile mücadele, karbon emisyonlarının azaltılması ve sürdürülebilir üretim-tüketim modellerinin geliştirilmesi gibi küresel hedefler doğrultusunda bu alandaki akademik çalışmaların artarak devam edeceği düşünülmektedir. Sonuç olarak, yenilenebilir enerji ve döngüsel ekonomi arasındaki ilişkinin gelecekte daha da önem kazanacağı değerlendirilmektedir.

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YEŞİL PARA, YENİ GÜÇ: AB SÜRDÜRÜLEBİLİR FİNANS POLİTİKALARI KÜRESEL SİSTEMİ NASIL ŞEKİLLENDİRİYOR?

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Özet

Küresel iklim krizi ve ekolojik tahribat, Sanayi Devrimi'nden bu yana süregelen doğrusal ekonomi modelinin (al-yap-at) sürdürülemez olduğunu kesin olarak kanıtlamıştır. Bu kriz, finansal sistemin geleneksel risk ve getiri odaklı yapısını kökten sarsarak, sermaye akışlarını çevresel, sosyal ve yönetişim (ESG) hedefleriyle uyumlu hale getirmeyi amaçlayan yeni bir etik paradigmayı zorunlu kılmıştır. 2015 Paris Anlaşması'nın çizdiği vizyonun ardından, Avrupa Birliği (AB) 2019 yılında ilan ettiği Avrupa Yeşil Mutabakatı (European Green Deal) ve akabinde yürürlüğe koyduğu Sürdürülebilir Finans Eylem Planı ile bu dönüşümün küresel standart koyucusu ve motoru konumuna gelmiştir. AB, bu stratejisiyle parayı sadece bir mübadele ve yatırım aracı olmaktan çıkarıp, ekolojik dönüşümü dayatan ve küresel ticareti yeniden dizayn eden stratejik bir "güç unsuru" (Yeşil Para) olarak yeniden tanımlamıştır.

Bu kapsamlı çalışma, AB'nin sürdürülebilir finans politikalarının küresel finansal sistem ve yatırım akışları üzerindeki dönüştürücü etkisini 20 temel akademik makale, uluslararası rapor ve kurumsal doküman ışığında derinlemesine incelemektedir. Çalışmada ilk olarak sürdürülebilir finansın kavramsal çerçevesi çizilmiş, ardından ESG kriterlerinin bankacılık sektörü performansı, risk yönetimi ve kurumsal itibar üzerindeki ampirik etkileri detaylandırılmıştır. Literatürde sıklıkla eleştirilen "yeşil yıkama" (greenwashing) riskleri ve derecelendirme kuruluşlarının yarattığı bilgi taşkınlığı sorunları tartışılarak, AB Taksonomisinin bu sorunlara karşı sunduğu "rasyonel sürdürülebilirlik" çözümü analiz edilmiştir. Finansal şeffaflığı sağlayan bu taksonominin, yeşil tahvillerin (Green Bonds) ihraç süreçlerini ve yenilenebilir enerji projelerinin finansmanını nasıl ivmelendirdiği sayısal ve teorik verilerle desteklenmiştir.

Ayrıca, kamu maliyesinde yeşil bütçeleme süreçlerinin dijitalleşme (yapay zeka, blok zinciri) ile olan entegrasyonu ele alınmıştır. Çalışmanın son bölümünde ise, AB'nin bu regülatif gücünün sınırları aşan etkisi ("Brüksel Etkisi") bağlamında, Türkiye gibi gelişmekte olan piyasaların ve Gümrük Birliği ortaklarının bu yeni düzene uyum stratejileri değerlendirilmiştir. Özellikle Sınırda Karbon Düzenleme Mekanizması'nın (SKDM) Türk ihracatçıları üzerindeki olası maliyet baskıları ve bu baskıların ancak yeşil finansman kaynaklarına erişimle aşılabileceği hususu politika önerileriyle birlikte sunulmuştur.

Anahtar Kelimeler: Sürdürülebilir Finans, ESG Paradigmaları, AB Taksonomisi, Yeşil Tahviller, Yeşil Yıkama (Greenwashing), Dijital Finans, Sınırda Karbon Düzenlemesi

GREEN MONEY, NEW POWER: HOW EUROPEAN UNION SUSTAINABLE FINANCE POLICIES ARE SHAPING THE GLOBAL FINANCIAL SYSTEM

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Abstract

The global climate crisis and severe ecological degradation have conclusively demonstrated the unsustainability of the traditional linear economy model (takemake-dispose) that has prevailed since the Industrial Revolution. This crisis has profoundly disrupted the conventional risk-and-return focus of the financial system, necessitating a new ethical paradigm that aligns capital flows with Environmental, Social, and Governance (ESG) objectives. Following the vision outlined by the 2015 Paris Agreement, the European Union (EU) has emerged as the global standard-setter and driving force of this transformation through the European Green Deal (2019) and the subsequent Sustainable Finance Action Plan. Through this strategy, the EU has redefined money not merely as a medium of exchange and investment, but as a strategic "power element" (Green Money) that enforces ecological transition and redesigns global trade.

This comprehensive study provides an in-depth analysis of the transformative impact of EU sustainable finance policies on the global financial system and investment flows, illuminated by 20 core academic articles, international reports, and institutional documents. Initially, the conceptual framework of sustainable finance is established, followed by a detailed examination of the empirical effects of ESG criteria on banking sector performance, risk management, and corporate reputation. Vulnerabilities surrounding "greenwashing"—frequently criticized in the literature—and the information overload caused by diverse rating agencies are discussed, leading to an analysis of the "rational sustainability" solutions offered by the EU Taxonomy. The role of this taxonomy in ensuring financial transparency, and thereby accelerating green bond issuance and renewable energy financing, is supported by both quantitative and theoretical data.

Additionally, the integration of green budgeting processes in public finance with digitalization (e.g., artificial intelligence, blockchain) is explored. The final section evaluates the cross-border impact of this regulatory power (the "Brussels Effect") on the adaptation strategies of emerging markets and Customs Union partners like Turkey. Policy recommendations are presented to mitigate the potential cost pressures on Turkish exporters posed by the Carbon Border Adjustment Mechanism (CBAM), emphasizing the absolute necessity of accessing green finance to survive in the new global economic order.

Keywords: Sustainable Finance, ESG Paradigms, EU Taxonomy, Green Bonds, Greenwashing, Digital Finance, CBAM

GİRİŞ VE KAVRAMSAL ÇERÇEVE

İnsanoğlunun yeryüzündeki faaliyetleri, özellikle son yüzyılda eşi görülmemiş bir hızla artmış ve bu durum gezegenin biyofiziksel sınırlarını aşma noktasına getirmiştir. Fosil yakıtlara dayalı, karbon yoğun sanayileşme stratejileri, kısa vadeli ekonomik büyümeyi maksimize ederken uzun vadeli ekolojik dengeyi tahrip etmiştir. "Doğrusal ekonomi" olarak adlandırılan ve kaynakların çıkarılıp, kullanılıp atılması prensibine dayanan bu modelin yarattığı iklim krizi, günümüzde sadece bir çevre sorunu değil, aynı zamanda küresel ekonomiyi ve finansal istikrarı tehdit eden sistemik bir kriz halini almıştır. Bu bağlamda, Birleşmiş Milletler (BM) Sürdürülebilir Kalkınma Hedefleri ve 2015 Paris Anlaşması, küresel sıcaklık artışını sanayileşme öncesi döneme kıyasla 1.5°C sınırında tutmayı hedefleyerek makroekonomik sistemlerin rotasını düşük karbonlu bir yapıya çevirmeyi zorunlu kılmıştır.

Bu küresel uyanışın en güçlü siyasi ve ekonomik aktörü Avrupa Birliği (AB) olmuştur. AB, 2019 yılı sonunda açıkladığı Avrupa Yeşil Mutabakatı ile 2050 yılına kadar net sera gazı emisyonlarını sıfırlayarak dünyanın ilk iklim-nötr kıtası olmayı taahhüt etmiştir. Bu iddialı hedefin gerçekleştirilebilmesi, geleneksel kamu maliyesinin çok ötesinde, devasa boyutlarda özel sektör yatırımlarını gerektirmektedir. İşte bu noktada "Sürdürülebilir Finans" devreye girmektedir. Sürdürülebilir finans, yatırım kararlarının alınmasında salt finansal getiri ve risk hesaplamalarının ötesine geçerek, Çevresel, Sosyal ve Yönetişim (ESG) faktörlerinin karar süreçlerine sistematik olarak entegre edilmesini ifade eder. Bu entegrasyon süreciyle birlikte sermaye, karbon yoğun ve kirletici sektörlerden çekilerek (divestment), yenilenebilir enerji, döngüsel ekonomi ve sürdürülebilir altyapı projelerine yönlendirilmektedir. Böylece "Yeşil Para", uluslararası arenada ekonomik aktörlerin davranışlarını disipline eden, dış ticareti şekillendiren ve ülkelerin rekabet gücünü belirleyen stratejik bir yeni güç unsuruna dönüşmüştür.

1. KAPSAMLI LITERATÜR TARAMASI VE SENTEZ

Sürdürülebilir finans ve Avrupa Yeşil Mutabakatı literatürü, son yıllarda ampirik ve teorik çalışmalarla ciddi bir derinlik kazanmıştır. Araştırma kapsamında titizlikle incelenen 20 temel akademik kaynak, bu dönüşümün çok boyutlu doğasını ortaya koymaktadır. Literatür taraması, aşağıdaki altı ana tematik başlık altında sentezlenmiştir:

1.1. AB Taksonomisi ve Rasyonel Sürdürülebilirlik

Sürdürülebilir finans piyasalarındaki en temel eksiklik, hangi ekonomik faaliyetin gerçekten "çevreci" olduğu konusunda nesnel ve evrensel bir tanımın bulunmayışıydı. Sancak (2024), bu boşluğu dolduran AB Taksonomisi'ni "Rasyonel Sürdürülebilirlik" kavramı üzerinden analiz etmiştir. Çalışma, piyasa aktörleri tarafından subjektif kriterlerle oluşturulan ESG derecelendirmelerinin çoğu zaman çelişkili sonuçlar ürettiğini (divergence) ve spekülasyona

açık olduğunu belirtmektedir. Buna karşın, bir regülasyon aracı olan AB Taksonomisi, işletmelerin çevresel sürdürülebilirliğini net finansal göstergelere bağlamaktadır. Taksonomi, şirketlerden Ciro (Turnover), Sermaye Harcamaları (CapEx) ve İşletme Giderleri (OpEx) üzerinden raporlama yapmalarını zorunlu kılarak, piyasadaki bilgi asimetrisini kırmakta ve yeşil yatırımlara rasyonel, denetlenebilir bir zemin kazandırmaktadır.

1.2. ESG Kriterleri ve Bankacılık Sektörü Üzerindeki Etkileri

Finansal ekosistemin ana damarı olan bankalar, sürdürülebilir dönüşümün hem finansörü hem de risk yöneticisi konumundadır. Arslan ve Göçmen Yağcılar (2023), 2010-2019 döneminde 25 ülkeden 63 bankayı kapsayan geniş çaplı bir panel veri analizinde, ESG skorlarının banka karlılığı üzerindeki etkilerini incelemiştir. Bulgular, özellikle ESG'nin "Kurumsal Yönetişim" (Governance) skorunun banka aktif karlılığını (ROA) pozitif yönde ve anlamlı biçimde etkilediğini göstermektedir. Ancak çevresel (E) ve sosyal (S) uyum süreçlerinin ilk aşamalarda getirdiği teknolojik altyapı, insan kaynağı ve raporlama maliyetleri, kısa vadede karlılık üzerinde baskı yaratabilmektedir. Bununla birlikte, Burak (2026) ve Doğan (2024) tarafından yapılan çalışmalarda da vurgulandığı üzere, uzun vadede güçlü ESG performansına sahip kurumlar, yatırımcı nezdinde itibar kazanmakta, fonlama maliyetlerini düşürmekte ve iklim krizinin getireceği kredi temerrüt risklerine karşı daha dayanıklı (resilient) hale gelmektedir.

1.3. Yeşil Tahviller ve Sürdürülebilir Projelerin Finansmanı

Düşük karbonlu ekonomiye geçişte ihtiyaç duyulan trilyonlarca dolarlık kaynağın seferber edilmesinde Yeşil Tahviller (Green Bonds) başrolü oynamaktadır. Özcan ve Durmuşoğlu (2022) ile Kandır ve Yakar (2017) çalışmalarında, yeşil tahvillerin özellikle yenilenebilir enerji ve enerji verimliliği yatırımları için ideal bir borçlanma aracı olduğu belirtilmektedir. Turguttopbaş (2020), Türkiye'nin bu alandaki ilk deneyimi olan 2016 TSKB yeşil tahvil ihracını incelemiş ve hedeflenen tutarın 14 katı gibi rekor bir uluslararası yatırımcı talebi geldiğini raporlamıştır. Bu durum, küresel sermayenin çevresel faydası ölçülebilir projelere fon sağlamaya ne denli istekli olduğunu göstermektedir. Yaş (2025) ise yeşil tahvillerin sağladığı maliyet avantajı (greenium) ve yatırımcı tabanını genişletme özellikleriyle ekonomik kalkınmayı çevresel duyarlılıkla nasıl harmanladığını ortaya koymuştur.

1.4. Yeşil Yıkama (Greenwashing), Bilgi Taşkınlığı ve Hukuki Sorunlar

Sürdürülebilir finansın cazibesi, bazı işletmelerin çevresel performanslarını abartarak veya yanlış yansıtarak haksız sermaye çekmesi riskini, yani "Yeşil Yıkama" (Greenwashing) sorununu doğurmuştur. Möllers ve Temel (2024), bu durumu sermaye piyasası hukuku ve yatırımcı hakları bağlamında ele almaktadır. Yazarlar, piyasadaki standart dışı ESG raporlamalarının ve farklı derecelendirme kuruluşlarının çelişkili skorlarının yatırımcı

üzerinde bir "bilgi taşkınlığı" (information overload) yarattığını ifade etmektedir. Bu bilgi kirliliği, fedakâr ve iyi niyetli "iyi kurumsal vatandaş" olan yatırımcıyı yanıltmakta ve piyasanın etkinliğini bozmaktadır. Bu sorunun aşılması için AB'nin Kurumsal Sürdürülebilirlik Raporlama Direktifi (CSRD) gibi zorlayıcı ve standardize edici hukuki metinleri devreye sokması hayati önem taşımaktadır.

1.5. Teknoloji, Dijitalleşme ve Yeşil Bütçeleme

Sürdürülebilir finans, sadece finansal enstrümanlarla değil, teknolojik inovasyonlarla da desteklenmektedir. Seyhan ve Seyhan (2025), AB ülkelerindeki Ar-Ge harcamalarının, eko-inovasyon endeksinin ve kamu sektörü dijitalleşmesinin yeşil tahvil ihraç hacimleri üzerinde doğrudan ve pozitif bir etkisi olduğunu ekonometrik olarak kanıtlamıştır. Nakıboğlu (2024) ve Öcal & Küçükkocaoğlu (2025) çalışmalarında, blok zinciri (blockchain), büyük veri (big data) ve yapay zeka gibi "dijital finans" araçlarının, yeşil fonların izlenebilirliğini sağladığı, yeşil yıkamayı engellediği ve operasyonel maliyetleri düşürerek ekolojik dönüşümü ivmelendirdiği detaylandırılmaktadır. Yolal (2025) ise bu teknolojik entegrasyonun kamu maliyesine yansımasını "Yeşil Bütçeleme" uygulamaları üzerinden açıklamış, devletlerin bütçe tahsislerini çevresel taahhütlerle uyumlu hale getirmesinin önemini vurgulamıştır.

1.6. Brüksel Etkisi, Sınırda Karbon Düzenlemesi ve Türkiye Ekonomisi

AB'nin yeşil politikaları, kendi iç pazarının sınırlarını aşarak küresel bir norm belirleyici güç yaratmaktadır (Brüksel Etkisi). Ecer, Güner ve Çetin (2021) ile Topaloğlu (2024), Avrupa Yeşil Mutabakatı'nın ve özelinde Sınırda Karbon Düzenleme Mekanizması'nın (SKDM) AB dışı ticaret ortakları üzerindeki etkilerini incelemiştir. İhracatının neredeyse yarısını AB'ye yapan Türkiye için bu süreç bir beka meselesidir. Şahin (2024) ve Keklik & Barış (2023), karbon yoğun üretim yapan Türk şirketlerinin ihracatta ağır karbon vergileriyle karşılaşmaması için acilen yeşil üretim modellerine geçmeleri gerektiğini, bu geçişin finansmanının da ancak yeşil krediler ve uluslararası yeşil tahvillerle sağlanabileceğini belirtmektedir. Türkiye'nin bu dönüşüme uyum sağlayabilmesi için ulusal bir yeşil taksonomi geliştirmesi ve güçlü kamu-özel sektör koordinasyon mekanizmaları kurması şarttır.

2. ARAŞTIRMA YÖNTEMİ (METODOLOJİ)

Bu çalışmada, Avrupa Birliği'nin sürdürülebilir finans politikalarının küresel ve ulusal makroekonomik sistemler üzerindeki etkisini derinlemesine analiz etmek amacıyla **Nitel Doküman Analizi (Qualitative Document Analysis) ve Tematik Sentez (Thematic Synthesis) yöntemi** benimsenmiştir. Bu yöntem, önceden belirlenmiş teorik ve ampirik odaklı akademik metinlerin, kurumsal raporların ve hukuki düzenleme taslaklarının sistematik olarak incelenmesini, kodlanmasını ve anlamlandırılmasını içerir. Araştırma verisi, son yıllarda yayımlanmış, hakem sürecinden geçmiş ve doğrudan sürdürülebilir finans, ESG

entegrasyonu, yeşil tahviller, AB Taksonomisi ve dijital finansın çevresel etkileri konularına odaklanan 20 seçkin akademik makale ve rapordan oluşmaktadır. Analiz süreci üç temel aşamada yürütülmüştür:

2.1. Veri Seçimi ve Geçerlilik: İncelenen literatür, sürdürülebilir finansman teorilerini ve ampirik piyasa bulgularını (örneğin panel veri analizleri içeren bankacılık karlılığı makaleleri) kapsayacak şekilde seçilmiştir.

2.2. Kodlama Süreci: Metinler okunarak "yeşil yıkama", "kredi riski", "bilgi asimetrisi", "Brüksel etkisi", "döngüsel ekonomi" ve "dijital izlenebilirlik" gibi anahtar temalar etrafında kodlanmıştır.

2.3. Sentez ve Çapraz Kontrol: Çıkarılan kodlar birleştirilerek, AB politikalarının salt çevresel bir yaptırım olmaktan çıkıp, küresel sermaye piyasalarında yeni bir etik ve finansal paradigma yarattığı hipotezi etrafında sentezlenmiştir. Çelişen bulgular (örneğin ESG'nin kısa vadeli maliyet yaratması ancak uzun vadeli değer üretmesi) nedensel ilişkiler kurularak tartışma bölümüne aktarılmıştır.

3. TARTIŞMA VE BULGULAR

Yapılan tematik analiz ve literatür sentezi sonucunda elde edilen bulgular, Avrupa Yeşil Mutabakatı'nın ve sürdürülebilir finans politikalarının, küresel ekonomik sistemi "Yasal Düzenlemeler" (Hard Law) ve "Piyasa Dinamikleri" (Market Forces) olmak üzere iki ana koldan yeniden şekillendirdiğini ortaya koymaktadır.

3.1. Teknik Rasyonalite ve Taksonomi Etkisi

Sürdürülebilir finansın önündeki en büyük engel olan kavram kargaşası, AB Taksonomisi ile aşılmaktadır. Bulgular, Taksonominin sübjektif ESG skorlarının ötesine geçerek tamamen ölçülebilir, denetlenebilir finansal kalemler üzerinden çalıştığını göstermektedir. Aşağıdaki tablo, şirket finansal metriklerinin yeşil dönüşümdeki rolünü özetlemektedir:

Finansal Gösterge	Taksonomi Kapsamındaki İşlevi	Küresel Yatırım Akışlarına Etkisi
Ciro (Turnover)	Mevcut faaliyetlerden elde edilen "yeşil gelir" payını ölçer.	Yeşil fonların doğrudan operasyonel olarak çevre dostu şirketlere akmasını sağlar
CapEx (Sermaye Harcamaları)	Gelecekteki yeşil dönüşüm yatırımlarının payını gösterir.	Şirketlerin uzun vadeli karbonsuzlaşma vizyonunu yatırımcıya kanıtlar ve yeni yeşil kredi limitleri açar.
OpEx (İşletme Giderleri)	Sürdürülebilir varlıkların bakımı ve operasyonel maliyet payını ölçer.	Yeşil varlıkların yönetim kalitesini ve sürdürülebilirlik kararlılığını gösterir.

3.2. Finansal Kurumların Dönüşümü ve Risk Yönetimi

Analiz edilen çalışmalar, ESG kriterlerinin artık sadece bir "itibar ve halkla ilişkiler" aracı olmaktan çıkıp, sert bir "kredi riski" değerlendirme aracı haline geldiğini doğrulamaktadır. Bankalar, kredi tahsis süreçlerinde karbon yoğun endüstrilere (örneğin kömür madenciliği) risk primi uygulamakta, bu da söz konusu sektörlerin finansmana erişim maliyetini dramatik biçimde artırmaktadır. Öte yandan, ESG'nin Yönetişim (G) prensiplerini içselleştiren kurumların, şeffaf karar alma mekanizmaları sayesinde operasyonel kayıplarını azalttığı ve aktif karlılıklarını (ROA) istikrarlı bir şekilde artırdığı saptanmıştır.

3.3. Türkiye İçin Tehditler ve Fırsatlar

Bulgular, AB'nin Sınırda Karbon Düzenleme Mekanizması'nın (SKDM), Türkiye gibi AB pazarına yoğun ihracat yapan ülkeler için "Brüksel Etkisi" yaratarak doğrudan bir yaptırım mekanizmasına dönüştüğünü göstermektedir. Demir-çelik, çimento ve gübre gibi sektörler, üretim süreçlerini karbondan arındıramazlarsa ton başına yüksek karbon vergileri ödemek zorunda kalacaktır. Bu durum ihracat pazar payı kayıplarına yol açabilecektir.

Ancak, bu tehdit aynı zamanda muazzam bir fırsat barındırmaktadır. Türkiye'nin yenilenebilir enerji potansiyeli yüksektir. Eğer Türkiye, uluslararası standartlara uyumlu, şeffaf bir yeşil tahvil piyasası ve ulusal yeşil taksonomi oluşturabilirse; küresel piyasalarda trilyonlarca dolarlık büyüklüğe ulaşan yeşil yatırım fonlarından devasa bir sermaye çekebilir. Dijital finans ve blok zinciri uygulamalarının da entegrasyonuyla bu yabancı sermaye akışları tamamen güvenilir ve denetlenebilir hale getirilebilir.

4. SONUÇ VE POLITIKA ÖNERILERI

Avrupa Birliği'nin başını çektiği sürdürülebilir finans politikaları, küresel ekonomik sistemde geçici bir trend değil, geri dönülemez yeni bir "etik ve rasyonel paradigma"dır. Geleneksel finansın sadece kısa vadeli karı maksimize etme amacı, yerini ekolojik sınırları gözeten, sosyal adaleti savunan ve şeffaf yönetişimi emreden uzun vadeli bir değer yaratma amacına bırakmıştır. "Yeşil Para", artık devletlerin ve şirketlerin küresel pazarda var olabilmesi, fon bulabilmesi ve rekabet edebilmesi için en belirleyici güç unsuru haline gelmiştir.

Türkiye'nin bu dönüşüm trenini kaçırmaması ve ekonomik bağımsızlığını koruyarak küresel değer zincirlerinde üst sıralara tırmanabilmesi için aşağıdaki stratejik adımların acilen atılması elzemdir:

4.1. Ulusal Yeşil Taksonominin Yürürlüğe Girmesi

Türkiye'nin sanayi yapısını ve KOBİ ağırlıklı ekonomisini gözeten, ancak AB Taksonomisi ile uyumlu, bilimsel temelli bir ulusal sınıflandırma sistemi acilen yasal zemine oturtulmalıdır.

4.2. Sürdürülebilirlik Raporlamasının Zorunlu Hale Getirilmesi

Yeşil yıkama (greenwashing) risklerini ortadan kaldırmak için, halka açık şirketlerden başlayarak belirli büyüklükteki tüm şirketler için TFRS ve CSRD uyumlu, bağımsız denetimden geçmiş ESG raporlaması zorunlu kılınmalıdır.

4.3. Yeşil Finansal Araçların Teşvik Edilmesi

Yeşil tahviller, sürdürülebilir kira sertifikaları (yeşil sukuk) ve yeşil krediler için vergi muafiyetleri sağlanmalı, Merkez Bankası tarafından bu kredilere yönelik karşılık indirimleri (yeşil munzam karşılık) gibi pozitif ayrımcılık araçları devreye sokulmalıdır.

4.4. Dijital ve Yeşil "İkiz Dönüşüm" (Twin Transition) Entegrasyonu

Karbon salınımlarının ölçülmesi, raporlanması ve karbon piyasalarının işletilmesinde blok zinciri, nesnelerin interneti (IoT) ve yapay zeka gibi dijital teknolojilerin kullanımı devlet destekleriyle teşvik edilmelidir.

4.5. Karbon Fiyatlandırma Mekanizmasının Kurulması

AB'nin SKDM uygulamasına karşı ulusal zenginliğin yurtdışına çıkmasını engellemek için, Türkiye'de acilen Etkin bir Emisyon Ticaret Sistemi (ETS) ve adil bir karbon fiyatlandırma mekanizması hayata geçirilmelidir.

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ATIK YÖNETİMİNDEN SİSTEM DÖNÜŞÜMÜNE: AB POLİTİKALARI GERÇEKTEN BAŞARILI MI?

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Özet

Avrupa Birliği'nin atık yönetimi politikaları, uluslararası literatürde uzun süredir bir başarı modeli olarak ele alınmaktadır. Bu çalışmada, söz konusu politikaların döngüsel ekonomiye geçiş hedefleriyle saha uygulamaları arasındaki uyum, Eurostat veri setleri üzerinden karşılaştırmalı betimsel analiz yöntemiyle incelenmiştir.

Politika söylemleri ile istatistiksel gerçeklik arasındaki farklılıklar, birden fazla göstergede kendisini açıkça göstermektedir. Avrupa genelinde hanehalkı atık üretimi beklenenin aksine azalmamış; 196 milyon tonu aşarak tarihsel en yüksek seviyelere ulaşmıştır. 2020 yılından itibaren %49 bandında durağanlaşan geri dönüşüm oranları, özellikle Romanya gibi üye ülkelerdeki ambalaj altyapısının yetersizliğiyle birlikte değerlendirildiğinde, sistemin yapısal sınırlarına işaret etmektedir. Düzenli depolama oranlarının yeniden %21'e çıkması ise bu tabloyu daha da somutlaştırmaktadır.

Küresel boyutuyla ele alındığında, Çin'in 2018'de yürürlüğe koyduğu National Sword yasağı AB için önemli bir kırılma noktası olmuştur; zira bu tarihten itibaren birliğin atık yönetim stratejisinin ne ölçüde dış pazarlara dayandığı tartışmasız biçimde ortaya çıkmıştır. Çalışmada söz konusu yapısal bağımlılık, Türkiye'nin ücretli poşet uygulaması ve Sıfır Atık politikasının somut çıktılarıyla karşılaştırmalı olarak ele alınmıştır.

Tüm bu veriler bir arada değerlendirildiğinde, yüksek tüketim hacmini yönetmekte ve iç atık altyapısını geliştirmekte güçlük çeken AB'nin mevcut modelinin, kapalı döngüsel bir sistemden çok dışa bağımlı bir atık yönetimi görünümü sergilediği anlaşılmaktadır

Anahtar Kelimeler: Döngüsel Ekonomi, Atık Yönetimi, Eurostat Verileri, Çöp Sömürgeciliği, Çin National Sword Politikası

FROM WASTE MANAGEMENT TO SYSTEM TRANSFORMATION: ARE EU POLICIES REALLY SUCCESSFUL?

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Abstract

The European Union's waste management policies are seen as a benchmark in international literature. This study assesses how these policies meet the targets of the circular economy transition. It uses Eurostat datasets in a comparative descriptive analysis.

There is a gap between policy rhetoric and statistical reality across many indicators. Household waste generation in Europe has not declined. Instead, it has reached more than 196 million tons. Recycling rates have stagnated at about 49% since 2020. This is concerning, especially given the infrastructure issues in member states like Romania. These problems show the system's structural limits. The rise of landfill rates to 21% further confirms this picture.

Globally, China's 2018 National Sword ban was a turning point for the EU. Only after this policy did the bloc's reliance on external markets become clear. This study examines this dependency and compares it to Turkey's paid plastic bag regulation and Zero Waste policy.

Based on all the evidence, the EU does not have a self-sufficient circular system. Its current model is a waste-management approach that still relies on external outlets. This finding raises questions about the credibility of the bloc's green transition narrative.

Keywords: Circular Economy, Waste Management, Eurostat Data, Waste Colonialism, China National Sword Policy

GİRİŞ

Son yıllarda atık yönetimi, sadece çevre politikalarının değil, aynı zamanda küresel ticaret ve kaynak ekonomisinin de önemli bir konusu hâline gelmiştir. Ham madde fiyatlarındaki dalgalanmalar ve tedarik zinciri sorunları, sanayileşmiş ülkelerde atığın yalnızca bertaraf edilmesi gereken bir sorun olarak değil, yeniden kullanılabilecek değerli bir kaynak olarak görülmesine yol açmıştır (Avrupa Çevre Ajansı, 2025). Bu bakış açısının en kapsamlı yasal altyapısını ise Avrupa Birliği oluşturmuştur.

Bu kapsamda, AB 2008 Atık Çerçeve Direktifi ile atık hiyerarşisini bağlayıcı hale getirmiştir. 2020 Döngüsel Ekonomi Eylem Planı (CEAP) ise bu çerçeveyi genişletmiştir (Avrupa Komisyonu, 2026). 2035 yılına kadar, belediye atıklarının %65'inin geri dönüştürülmesi planlanmaktadır. Ayrıca, düzenli depolama oranının %10'a indirilmesi hedeflenmektedir. Bu yasal altyapı, uluslararası literatürde çevre politikasında bir referans noktası hâline gelmiştir (Avrupa Çevre Ajansı, 2025).

Ancak tüm bu düzenlemelere rağmen belirlenen hedefler ile sahadan elde edilen veriler arasında belirgin farklılıklar gözlemlenmektedir. Özellikle hanehalkı atık üretiminin artış eğilimini sürdürmesi, geri dönüşüm oranlarının 2020 sonrasında durağanlaşması ve düzenli depolama rakamlarının yeniden yükselmesi, sistemin yapısal sınırlarına ilişkin önemli bulgular sunmaktadır (Eurostat, 2024). Bu tıkanıklığın boyutu yalnızca AB'nin iç dinamikleriyle açıklanamaz. Nitekim, Çin'in 2018 yılında yürürlüğe koyduğu National Sword politikasıyla dış kaynaklı atık alımını durdurması, AB'nin geri dönüşüm performansının ne ölçüde dış pazarlara dayandığını gözler önüne sermiştir (Brooks vd., 2018).

Bu çalışmada, yukarıda çizilen tablo Eurostat veri setleri üzerinden incelenmekte; ayrıca, Türkiye'nin atık yönetimi politikalarıyla kurulan karşılaştırma aracılığıyla AB merkezli değerlendirmelerin ötesinde bir perspektif geliştirilmesi amaçlanmaktadır (T.C. Çevre, Şehircilik ve İklim Değişikliği Bakanlığı, 2026).

1. YÖNTEM VE VERİ KAYNAKLARI

Bu çalışma, Avrupa Birliği'nin atık yönetimi performansını ve döngüsel ekonomiye geçiş iddiasını değerlendirmek amacıyla karşılaştırmalı betimsel analiz yöntemini benimsemiştir (Eurostat, 2024). Araştırma sürecinde izlenen metodolojik adımlar ve veri seçim kriterleri aşağıda açıklanmaktadır.

Veri Setlerinin Seçimi: Analizler, Avrupa İstatistik Ofisi (Eurostat) tarafından sağlanan ve atık yönetiminin dört temel boyutunu kapsayan resmi veri setleri üzerinden yürütülmüştür. Bu kapsamda hanehalkı atık üretimini izlemek için evsel atık verileri (Eurostat, ten00110), geri dönüşüm performansını ölçmek için belediye atıkları (Eurostat, cei_wm011) ve ambalaj

atıkları veri setleri (Eurostat, ten00063), sistemin nihai çıktısını değerlendirmek için ise düzenli depolama oranlarına ilişkin veriler (Eurostat, ten00138) kullanılmıştır.

Zaman Kapsamı ve Filtreleme: Çalışma, AB'nin 2008 Atık Çerçeve Direktifi sonrasında hız kazanan dönüşüm sürecini analiz edebilmek amacıyla 2004-2024 yıllarını kapsayan boylamsal bir perspektif sunmaktadır (Avrupa Komisyonu, 2026). 2018 yılı Çin'in National Sword kararı (Brooks vd., 2018), 2020 yılı ise pandemi sonrası durağanlaşma evresi açısından yapısal kırılma noktaları olarak ele alınmıştır (Eurostat, 2025).

Analitik Yaklaşım: Veriler değerlendirilirken yalnızca AB-27 ortalamalarıyla yetinilmemiş; gelişmiş bir geri dönüşüm altyapısına sahip Almanya ile yapısal sorunlar yaşayan Romanya örneği üzerinden merkez-çevre karşılaştırması yapılmıştır (Avrupa Sayıştayı, 2025). Bu tercih, ortalama değerlerin arkasında kalan ülkeler arası performans farklılıklarını görünür kılmak amacıyla benimsenmiştir.

Küresel Karşılaştırma: AB'nin atık ihracatına dayanan yapısını doğrulamak amacıyla Çin Ulusal İstatistik Bürosu'nun (NBS) sunduğu atık bertaraf kapasitesi verileri (NBS, 2025) ile Eurostat'ın dışa aktarılan atık verileri birlikte değerlendirilmiştir. Bu çapraz analiz, sistemin dışa bağımlılığını somutlaştıran ilişkileri ortaya koymaya olanak tanımıştır (Brooks vd., 2018).

Benimsenen yöntemle, yalnızca politika belgelerine dayalı bir literatür taramasının ötesine geçilerek sahadan elde edilen nicel verilerin sebep-sonuç ilişkileri çerçevesinde yorumlanması hedeflenmiştir (UNECE, 2026).

2. AB ATIK YÖNETİMİ POLİTİKALARININ EVRİMİ

Avrupa Birliği'nin atık yönetimi anlayışının temelinde, atıkların işlenmesine ilişkin bir öncelik sıralaması olan "Atık Hiyerarşisi" paradigması yer alır. Bu yapı, hammaddenin ekonomik değerini mümkün olduğunca uzun süre korumayı amaçlar. Sıralama şu aşamalardan oluşur: atığın oluşmasını önleme (üretimin ve tüketimin azaltılması), yeniden kullanım (kullanılmış ürünlerin tekrar kullanıma kazandırılması), geri dönüşüm (atık malzemelerin yeni ürünlere dönüştürülmesi), enerji geri kazanımı (atıklardan enerji üretilmesi) ve bertaraf (atıkların çevreye en az zarar verecek şekilde yok edilmesi). Birlik, bu teorik çerçeveyi hayata geçirmek için son yirmi yılda kapsamlı bir çevre mevzuatı oluşturmuştur.

2.1. Normatif Güç ve Uygulama Boşluğu: Mevzuatın Sınırları

AB'nin döngüsel ekonomi stratejisi üç düzenleyici sütun üzerine kurulmuştur.

Bunlardan ilki Atık Çerçeve Direktifidir. Bu direktif, üye ülkeler için bağlayıcı hedefler belirler. Ayrıca Genişletilmiş Üretici Sorumluluğu (EPR) mekanizmasını güçlendirmiştir

(Avrupa Komisyonu, 2026). 2035 yılına kadar belediye atıklarının %65'inin geri dönüştürülmesi hedeflenmektedir. Düzenli depolama oranı ise %10 ile sınırlandırılacaktır. Bu hedefler direktifin en kritik sayısal yükümlülükleri arasındadır.

İkinci sütun Yeni Ambalaj ve Ambalaj Atıkları Yönetmeliğidir (PPWR). Şubat 2025 itibarıyla yürürlüğe girmiştir. Bu düzenleme, atık yönetimini tasarım aşamasına taşır ve lojistik süreçleri yeniden yapılandırır (Avrupa Komisyonu, 2026). 2030 yılı için %70'lik bir geri dönüşüm hedefi belirlenmiştir. Ayrıca, ambalajların piyasadaki dolaşımına ve geri kazanılabilirliğine yönelik sıkı standartlar getirilmiştir (Eurostat, 2025).

Üçüncü sütun Döngüsel Ekonomi Yasasıdır (2025/2026). Bu yasa, odağı atık fazından üretim fazına kaydırır. Ağustos 2025'te istişareye açılmıştır. Düzenleme ekotasarım kriterlerini merkeze alır. Ürünlerin fabrikadan çıkmadan önce yaşam döngüsü parametrelerini denetler. Ayrıca, sürdürülebilir ürün pasaportu gibi dijital izlenebilirlik araçlarını devreye almayı hedeflemektedir (Lebib Yalkın, 2026).

Avrupa Çevre Ajansı'nın "Europe's Environment 2025" raporu, bu yasal altyapıyı küresel ölçekte bir referans çerçeve olarak nitelendirmektedir (Avrupa Çevre Ajansı, 2025). Bununla birlikte, mevzuatın teknik bütünlüğü saha uygulamalarındaki yapısal aksaklıkları gidermede tek başına yeterli olmamaktadır (Avrupa Sayıştayı, 2025). Makro hedefler ile üye ülkelerdeki mikro düzey veriler arasındaki farklılıkların derinleşmesi, sistemin ciddi bir verimlilik sorunuyla karşı karşıya olduğuna işaret etmektedir (Eurostat, 2024).

3. EUROSTAT VERİLERİ IŞIĞINDA SİSTEMİN ANALİZİ

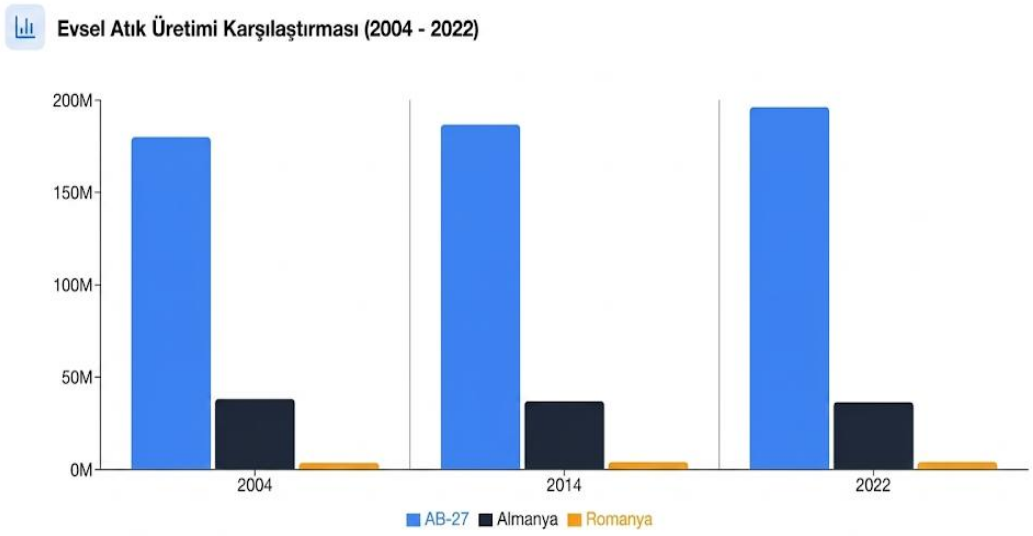
AB'nin atık yönetimi performansını nesnel biçimde değerlendirmenin en güvenilir yolu Eurostat'ın resmi veri tabanlarına başvurmaktır. Hanehalkı atık üretimi, belediye atıklarının geri dönüşüm oranları, ambalaj atıkları ve düzenli depolama verileri birlikte incelendiğinde dört temel sorun alanı öne çıkmaktadır (Eurostat, 2024).

3.1. Mutlak Atık Üretimindeki Artış Eğilimi

Döngüsel ekonomi modelinin öncelikli hedefi atık oluşumunu kaynağında azaltmaktır (Avrupa Komisyonu, 2026). Ancak Eurostat'ın hanehalkı atık verileri bu hedefin henüz karşılanmadığını göstermektedir. 2004 yılında AB genelinde evsel atık üretimi 180 milyon ton civarında seyrediyorken, bu rakam 2022 yılında 196,1 milyon tona yükselmiştir (Eurostat, ten00110). Söz konusu artış yalnızca AB ortalamasında değil, geri dönüşüm performansıyla öne çıkan üye ülkelerde de gözlemlenmektedir. Almanya'da evsel atık üretimi 2006'daki 34,6 milyon ton seviyesinden 2022'de 36,3 milyon tona çıkmıştır (Eurostat, ten00110).

Bu tablo, birliğin atığı işleme kapasitesini geliştirmiş olmasına karşın tüketim kaynaklı atık hacmini kontrol altına almakta yetersiz kaldığını ortaya koymaktadır (Avrupa Sayıştayı, 2025).

Şekil 1. Hanehalkı Atık Üretimindeki Artış Eğilimi



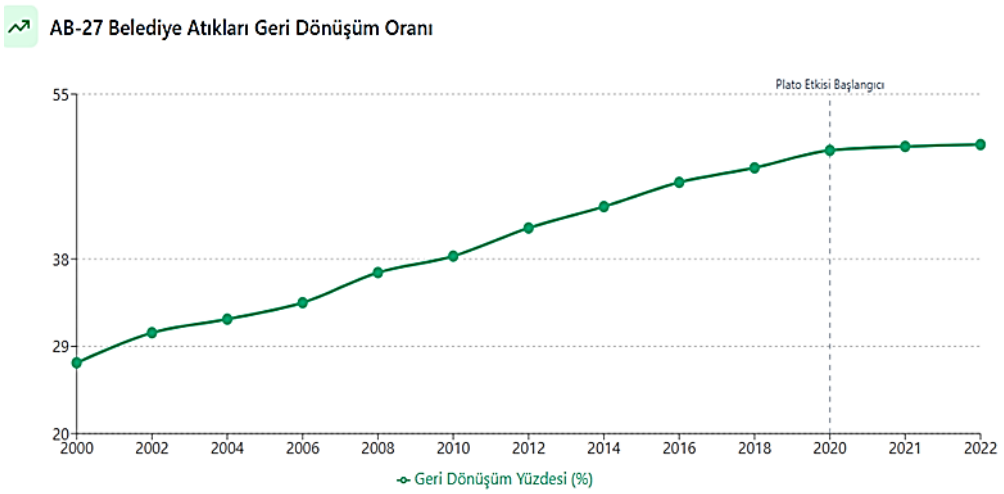
Kaynak: Yazar tarafından Eurostat verilerinden derlenmiştir (ten00110).

3.2. Geri Dönüşüm Oranlarındaki Durağanlaşma

Belediye atıklarının geri dönüşüm oranı, 2000'lerin başındaki %27 seviyesinden 2020'lere gelindiğinde %49'a ulaşmıştır (Eurostat, cei_wm011). Bu ilerleme, uzun vadeli politika taahhütlerinin somut bir çıktısı olarak değerlendirilebilir. Bununla birlikte, 2020 yılından itibaren söz konusu oranın %49-%50 bandında durağanlaştığı görülmektedir (Eurostat, cei_wm011).

Bu durağanlaşmanın temel nedeni, kâğıt, karton ve cam gibi ayrıştırması görece kolay malzemelerin büyük ölçüde geri kazanım süreçlerine dahil edilmiş olmasıdır. Çok katmanlı plastikler ve tekstil atıkları gibi teknik açıdan daha güç malzemelerin geri dönüşümü ise mevcut teknoloji ve maliyet koşullarında ciddi bir engelle karşılaşmaktadır (Avrupa Çevre Ajansı, 2025). AB'nin 2035 yılı için belirlediği %65 hedefine ulaşılabilmesi, bu teknik ve ekonomik engellerin aşılmasına bağlıdır (Avrupa Komisyonu, 2026).

Şekil 2. AB Belediye Atıkları Geri Dönüşüm Oranlarında Gözlemlenen Plato Etkisi



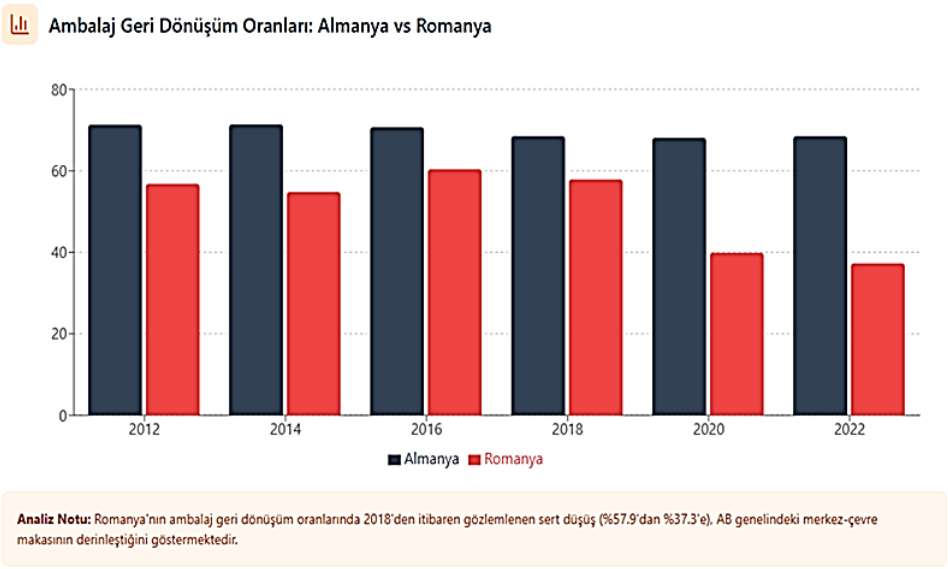
Kaynak: Yazar tarafından Eurostat verilerinden derlenmiştir (cei_wm011).

3.3. Doğu Avrupa'da Altyapı Sorunları: Romanya Örneği

AB geneli ortalamaları üye ülkeler arasındaki yapısal farklılıkları gizleyebilmektedir. Ambalaj atıklarının geri dönüşüm oranı AB genelinde %67 civarında seyretmekte olup bu ortalama, Almanya gibi gelişmiş altyapıya sahip ülkelerin katkısıyla şekillenmektedir (Eurostat, ten00063).

Romanya'ya ait veriler bu bağlamda dikkat çekici bir tablo ortaya koymaktadır. Eurostat kayıtlarına göre Romanya, 2012 yılında ambalaj atıklarının %56,8'ini geri dönüştürürken bu oran 2022'de %37,3'e gerilemiştir (Eurostat, ten00063). On yıllık süreçte gözlemlenen bu düşüşün iki temel açıklaması bulunmaktadır. Birincisi, AB denetim mekanizmalarının sıkılaşmasıyla birlikte daha önce geri dönüştürülmüş olarak raporlanan bazı atıkların fiilen işlenmediği anlaşılmıştır (Avrupa Sayıştayı, 2025). İkincisi, ekonomik baskılar altında Doğu Avrupa'daki atık toplama altyapısı işlevselliğini önemli ölçüde yitirmiştir (Avrupa Çevre Ajansı, 2025).

Şekil 3. Merkez ve Çevre AB Ülkeleri Arasındaki Geri Dönüşüm Makasının Açılması



Kaynak: Yazar tarafından Eurostat verilerinden derlenmiştir (ten00063).

3.4. Düzenli Depolama Oranlarındaki Yeniden Artış

Düzenli depolama, atık hiyerarşisinin en alt basamağında yer almakta ve çevresel açıdan en maliyetli bertaraf yöntemi olarak kabul edilmektedir. AB, bu yönteme başvurulan atık oranını 2020 yılı itibarıyla %19'a indirmeyi başarmıştır. Ancak 2022 verileri, söz konusu oranın yeniden %21'e yükseldiğini göstermektedir (Eurostat, ten00138). Geri dönüşüm tesislerinin kapasitelerini aştığı koşullarda işlenemeyen atıkların düzenli depolama sahalarına yönlendirildiği anlaşılmaktadır. Malta, Kıbrıs ve Bulgaristan gibi üye ülkelerde atıkların yarısından fazlasının hâlâ bu yöntemle bertaraf edildiği görülmektedir (Eurostat, ten00138).

ÜLKE	KATEGORİ	LANDFILL ORANI (%)	DURUM
Belçika	İyi Örnek	%1.0	✅
Danimarka	İyi Örnek	%1.1	✅
Hollanda	İyi Örnek	%1.2	✅

ÜLKE	KATEGORİ	LANDFILL ORANI (%)	DURUM
Malta	Kötü Örnek	%82.5	⚠️
Bulgaristan	Kötü Örnek	%64.0	⚠️
Kıbrıs	Kötü Örnek	%52.3	⚠️

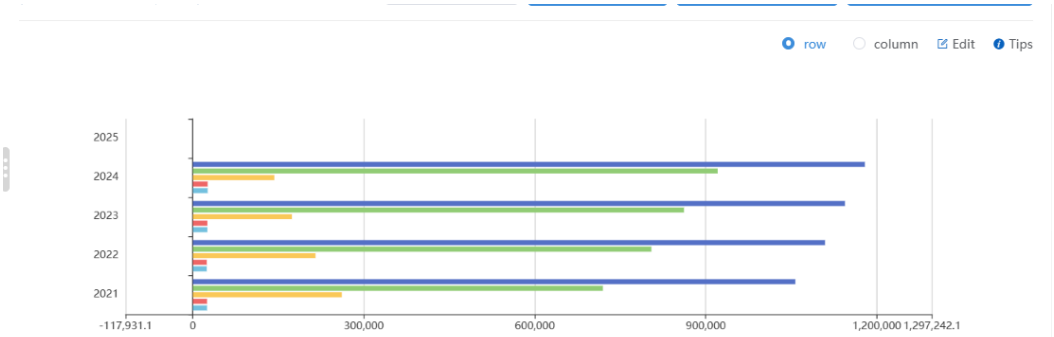
Kaynak: Yazar tarafından Eurostat verilerinden derlenmiştir (ten00138).

3.5. Küresel Boyut: Çin'in Atık Politikasının AB Üzerindeki Etkileri

AB'nin düzenli depolama oranlarındaki artışla karşı karşıya kaldığı dönemde Çin, atık yönetimi alanında köklü bir dönüşüm gerçekleştirmiştir. Çin Ulusal İstatistik Bürosu'nun verilerine göre Çin, mekanik geri dönüşüm süreçlerine olan bağımlılığını azaltarak atıktan enerji üretimini temel bir strateji olarak benimsemiştir (NBS, 2025).

Bu dönüşümün somut göstergeleri iki başlık altında değerlendirilebilir. Düzenli depolama kapasitesi açısından bakıldığında, 2021 yılında günlük 261 bin ton atığın toprağa gömüldüğü Çin'de bu rakam 2024 itibarıyla 143 bin tona indirilmiştir (NBS, 2025). Yakma tesislerindeki kapasite artışı açısından ise günlük işleme kapasitesi yalnızca üç yılda 719 bin tondan 920 bin tona yükselmiştir (NBS, 2025).

Çin'in 2018 yılında yürürlüğe koyduğu National Sword politikasıyla dış kaynaklı atık alımını durdurması AB için kritik bir kırılma noktası oluşturmuştur (Brooks vd., 2018). Bu tarihe kadar atıklarının önemli bir bölümünü Çin'e ihraç ederek geri dönüşüm istatistiklerini olumlu yönde şekillendiren AB, kendi iç atık yönetim kapasitesinin yetersizliğiyle doğrudan yüzleşmek durumunda kalmıştır (Brooks vd., 2018). Düzenli depolama oranlarının yeniden %21'e çıkmasının ardında bu yapısal bağımlılığın payı göz ardı edilemez (Eurostat, ten00138).



Indicators	2025	2024	2023	2022	2021
Capacity for Harmless Wastes Treatment(ton/day)		1179311	1144391	1109435	1057064
Capacity for Harmless Wastes Treatment, Incinerate(to...		920979	861777	804670	719533
Capacity for Harmless Wastes Treatment, Landfill(ton/d...		143114	173880	215167	261555
Consumption Wastes Collected and Transported (1000...		25961.2	25407.8	24444.7	24869.2
Volume of Harmless Wastes Treatment(10000 tons)		25961.0	25401.7	24419.3	24839.3

Kaynak: https://data.stats.gov.cn/dg/website/page.html#/pc/national/en/yearData

4. TARTIŞMA: AB'NİN YAPISAL SORUNLARI VE TÜRKİYE İLE KARŞILAŞTIRMALI ANALİZ

AB atık yönetimi sisteminin yukarıda ortaya konan yapısal sorunları, benzer gelişmişlik düzeyindeki ülkelerin politika tercihlerini karşılaştırmalı olarak değerlendirmeyi zorunlu kılmaktadır. Bu bölümde Türkiye'nin atık yönetimi politikaları, AB'nin yaşadığı deneyimler ışığında incelenmektedir.

4.1. Ücretli Poşet Uygulaması ve Sıfır Atık Projesi: Kaynağında Azaltma Yaklaşımı

Önceki bölümlerde ele alındığı üzere AB atık politikalarındaki temel yapısal sorun, atık hiyerarşisinin en üst basamağını oluşturan kaynağında azaltma ilkesinin operasyonel düzeyde hayata geçirilememesidir. Birlik, ambalaj atıklarının geri kazanımında yüksek teknik standartlara ulaşmış olmakla birlikte mutlak atık üretim hacmindeki artışı ve kontrolsüz ambalaj talebini sınırlandırmada yetersiz kalmıştır (Avrupa Sayıştayı, 2025).

Türkiye bu alanda daha doğrudan müdahale araçlarına yönelmiştir. 2017 yılında başlatılan Sıfır Atık Projesi, kurumsal atık yönetiminin ötesine geçerek toplumsal ölçekte bir farkındalık ve ayrıştırma disiplini oluşturmayı hedeflemiştir (T.C. Çevre, Şehircilik ve İklim Değişikliği

Bakanlığı, 2026). Bu stratejinin en ölçülebilir çıktısı, 2019 yılında yürürlüğe giren ücretli poşet uygulamasıyla elde edilmiştir. Söz konusu düzenleme, yürürlüğe girdiği ilk yıl itibarıyla plastik poşet kullanımını %80 oranında azaltmıştır (T.C. Çevre, Şehircilik ve İklim Değişikliği Bakanlığı, 2026). Bu sonuç, tüketici davranışlarını doğrudan hedef alan mali yükümlülük modellerinin kısa vadede somut etkiler yaratabildiğini göstermektedir.

4.2. Depozito Yönetim Sistemi ve Altyapı Sorunları

Türkiye'nin AB standartlarının gerisinde kaldığı alan, toplanan atığın endüstriyel düzeyde ayrıştırılmasıdır. Almanya'nın geri dönüşüm alanındaki başarısı büyük ölçüde üreticileri atık sorumluluğuyla yükümlü kılan Genişletilmiş Üretici Sorumluluğu (EPR) sistemine dayanmaktadır (Avrupa Çevre Ajansı, 2025). Türkiye'de kurulum sürecinde olan Depozito Yönetim Sistemi (DYS), bu modelin bir uyarlaması niteliğindedir (T.C. Çevre, Şehircilik ve İklim Değişikliği Bakanlığı, 2026). Sistemin etkin biçimde işlerlik kazanması durumunda kayıt dışı atık toplayıcıları üzerindeki yükün azalması ve Türkiye'nin geri dönüşüm verilerinin uluslararası karşılaştırmalara dahil edilebilecek düzeyde şeffaflaşması beklenmektedir.

4.3. Atık İthalatı ve Yapısal Bağımlılık Sorunu

AB'nin atık yönetimi sistemine ilişkin en tartışmalı konulardan biri, Eurostat'ın geri dönüşüm oranı hesaplamalarında ihraç edilen atıkları da başarı hanesi olarak kaydetmesidir (UNECE, 2026). Bu yöntem, birliğin gerçek geri dönüşüm kapasitesini olduğundan yüksek gösterme riskini beraberinde getirmektedir.

Çin'in 2018'de dış kaynaklı atık alımını durdurmasının ardından Avrupa'dan kaynaklanan plastik atıkların önemli bir bölümü Türkiye gibi ülkelere yönelmiştir (Brooks vd., 2018). Türkiye, bu süreçte Avrupa'dan en fazla plastik atık ithal eden ülkeler arasına girmiştir. Türkiye'nin 2021 yılında karışık plastik atık ithalatına kısıtlama getirmesi ise AB geri dönüşüm istatistiklerindeki durağanlaşmayla eş zamanlı gerçekleşmiştir (Eurostat, cei_wm011). Bu örtüşme, AB'nin geri dönüşüm performansının dış pazarlara olan bağımlılığını somut biçimde yansıtmaktadır.

5. SONUÇ VE ÖNERİLER

Bu çalışmada AB'nin atık yönetimi politikalarının döngüsel ekonomiye geçiş hedefleriyle ne ölçüde örtüştüğü, Eurostat veri setleri üzerinden analitik bir perspektifle değerlendirilmiştir. Elde edilen bulgular, birliğin geri dönüşüm kapasitesini geliştirme konusunda kaydettiği ilerlemeye karşın sistemin yapısal sınırlarını aşamadığını ortaya koymaktadır (Avrupa Sayıştayı, 2025).

Çalışmanın temel bulguları üç başlık altında özetlenebilir. Birincisi, hanehalkı atık üretiminin 196 milyon tona ulaşması, tüketim kaynaklı atık hacminin mevcut politika araçlarıyla kontrol

altına alınamadığını göstermektedir (Eurostat, ten00110). İkincisi, geri dönüşüm oranlarının 2020 sonrasında %49 bandında durağanlaşması ve Romanya gibi üye ülkelerdeki altyapı sorunları, sistemin teknik ve kurumsal kapasitesine ilişkin ciddi soru işaretleri doğurmaktadır (Eurostat, cei_wm011; Eurostat, ten00063). Üçüncüsü, düzenli depolama oranlarının yeniden %21'e yükselmesi ve Çin'in National Sword politikasının ardından yaşanan süreç, AB'nin geri dönüşüm başarısının ne ölçüde dışa bağımlı bir yapıya dayandığını açıkça ortaya koymuştur (Brooks vd., 2018; Eurostat, ten00138).

Türkiye ile kurulan karşılaştırma, kaynağında azaltmaya yönelik doğrudan müdahale araçlarının kısa vadede ölçülebilir sonuçlar üretebileceğini göstermektedir (T.C. Çevre, Şehircilik ve İklim Değişikliği Bakanlığı, 2026). Bununla birlikte Türkiye'nin endüstriyel düzeyde atık ayrıştırma kapasitesi ve şeffaf raporlama altyapısı açısından AB standartlarının gerisinde kaldığı görülmektedir.

Araştırma bulguları ışığında aşağıdaki politika önerileri geliştirilmiştir.

Üretim aşamasında yapısal dönüşüm açısından değerlendirildiğinde, mevcut politikaların ağırlıklı olarak atığın yönetilmesine odaklandığı, atık oluşumunu kaynağında önlemeye yönelik araçların ise sınırlı kaldığı görülmektedir (Avrupa Komisyonu, 2026). Virgin plastik üretiminin vergilendirilmesi ve geri dönüştürülmüş hammadde kullanımının teşvik edilmesi, bu dengesizliği gidermeye katkı sağlayabilir.

Dijital izlenebilirlik ve şeffaflık açısından ise Romanya örneğinde gözlemlenen raporlama tutarsızlıklarının önüne geçmek amacıyla atıkların sınır ötesi hareketlerinin dijital araçlarla izlenmesi, veri güvenilirliğini artırabilir (UNECE, 2026).

Tüketim hacminin yönetimi bağlamında ele alındığında, yıllık 196 milyon tona ulaşan evsel atık üretiminin yalnızca geri dönüşüm kapasitesinin genişletilmesiyle yönetilebilir düzeye çekilmesinin güç olduğu anlaşılmaktadır (Eurostat, ten00110). Bu nedenle tüketim odaklı politika araçlarının atık yönetimi stratejileriyle bütünleşik biçimde ele alınması gerekmektedir.

Sonuç olarak AB, atık yönetimi alanında uluslararası ölçekte kapsamlı bir yasal çerçeve oluşturmuştur. Ancak mevcut bulgular, birliğin gerçek anlamda döngüsel bir ekonomiye geçiş yapabilmesi için tüketim hacmini sınırlandırmaya yönelik yapısal adımlar atması ve atık yönetimi stratejisindeki dışa bağımlılığı azaltması gerektiğine işaret etmektedir (Avrupa Çevre Ajansı, 2025).

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SMART CIRCULARITY AT THE END OF THE LINE: INTEGRATING INDUSTRY 4.0 TECHNOLOGIES INTO ROBOTIC PALLETIZING AND PACKAGING SYSTEMS FOR RESOURCE-EFFICIENT INDUSTRIAL ECOSYSTEMS

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Abstract

The twin transition, the coupling of digital and green transformation, reframes end-of-line (EOL) packaging from a cost centre into a strategic lever for resource efficiency and circularity. This paper examines how Industry 4.0 technologies, including industrial robotics, collaborative robots (cobots), the Industrial Internet of Things (IIoT), digital twins, and data-driven process control, can be embedded into robotic palletizing, stretch wrapping, and strapping operations to reduce material consumption, energy use, and waste while improving supply-chain resilience. Drawing on the operational logic of turnkey EOL packaging lines and on the circular-economy principles of narrowing, slowing, and closing resource loops, the study develops a conceptual framework linking smart-manufacturing capabilities to measurable sustainability outcomes. A qualitative analysis of representative deployment patterns in the food and dairy processing sector suggests that sensor-enabled material optimization (for example, adaptive pre-stretch control in stretch wrapping) and predictive maintenance can jointly lower consumable use and unplanned downtime, contributing to both environmental and economic performance. The paper argues that the EOL stage, which is often overlooked in digital-transformation agendas, is a high-leverage intervention point for industrial symbiosis and just transition, and it identifies governance, standardization, and workforce conditions required to realize this potential. The contribution is a structured agenda for practitioners and policymakers seeking to align factory-floor automation with EU twin-transition objectives.

Keywords: Industry 4.0, Smart Manufacturing, Circular Economy, End-of-line Packaging, Robotic Palletizing, Resource Efficiency, Twin Transition

INTRODUCTION

Industrial policy in the European Union increasingly rests on the idea of a twin transition, in which digital transformation and the shift toward a circular, low-carbon economy reinforce one another rather than proceeding on separate tracks. For manufacturers, this framing raises a concrete question: which parts of the production system offer the greatest combined return in digital capability and resource efficiency? Much of the existing literature concentrates on core transformation processes such as machining, forming, and assembly, while the end-of-line (EOL) stage, where finished goods are palletized, wrapped, strapped, and prepared for dispatch, receives comparatively little attention.

This neglect is difficult to justify on material grounds. EOL operations are intensive consumers of secondary packaging such as stretch film, strapping, corner boards, and pallets, and they sit at the interface between the factory and the logistics network. Decisions taken at this stage directly affect load stability, transport efficiency, packaging waste, and the recoverability of materials downstream. The EOL stage is therefore a natural meeting point for the two halves of the twin transition: it is highly automatable and data-rich, and it governs a large share of a facility's consumable footprint.

This paper asks how Industry 4.0 technologies can be integrated into EOL packaging systems to advance circular-economy objectives without compromising throughput or supply-chain resilience. It proceeds conceptually rather than empirically, synthesizing established smart-manufacturing principles with circular-economy theory to produce an integrative framework and a research and policy agenda. Section 2 reviews the relevant literature; Section 3 sets out the conceptual framework; Section 4 discusses deployment patterns and their sustainability implications; Section 5 considers governance and just-transition dimensions; and Section 6 concludes.

1. CONCEPTUAL BACKGROUND

1.1. Industry 4.0 and Smart Manufacturing

Industry 4.0 denotes the convergence of cyber-physical systems, the Industrial Internet of Things (IIoT), cloud and edge computing, advanced robotics, and data analytics within manufacturing environments (Kagermann et al., 2013). Its defining feature is not automation per se, which predates the concept by decades, but the horizontal and vertical integration of information flows: machines, products, and management systems exchange data continuously, enabling real-time monitoring, adaptive control, and predictive decision-making. In EOL packaging, the relevant building blocks are industrial and collaborative robots for palletizing, sensorized wrapping and strapping equipment, vision systems for quality and load verification, and supervisory platforms that aggregate machine data.

1.2. Circular Economy and Resource Efficiency

The circular economy reconceives production and consumption around the goals of narrowing (using fewer resources per unit), slowing (extending product and material lifetimes), and closing (recovering materials at end of use) resource loops (Bocken et al., 2016). Applied to packaging, narrowing corresponds to material reduction, that is, using less film or fewer straps to secure a load, while closing relates to recyclability and material recovery. Resource efficiency, the ratio of output to material and energy input, provides the operational metric through which circular ambitions become measurable at the factory floor.

1.3. The Twin Transition as an Integrative Lens

The twin transition literature argues that digital tools are enablers rather than ends: sensing and analytics make resource flows visible, and visibility is a precondition for optimization (European Commission, 2022). This perspective motivates the present study's central claim, namely that the sustainability value of digitalizing EOL packaging lies less in labour substitution than in the fine-grained control of material and energy consumption that digital instrumentation makes possible.

2. A FRAMEWORK LINKING SMART EOL PACKAGING TO CIRCULAR OUTCOMES

The proposed framework connects four Industry 4.0 capability clusters to circular-economy mechanisms and, in turn, to sustainability outcomes. The logic is that each digital capability acts on a specific resource loop, and that the outcomes are jointly economic and environmental, consistent with the twin-transition premise.

Table 1. Mapping of Industry 4.0 Capabilities to Circular-Economy Mechanisms and Outcomes in End-of-Line Packaging

Industry 4.0 capability	***Mechanism in EOL packaging***	***Circular loop***	***Expected outcome***
IIoT sensing & adaptive control	*Dynamic pre-stretch and film-tension control; strap-tension feedback*	*Narrowing*	*Lower consumable use per pallet*
Predictive maintenance & analytics	*Condition monitoring of robots, wrappers, conveyors*	*Slowing*	*Longer asset life; less downtime & scrap*

Industry 4.0 capability	*Mechanism in EOL packaging*	*Circular loop*	*Expected outcome*
Digital twin & simulation	*Virtual commissioning of pallet patterns and line layout*	*Narrowing*	*Optimized load stability with minimal material*
Vision & traceability systems	*Load verification; material and batch data capture*	*Closing*	*Better sorting/recovery; symbiosis data*

3. DEPLOYMENT PATTERNS AND SUSTAINABILITY IMPLICATIONS

3.1. Material Optimization through Adaptive Wrapping

Stretch wrapping is the clearest illustration of how digitalization narrows a resource loop. Conventional wrappers apply film at a fixed pre-stretch ratio and fixed wrap count, settings typically chosen conservatively to guarantee load stability across all products. Sensor-enabled wrappers instead measure film tension and load geometry in real time and adjust pre-stretch and the number of wraps to the minimum required for a stable load. Because pre-stretch determines how far a given length of film is elongated before application, even modest increases in achievable pre-stretch translate into proportional reductions in film mass per pallet. The environmental saving is twofold: less plastic consumed and less plastic entering the waste stream, the latter being directly relevant to closing the material loop.

3.2. Robotic and Collaborative Palletizing

Robotic palletizing, whether by conventional six-axis robots or by collaborative robots working alongside operators, contributes to circularity indirectly but meaningfully. Precise, repeatable placement produces denser and more stable pallet patterns, which improves cube utilization in transport and reduces the secondary packaging needed to stabilize a load. A common configuration in small- and medium-volume lines is the palletizing of boxes or crates onto two pallet positions with manual pallet feeding, an arrangement that balances automation benefits against capital cost and footprint. Digital twins allow these pallet patterns and cell layouts to be optimized virtually before commissioning, avoiding the material and energy waste associated with physical trial-and-error.

3.3. Predictive Maintenance and Resilience

Condition monitoring of robots, conveyors, and wrapping equipment supports the slowing loop by extending asset life and reducing the scrap and rework generated by unplanned failures. It also reinforces supply-chain resilience: an EOL line that fails unexpectedly can

halt dispatch for an entire facility. By converting maintenance from a reactive to a predictive activity, IIoT instrumentation reduces both the environmental footprint of premature component replacement and the economic cost of disruption. This is a concrete instance of the twin transition's mutually reinforcing logic.

3.4. Data, Traceability, and Industrial Symbiosis

Finally, the data captured at the EOL stage, covering material types, quantities, and batch information, has value beyond the individual facility. When shared across an industrial ecosystem, such data can support industrial symbiosis, in which one firm's packaging waste becomes another's feedstock, and can improve downstream sorting and recovery. Realizing this requires interoperable data standards, a governance challenge addressed in the next section.

4. GOVERNANCE, STANDARDIZATION, AND JUST TRANSITION

Technical feasibility is necessary but not sufficient. Three governance conditions shape whether smart EOL packaging delivers on its twin-transition promise. First, standardization: the material- and process-data generated by EOL systems is only useful for circularity and symbiosis if it is interoperable across vendors and firms, which calls for common data models and, potentially, regulatory support. Second, measurement and disclosure: resource-efficiency gains must be quantified through consistent metrics, such as film mass per pallet, energy per pallet, and downtime rates, if they are to inform investment and policy. Third, the just-transition dimension: the introduction of cobots and automation reshapes EOL work rather than simply eliminating it, shifting operators toward supervisory and data-handling roles. Ensuring that this shift is accompanied by reskilling and improved working conditions is essential to the social-inclusion goals embedded in the EU twin-transition agenda.

5. CONCLUSION

This paper has argued that the end-of-line packaging stage, frequently overlooked in digital-transformation strategies, is a high-leverage intervention point for the twin transition. By mapping four Industry 4.0 capability clusters onto the narrowing, slowing, and closing loops of the circular economy, it has shown how sensing, analytics, simulation, and traceability can reduce material and energy consumption while strengthening supply-chain resilience. The central insight is that the sustainability value of digitalizing EOL packaging lies primarily in the fine-grained control of resource flows rather than in labour substitution. Two limitations bound these conclusions. The analysis is conceptual and draws on representative deployment patterns rather than primary quantitative data; empirical validation through facility-level case studies and life-cycle assessment is a clear next step. In addition, outcomes are context-dependent, varying with product type, volume, and existing infrastructure. Future research

should quantify the material and energy savings achievable in specific sectors, with the food and dairy processing industry being a promising candidate, and should examine the governance and workforce arrangements that allow these gains to be realized equitably. For practitioners and policymakers alike, the message is that resilient, resource-efficient industrial ecosystems are built not only in the core of the factory but also at its end of line.

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DIGITAL TRANSFORMATION OF ISLAMIC MICROFINANCE (BMT) AND ITS IMPACT ON FINANCIAL INCLUSION IN INDONESIA

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Abstract

Islamic microfinance institutions, particularly Baitul Maal wa Tamwil (BMT), have long served as a cornerstone of financial inclusion for underserved communities in Indonesia. As digital transformation accelerates across the global economy, BMT institutions face both significant opportunities and systemic challenges in adopting financial technology to expand their outreach. This paper examines the digital transformation trajectory of BMT in Indonesia and its implications for financial inclusion, drawing on a systematic review of recent literature and publicly available data from the Otoritas Jasa Keuangan (OJK) and Bank Indonesia. The study finds that while digital adoption among BMT institutions remains limited—with only approximately 300 of 4,500 cooperatives actively implementing fintech solutions—early evidence points to measurable gains in customer reach, transaction frequency, and fund mobilisation. Key enablers include management commitment, mobile application development, and regulatory support under Indonesia's National Strategy for Financial Inclusion 2020–2024. Barriers include low digital literacy, infrastructure inequality, and fragmented regulatory oversight. This paper argues that targeted policy interventions and inter-institutional collaboration are essential to unlock the full potential of digital BMT in driving equitable financial inclusion across Indonesia's diverse archipelago.

Keywords: Islamic Microfinance, BMT, Digital Transformation, Financial Inclusion, Indonesia, Fintech Syariah

INTRODUCTION

Indonesia, the world's largest Muslim-majority nation with approximately 242 million Muslims representing around 87 percent of its population (Statista, 2024), presents a unique context for the study of Islamic microfinance. Despite this demographic reality, Islamic banking accounted for only 7.5 percent of total banking assets in 2023 (Statista, 2024), a figure that underscores the persistent gap between the potential and actual penetration of Shariah-compliant financial services. Within this landscape, Baitul Maal wa Tamwil (BMT)—grassroots Islamic microfinance cooperatives—have emerged as a vital mechanism for delivering financial services to low-income and underserved segments of Indonesian society.

BMTs operate on a dual mandate: as Baitul Maal, they collect and distribute zakat, infaq, and sadaqah; as Baitul Tamwil, they function as Shariah-compliant financial intermediaries, mobilising savings and disbursing financing based on profit-and-loss sharing contracts such as mudharabah and musyarakah (Hijriah et al., 2025; Septianingsih et al., 2024). This institutional duality positions BMT uniquely within Indonesia's financial architecture, bridging social welfare objectives and commercial microfinance.

The rapid expansion of financial technology (fintech) globally has created new pathways for extending financial inclusion to previously unreachable populations. In Indonesia, the government's Digital Finance Innovation Roadmap and Action Plan 2020–2024 formalised the policy framework for leveraging digital tools to broaden financial access (ADB, 2022). Against this backdrop, BMT institutions are increasingly pressured to digitalise their operations in order to remain competitive and socially relevant. Yet, as of 2023, only approximately 300 of the estimated 4,500 BMT-type cooperatives in Indonesia were actively developing or implementing fintech solutions (K.N.E.K.S., 2023, as cited in Baitul Maal Wa Tamwil Digitalization and Millennials Acceptance, 2025).

This paper investigates the nature and extent of digital transformation among BMT institutions in Indonesia, and examines how such transformation affects their capacity to advance financial inclusion. The study is structured as follows: Section 2 provides a review of relevant literature; Section 3 presents an analysis of the current state of BMT digitalisation; Section 4 discusses the implications for financial inclusion; Section 5 identifies key challenges and enabling factors; and Section 6 concludes with policy recommendations.

1. LITERATURE REVIEW

1.1. BMT and Financial Inclusion in Indonesia

BMT institutions have historically played a critical role in addressing financial exclusion in Indonesia. As Septianingsih et al. (2024) demonstrate through a systematic review of

empirical studies, BMTs provide financing for micro-enterprises and small businesses, training and mentoring services, local economic development support, and the management of social funds (ZISWAF). These functions effectively increase financial inclusion by extending access to financial services for individuals and community groups previously underserved by conventional financial institutions.

Financial inclusion in Indonesia has improved substantially in recent years, with Bank Indonesia data indicating that the national financial inclusion rate reached 85.1 percent in 2022 (Digital transformation in the financial system, 2024). However, the same data reveal a significant gap in digital financial literacy, which stood at only 48 percent, creating what researchers describe as an urgent need to optimise fintech as an instrument to accelerate national financial inclusion (Digital transformation in the financial system, 2024). In 2019, before the surge in digital financial services, overall financial inclusion in Indonesia was estimated at 49 percent and financial literacy at 38 percent (ADB, 2022).

Research has confirmed that financial inclusion has a statistically significant negative effect on income inequality in Indonesia. Panel data analysis across 33 provinces from 2015 to 2023 demonstrates that greater access to formal financial services contributes to more equitable income distribution (Examining the Connection Between Financial Inclusion and Income Inequality, 2025). This finding provides a strong macroeconomic rationale for policies that expand the reach of Islamic microfinance institutions such as BMT.

1.2. Digital Transformation in Islamic Finance

The intersection of digital transformation and Islamic finance has attracted growing scholarly attention. Innovations such as Shariah-compliant fintech platforms, halal e-commerce, and Islamic digital banking have significantly driven the progress of the Shariah economy, although challenges such as low digital literacy, infrastructure inequality, and weak Shariah-specific regulations remain major obstacles (Digital Transformation in the Indonesian Banking Industry, 2020).

At the macro level, Indonesia's Bank 5.0 initiative and the OJK Digital Resilience Guidelines (2024) frame digital financial transformation as a coordinated socio-technical process that supports resilience and inclusion (Frontiers in Sustainability, 2026). This regulatory orientation signals a shift from efficiency-driven digitisation toward value-oriented and socially aligned digital transformation, in which organisational priorities increasingly incorporate legitimacy, accountability, and long-term societal impact.

The Technology Acceptance Model (TAM), first proposed by Davis et al. (1989) and refined by Venkatesh et al. (2003), has been widely applied to study fintech adoption in Islamic financial contexts. The two primary constructs—perceived usefulness and perceived ease of

use—significantly influence an individual's intention to adopt a technology (Baitul Maal Wa Tamwil Digitalization and Millennials Acceptance, 2025). Studies applying TAM to Islamic fintech have consistently found that religiosity and Shariah compliance are additional determinants of adoption intention among Muslim users (Asri et al., 2025).

Research on digital financial inclusion as a mediating variable has produced important insights for the MSME context. Using partial least squares structural equation modelling (PLS-SEM) on survey data from 260 culinary MSME owners, Utomo et al. (2024) demonstrate that digital financial inclusion (DFI) mediates the relationship between digital financial literacy and business performance. DFI drives improvement by expanding market reach, increasing operational efficiency, facilitating transactions, and broadening access to financing (Digital Financial Inclusion as a Mediator, 2025). MSMEs contribute approximately 60 percent of Indonesia's GDP and employ nearly 97 percent of the national workforce, making this finding highly significant for BMT-supported micro-enterprises.

1.3. BMT Digitalisation: Emerging Evidence

Empirical evidence on the digital transformation of specific BMT institutions is beginning to emerge. A qualitative study of BMT UGT Nusantara's Umbulsari Branch found that its digital transformation was implemented in stages through strategic planning, the development of technological infrastructure and the Mobile UGT application, customer outreach, and the implementation and optimisation of digital services (Digital Transformation and Customer Growth in Islamic Microfinance, 2025). The study identified management commitment, technological infrastructure readiness, human resource competence, and outreach and education strategies as key success factors.

The impact of this transformation on customer growth was evidenced by an increase in customer numbers, expansion of user segments, higher transaction frequency, and increased fund mobilisation and service reach (Digital Transformation and Customer Growth in Islamic Microfinance, 2025). Despite these gains, the same study noted that the level of utilisation of digital services by customers remained suboptimal, indicating a persistent gap between technology availability and user adoption.

2. CURRENT STATE OF BMT DIGITALISATION IN INDONESIA

Indonesia's BMT sector is characterised by considerable institutional diversity and fragmented regulatory oversight. BMT institutions may be supervised either by the OJK or by the Ministry of Cooperatives and SMEs, depending on their legal form (Journals of IIUM, 2021). This regulatory fragmentation complicates the collection of comprehensive sector-wide data, as not all BMTs are required to report to a single regulatory body.

According to OJK data, approximately 4,500 BMT-type cooperatives operated in Indonesia as of recent estimates, though the actual figure may be higher given the number of institutions operating outside formal regulatory reporting frameworks (K.N.E.K.S., 2023, as cited in Baitul Maal Wa Tamwil Digitalization and Millennials Acceptance, 2025). Of these, only around 300—approximately 6.7 percent—were actively developing or implementing fintech solutions at the time of that estimate. The financial digitalisation models adopted include digital financial reporting and digital financial transactions.

At the broader Islamic finance level, Indonesia's Islamic financial industry assets reached IDR 2,582.25 trillion in 2023, representing year-on-year growth of 9.04 percent (OJK LPKSI, 2023). Indonesia ranked third in the 2023 Islamic Finance Development Indicator (IFDI) and third in the Global Islamic Fintech Index 2023, reflecting the country's growing stature in global Islamic finance despite the relatively low penetration of Islamic banking within the domestic financial system.

The emergence of "digital BMT" as a distinct institutional category represents an important conceptual and practical development. Ascarya and Sakti (2022) coined the term to describe fintech innovation developed specifically for microfinance institutions, while Haidar (2021) used the parallel term "fintech-micro." These digital BMT models are expected to emphasise financial inclusion by empowering individuals and micro-enterprises, particularly in overcoming bureaucratic and infrastructure barriers, though they face challenges related to data security, regulatory compliance, and unequal technology access.

3. IMPLICATIONS FOR FINANCIAL INCLUSION

The digitalisation of BMT operations carries significant implications for financial inclusion across multiple dimensions: access, usage, quality, and welfare impact.

With respect to access, digital platforms and mobile applications reduce the physical and transactional barriers that have historically limited BMT's ability to serve geographically dispersed populations. Indonesia's archipelagic geography, comprising over 17,000 islands, has long constrained the outreach of formal financial institutions (ADB, 2022). Mobile-enabled BMT services can extend institutional reach to rural and remote communities at a fraction of the cost of establishing physical branches.

In terms of usage, evidence from the BMT UGT Nusantara case study indicates that digital transformation increases transaction frequency and expands user segments, suggesting that existing members transact more frequently and new demographic groups—particularly younger, digitally literate populations—are attracted to BMT services (Digital Transformation and Customer Growth in Islamic Microfinance, 2025). This aligns with

broader findings that the Muslim millennial generation actively uses technology for everyday financial needs (Baitul Maal Wa Tamwil Digitalization and Millennials Acceptance, 2025).

The quality dimension of financial inclusion encompasses the range and suitability of financial products available to users. Digital transformation enables BMT institutions to offer more diversified and responsive product portfolios, including digital savings accounts, online financing applications, and real-time transaction monitoring. The integration of digital payment infrastructure with ZISWAF management functions can also enhance the efficiency and transparency of social fund distribution.

Regarding welfare impact, research consistently links financial inclusion to poverty reduction and reduced income inequality. As Examining the Connection Between Financial Inclusion and Income Inequality (2025) demonstrates, greater access to formal financial services contributes to more equitable income distribution at the provincial level in Indonesia. To the extent that digital BMT expands the reach and depth of financial inclusion, its welfare impact can be expected to be proportionally significant, particularly for low-income and rural households.

A critical enabling pathway is the mediation of digital financial literacy. Research by Utomo et al. (2024) demonstrates that digital financial inclusion mediates the relationship between digital financial literacy and MSME performance. This suggests that BMT digital transformation initiatives must be accompanied by financial literacy programs to maximise their inclusion impact—a finding with direct implications for BMT outreach and education strategies.

4. CHALLENGES AND ENABLING FACTORS

4.1. Key Challenges

Several interlocking challenges constrain the pace and depth of BMT digitalisation in Indonesia. First, digital literacy gaps remain pervasive, particularly among the rural and low-income populations that constitute BMT's primary clientele. Bank Indonesia data showing that digital financial literacy stood at only 48 percent in 2022, against a financial inclusion rate of 85.1 percent, highlights the critical importance of addressing this gap (Digital transformation in the financial system, 2024).

Second, infrastructure inequality creates asymmetric conditions for digital adoption. While internet penetration has grown rapidly—adults with internet access increased more than three-fold from 13 to 51 percent between 2011 and 2019—Indonesians in the top 10 percent of the income distribution remain five times more likely to be connected than those in the lowest 10 percent (World Bank, 2023). Cost and affordability continue to constrain fixed broadband adoption by 44 percent of Indonesian households.

Third, regulatory fragmentation between the OJK and the Ministry of Cooperatives and SMEs creates compliance complexity for BMT institutions. The absence of a unified regulatory framework specific to digital BMT operations inhibits institutional innovation and creates uncertainty for fintech developers seeking to partner with BMT networks (Septianingsih et al., 2024).

Fourth, human resource capacity constraints within BMT institutions limit their ability to implement and maintain digital systems. As the BMT UGT Nusantara case study demonstrates, human resource competence is a critical success factor for digital transformation, yet many smaller BMT institutions lack the technical expertise required to develop and manage digital financial platforms (Digital Transformation and Customer Growth in Islamic Microfinance, 2025).

4.2. Enabling Factors

Notwithstanding these challenges, several enabling factors create a favourable environment for BMT digitalisation. The Indonesian government's National Strategy for Financial Inclusion 2020–2024 provided legal basis and institutional momentum for expanding digital financial services, resulting in a tripling of e-money and branchless banking agents and the introduction of cashless social assistance programs (ADB, 2022).

The establishment of OJK's Eastern Indonesia Financial Innovation Lab (EIFIL) exemplifies institutional innovation designed to accelerate digital transformation at the regional level. By enabling regional development banks to collaborate with the fintech sector, EIFIL provides a replicable model for BMT-fintech collaboration (ADB, 2022).

Management commitment has emerged consistently in the empirical literature as a key internal enabler of successful digital transformation. The staged implementation approach observed at BMT UGT Nusantara—progressing from digital strategy planning through infrastructure development, customer outreach, and service optimisation—offers a practical framework applicable to other BMT institutions.

The growing Islamic fintech ecosystem in Indonesia, reflected in the country's third-place ranking in the Global Islamic Fintech Index 2023 (OJK LPKSI, 2023), provides BMT institutions with an expanding pool of technology partners, digital financial products, and regulatory guidance. The emergence of purpose-built digital BMT platforms creates opportunities for institutional leapfrogging, enabling smaller cooperatives to access sophisticated financial technology without the need for significant in-house technical capacity.

5. CONCLUSION AND POLICY RECOMMENDATIONS

This paper has examined the digital transformation of BMT institutions in Indonesia and its implications for financial inclusion. The evidence reviewed suggests that digital transformation carries substantial potential for expanding the reach and depth of BMT-mediated financial inclusion, yet the pace of adoption remains constrained by structural, regulatory, and capacity-related barriers.

The finding that only approximately 300 of 4,500 BMT-type cooperatives have actively engaged with fintech development—a penetration rate of roughly 6.7 percent—underscores the scale of the challenge and the magnitude of the opportunity that remains. At the same time, early evidence from institutions such as BMT UGT Nusantara demonstrates that digital transformation, when properly planned and implemented, can yield measurable gains in customer reach, transaction frequency, and fund mobilisation.

Based on the analysis presented, this paper advances four policy recommendations. First, the Indonesian government should establish a unified regulatory framework for digital BMT operations, consolidating oversight responsibilities between the OJK and the Ministry of Cooperatives and SMEs. This harmonisation would reduce compliance complexity and provide greater regulatory certainty for fintech-BMT partnerships. Second, targeted digital literacy programs should be integrated into BMT outreach activities, recognising the critical mediating role of digital financial literacy in translating financial inclusion access into welfare outcomes. Third, the EIFIL model should be replicated at the provincial level, creating regional innovation labs that facilitate BMT-fintech collaboration and support the development of locally appropriate digital financial solutions. Fourth, a national BMT apex body should be established to provide shared digital services—including technical infrastructure, data management, and regulatory compliance support—while preserving the local autonomy that has historically been central to BMT's community embeddedness.

Future research should employ longitudinal and cross-sectoral methodologies to track the welfare impact of BMT digitalisation over time, and should investigate the role of Shariah governance frameworks in shaping the adoption and acceptance of digital financial products among BMT members.

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ANALYSIS OF OBSTACLES AND STRATEGIES FOR IMPLEMENTING FINANCIAL TECHNOLOGY IN ISLAMIC BANKING SERVICES: A CASE STUDY OF BSI KC JAKARTA SAHARJO, SOUTH JAKARTA

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Abstract

This article analyzes the barriers and strategies for implementing financial technology in Islamic banking services at BSI KC Jakarta Saharjo, South Jakarta. The study focuses on the main implementation barriers, employee and customer perceptions, the bank's institutional strategy, and the impact of fintech implementation on service quality and customer experience. The research used a descriptive qualitative approach with a case study design. Data were collected through interviews, observations, documentation, and supporting data in the form of digital service user questionnaires. The results indicate that fintech implementation faces four main barriers: limited digital literacy among some customers, technical and system constraints, user resistance to digital service transformation, and the need to maintain Sharia compliance and customer trust. Nevertheless, fintech is perceived positively because it can increase the speed, convenience, efficiency, and flexibility of transactions. The bank's strategy is implemented through customer education, improving employee competency, strengthening digital security, and optimizing technology-based services that remain compliant with Sharia principles. The study concludes that successful fintech implementation in Islamic banking requires user readiness, reliable digital infrastructure, institutional support, and consistent Sharia compliance.

Keywords: Financial Technology, Islamic Banking, Digital Services, Implementation Barriers, Banking Strategy

INTRODUCTION

Digital transformation has transformed the way financial institutions design, deliver, and evaluate services to customers. In the banking context, financial technology (fintech) is no longer understood simply as a complementary transaction channel, but rather as part of the business model, service strategy, and operational efficiency improvement. This shift also extends to Islamic banking, which is required to provide fast, secure, and easily accessible services while remaining aligned with Sharia principles (Alshater et al., 2022; Selim, 2022; Idrees, 2024; Utami & Umi Khulsum, 2025).

For Islamic banking, digitalization has a more complex dimension than for conventional banking (Zouari & Abdelhedi, 2021). Service innovation is judged not only by speed and convenience, but also by its compliance with the principles of prohibiting *riba* (usury), *ghara*r, and *maysir* (*gambling*). Therefore, fintech implementation must be positioned within a framework of sharia compliance, consumer protection, data security, and institutional accountability (Nurhayati & Juliana, 2025).

Industry developments demonstrate that digital transformation has become a key strategic agenda in Indonesia's Islamic banking sector. Financial Services Authority (OJK) statistics as of January 2025 show total Islamic banking assets reached approximately IDR 948.21 trillion, third-party funds IDR 737.39 trillion, and financing approximately IDR 639.07 trillion. This data demonstrates continued growth in Islamic banking and offers significant room to strengthen digital services (OJK, 2025).

In the context of BSI, digital transformation is a key pillar of service improvement. Customer transaction activity is dominated by electronic channels and the use of digital applications such as BYOND by BSI. However, fintech implementation at the branch office level is not always smooth sailing. Initial observations at BSI's Jakarta Saharjo branch indicate challenges such as uneven customer digital literacy, technical disruptions to the network and system, the need for user assistance, and demands that digital innovation remain aligned with Sharia principles (BSI, 2025).

Based on this context, this article aims to analyze the main obstacles to fintech implementation in Islamic banking services at BSI KC Jakarta Saharjo, examine employee and customer perceptions, examine the bank's strategies in overcoming these obstacles, and explain their impact on service quality and customer experience. This article does not present a separate literature review section, but rather organizes the discussion directly into an introduction, method, results and discussion, conclusion, and references, following the format of a scientific article.

1. METHOD

This research uses a descriptive qualitative approach with a case study design. This approach was chosen because the research aims to gain a deeper understanding of the fintech implementation process, employee and customer experiences, digital service barriers, and bank strategies in a real-life operational context (Moleong, 2017).

The research location was PT Bank Syariah Indonesia's Jakarta branch, Saharjo, in South Jakarta. This location was chosen because it is within BSI's digital transformation ecosystem and serves as a direct point of interaction between the company's digital policies, employee readiness, customer experience, and daily service operational dynamics. Data collection was conducted in two phases: November 2025 and early 2026.

The research informants were selected purposively. They included two employees of BSI's Jakarta Saharjo branch involved in customer service, funding, and transactions, and four active customers who use BSI's digital services. Furthermore, the research was supported by questionnaire data from 33 digital service users as supplementary data to enrich the general trends of customer experiences.

Data collection techniques included semi-structured interviews, observation, and documentation. Interviews were used to explore informants' perceptions, experiences, and strategies. Observations were used to examine digital service practices at branches, while documentation was used to review official publications, company reports, regulations, and supporting documents related to digital Islamic banking services (Sugiyono, 2019).

Data analysis was conducted using the Miles, Huberman, and Saldana model, which includes data reduction, data presentation, conclusion drawing, and verification. The data were grouped into four main themes: barriers to fintech implementation, employee and customer perceptions, bank strategies, and the impact of implementation on service quality and customer experience. Data validity was strengthened through source triangulation, technical triangulation, and member checking.[7]

2. RESULT AND DISCUSSION

2.1. Barriers to Fintech Implementation

The research results indicate that the barriers to fintech implementation at BSI's Jakarta Saharjo branch are multidimensional. The first obstacle is limited digital literacy among some customers. Not all customers have the same level of understanding regarding digital application usage, transaction features, and account security procedures. This situation results in some customers still requiring employee assistance, especially during initial activation, using certain features, or when transaction issues occur.

The second obstacle is technical and system constraints. Digital services are highly dependent on network stability, application reliability, and system integration. When network disruptions, slow transactions, or application errors occur, customers tend to immediately contact the bank or visit a branch for assistance. This demonstrates that the quality of digital systems is integral to the quality of service itself.

The third barrier is resistance to change. Some customers still feel safer and more comfortable transacting in person at a branch office than using an app independently. This resistance doesn't mean a complete rejection of digital services, but rather demonstrates the need for a process of familiarization, proof of benefits, and ongoing support.

The fourth barrier relates to Sharia compliance and trust. In Islamic banks, digital innovation is not only efficient and fast; it must also maintain clarity of contracts, transparency, security, and be free from elements that conflict with Sharia principles. Customer trust in BSI's digital services is shaped not only by technical factors but also by the belief that the services remain compliant with Islamic values.

2.2. Employee and Customer Perceptions of Fintech Effectiveness

In general, employees and customers view fintech implementation positively. From an employee perspective, digital services help speed up service processes, reduce queues, and improve operational efficiency. Employees also view fintech as a means of shifting routine transactions to electronic channels, allowing branch services to focus on needs that require in-person handling.

From a customer perspective, fintech is perceived as a platform that offers convenience, speed, flexibility, and efficiency in transactions. Customers can make transfers, payments, purchases, and check balances without having to visit a branch office. However, this positive perception is not universally shared. Customers unfamiliar with using applications still experience technical difficulties and require assistance. Therefore, the effectiveness of fintech is heavily influenced by actual user experience, digital literacy levels, and perceived system quality.

2.3. Bank Strategies in Overcoming Obstacles

The first strategy implemented by the bank was customer education and support. Employees provided direct explanations regarding app activation, basic feature usage, and transaction security measures. This education was crucial because some implementation barriers stemmed not from technological shortcomings but from limited user understanding.

The second strategy is improving employee competency. Digital transformation requires employees not only to understand service procedures but also to act as digital facilitators for

customers. Employees must be able to explain the benefits, risks, and how to use applications in easy-to-understand language. At the branch level, employees serve as a bridge between technology and the real-life customer experience.

The third strategy is strengthening digital systems and security. Data security, application stability, and rapid response to disruptions are key elements in building customer trust. In digital banking, system disruptions can directly impact customer perceptions of service quality and the bank's credibility.

The fourth strategy is the development of Sharia-compliant services. BSI must ensure that the development of digital features remains aligned with Sharia principles, is transparent, secure, and creates no uncertainty for customers. This strategy demonstrates that the success of Sharia fintech is determined not only by technological modernization but also by the ability to maintain a Sharia-compliant identity in every innovation.

2.4. The Impact of Fintech Implementation on Service Quality and Customer Experience

The implementation of fintech has had a positive impact on service quality at BSI's Jakarta Saharjo branch. Services have become faster, more convenient, more flexible, and more efficient. Customers no longer need to visit the branch for routine transactions, while employees can reduce the burden of manual service. Thus, fintech contributes to the modernization of Islamic banking services. From a customer experience perspective, fintech creates a more convenient and flexible experience, especially for customers accustomed to using digital services. However, this positive impact has not been felt evenly. Some customers still face digital literacy challenges, technical glitches, or a lack of confidence when using digital services independently. Therefore, improving service quality through fintech must be seen as an ongoing process that requires system stability, user education, mentoring, and strengthening trust.

Overall, the implementation of fintech in Islamic banking services is a socio-technological process. Good technology still requires user acceptance, organizational support, quality infrastructure, and Sharia legitimacy. The research findings confirm that digital literacy, trust, system reliability, and Sharia compliance are the main factors determining the success of fintech implementation at BSI's Jakarta Saharjo branch.

3. CONCLUSION

This study concludes that the implementation of financial technology in Islamic banking services at BSI KC Jakarta Saharjo provides tangible benefits but faces multidimensional obstacles. The main obstacles include limited digital literacy among some customers,

technical and system constraints, resistance to change, and the need to maintain Sharia compliance and customer trust.

Employees and customers generally view fintech positively because it improves the speed, convenience, efficiency, and flexibility of services. However, the effectiveness of implementation is greatly influenced by user experience, system quality, and customer readiness to use digital services independently.

The bank's strategy to overcome these obstacles involves educating and mentoring customers, improving employee competency, strengthening digital security systems, and developing services that adhere to Sharia principles. This strategy demonstrates that the success of fintech in Islamic banking depends not only on technology but also on the readiness of people, organizations, and Sharia governance.

The impact of fintech on service quality and customer experience is evident in increased transaction speed, service efficiency, and access flexibility. However, these benefits need to be continuously strengthened through improvements in digital literacy, system stability, data protection, and consistent Sharia compliance. Therefore, the successful implementation of fintech in Islamic banking requires a balance between technological innovation, user readiness, service quality, and Sharia values.

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SUSTAINABLE CONSUMPTION BEHAVIOR: A PLANNED BEHAVIOR THEORY PERSPECTIVE

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Abstract

This study aims to investigate the factors that influence sustainable consumption behavior (SCB) using the Theory of Planned Behavior (TPB). This study examines the influence of environmental awareness, health awareness, attitudes, subjective norms, and perceived behavioral control on shaping individual consumption choices, particularly in relation to the purchase of organic food. A quantitative approach was used with a structured questionnaire distributed to 100 respondents. Data were analyzed using SPSS to test the relationship between variables and their impact on SCB. The results showed that environmental concern had the most decisive influence on SCB (β = 0.487), followed by attitudes (β = 0.308) and subjective norms (β = 0.151). However, perceived behavioral control (β = -0.074) did not significantly affect SCB. These findings suggest that individuals with higher environmental concerns are more likely to adopt sustainable consumption practices, and social attitudes and norms also play an essential role. These findings provide practical insights for policymakers and business professionals. These findings highlight the importance of promoting environmental awareness and encouraging positive attitudes and norms towards sustainable practices. For business professionals, these findings underscore the importance of marketing environmentally friendly products to consumers who prioritize environmental concerns. This study contributes to the understanding of SCB, especially in developing countries, by applying the SDGs in the context of sustainable consumption. These findings provide a foundation for future research and offer practical guidance for promoting sustainable consumption on a broader scale.

Keywords: Sustainable Consumption Behavior, Theory of Planned Behavior, Environmental Concern, Attitude, Subjective Norms, Perceived Behavioral Control, Organic Food

INTRODUCTION

Sustainable consumption behavior in the social sciences and humanities is a field of study that requires further research and deeper exploration of several constructs, particularly those related to the Sustainable Development Goals (SDGs). The 2024 Sustainable Development Index shows that no country has achieved a score of 0.9 over the last decade, and the global average has stagnated at 0.53. This gap requires strategies to encourage sustainable consumption behavior to advance and support the SDGs and achieve international targets, which require cross-sector collaboration (Arora & Mishra, 2019; Gunawan et al., 2025). Modern societies face choices in which consumption dominates the economy, accounting for more than 50% of GNP in industrialized countries. One example is agriculture in the 4.0 era, where advanced technology has become a new paradigm. But excessive consumption intensity causes environmental degradation and social problems, such as pollution, global warming, land degradation, and biodiversity loss, which impact sustainability and environmental quality (Pérez-Pons et al., 2021; Xue et al., 2021).

Sustainable consumption behavior includes consumer interest in environmental friendliness, participation in recycling, and a healthier and more minimalist lifestyle (Awuni & Du, 2016; Chi, 2022; Gunawan et al., 2025; Parker et al., 2019). This diversity reflects the complexity of consumer behavior, which evolves alongside awareness of the individual's impact on the environment (Piligrimiene et al., 2020). Research in this field primarily focuses on consumer choices and individual behavior regarding environmental and health issues that influence sustainable consumption (Liu et al., 2012; Şener & Hazer, 2008; Wang et al., 2014; Young et al., 2010). Previous studies explain that measuring sustainable consumption behavior is related to perceived environmental risks and concerns, and emphasize the importance of understanding pro-environmental attitudes and behaviors that contribute to sustainable consumption (Panda et al., 2020; Secondi et al., 2015; Yarimoglu & Binboga, 2019). Although sustainable consumption is an important part of achieving the SDGs, empirical research on the relationship between sustainable consumption behavior and other constructs involving long-term decisions remains limited, as these constructs differ from traditional economic models. The theme of sustainability has become a relevant field across many disciplines, including ethics, economics, and management. The 2030 Agenda for Sustainable Development, adopted by all UN member states in 2015, includes 17 Sustainable Development Goals (SDGs), which provide a shared plan for global partnerships to achieve a balance between human life and the planet, now and in the future. Therefore, encouraging individuals to consume sustainably is a key aspect in improving positive environmental outcomes and reducing global environmental threats such as pollution and excessive pesticide use (Mastria et al., 2023).

Several theoretical frameworks, such as the Theory of Planned Behavior (TPB), can be used to address the driving factors of sustainable consumption behavior, which emphasize attitudes, subjective norms, and behavioral control (Ajzen, 1991; Stern, 2000). Sustainable consumption behavior is important for conserving natural resources, reducing environmental impact, and minimizing waste. In addition, it can improve social and economic welfare, support the local economy and fair labor practices, and promote health by reducing exposure to toxic chemicals and encouraging healthy lifestyles (Ghaffar & Islam, 2024; Panait et al., 2023; Sheikh et al., 2023).

Recent discussions highlight the importance of value-based planned consumption, in which consumer behavior aligns with personal values that reflect concern for the environment and ethics (Linggadjaya et al., 2022). Adopting sustainable behavior is one of the best ways to address key issues of sustainable food consumption globally (Saari et al., 2021; Shah et al., 2022; Xu et al., 2022). This concept helps develop personal beliefs about sustainable behavior, providing a deeper understanding of the motivations that drive sustainable consumption and impact environmental outcomes. Although there has been theoretical progress, empirical research on the relationship between sustainable consumption practices is still primarily conducted in developed Western countries, with definitions that do not fully explore the constructs that can promote sustainability. Therefore, more inclusive research is needed, especially in developing countries. Gunawan et al. explain that an incomplete understanding of how individual choices can contribute to broader social impacts, both environmental awareness and social factors, is fundamental in shaping behavior (Gunawan et al., 2025). Environmental awareness, as a measure of a person's recognition and concern for the natural environment, serves as a fundamental cognitive driver of a person's actions (Agrawal & Gupta, 2018; Peña-Vinces et al., 2020; Pinho & Gomes, 2023).

To address these shortcomings, this study aims to investigate understanding of sustainable consumption behavior further, using SPSS to examine the research questions. The modeling approach integrates aspects of environmental awareness, health awareness, attitudes, subjective norms, and behavioral control to prepare for sustainable consumption behavior. Specifically, this study aims to (1) evaluate which variables have a more substantial influence on sustainable consumption behavior and (2) explore the formation of sustainable consumption behavior using TPB theory as a theoretical framework. The results of this study can provide deep insights into the factors that drive an individual's sustainable consumption behavior in organic food. Practically, the results of this study have important implications for policymakers and business strategists in determining appropriate policies. Understanding the factors that influence individuals to engage in sustainable consumption behavior is necessary to develop regulations and incentives that encourage environmentally responsible behavior. For business strategies, this provides targeted information to promote environmentally

friendly products that are good for oneself and consider future generations. Furthermore, from a business perspective, product managers can use the results of this study to design and market organic products aligned with the target audience. These consumers care about the environment, thereby encouraging sustainability. Overall, the insights gained from this study provide a basic framework for developing long-term strategies that not only support the achievement of SDGs but also promote a shift towards more sustainable consumption patterns globally.

1. CONCEPTUAL FRAMEWORK AND HYPOTHESIS

1.1. Sustainable Consumption Behaviour

SCB is often used interchangeably with terms such as “pro-environmental consumer behavior” (Saari et al., 2021), and Biswas & Roy (2015) explain that SCB refers to green consumption behavior. SCB is also referred to as “ethical consumption behavior” (Ganglmair-Wooliscroft & Wooliscroft, 2019). Sustainable consumption (SC) plays a fundamental role and provides legitimacy to sustainable consumption behavior. Theoretically, the emergence of sustainable consumption originated in ethical consumer research (Figueroa-García et al., 2018), which focused on its environmental aspects and sought to understand it. In the long term, organizations must be able to adjust their strategies to understand the changing demands of society, including the environmental and social aspects of the products they offer and the decision-making behind consumption (Haessler, 2020). Furthermore, the role of sustainable consumption provides a macro framework that emphasizes the idea of sustainability with a holistic approach in its research, as explained by (P. Wang et al., 2014) "sustainable consumption is a broad term that combines several important issues, such as understanding needs, improving quality of life, improving resource efficiency, increasing the use of renewable energy sources, minimizing waste, taking a life cycle perspective, and considering the dimension of justice. "Sustainable consumption" is more than just buying and consuming environmentally friendly products. It aligns with lifestyle changes, such as refraining from hyperconsumption, future orientation, and responsibility towards future generations (Dimitrova et al., 2022). A similar view is expressed by Abdulrazak & Quoquab (2018), who argue that sustainable consumption goes beyond environmental concerns by ensuring and managing existing resources, thereby meeting current demands and satisfying the needs of future generations.

Sustainable consumption behavior is a term that has emerged from various perspectives, namely policymakers', marketing's, consumer interests', and ethics', each studied using different methodologies (Onwezen et al., 2013). Sustainable consumption behavior can be studied in several sectors, including the food product market sector (Feil et al., 2020; Fischer et al., 2017; Mancini et al., 2017). More broadly, it discusses interest in organic product labels

and fair trade in purchasing decisions, as well as consumer awareness and willingness to pay for environmentally friendly local products (Tomşa et al., 2021). Customers are key stakeholders in providing demands and preferences that have a strong influence on company strategy (Aibar-Guzmán & Somohano-Rodríguez, 2021). Furthermore, sustainable consumption behavior is a series of deliberate and effective actions by consumers that impact their quality of life, while preserving the environment and resources for future generations (Guzmán Rincón et al., 2021). Research shows that sustainable consumption behavior is influenced by several determinants, namely pre-behavioral factors such as individual values or the consumers themselves (Kadic-Maglajlic et al., 2019; Lee et al., 2015; Sharma & Foropon, 2019), and then influenced by attitudes, subjective norms, and perceived behavioral control (Matharu et al., 2021; Vantamay, 2018). The study (Dong & Hua, 2018) explains that SCB is connected to nature or to a person's love for nature. SCB indicates the need to re-examine this research in a broader context, according to Y. Wang & Hao (2018), to fill a gap in previous research by examining the impact of external social factors, namely internet use, on SCB. The results of the study show that there is no significant difference in sustainable consumption behavior. However, it can increase the likelihood of transitioning from a pro-environmental attitude to sustainable behavior. Similarly, the study by Choudhary et al. (2019) found that interventions to disseminate information through social media can have a targeted effect on sustainable purchasing behavior. The complexity of SCB, which requires further exploration and broader study (Piligrimiene et al., 2020; P. Wang et al., 2014; Wu et al., 2016), provides arguments for considering broader study of both internal and external factors as important predictors of individual sustainable consumption behavior. Based on the above literature, this study aims to examine in depth sustainable purchasing behavior, including the internal and external factors that can influence it.

(Gunawan et al., 2025) Explains that sustainable consumption behavior is a holistic construct that integrates both consumption processes and broader behaviors, including long-term environmental and social considerations. This differs from ordinary consumption, which focuses only on meeting short-term economic needs, because sustainable consumption behavior is future-oriented (Gunawan et al., 2025). TPB predicts whether individuals actually follow through on their intentions to behave in an environmentally conscious manner. The gap between intention and behavior is a significant issue in sustainability research, where actions such as reducing waste, buying environmentally friendly products, or saving energy can motivate people toward long-term goals rather than immediate benefits. To bridge this gap, this study takes a TPB perspective by developing the psychological aspects of TPB, namely attitude, subjective norms, and perceived behavioral control, to present a more precise and more accurate picture of sustainable behavior, especially in the context of individual consumption.

1.2. Theory of Planned Behavior (TPB)

The Theory of Planned Behavior (TPB) is one of the theories that influences consumer behavior. (Saari et al., 2021) explains that research on sustainable consumer behavior intentions refers to the willingness of people to act and consume more sustainably by making sacrifices or paying more to obtain the benefits they receive. Because the construct of behavioral intention is often considered a mediator that can facilitate several expected outcomes (i.e., attitudes, subjective norms, perceived behavioral control), the theory of planned behavior developed by Ajzen offers an alternative approach to understanding consumer decision-making with a focus on behavior, which aims to provide a conceptual framework for understanding behavioral factors. TPB, as explained by Ajzen, predicts human behavior based on the intention to do it. Three types of beliefs influence this intention: 1) beliefs about behavior, which are related to the consequences and subjective evaluation of behavior, 2) normative beliefs, which are influenced by social expectations and norms, and 3) Control beliefs related to perceptions of factors that influence the ability to perform the behavior. The more positive the attitude, subjective norms, and perceived behavioral control towards a person's behavior, the greater the intention to perform it (Ajzen 2015, n.d.). In this case, individual behavior will be affected if they have absolute control; however, it is challenging to identify all the factors that influence it. Therefore, this study employs the TPB perspective to examine sustainable consumption behavior in organic food in Indonesia. The Theory of Planned Behavior (TPB) is used to measure the purchasing process with attitudes, subjective norms, and perceived behavioral control as predictors of individual intentions (Ajzen & Fishbein, 1977; Sharma & Foropon, 2019). TPB has been proven effective in research on positive customer behavior and green research (Kumar & Yadav, 2021; Sun & Wang, 2020). Research in Pakistan shows that health awareness, environmental concerns, and food safety influence subjective norms in organic food purchasing, validating TPB (Ishaq et al., 2021). The use of the TPB perspective in this study is justified because the TPB has been extensively researched to analyze offline and online purchasing behavior (Ahmed et al., 2021; Ayar & Gürbüz, 2021). TPB provides a framework for examining the influence of environmental concerns and trust in brands on sustainable consumption through the mediation of xenocentric behavior. Furthermore, TPB is also widely used in studies on sustainable consumption (Rausch & Kopplin, 2021). This study examines the factors that influence sustainable consumption behavior in support of environmental awareness policies. Azjen explains 1) individual attitudes are the result of positive or negative influences on behavior, beliefs can influence attitudes at certain times, and beliefs are the main determinants of individual attitudes, because attitudes toward behavior depend on the strength of beliefs and subjective evaluations of results, 2). Important desires determine subjective norms and whether we agree to do something, and, based on actions observed or inferred by others, they can serve as a reference for ourselves, thereby forming beliefs that can motivate individuals,

and 3). Perceived behavioral control depends on beliefs about resources and barriers that can influence behavior, such as skills, time, money, and cooperation with others. Based on the TPB perception, to learn more about sustainable consumption behavior. Therefore, this study proposes the following hypotheses:

H_1: Attitudes have a positive effect on sustainable consumption behavior.

H_2: Subjective norms have a positive effect on sustainable consumption behavior.

H_3: Perceived behavioral control has a positive effect on sustainable consumption behavior.

1.3. Environmental Concern

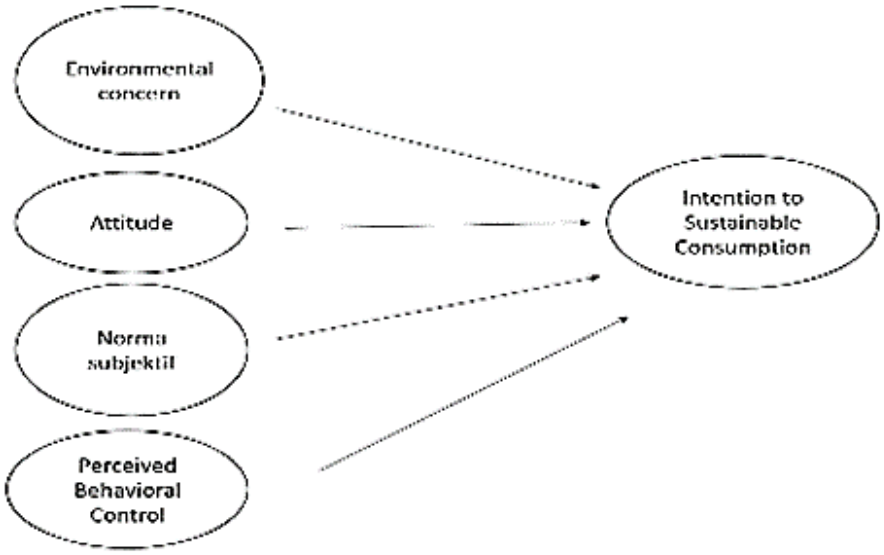
Environmental concern is an overall value orientation towards the natural environment, encompassing the level of concern about the future of the environment and the extent to which humans are damaging it (Vainio & Paloniemi, 2014). A similar opinion is expressed by Diekmann & Franzen (2019), who define environmental concern as an individual's awareness of the environment being threatened by pollution or excessive use of resources. Attitudes towards the environment can influence behavioral intentions and awareness of making sacrifices (Aldrich et al., 2007; Kotchen & Reiling, 2000). Dunlap and Jones define environmental concern as "a person's level of awareness of environmental issues and support for efforts to resolve them and willingness to contribute personally to their resolution." thus stating that there is a threat to the environment, where it is important to address environmental problems with collective efforts to resolve environmental problems and issues related to social change processes such as social issues and progress (Allen & Marquart-Pyatt, 2018). Individuals who care about the environment tend to choose ethical consumption, even if it means sacrificing short-term benefits for long-term sustainability (Berki-Kiss & Menrad, 2022). This change reflects an individual's personal environmental values and social responsibility towards future generations. Therefore, the hypothesis proposed in this study is:

H_4: Environmental awareness has a positive effect on sustainable consumption behavior.

2. METHODOLOGY

This study employed a sequential method, characterized by interrelated stages (Creswell & Clark, 2017). The study commenced with a comprehensive literature review, followed by a document evaluation to gather detailed information about the phenomenon of sustainable consumption behavior from the TPB perspective and environmental awareness.

Figure 1. Proposed Research Model



Source: Author's work

The next step is to use existing questionnaires from previous studies that have been adopted and adapted to the construct being studied, and to retest them to determine their suitability for data evaluation. This selection ensures diversity in questions and demographics, such as age, gender, and educational background, so that it represents individuals who are actively involved in sustainable consumption practices. The diverse composition of participants facilitates a deeper understanding. A preliminary test of the instrument was conducted with 30 respondents, which confirmed that it was understandable and suitable for collecting further data. The main sample in this study consisted of consumers who were aware of and had access to information on sustainability issues. Given the limitations in identifying a population of Indonesian consumers who prioritize sustainability, this study used purposive sampling. The survey was conducted online among members of environmental and sustainability-focused groups who are active on social media, as well as attendees of special environmental and sustainability-related events. There were 150 respondents, but only 100 valid responses were collected. According to Hair, the number of respondents used should be at least ten times the number of research indicators (Hair et al., 2017). SPSS software was used for data analysis in this study due to its accuracy in processing usually distributed data and identifying the effects or relationships between variables, making it particularly suitable for quantitative research involving small datasets. The methodological framework used provides a comprehensive

investigation of the positive relationship between the identified variables and a deeper understanding of sustainable consumption behavior from a TPB perspective.

3. RESULTS AND DISCUSSION

3.1. Results

The demographic profile of respondents shows that the majority are young or middle-aged consumers, aged under 55. This age group generally exhibits a higher awareness of sustainable and environmentally friendly consumption behaviors, mainly due to their greater access to information related to environmental and sustainability issues. As a result, young or middle-aged adults tend to adopt more progressive values and show increased concern for social and environmental issues. Additionally, most respondents hold a bachelor's degree and are considered educated.

Table 1. Demographic Profile of Respondents

Variables	Frequency	%
Gander		
Male	51	51.0
Female	49	49.0
Age		
18 sd 30	26	26.0
30 sd 55	62	62.0
55 sd 85	12	12.0
Education		
Senior High School	9	9.0
Bachelor	39	39.0
Master	31	31.0
Doctor	12	12.0

Table 1 shows the detailed demographic profile of the respondents used in the study. Based on gender, there were 51 male respondents and 49 female respondents, indicating an almost balanced distribution in sustainable consumption behavior. Furthermore, based on the age of the respondents, there is a variation in age, with sustainable consumption behavior predominantly occurring in the 30-55 age group, which accounts for 62% of the respondents. This suggests that most respondents belong to the productive age group, which is likely to encourage sustainable consumption behavior. In terms of educational level, the majority of respondents hold a bachelor's degree, accounting for 39% of the respondents. This reflects

the level of education required to access information on sustainability issues and environmental concerns, which are addressed through sustainable consumption behavior.

To test the reliability of the analysis and the validity of the research, the analysis uses factor analysis, with a significance level of ≥ 0.50 considered valid. Factor analysis was used to analyze the measurement model (Hair et al., 2022). This study evaluated the measurement model by assessing content validity through a review of relevant literature and by conducting instrument trials—factor loadings. Factor analysis shows that all item loadings are greater than 0.7. The purpose of this study is to test the average variance extracted (AVE), outer loadings, composite reliability (CR), and Cronbach's alpha. It shows that all factor loadings are greater than 0.5. In addition, all CR values were greater than 0.7, and AVE values were greater than 0.5, supporting the reliability and validity requirements (Hair et al., 2022), as shown in detail in Table 2.

Table 2. Reliabilitytestingand Convergentvalidity

Constructs	Cronbach's alpha	Composite reliability	Average variance extracted(AVE)
Gender	0.822		
Age	0.818		
Education	0.838		
Environmental Concern	0.697	0.928	0.957
Attitude	0.737	0.872	0.896
Norma Subjektif	0.718	0.888	0.912
Perceived Behavior	0.706	0.832	0.849
Sustainable Consumption Behavior	0.722	0.928	0.957

The reliability of each construct was measured using Cronbach's alpha, composite reliability, and average variance extracted (AVE). The Gender, Age, and Education constructs showed fairly good Cronbach's alpha values of 0.822, 0.818, and 0.838, respectively, indicating good internal consistency. The Environmental Concern construct, with a Cronbach's alpha of 0.697, had a composite reliability value of 0.928 and an AVE of 0.957, indicating excellent reliability and convergent validity. The Attitude construct has a Cronbach's alpha of 0.737, composite reliability of 0.872, and AVE of 0.896, indicating good internal consistency and validity. Subjective Norm also shows satisfactory results with a Cronbach's alpha of 0.718, composite reliability of 0.888, and AVE of 0.912. Similarly, Perceived Behavior has a Cronbach's alpha of 0.706, composite reliability of 0.832, and AVE of 0.849, indicating good reliability. Finally, Sustainable Consumption Behavior has a Cronbach's alpha value of 0.722, composite reliability of 0.928, and AVE of 0.957, indicating excellent reliability and validity. Overall, these results show that all constructs tested have sufficiently high reliability and

validity for further analysis. This supports the reliability and validity requirements (Hair et al., 2022).

Further assessment of the structural model shows that the analysis used several descriptive statistics to characterize the variables. The sample size (N) was 100 data points per variable. The range measures the difference between the maximum and minimum values, as in the "Age" variable, which has a range of 2. Minimum and maximum indicate the smallest and largest values, as in the "Education" variable, which ranges from 1 to 4. The sum indicates the total data value, while the mean (or average), as in the "Gender" variable with an average of 1.49, describes the median value of the data. Standard deviation measures data variation; a value of 0.603 for the "Age" variable indicates moderate variation. At the same time, variance is the square of the standard deviation, which in the 'Age' variable is 0.346. Skewness measures the tilt of the data distribution; a value of 0.041 in "Gender" indicates a symmetrical distribution. Finally, kurtosis measures the concentration of data around the mean, with a value of -2.040 for "Gender" indicating that the data distribution is flatter than a normal distribution.

Multiple linear regression analysis concluded that the contribution of each variable to Sustainable Consumption Behavior varies, where each variable has been normalized to eliminate the influence of units. Based on the β value, Environmental Concern has the most significant contribution with a β value of 0.487, indicating that concern for the environment plays a significant role in influencing sustainable consumption behavior. This is followed by Attitude, which makes a significant contribution with a β value of 0.308. Meanwhile, Subjective Norm has a minor contribution with a β value of 0.151, indicating a moderate influence on sustainable consumption behavior. However, Perceived Behavioral Control shows a negative β value of -0.074, which indicates that this variable does not have a significant effect on Sustainable Consumption Behavior. Thus, Environmental Concern is the main factor influencing sustainable consumption behavior. At the same time, Perceived Behavioral Control is not found to be significant in this model, as indicated by the results of the t-test conducted.

The regression analysis results show that a Sig. Value < 0.05 indicates a significant effect on the dependent variable, namely Sustainable Consumption Behavior (SCB). Based on these results, four variables have a significant effect on organizational performance (OP). The first variable, Environmental Concern, with β of 0.486 and p = 0.000, shows a significant positive effect on SCB. Attitude, with β = 0.169 and p = 0.000, and Subjective Norm, with BETA = 0.151 and p = 0.000, both show a significant positive contribution to the increase in Sustainable Consumption Behavior. Overall, the increase in these four variables contributed significantly to the changes that occurred in SCB, reflecting a positive influence on more sustainable consumption behavior. Furthermore, the ANOVA test results showed that the

regression model used in this study was of good quality. The F value of 159.803 indicates that the independent variables together can explain a significant amount of variation in the dependent variable, namely Sustainable Consumption Behavior (SCB). This shows that the factors tested have a significant contribution to changes in sustainable consumption behavior. In addition, the Sig. A value of 0.000, which is less than 0.05, indicates that this regression model is statistically significant. Thus, it can be concluded that the combination of independent variables collectively has a significant effect on SCB, reinforcing that this regression model is reliable in explaining the variation in sustainable consumption behavior.

The results of the analysis show a strong, positive relationship between the independent variables (Environmental Concern, Health Consciousness, Attitude, Subjective Norm, and Perceived Behavioral Control) and the dependent variable Sustainable Consumption Behavior (SCB), as reflected in the Correlation Coefficient (R) of 0.946. This value indicates that the higher the value of these independent variables, the higher the intention to engage in sustainable consumption. In addition, the Coefficient of Determination (R^2) of 0.895 indicates that approximately 89.5% of the variation in sustainable consumption behavior is explained by the independent variables in the model. Factors outside this model explain the remaining 10.5%. The Adjusted R^2 value of 0.889 indicates that adding variables to the model does not lead to overfitting, so all variables included provide a consistent and stable contribution to the model. Finally, the Std. The estimated value of 0.268 indicates that this model has a relatively small average deviation between observed and predicted values, suggesting it can accurately predict actual data.

The regression model developed in this study exhibits excellent explanatory power, accounting for 89.5% of the variation in sustainable consumption behavior, which is attributed to five independent variables: Environmental Concern, Attitude, Subjective Norm, and Perceived Behavioral Control. These results confirm that the combination of these five variables contributes significantly to shaping sustainable consumption behavior. Furthermore, the ANOVA test yielded an F value of 159.803 with a significance level of 0.000, which is less than 0.05, indicating that the regression model is statistically significant. In other words, the five independent variables together have a strong influence on sustainable consumption behavior (SCB). Based on these test results, the regression model used is proven to be feasible and effective in explaining the relationship between the variables studied, strengthening the validity and relevance of the results of this study.

Sustainable consumption and production have gained significant attention in several countries, both developed and developing, with diverse research constructs from culture, economic growth, political climate, and macroeconomic factors (Wang et al., 2019). This variance highlights the need to conduct research across contexts by examining sustainable consumption behavior in developing economies. The results of this study contribute to

understanding sustainable consumption behavior by proposing a conceptual model that integrates environmental concern with the TPB perspective. Specifically, the results of the study indicate that the combination of independent variables, namely Environmental concern, Attitude, Subjective Norms, and Perceived Behavioral Control, together influences sustainable consumption behavior (SCB). The results of this study (Bamberg, 2003) indicate that the environmental psychology literature suggests a weak relationship between environmental attitudes and behavioral intentions, and that environmental concerns, which indirectly influence behavior, exist. Furthermore, this is supported by TPB theory (Ajzen, 1991). Environmental concern has been shown to influence behavioral intention, which in turn mediates sustainable consumption behavior and has a direct effect on individuals (Sarri et al., 2021). Due to the complexity of the relationship between environmental concern and sustainable consumption behavior, further research is needed to investigate other variables that may influence it (Dunlap & York, 2008). Therefore, in this study, the researchers examine how the TPB perspective and environmental concern can influence individual sustainable consumption behavior.

Individuals are developing greater environmental concern, becoming more sensitive to balance, and beginning to consume consciously to achieve greater sustainability (Bartolo et al., 2023). This reflects the important role of normative beliefs and ethical values in shaping sustainable consumption behavior. Optimizing the use of more environmentally friendly products that are beneficial in themselves will foster consumer responsibility by aligning with product functionality and conditions. This involves choosing products that are not only useful but also suitable for specific situational needs, such as environmental considerations for future generations (Sheth et al., 1991). Consumers are increasingly aware of the environmental impact of their purchasing decisions and, as a result, delay or choose not to buy products that do not meet policy and sustainability criteria (Matharu et al., 2021). This suggests the increasing impact of situational factors, including product functionality and environmental friendliness, on sustainable consumption behavior. Normative preferences in sustainable consumption significantly encourage sustainable consumption behavior, with preferences shaped by consumer values and beliefs that are considered more important, mainly social and environmental issues (Toti & Moulins, 2016). The results of this study indicate that environmental awareness, behavioral intentions, subjective norms, and planned behavioral control all influence sustainable consumption behavior. These results support existing research (Saari et al., 2021), which explains that sustainable consumer behavior intentions refer to people's willingness to act and consume more sustainably by making sacrifices or paying more to obtain the benefits they receive. This is because the construct of behavioral intention is often considered a mediator that can facilitate several expected outcomes (i.e., attitudes, subjective norms, perceived behavioral control). Environmental concern drives responsibility towards nature and sustainability, which leads to behaviors that support the

conservation of natural resources (Pinho & Gomes, 2023). Furthermore, sacrifice for the welfare of others and the environment plays an important role in sustainable behavior (Guiao & Lacap, 2022). These two factors highlight the importance of responsible consumption as a link between individual values and sustainable behavior.

4. CONCLUSION

Environmental concern and the TPB perspective in exploring sustainable consumption behavior are multidimensional concepts that can influence a person's decision to consume. Sustainable consumption behavior, driven by environmental awareness, attitudes, subjective norms, and perceived behavioral control, is closely related to sustainable consumption. These elements serve as alternative pathways to encourage more sustainable consumer habits. This study was conducted on consumers who have broad access to sustainable products in Indonesia, showing positive results. Future research will focus on sustainability issues by incorporating moderating and mediating variables to gain a deeper understanding of sustainable consumption behavior in Indonesia.

5. ACKNOWLEDGMENT

The author would like to express his most profound gratitude for the support and constructive suggestions provided by Dr. Ribhan and Dr. Roslina during the completion of this research. This research was conducted as part of the Doctoral Program in Economics at the University of Lampung. The author also thanks the Faculty of Economics and Business for its academic and institutional support. Finally, the author would like to express his gratitude to all respondents and partner institutions for their significant contributions to the completion of this research.

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ISLAMIC VIEWS ON CRYPTOCURRENCY

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Abstract

This study aims to examine in depth the Islamic perspective on cryptocurrency through a qualitative research approach based on document analysis, literature study, and comparison of fatwas from various Islamic religious authorities worldwide. The rapid development of digital financial technology, particularly the emergence of cryptocurrencies such as Bitcoin, Ethereum, and various other altcoins, has raised fundamental questions regarding their status in Islamic law (fiqh muamalah). The research method used is descriptive qualitative with a normative-doctrinal approach, involving analysis of the Quran, Hadith, fiqh principles, and contemporary fatwas from the Indonesian Ulema Council (MUI), the National Sharia Council, Al-Azhar Egypt, the Fiqh Council of the OIC, and other religious authorities. The results of the study indicate that there are significant differences of opinion (ikhtilaf) among contemporary scholars regarding the law on cryptocurrency, which are divided into three main views: absolutely prohibiting it, allowing it with conditions, and reliance on the mechanism of its use. This study identifies five main dimensions of study, namely: (1) the concept of mal (wealth) in Islam and its relevance to digital assets; (2) the elements of gharar (uncertainty) and maysir (speculation); (3) the aspect of usury in digital transactions; (4) the function of currency from the perspective of maqashid sharia; and (5) governance and transparency in blockchain systems. This study concludes that comprehensive and adaptive sharia regulations are needed for digital financial innovation, as well as recommendations for stakeholders in the sharia financial industry in responding to this phenomenon.

Keywords: Cryptocurrency, Bitcoin, Islamic Law, Fiqh Muamalah, Sharia Finance, Gharar, Maysir, Fatwa, Blockchain, Fintech

INTRODUCTION

The digital financial technology (fintech) revolution has changed fundamentally the way humans transact, store value, and exchange economy. Among the most disruptive innovations in the global financial landscape is the emergence of cryptocurrency, a form of digital asset that uses cryptography to secure transactions and control the creation of new units. Since the emergence of Bitcoin in 2009 introduced by an anonymous entity named Satoshi Nakamoto, The cryptocurrency ecosystem has grown into a trillion-dollar industry with thousands of types of digital assets circulating throughout the world (Nakamoto, 2008; Ali et al., 2014).

The cryptocurrency phenomenon has not only captured the attention of the financial world conventional, but also raises profound epistemological and normative questions from the perspective of Islamic law. As a comprehensive religion with a legal system that covers all aspects of human life, including muamalah (economic transactions), Islam has a set of principles and rules that serve as a reference in assessing each form transactions and financial instruments. The fundamental question that arises is: whether Does cryptocurrency meet the criteria for legitimate wealth (mal) in Islam? Are transactions cryptocurrency contains elements of gharar (uncertainty) and maysir (gambling) which Is it forbidden? What is the position of cryptocurrency in the context of the function of money from the perspective of maqashid sharia?

The urgency of this study is further strengthened considering the number of cryptocurrency users in Muslim countries continue to increase significantly. Indonesia, as a country with the world's largest Muslim population, recorded exponential growth in transactions crypto assets. Data from the Commodity Futures Trading Regulatory Agency (Bappebti) shows that the number of crypto investors in Indonesia will reach 19.75 million people in 2023, exceeds the number of stock investors (Bappebti, 2023). This condition creates a need urge for comprehensive and responsive Islamic legal guidance to technological development.

The complexity of this problem is reflected in the diversity of views that put forward by Islamic scholars and religious institutions in various parts of the world. On the one hand, several religious authorities such as the Saudi Arabian Council of Senior Scholars and several clerics Egypt prohibits cryptocurrency on the grounds that it contains elements of gharar excessive, has no real asset backing, and has the potential for misuse for illegal activities. (Haqqi, 2018). On the other hand, a number of contemporary scholars and Islamic financial institutions is of the view that cryptocurrency can be accepted under certain conditions, as long as the mechanisms transactions comply with sharia principles (Adam, 2017; Meera, 2018). Meanwhile, MUI Fatwa Number 13 of 2021 concerning the Law on Crypto Assets as Commodities Being traded on a Futures Exchange provides a more structured legal framework in Indonesian context (MUI, 2021).

This research aims to: (1) identify and analyze legal views Islam on cryptocurrency from various perspectives of scholars and religious institutions; (2) mapping the dimensions of sharia studies relevant to evaluating cryptocurrencies; (3) analyze the fiqh arguments from various legal positions put forward by scholars. scholars; and (4) formulating managerial implications for the Islamic financial industry and stakeholders related interests. By using qualitative research methods that are comprehensive and multidimensional, this research is expected to provide a contribution meaningful academics in the treasury of Islamic economics and sharia business law.

1. LITERATURE REVIEW

1.1. The Concept of Mal (Property) in Islamic Law

The fundamental basis for assessing cryptocurrency from an Islamic perspective is the concept of mall (treasure). The fuqaha (Islamic jurists) define mal as everything which can be owned, saved and used according to Sharia (Zuhayli, 2002). Hanafiyah defines a mall strictly as something that has material properties and can be stored. Meanwhile, the majority of fuqaha from the Maliki, Syafi'i, and Hanbali schools of thought provide a definition broader, namely something that has value among humans and can traded (Harahap & Yusuf, 2018). This difference in definition has direct implications regarding the legal status of digital assets such as cryptocurrencies.

In the context of contemporary Islamic economics, Chapra (2000) argues that the concept of Malls must be interpreted dynamically to accommodate economic developments. modern, as long as the substance of its value and benefits can be identified objectively. Ibn Ashur (1946) in his magnum opus "Maqashid al-Shari'ah al-Islamiyah" emphasized that one of the one of the main goals of sharia is hifz al-mal (protection of assets), which implies that every form of property that is socially recognized and has measurable value is worthy receive protection from Islamic law. In line with this, Al-Qaradawi (2014) states that wealth in Islam is not limited to physical form alone, but rather also includes rights and benefits that have economic value.

Several contemporary Muslim scholars have applied the concept of mal to assets. digital. Laldin and Furqani (2018) argue that cryptocurrency can be categorized as a mall through the letter approach (customs that apply in society), remembering This digital asset has gained wide recognition in the global community as a medium exchange of values. However, Hassan et al. (2019) reminds us that social recognition (taqawwum) alone is not enough; it is also necessary to have real benefits (manfa'ah) that can be consumed and does not conflict with sharia principles.

1.2. Money in Islamic Perspective and the History of Islamic Economic Thought

The understanding of money (nuqud) in Islam has very deep roots. in the history of Islamic economic thought. Classical scholars such as Al-Ghazali (1097 AD), Ibn Khaldun (1377 AD), and Ibn Taymiyah (1318 AD) have formulated the theory of money which comprehensive long before Western economics developed similar theories. Al-Ghazali in "Ihya Ulumiddin" emphasizes that the function of money is as a medium of exchange (wasa'il) al-mubadalah) and may not be traded as a commodity, because this will resulting in usury (Ahmad, 2011).

Ibn Khaldun in his "Muqaddimah" identifies gold and silver as the ideal value standard because it has the necessary properties: portability, durability, divisible, and rare. Ibn Khaldun's thoughts later became a reference for some contemporary scholars who reject cryptocurrency because it has no precious metal backing (Al-Hamad, 2017). In contrast, Ibn Taymiyah held a more flexible view by accepting the validity of fiat money (fulus) as long as it is recognized by a legitimate authority and functions as an effective medium of exchange (El-Gamal, 2006).

In the context of modern Islamic finance, Iqbal and Mirakhor (2011) identified three functions of money in Islam: (1) as a medium of exchange; (2) as a unit of value (unit of account); and (3) as a store of value. Cryptocurrency, in theory, can fulfills all three functions, although its extreme price volatility creates serious questions about its ability as a stable store of value (Oziev & Yandiev, 2018). Meera (2018) in her study proposed the concept of "Islamic digital currency" which is based on precious metals as an alternative that is more compatible with the principles sharia.

1.3. Gharar, Maysir, and Riba in Digital Transactions

The three main prohibitions in Islamic muamalah are most relevant to cryptocurrencies are gharar (excessive uncertainty), maysir (speculation/gambling), and riba (interest/rent). Gharar etymologically comes from the word "gharra" which means danger or deception. Terminologically, gharar is defined as uncertainty in the object or price of a contract. can harm one of the parties (Ibn Rushd, 2000). Scholars distinguish between gharar yasir (minor uncertainty that is forgiven) and gharar fahish (serious uncertainty that is forgiven) result in the transaction being cancelled), where the latter is the object of the prohibition in Islamic jurisprudence.

The extremely high and unpredictable volatility of cryptocurrency prices is one of the reasons why one of the main arguments for the ulama who forbid it on the basis of gharar fahish. Bitcoins, for example, experienced a price drop of up to 80% in a short time and an increase up to several hundred percent in the same period. Palestinian Fatwa Committee (2017) states that this extreme uncertainty is a form of gharar that cannot be tolerated in Islamic

transactions. In line with this view, the Council of Senior Arab Scholars Saudi Arabia in its fatwa (2018) added that the non-transparent nature of cryptocurrency and anonymous has the potential to facilitate illicit activities such as money laundering and financing of terrorism.

However, a number of scholars present a different perspective. Adam (2017) in his dissertation argues that gharar in cryptocurrency is not inherently better large from conventional financial instruments such as derivatives or futures contracts that have been accepted by many Islamic financial institutions with certain modifications. Furthermore, Mufti Taqi Usmani (2018), who is generally skeptical of cryptocurrencies, admits that that not all crypto transactions contain speculative elements; some users using it as a legitimate medium of exchange. In relation to maysir, Al Suwailem (2012) provides an analytical framework that distinguishes between speculation and forbidden (zero-sum games with gambling intentions) and permissible business risks (productive risk-taking), this framework was then used by several scholars to analyzing the speculative dimension in cryptocurrency trading.

1.4. Blockchain and Transparency Study from a Sharia Perspective

Blockchain technology, which is the foundation of cryptocurrency, has unique characteristics. which needs to be studied specifically from a sharia perspective. Blockchain is a distributed ledger technology (DLT) that records every transaction permanently, transparently, and without can be changed (immutable) without the need for centralized authority. This characteristic, paradoxically, has compliance with Islamic principles of transparency and honesty in transactions (Umar, 2020).

Dusuki and Abdullah (2007) in their study of maqashid sharia and Islamic finance emphasizes the importance of transparency as a fundamental value in Islamic transactions. From this perspective, blockchain technology provides an audit trail that transparent and non-manipulable can actually be considered as a mechanism that supports the principles of amanah (trust) and shiddiq (honesty) in transactions. Some Islamic financial institutions have begun to explore the application of blockchain for smart Sharia-compliant contracts, technology-based murabahah contracts, and verification halal supply chain (Omar et al., 2019).

However, critics point out that anonymity in some types cryptocurrency actually contradicts the Islamic principle of transparency. Islam requires there must be clarity about the identity of the parties involved in the transaction (ta'aruf) as a condition for the validity of the contract. Mohamad (2018) argues that the development of "regulated cryptocurrency" which integrating Know Your Customer (KYC) and Anti-Money Laundering mechanisms (AML) into its crypto protocol has the potential to address sharia objections regarding anonymity.

1.5. Contemporary Fatwas on Cryptocurrency

A comparative study of contemporary fatwas on cryptocurrency express a broad spectrum of views. In Indonesia, the MUI through Fatwa Number 13 In 2021, it was stated that cryptocurrency is haram to be used as a medium of exchange (medium). of exchange) and means of payment, but allows trading as a commodity or digital assets in futures contracts with certain conditions that meet standards Sharia law (MUI, 2021). This fatwa is a response to the increasing trading of Islamic assets. crypto in Indonesia and the need for a clear legal framework.

At the international level, the Accounting and Auditing Organization for Islamic Financial Institutions (AAOIFI) based in Bahrain have not yet issued a definitive standard about cryptocurrency to date, although this issue has been on the discussion agenda them (AAOIFI, 2022). International Islamic Fiqh Council (International Islamic Fiqh Academy/IIFA) which is affiliated with the Organization of Islamic Cooperation (OIC) is also in the process of the process of developing comprehensive guidelines on digital currencies (IIFA, 2021). Meanwhile, Therefore, Bank Negara Malaysia and the Financial Services Authority (OJK) of Indonesia have started develop a regulatory framework for crypto assets that takes into account aspects sharia (Zainudin et al., 2020).

At the national level in various Muslim countries, there is significant variation in regulations. The United Arab Emirates through the Abu Dhabi Global Market (ADGM) has a regulatory framework that relatively progressive and accommodating towards crypto assets, including in the context of Islamic finance (ADGM, 2019). On the other hand, countries such as Bangladesh, Pakistan, and Egypt implementing more restrictive policies, although for reasons that are not always purely religious (Jalil et al., 2022). Malaysia, through Suruhanjaya Security Malaysia, implementing a middle-of-the-road approach by allowing trading of certain crypto assets which has received regulatory approval (Aziz, 2021).

2. RESEARCH METHODOLOGY

2.1. Research Approach and Type

This research uses a qualitative approach with a descriptive research type. analytical and normative-doctrinal. The selection of qualitative methods is based on the nature of the problem which is studied, namely in the form of interpretation of Islamic legal texts, analysis of fatwas, and studies comparison of the views of scholars—which requires in-depth contextual understanding than statistical measurements (Creswell, 2014). The normative-doctrinal approach was chosen because This research is based on an analysis of primary sources of Islamic law (the Koran) and Hadith) and secondary (ijma, qiyas, and ijtihad of the

ulama) in order to produce a coherent and scientifically justifiable legal proposition (Bogdan & Biklen, 2007).

This research integrates three methodological perspectives: (1) classical fiqh perspective which refers to the opinions of fuqaha from the four main schools of thought (Hanafi, Maliki, Syafi'i, and Hambali); (2) contemporary ijtihad perspective which refers to fatwas official religious institutions and the opinions of contemporary scholars; and (3) the perspective of maqashid sharia which uses the framework of sharia objectives as an instrumental evaluation tool. The integration of these three perspectives allows for a more holistic analysis and avoids legal atomism which often results in conclusions that are too narrow or contextual.

2.2. Data Sources and Data Collection Techniques

The data sources in this study consist of two main categories. First, data sources primer which includes: Al-Quran and Hadith texts relevant to the topic of muamalah and finance; classical fiqh books from the four main schools of thought; official fatwas from Islamic institutions national and international Islamic religion (MUI, AAOIFI, IIFA, Al-Azhar Egypt, Dewan Saudi Arabian scholars); and government regulations in related Muslim countries cryptocurrency. Second, secondary data sources include indexed scientific journal articles Scopus and Web of Science in the fields of Islamic economics, Islamic law, and Islamic finance; academic textbooks and monographs; reports from leading research institutions; and dissertations and theses from doctoral programs at leading universities.

Data collection techniques used include: (1) document study (document analysis) of the primary and secondary sources that have been identified; (2) content analysis (content analysis) of relevant fatwas and regulations; (3) comparative analysis towards the views of scholars from various Islamic scientific traditions; and (4) tracing systematic literature review using academic databases JSTOR, Google Scholar, EBSCOhost, and ProQuest to identify research relevant previous research. The literature search period was limited to publications between 2009 (the year Bitcoin appeared) to 2024.

2.3. Data Analysis Techniques

Data analysis in this study follows the thematic analysis model. developed by Braun and Clarke (2006), which was adapted for the study context Islamic law. The analysis process consists of six stages: (1) familiarization with the data through in-depth reading of all sources; (2) initial coding for identifying relevant units of meaning; (3) searching for main themes that reflects the pattern of Islamic legal argumentation regarding cryptocurrency; (4) review and theme refinement; (5) defining and naming the theme; and (6) compiling the report a conclusion that integrates thematic findings with academic arguments. coherent.

Research validity is maintained through source triangulation (using various sources) data from different scientific traditions), triangulation of methods (combining analysis documents, content analysis, and comparative analysis), as well as member checking through consultation with experts in Islamic law and sharia economics. The researcher's reflexivity is also taken into account by documenting the epistemological assumptions that the researcher brings into the study. analysis process, so that readers can assess the objectivity and limitations of the findings research (Lincoln & Guba, 1985).

3. RESULTS AND DISCUSSION

3.1. Spectrum of Scholars' Views on Cryptocurrency Law

The results of the analysis of various fatwas and views of scholars reveal three positions main laws, each of which has different fiqh arguments. The position The first is the absolute prohibition of cryptocurrencies, which is supported by the Council of Senior Scholars Saudi Arabia (2018), several scholars of Al-Azhar University in Egypt, and the Palestinian Fatwa Committee. Arguments They center on four main points: first, cryptocurrencies have no asset backing. so that its value is purely based on speculation; second, its extreme price volatility is a form of gharar fahish that cannot be tolerated; third, its anonymous nature facilitating illicit activities; and fourth, the creation of cryptocurrency through a mechanism "mining" has no equivalent in traditional fiqh and potentially contains elements exploitation.

The second position is conditional permissibility, which is represented by a number of institutions Islamic finance such as Bahrain's Sharia Review Bureau, several scholars from Malaysia and Indonesia, as well as several clerics from Türkiye and the Gulf region. This group is of the opinion that cryptocurrency can be allowed as long as: it is used solely as a medium exchange and not for speculation; there is clear regulation from the legitimate authorities; The transaction mechanism is transparent and free from fraud; and is not used for forbidden goals (Mufti Faraz Adam, 2017). Supporters of this position often referring to the fiqh principle "al-ashl fi al-mu'amalat al-ibahah" (the original law in muamalah is permissibility) which requires strong and specific arguments to determine forbidden.

The third position is the dependence of law on the context and mechanisms of use (tafriq al-halal min al-haram), which is the most nuanced position. MUI through Fatwa Number 13 of 2021 adopts this position by distinguishing between cryptocurrency as a medium of exchange (haram) and as a commodity traded on the futures exchange with certain conditions (allowed). This differentiation approach has received support from a number of academics such as El-Gamal (2006) who are of the opinion that Islamic law must responsive to context without sacrificing its fundamental principles. In From this perspective, there is no single answer to the question "is cryptocurrency halal or not?" haram?", because the answer depends on the type of cryptocurrency, its transaction mechanism, its intended use, and its regulatory context.

3.2. Analysis of Gharar Dimensions in the Cryptocurrency Ecosystem

An in-depth study of gharar in cryptocurrency produced findings that is more complex than the simplification often presented in public discussions. First, it is necessary differentiate between gharar at the macro level (system) and gharar at the micro level (transaction) individual). At the macro level, systemic uncertainty is indeed high considering the value of cryptocurrency is highly dependent on market dynamics that are difficult to predict, changes regulations, and global investor sentiment. However, at the individual spot transaction level (purchase and direct sales), the object of the transaction is clear (crypto tokens), the price is agreed upon at the time transactions, and handovers occur instantly in the blockchain system—this condition is relatively fulfill the requirements of a valid sale and purchase agreement (Al-Kasani, 2000).

Second, it is also necessary to distinguish between gharar al-mabi' (uncertainty in the object being traded) and gharar al-thaman (uncertainty in price). The volatility of cryptocurrency is a form of gharar al-thaman in the temporal dimension (the value can change after the transaction), which in Islamic jurisprudence is seen as different from gharar which occurs when the contract takes place. The majority of fuqaha are of the opinion that post-transaction price fluctuations do not invalidate the contract. completed buying and selling (Ibn Qudamah, 2000). The implication is the purchase of cryptocurrency for long-term investment purposes does not automatically contain gharar prohibits, unlike cryptocurrency-based derivative trading which is indeed contains more substantial gharar.

Third, there is debate about whether the high volatility of cryptocurrencies is inherent or accidental phenomenon. If it is assumed that the value of cryptocurrency will increase stable along with wider adoption and more mature regulation—as occurred in other new financial instruments in history—then the gharar that exists is of a temporary and can be reduced. This is different from gharar which is inherent and permanent on instruments that are clearly prohibited such as gambling. Oziev and Yandiev (2018) in their study of cryptocurrencies from an Islamic perspective concluded that gharar evaluation must be carried out dynamically following the development of the cryptocurrency ecosystem, not statically based on market conditions at that time a certain point in time.

3.3. Functions of Money, Maqashid Syariah, and Cryptocurrency

Evaluation of cryptocurrency through the maqashid sharia framework provides a perspective which is more holistic than purely technical fiqh analysis. Maqashid Sharia identifies hifz al-mal (protection of wealth) as one of the five objectives sharia fundamentals, along with hifz al-din (protection of religion), hifz al-nafs (protection of the soul), hifz al-'aql (protection of the mind), and hifz al-nasl (protection of descendants). In the context of hifz al-mal, the question is not simply whether cryptocurrency is technically meets the definition of a mall,

but does its existence contribute to or threaten the objectives systemic protection of assets (Ibn Ashur, 2006).

From a broader maqashid perspective, cryptocurrency has positive potential. in supporting sharia objectives. First, in the context of financial inclusion inclusion), cryptocurrency can be an instrument that empowers communities that so far not served by the conventional banking system (unbanked and underbanked) populations), including in Muslim-majority countries in Sub-Saharan Africa and Asia South (Shanmugam & Zahari, 2009). Second, low transaction costs and speed high cross-border transfers in some types of cryptocurrencies can facilitate cheaper remittances for Muslim migrant workers, which is directly contribute to the well-being of their families. Third, blockchain transparency has the potential to support more accountable and efficient waqf and zakat governance (Nofer et et al., 2017).

However, from the same maqashid perspective, there are also serious risks. that need to be considered. First, the extreme volatility of cryptocurrencies threatens its ability as a store of value is necessary for effective hifz al-mal. People who store most of their wealth in cryptocurrency are vulnerable suffered huge losses in a short period of time—a condition that clearly contradicts The purpose of sharia is to protect assets. Second, the use of cryptocurrency in transactions dark web and money laundering can be used to finance criminal activities. which is detrimental to society, which is contrary to the maqashid as a whole. Third, the electrical energy required for "mining" cryptocurrency—especially Bitcoin— using the Proof of Work mechanism—is very large and raises questions about environmental justice in the Islamic perspective of the caliphate (khalifatullah fil ardh/earth management) (De Vries, 2019).

3.4. Comparative Analysis of Sharia Regulation of Cryptocurrency in Various Countries

A comparative analysis of sharia regulatory approaches in various Muslim countries reveals diversity that reflects differences in the interpretation of Islamic law, regulatory capacity, and national economic interests. Malaysia occupies a leading position in developing a regulatory framework that seeks to integrate the principles sharia with the realities of the cryptocurrency market. Suruhanjaya Security Malaysia (SC) has developed "Guidelines on Digital Assets" which classifies crypto assets into several categories with different regulatory treatment, and the Sharia Advisory Council SC plays an active role in determining the halal criteria for crypto assets that may be traded (SC Malaysia, 2020).

United Arab Emirates, particularly through Abu Dhabi Global Market (ADGM) and Dubai International Financial Centre (DIFC), takes a progressive approach by creating a regulatory sandbox for digital financial innovation, including those based on sharia. This approach has attracted investment from a number of cryptocurrency projects and blockchain that claims sharia compliance, despite challenges in verifying claims remains significant (Al-Suwailem,

2020). Indonesia, as a country with a population of The largest Muslim, through the MUI and Bappebti has developed a framework that separating sharia regulations from capital market regulations, where both must be fulfilled simultaneously for the full legality of crypto assets (Bappebti, 2023).

Bahrain through the Central Bank of Bahrain (CBB) has issued specific regulations for the Crypto-Asset Module which includes Sharia guidelines. AAOIFI, which is headquartered in Bahrain is one of the Islamic financial standardization institutions that is actively studying the implications sharia of crypto assets, although a definitive standard has not yet been published (AAOIFI, 2022). Pakistan, after having banned cryptocurrency through a court ruling, is now in the process of developing a more structured regulatory framework with considering the fatwa from the Council of Islamic Ideology which is the highest religious authority in Pakistan (State Bank of Pakistan, 2021).

3.5. Prospects for the Development of Sharia-Compliant Cryptocurrencies

Literature review and document analysis identified several directions for development which has the potential to produce crypto instruments that are more in line with the principles Sharia. First, gold-backed stablecoins, whose value is pegged to gold price. This instrument received a warmer welcome from a number of scholars because integrating Islamic principles of real commodity-based money (nuqud) with advantages of blockchain technology. Several projects such as OneGram and Islamic Coin have developed by claiming sharia compliance, although such claims need to be independently verified (Hassan & Noor, 2020).

Second, Central Bank Digital Currency (CBDC) issued by the central bank Muslim countries with the support of official religious authorities have the potential to become a more sharia-acceptable alternative to cryptocurrencies decentralized. Bank Negara Malaysia, Bank Indonesia, and several other central banks The Gulf is currently reviewing the implementation of CBDC, taking into account its suitability with sharia principles (BIS, 2021).

Third, sharia-based smart contracts that automate the implementation of Islamic muamalah contracts - such as murabahah, musharakah, and ijarah—in a blockchain environment has the potential to increase efficiency, transparency, and Sharia compliance in Islamic financial transactions (Muneeza et al., 2018).

Fourth, real asset tokenization which changes ownership of productive assets—such as property, agricultural commodities, or infrastructure—become tokens tradable digital, is a more readily accepted blockchain application from a sharia perspective because it has real underlying assets. This model can facilitate more democratic and inclusive investment access, in accordance with the spirit of distribution of wealth in Islam (Alam et al., 2019). However,

the implementation of all This alternative requires a comprehensive regulatory framework, sharia supervision, strict, and ongoing community education.

3.6. Implications of the MUI Fatwa in the Context of the Indonesian Islamic Financial Ecosystem

MUI Fatwa Number 13 of 2021 concerning the Law on Crypto Assets as Commodities Being traded on the Futures Exchange is an important milestone in sharia regulation cryptocurrency in Indonesia. This fatwa explicitly states three main points: (1) cryptocurrency is haram to use as currency because it contains gharar, dharar (danger), and contrary to statutory regulations; (2) cryptocurrency as Trading commodities or digital assets is permissible if they meet the following conditions: has a physical/digital form, has value, the quantity is known definitively, can handed over, owned by the seller, and is an item that is bought and sold; (3) The use of cryptocurrency for investment is haram because it contains gharar, dharar, qimar (gambling), and does not fulfill the maqashid sharia (MUI, 2021).

However, the implementation of this fatwa faces a number of practical challenges. First, the boundary between permissible "commodity trading" and permissible "speculative investment" prohibited is often unclear in market practice. Second, this fatwa requires effective certification and oversight mechanisms to ensure that futures exchanges who trade crypto assets strictly comply with the conditions set out. Third, public education about the implications of this fatwa is still very limited, so that many people... Muslim investors who do not yet understand the sharia legal framework applicable to investments their crypto (Sudarsono et al., 2023).

From a comparative perspective, this MUI fatwa is in a middle position between fatwas that exist in the Islamic world. On the one hand, this fatwa is more accommodating than Saudi Arabian fatwa which absolutely forbids it; on the other hand, it is more restrictive than the views of Malaysian ulama are relatively more permissive. This middle position reflects MUI's efforts to balance compliance with sharia principles fundamental and responsive to the economic needs of the Indonesian Muslim community which continues to develop (Khoiruddin & Harahap, 2022).

4. CONCLUSION

Based on the comprehensive analysis that has been carried out, this research produces some main conclusions. Firstly, the Islamic view of cryptocurrencies is not is not a single consensus, but rather a spectrum of opinion that reflects the richness of the tradition of ijtihad in Islamic law. The diversity of existing fatwas—from absolute prohibition to conditional permissibility—reflecting the complexity of the problem which is not has direct precedent in

classical fiqh, thus requiring contemporary ijtihad which is creative but still adheres to the maqashid sharia.

Second, the evaluation of Islamic law on cryptocurrency must be contextual and multidimensional. There is no single answer that applies to all types of cryptocurrency. in all contexts of use. A proper assessment must take into account: the type and specific characteristics of crypto assets; their purpose and mechanisms of use; regulatory framework applicable; as well as market conditions and the ever-evolving technology ecosystem. The approach The differentiation (tafriq) adopted by the MUI is the right step in this direction, although it still requires more detailed elaboration and implementation.

Third, the dimensions of gharar and maysir in cryptocurrency are real and significant. but it is not absolute and inherent. There are certain conditions under which transactions cryptocurrency can be done with a level of gharar that is still within tolerance limits sharia, especially in spot transactions with clear underlying assets, strong regulations, and productive use purposes. In contrast, derivative trading, leverage, and cryptocurrency-based speculative instruments clearly contain prohibited elements in Islamic law.

Fourth, blockchain technology is the foundation of cryptocurrency in essence. compatible with Islamic values of transparency, honesty and transaction efficiency. The positive potential of this technology in supporting financial inclusion, management accountability Religious social funds (zakat and waqf), as well as the efficiency of muamalah transactions need to be explored further by the Islamic finance community. The main challenge is not the technology itself, but on how to use it within a framework that is consistent with values and sharia principles.

Fifth, synergy is needed between religious authorities, financial regulators, academics, and industry players to develop a cryptocurrency regulatory framework that comprehensive and responsive to technological developments. The experience of Malaysia, Bahrain, and the United Arab Emirates in developing a regulatory framework that integrates Sharia considerations can be a valuable reference for Muslim countries. others, including Indonesia.

5. MANAGERIAL IMPLICATIONS

5.1. For Islamic Financial Institutions

Islamic financial institutions need to develop proactive and structured strategies. in dealing with the cryptocurrency phenomenon. First, Islamic banks and financial companies Sharia needs to form a special research and development unit tasked with monitoring developments in blockchain and cryptocurrency technology and examine their implications for sharia products and services. This unit should consist of multidisciplinary teams: technologists, economists sharia, and Islamic legal experts. Second, Islamic financial institutions need to

collaborate with The Sharia Supervisory Board (SSB) to develop more detailed operational guidelines about the limitations and conditions of involvement in the cryptocurrency ecosystem, beyond guidance general given by the MUI fatwa.

Third, exploring the application of blockchain technology in financial products existing sharia—such as blockchain-based sukuk, musharakah financing platforms that transparent, and smart contract-based zakat distribution system—is a strategic step which can increase the competitiveness and relevance of Islamic financial institutions in the digital era. This investment in technology infrastructure will be a significant competitive advantage. in the long term. Fourth, developing digital sharia financial literacy for customers and employees become a strategic necessity. Islamic financial institutions that are able to become a trusted reference for questions about the halal-haram status of financial instruments digital will gain stronger customer trust and loyalty.

5.2. For Regulators and Religious Authorities

Financial regulators and Islamic religious authorities have a great responsibility in establishing a cryptocurrency ecosystem that is safe and compliant with Sharia principles. First, OJK and Bappebti need to develop a more comprehensive regulatory framework and adaptive for crypto assets, by including the sharia dimension as one of the criteria assessment. This can be done through the formation of a joint technical committee which involving the DSN-MUI and blockchain technology experts. Second, the MUI and Islamic fatwa institutions others need to develop more dynamic research platforms to respond The rapid development of the cryptocurrency ecosystem. Static fatwas will not be adequate in facing the ever-growing technological innovations.

Third, it is necessary to harmonize regulations at the regional and international levels through forums such as the IFSB (Islamic Financial Services Board), AAOIFI, and the OIC. Diversity current regulations not only create uncertainty for industry players, but also opens up opportunities for regulatory arbitrage which can be detrimental to the public interest. Fourth, education and certification programs for religious court judges, sharia consultants, and sharia auditors on blockchain technology and cryptocurrency need to be developed systematically to ensure adequate human resource capacity in oversee the implementation of regulations.

5.3. For Cryptocurrency Industry Players

Cryptocurrency industry players who want to enter the large Muslim market need to taking several strategic steps. First, proactive product development designed to comply with sharia principles—not simply claim halalness— is a strategy that can open access to the global Muslim market worth trillions of rupiah. dollar. This includes: full transparency in the working mechanisms of the crypto protocol; underlying clear and verified assets for

stablecoins; accountable governance mechanisms; and exception of use cases that clearly conflict with sharia. Second, collaboration with a credible sharia certification body to conduct halal audits and certifications independent will increase the trust of the Muslim community in crypto products that offered.

Third, industry players need to invest in educational programs that help the Muslim community understands blockchain and cryptocurrency technology accurately, avoid myths and misinformation that can be detrimental, and be able to make decisions informed investments that align with their religious beliefs. Third, active contributions in the regulatory development process—through public consultation, collaborative research, and dialogue with religious authorities—will help create a more sustainable ecosystem. conducive to the development of sharia-compliant cryptocurrencies.

5.4. For Academics and the Research Community

The academic community has a strategic role in filling the knowledge gap. that exist in cryptocurrency studies from an Islamic perspective. First, empirical research that examine the actual impact of cryptocurrency use on the well-being of Muslim communities in various countries are urgently needed to provide a factual database for decision making. regulatory decisions and fatwas. Second, the development of theoretical models that integrating the principles of Islamic economics with the realities of blockchain technology—such as “Islamic cryptocurrency” or “Shariah-compliant DeFi (Decentralized Finance)” model— is a highly relevant research agenda and has significant practical impact. Third, interdisciplinary collaboration between Islamic jurists, economists, computer scientists, and experts regulations need to be facilitated and encouraged through joint research programs, academic conferences, and collaborative scientific publications to produce comprehensive and applicable solutions.

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GOOD CORPORATE GOVERNANCE FROM A SHARIA PERSPECTIVE IN FINANCIAL INSTITUTIONS: SYSTEMATIC LITERATURE REVIEW AND BIBLIOMETRIC ANALYSIS

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Abstract

This study aims to analyze the development of Good Corporate Governance studies. Governance (GCG) from a sharia perspective in financial institutions through an approach Systematic Literature Review (SLR) and bibliometric analysis. The study was conducted on 40 articles for the period 2010–2024 obtained through Google Scholar-based Publish or Perish by following the PRISMA guidelines. Bibliometric analysis using VOSviewer for mapping the relationship between keywords and research trends. The results of the study show that Sharia-based GCG studies have developed significantly and are divided into three main focuses, namely implementation of governance principles, sharia compliance and supervisory mechanisms, as well as the influence of governance on financial performance. Research is still dominated by the financial sector. Islamic banking and quantitative approaches, while integration with sustainability issues and maqashid sharia are still limited. This finding indicates the need to develop a model sharia governance that is more comprehensive and adaptive to contemporary challenges.

Keywords: Good Corporate Governance, Islamic Corporate Governance, Sharia Governance, Systematic Literature Review, Bibliometric Analysis, VOSviewer

INTRODUCTION

Good Corporate Governance (GCG) is one of the important foundations in form organizational management that open, accountable, responsible, independent, and fair. In the context of financial institutions, the implementation of GCG principles is increasingly important because this sector is running at a high level high public trust and facing considerable systemic risk big. The global financial crisis and various cases of governance violations show that weaknesses in the monitoring system and internal controls can lead to broad impact on stability economy (Al-Suhaibani & Naifar, 2014).

From a sharia perspective, governance is not only interpreted as a mechanism managerial control, but also as a system based on moral values and Islamic principles, such as justice ('adl), trust, transparency (tabligh), and responsibility (mas'uliyyah). Therefore that is, the concept of Good Corporate Governance in Islamic financial institutions continue developing into an Islamic Corporation Governance that combines the principles of sharia principles in the structure and Company oversight mechanism (Faozan, 2015).

This integration can be seen from the existence of Sharia Supervisory Board, implementation compliance with sharia, as well as focus on achievement of sharia goals. Simultaneously with the development of the financial industry Sharia at the global level, analysis of implementation of Good Corporate Governance from a sharia perspective is increasing significantly. Studies that there is evidence that the implementation of the rules good governance in financial institutions Sharia has an impact on improving performance finance, institutional stability, control fraud, as well as increasing trust from stakeholders (Najib & Rini, 2016). In addition, Some studies also link Sharia-based Corporate Governance with performance measurement based on maqashid sharia as an approach alternatives to financial indicators traditional (Mukhibad et al., 2020).

However, the study continues to grow showing that research on Good Corporate Governance from a sharia perspective is still fragmented. Most of the research focuses on the relationship between governance and financial performance, while the other aspects conceptual, mapping research trends, as well as integration between variables such as compliance sharia, Islamic social reporting, and sustainability has not been analyzed in detail comprehensive. In addition, the dominance of research in the banking sector shows that there is the topic concentration is not yet fully able to describe developments themes comprehensively in the institution Islamic finance (Srairi, 2015). These limitations create chance using a systematic approach For Balanced Literature Review (SLR). bibliometrics. SLR with analysis allows identification of patterns, trends, and gaps in systematic research and structured. Meanwhile, the use of bibliometric mapping tools VOSviewer can display network like the relationship between

keywords, authors, and research topics, thus providing a more objective picture of development of science in the field the research.

Based on this background, This study aims to analyze research developments regarding Good Corporate Governance from a sharia perspective in financial institutions using Systematic Literature Review method and bibliometric analysis. In particular, This research aims to: (1) identify trends in publications and distribution of main themes, (2) mapping research groups based on relationships between keywords, and (3) finding gaps in research that can be a topic further research.

Thus, this research expected to contribute theoretical in improving understanding and development of governance concepts Islamic-based corporations, as well as providing practical benefits for financial institutions sharia in strengthening the system management that does not only focus on financial results, but also includes the principles of maqashid sharia and long-term sustainability.

1. LITERATURE REVIEW

1.1. The Concept of Good Corporate Governance in Financial Institutions

Good Corporate Governance (GCG) is a company management system that designed so that the business is run smoothly transparent, accountable, responsible, independent, and fair. In the financial institutions sector, the implementation of GCG principles have a high level of importance which is bigger than the sector others, because financial institutions responsible for managing funds come from the community and play a role important in ensuring system stability overall finances. Governance systemic, which is not good can cause risks lower public, And trust result in possibility of a crisis (Al-Suhaibani & Naifar, 2014).

In its implementation, GCG in institutions finance includes monitoring mechanisms by the board of commissioners, the performance of the audit committee, effective internal control system, as well as level of transparency in disclosure information. Empirical studies show that quality of governance affects stability and the financial performance of the institution, including in the context of countries that implementing a financial system based on sharia (Buallay, 2021).

However, the concept of GCG which conventional is considered not yet fully can consider ethical aspects and religious values, especially in institutions operating Islamic finance based on Islamic principles. By Therefore, the concept of Governance emerged Sharia Value Based Companies or those that known as Islamic Corporate Governance becomes an adaptation of corporate governance principles integrating sharia values.

1.2. Islamic Corporate Governance and Sharia Governance

Company Management based on principle Islam (Islamic Governance/ICG) is a development Corporate from the concept of corporate governance in general general corporate governance (GCG), where the principles of corporate governance management is integrated with values sharia values. Different from the system conventional company management, ICG integrating compliance with the law Islam as an inseparable part from internal control mechanisms Company. One of the important components in ICG there is a Supervisory Board Sharia (DPS), which is tasked with ensuring all operational activities of the institution finances run according to the principles sharia principles (Faozan, 2015; Pratiwi & Amaliyah, 2020).

This mechanism is known as sharia government, internal supervision based on namely the system compliance with sharia teachings. Research shows that the government's implementation Sharia is able to have a positive impact in in order to reduce the risk of action deviations and increase the level of organizational integrity (Najib & Rini, 2016). In addition, good disclosure regarding governance Sharia management is also related to increasing reputation and trust from stakeholders (Srairi, 2015). With Thus, Corporate Governance is based on Islam does not only play a role as a tool control, but also as a suggestion recognition of moral values.

1.3. Good Corporate Governance, Sharia Compliance and Performance

Extensive empirical research analyze the relationship between the application of principles GCG with achievements or work results Islamic financial institutions. Performance in general generally assessed based on indicators financial such as Return on Assets (ROA), Return on Equity (ROE), as well as ratios stability. Existing research shows that there is a governance mechanism good management has a positive impact on work results and bank stability sharia (Susanto & Walyoto, 2023; Umiyati et al., 2020). In addition to measuring performance conventional finance, approach based on maqashid sharia is also increasingly developed as another alternative in measurement. This approach evaluates how big is the institution's capacity finance in realizing goals sharia, such as achieving justice, improve social welfare, as well as ensure equitable distribution of wealth. Research shows that the implementation of Islamic-based Corporate Governance have a positive impact on improving company performance (Mukhibad et al., 2020; Safitri & Mukhibad, 2020).

Furthermore, a number of studies shows the relationship between governance with an effort to prevent action deviations within the organization as well as effective risk management. Implementation Good governance has been proven to improve level of transparency and strengthening the system internal control (Husaeni & Jayengsari, 2020). This shows that governance of sharia perspective does not only pursue benefits, but also pay attention to integrity and sustainability.

1.4. Theme Development and Gaps Study

Although research on Good Corporate Governance from a sharia perspective more and more, some major patterns still continues to appear in the literature. First, research tends to be more focus on the banking sector sharia compared to institutions non-bank finance. Second, the approach that used by most researchers quantitative, namely by testing the relationship between governance variables and performance. Third, conceptual analysis and mapping systematic about theme development is still classified as limited. Some studies conducted in various countries shows that management system and transparency in Sharia practices show differences in each region, which then influences differences in ability and image the institution (Buallay, 2021). However, there are still few comprehensive research describes the structure of intelligence and development topic use bibliometric approach.

In addition, the integration between Good Corporate Governance, Sharia compliance, maqashid sharia, as well as contemporary issues such as sustainability and social reporting Islam is still in its developing stage and has not been analyzed systematically in one integrated literature framework. Therefore Therefore, a literature review approach is needed systematically balanced with analysis bibliometrics to identify trends, topic groups, as well as weaknesses in research more objectively and organized.

2. RESEARCH METHODOLOGY

This research uses an approach Systematic Literature Review (SLR) which combined with bibliometric analysis to review research developments regarding Good Corporate Governance in the perspective of sharia in institutions finance. In Indonesian, Systematic Literature Review (SLR) means systematic literature review (Information et al., 2023). SLR aim is a literature review method that For identify, evaluate and interpret all findings related to a research topic in order to answer the research questions specific. The SLR method was chosen because it is capable of identify, evaluate, And synthesize the results of previous research systematic, transparent, and structured (Triandini et al., 2019). Through this approach, research does not just summarize previous findings, but also identify pattern, trends, and research gaps.

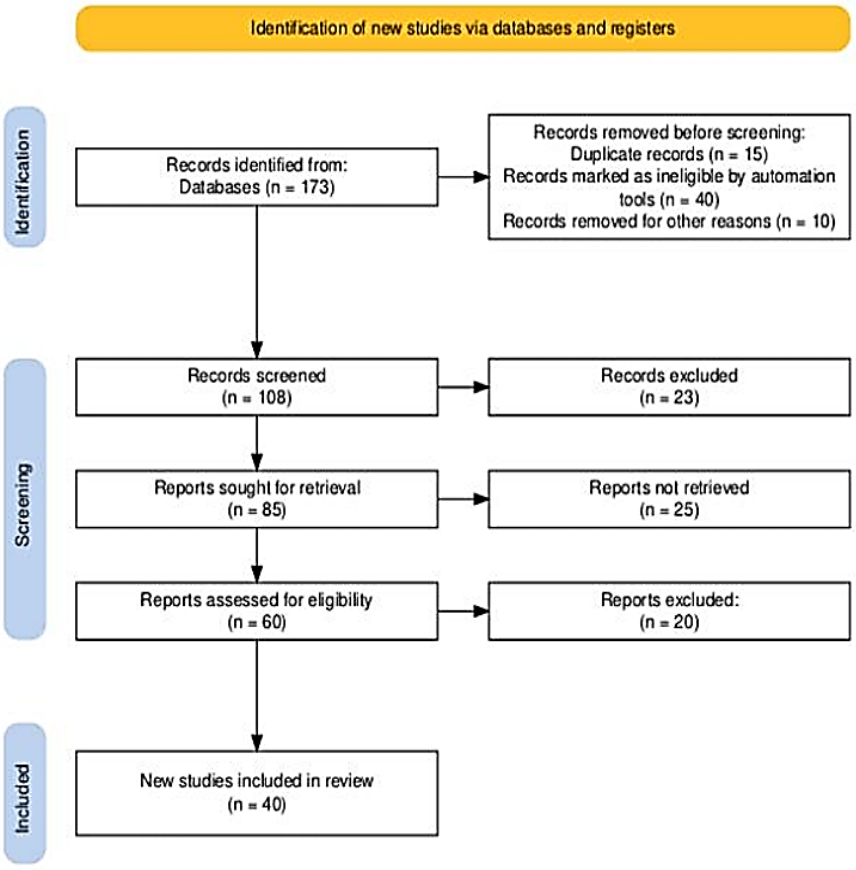
Formulating research questions becomes the initial stage in the implementation of SLR because determine the direction of search and selection literature. Based on the research objectives, The research questions asked are:

RQ_1: How is the research progressing? regarding Good Corporate Governance in the perspective of sharia in institutions finances during the period 2010–2024?
RQ_2: What variables and themes are most dominant in Islamic Corporate research Governance?

RQ$_3$: What are the research gaps? (research gap) which can still be obtained developed in further research?

The literature collection process was carried out using the Publish or Perish app (PoP) with Google Scholar database. Keywords used include “Good Corporate Governance”, “Islamic Corporate Governance” and “Sharia Governance” with publication year restrictions 2010 2024. Initial search results yielded 173 articles in the identification stage. Process literature selection follows guidelines PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) which aims to increase transparency and the quality of reporting of systematic reviews.

Figure 1. PRISMA (Preferred Reporting) Flowchart Items for Systematic Reviews and Meta Analyses



At the pre-screening stage, as many as 15 articles were removed due to duplication, 40 articles eliminated by automated tools, and 10 articles issued for other reasons, so that 108 articles remain for the screening stage. At the filtering stage based on the title and abstracts, a total of 23 articles were eliminated because it is not relevant to the research focus, so that there are 85 articles left for the process full text search. Of these, 25 articles are not accessible in the form full text, so 60 articles were assessed its eligibility through reading comprehensive. In the final stage, 20 articles eliminated for not meeting the criteria inclusion and methodological quality, so that There were 40 articles included in final analysis. In addition to qualitative analysis of the content article, this research also uses bibliometric analysis with the help of device VOSviewer software which developed by van Eck and Waltman (2010). Bibliographic data in the form of titles, abstract, keywords, author name, and year publications exported from Publish or Perish to be visualized in network form visualization, overlay visualization, and density visualization. This analysis is used to identify the relationship between words key, mapping research theme clusters, and see the trends in research developments Islamic Corporate Governance from time to time time.

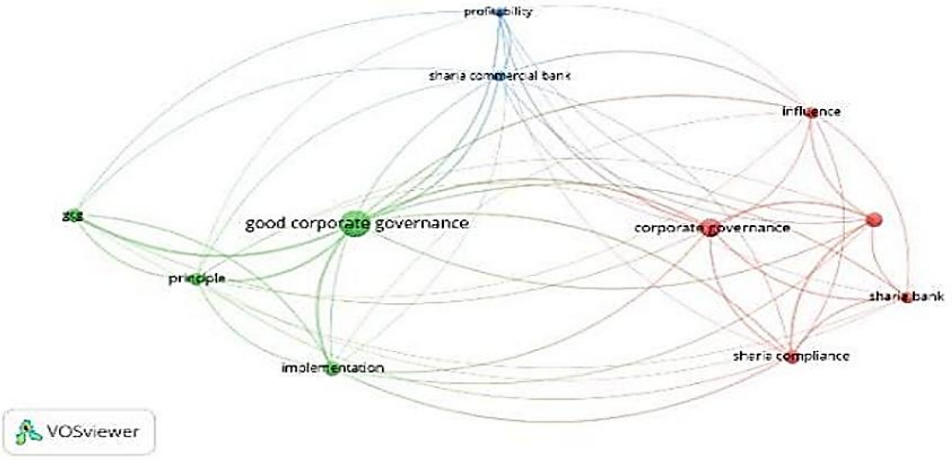
With a combination of SLR and analysis bibliometrics, this research expected to be able to provide an overview comprehensive regarding developments literature, dominant themes, and opportunities further research development in field of sharia governance in institutions finance.

3. RESULTS AND DISCUSSION

3.1. Bibliometric Analysis Results

This study uses analysis Bibliometrics to find trends latest research on GCG in Sharia perspective on financial institutions. In this analysis, the data that is visualize including the most writers influential, topic clusters, keywords main, and publication distribution patterns by year. Software such as VOSviewer or Bibliometrics is used to process data and create maps bibliometrics. Bibliometric analysis, using more than one hundred search results articles to identify the relationship between trends research and keywords indexed in Publish or Perish in the period 2010 to 2024, a network visualization map was obtained generated through software VOSviewer, the result of Network Visualization which is shown in the image below:

Figure 2. Network Visualization Result Image

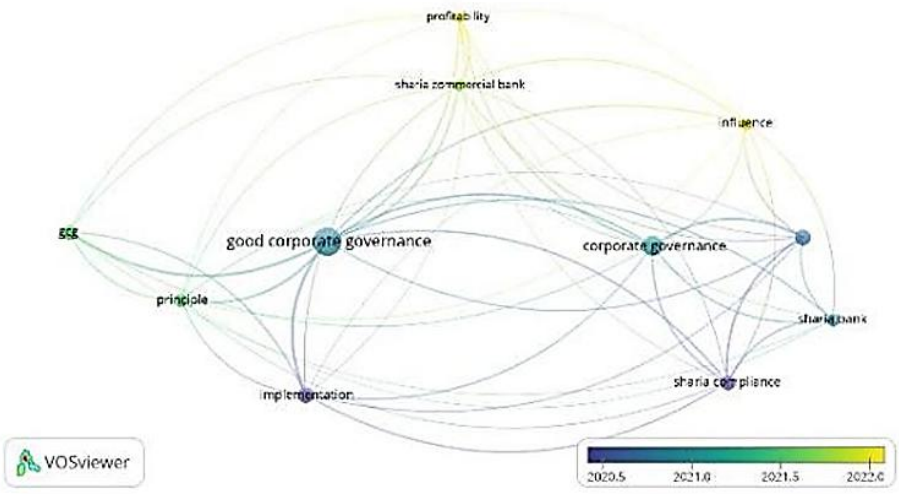


Based on the results of the analysis using VOSviewer, visualization maps on images shows the network of relationships between words key that represents the focus of the research regarding Good Corporate Governance (GCG) in the context of financial institutions. Each color show One cluster represent interrelated research themes related. The visualization is divided into Which three main clusters. The green cluster is centered on keywords good corporate governance as the largest node, which indicates that the term This is the main focus of the research. Cluster it also includes keywords such as principle, implementation, and gcg. Matter This indicates that most of research discusses basic concepts, principles, and implementation of GCG in financial institutions. The focus on this cluster tends to be conceptual and normative, namely how the system manage applied based on principle transparency, accountability, responsibility, independence, and fairness. Red cluster display keywords such as corporate governance, sharia compliance, influence, and bank. Even though there is the term sharia compliance, the context is more about compliance This cluster demonstrates research that analyzes the impact of corporate governance implementation on compliance and oversight aspects, as well as their impact on the institution's operations finance. Meanwhile, the blue cluster focuses on the performance aspect, with keywords such as profitability and commercial bank. This cluster shows that a number of studies link the implementation of corporate governance with particular performance finance, profitability. The relationship between the blue cluster with green and red clusters indicating that good governance is not only administrative dimension, but also has an impact on the financial performance of the institution.

In a way overall, map this shows that research on Good Corporate Governance in institutions structured finance in three main focuses, namely: (1) principles and implementation of governance, (2) compliance and its impact on operational, and (3) its impact on financial performance. The relationship between clusters strong enough to show that all three aspects are mutually integrated and become the foundation important in creating financial institutions transparent, accountable and sustainable.

Based on results using VOSviewer, the image is is an overlay visualization that analysis shows the development of research trends based on the average year of publication. Scale color at the bottom (2020–2022) indicates that the color blue represents relatively research longer, while the yellow color shows newer topics. Words keys such as implementation, sharia compliance, and corporate governance tends to be blue to green bluish, which means the topic is more much discussed in the early period (around 2020–2021). This shows that previous research focused more on aspects of implementation and compliance in financial institution governance.

Figure 3. Keyword Overlay Visualization Image



Meanwhile, keywords such as profitability and influence are visible in color more yellow, which indicates that the topic this is becoming a newer research trend (approaching 2022). This means that the direction of research starting to shift from conceptual discussions and implementation towards impact analysis or the influence of governance on performance and financial results. As for good corporate governance is in a state of transition (green), indicating

that this topic consistently researched throughout the period and be a liaison between research beginnings and latest trends.

Overall, the visualization This overlay shows a shift research focus from the aspect of governance implementation manage towards analyzing its impact on performance and profitability of financial institutions. This can be the basis for identify further research opportunities, especially in testing causal relationships and more comprehensive empirical models.

3.2. Results of the Systematic Literature Review

In this research, the Systematic process Literature Review was conducted on 40 articles that have passed the selection stage based on PRISMA guidelines. Article the article was published in the period 2010–2024 and obtained through search using Publish or Perish Google Scholar-based selection process focused on research that discusses Good Corporate Governance in sharia perspective on financial institutions, both from a conceptual and empirical perspective. The results of the study show that the research regarding sharia-based governance experienced considerable development significantly in the last decade. Summary of the characteristics of the article analyzed including author, year of publication, research methods, variables used, and the main findings of the research, which will be presented in Table 1.

RQ_1: How is the development research on Good Corporate Governance in a sharia perspective on financial institutions during the period 2010 2024?

Based on results analysis, research developments can be divided into in three main phases. In the period 2010 2015, research is still conceptual and normative, with a focus on integration principles of Good Corporate Governance with sharia values and discussion regarding internal oversight mechanisms and compliance. In the 2016–2019 period, research is starting to shift towards empirical by testing the influence of the mechanism corporate governance on performance financial institutions. Quantitative approach began to dominate with the use of regression analysis to measure the relationship between governance structure and indicators profitability. Furthermore, in the period 2020–2024, study show increasing number of publications and complexity of analysis. The focus of the research is not only on implementation, but also on the influence of governance on profitability, stability, and effectiveness of control risk. This shows the existence of evolution from a normative approach to a practical approach impact testing based.

RQ_2: What variables and themes are most dominant in Islamic research Corporate Governance?

From several articles analyzed, There are several dominant themes. First, the theme regarding implementation principles of Good Corporate Governance and internal oversight

mechanisms. Second, the theme regarding sharia compliance emphasize importance suitability operational financial institutions with sharia principles. Third, the theme regarding financial performance, in particular profitability measured through indicators such as ROA and ROE. Most of study positioning corporate governance as an independent variable which affects financial performance. Meanwhile, the use of performance indicators based on maqashid sharia is still relatively limited compared to the indicators conventional finance.

RQ_3: What are the research gaps? which can still be developed?

Based on the literature synthesis, there are several research gaps that can be become an opportunity for study development Next. First, the object of research is still dominated by the banking sector, while there are not many non-bank financial institutions analyzed in depth. Second, research approaches are still dominated quantitative methods, so that the approach qualitative or mixed-method can be alternatives to enrich understanding implementation of governance. In addition, integration between sharia governance and issues sustainability, social reporting, and digital transformation is still relatively limited. Therefore, further research can develop a governance model that more comprehensive by including these contemporary variables. Overall, the results of the Systematic This Literature Review shows that research on Good Corporate Governance in a sharia perspective has has grown significantly, but still have room for development especially in expanding the object of study and integration broader research variables.

Table 1. Article Analysis Results

No	Researchers (Year)	Object Study	Results
1	Al Suhaibani & Naifar (2014)	Institution Finance Islam	Islamic corporate governance support stability and structure sharia ownership.
2	Faozan (2015)	Bank Sharia Indonesia	Sharia governance through DPS improves operational compliance.
3	Najib & Rini (2016)	Bank Sharia Indonesia	Sharia compliance and ICG reduce risk fraud.
4	Srairi (2015)	Bank Sharia GCC	Disclosure governance improves bank performance.
5	Mukhibad et al. (2020)	Bank Sharia Indonesia	ICG has a positive effect on maqashid performance.
6	Buallay (2021)	Bank Sharia MENA	CG and sharia governance improves financial performance.

No	Researchers (Year)	Object Study	Results
7	Umiyati et al. (2020)	Bank Sharia Indonesia	ICG and sharia compliance increase profitability.
8	Husaeni & Jayengsari (2020)	Bank Sharia Indonesia	CG is effective in fraud prevention.
9	Susanto & Walyoto (2023)	Bank Sharia Indonesia	CG strengthening stability finance.
10	Safitri & Mukhibad (2020)	Bank Sharia Indonesia	ICG contributes on achievement maqashid sharia.
11	Haryati & Cahyati (2020)	Bank General Sharia Indonesia	GCG has a positive impact on the financial performance of Islamic banks.
12	Kholid & Bachtiar (2016)	Bank General Sharia Indonesia	Commissioners have a positive influence, audit committee has a negative influence, DPS has no influence influence the performance of maqashid.
13	Firmansy Ah & Devi (2017)	Institution Zakat Indonesia	GCG strategy is focused on transparency, accountability, and strengthening the management system.
14	Rahman & Haron (2019)	Bank General Sharia Indonesia	SSB and board structure influence the performance of maqashid.
15	Amelinda & Rachmaw heart (2021)	Bank General Sharia Indonesia	GCG has a significant impact on financial performance.
16	Lidyah (2019)	Bank General Sharia Indonesia	ICG no influence on fraud; Islamicity index influences fraud.
17	Rini (2014)	Bank Sharia Indonesia	The implementation of ICG is not optimal, especially in sharia compliance.
18	Qoyum et al. (2017)	Bank General Sharia Indonesia	Independent commissioners have a negative influence on ISR based CSR disclosure.
19	Institutions & Laela (2020)	Bank General Sharia Indonesia	Characteristics of the board affect the performance of maqashid sharia.
20	Ningseh (2021)	Bank Transactions Indonesia	Implementation GCG in harmony with the principle Islamic law.

4. CONCLUSION

Based on the results of Systematic Literature Review and bibliometric analysis, research This concludes that the study of Good Corporate Governance in sharia perspective on financial institutions experienced significant development during the period 2010–2024. Development This shows a shift in focus research from a conceptual approach and normative towards an empirical approach test the influence of governance on financial performance and stability of the institution.

Dominant research themes includes the implementation of Good Corporate Governance principles Corporate Governance, sharia compliance, oversight mechanism through the Council Sharia Supervisors, and the influence of governance on profitability as measured through indicators such as ROA and ROE. However However, most of the research is still focused on the Islamic banking sector and using quantitative methods, so that qualitative and mixed-method approaches still has room for development.

In addition, the integration between governance sharia with contemporary issues such as sustainability, Islamic social reporting, maqashid sharia, and digital transformation is still relatively limited. Therefore, further research is expected to be able to developing a sharia governance model more comprehensive by expanding object of study and research variables. In General Overall, this study provides systematic overview of the structure and direction of development of governance literature sharia-based and identify opportunities to strengthen the Islamic Corporate concept Governance in the future.

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ANALYSIS OF CRISIS COMMUNICATION STRATEGY AND RESTORING CUSTOMER TRUST FOLLOWING THE BYOND APPLICATION DISRUPTION BY BSI

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Abstract

This study analyzes the emergence of service disruptions. Recurring downtimes in the Byond by BSI application during 2025 and their impact on customer trust. To evaluate communication methods in crisis situations and efforts to restore the good name of PT Bank Syariah Indonesia Tbk. Researchers used a descriptive qualitative approach by collecting secondary data from official social media such as Instagram and Twitter as well as online news. The study shows that system disruptions that occurred in February, June, and September 2025 caused dissatisfaction because the bank's response seemed too uniform and used the same pattern. Restoring customer trust is not enough just by saying an apology, but also requires transparency, education about financial literacy, and concrete evidence that the technological infrastructure has improved.

Keywords: Crisis Communication, Customer Trust, Byond by BSI, Downtime

INTRODUCTION

Background

PT Bank Syariah Indonesia Tbk (BSI) is the largest state-owned Islamic bank in Indonesia. Established on February 1, 2021, through the merger of three state-owned Islamic banks—Bank Syariah Mandiri, BNI Syariah, and BRI Syariah—BSI plays a vital role in strengthening the national Islamic financial ecosystem and driving Indonesia to become a global hub for the halal industry. BSI was established as a result of the Ministry of State-Owned Enterprises' strategic transformation to integrate the strengths of government-owned Islamic banks.

BSI provides comprehensive Islamic financial services, including savings, financing, treasury, and digital services. All products adhere to Sharia principles established by the National Sharia Council of the Indonesian Ulema Council and are supervised by the Financial Services Authority. As a commercial Islamic bank, it also carries out social functions through the management of zakat, infaq, and waqf (endowments).

In 2023, BSI ranked among the top five banks in Indonesia by assets and among the top 10 global Islamic banks by market capitalization. The bank is the largest zakat contributor in Indonesia and continues to expand its reach, opening an international branch in Dubai in 2023.

Identification of problems

Identification problem in study This is based on the difference between expected reality and actual reality regarding the quality of digital banking services. Customers expect services with high stability, speed, and continuous accessibility, but the reality on the ground shows system disruptions (errors) that hinder transactions on mobile banking channels and ATMs (Kasus et al., 2024). This problem is actual and real, where the systemic failure has a significant negative impact, both financially (Ahsyar, 2025) and psychologically, including the emergence of concerns about the security of funds and the potential for material losses due to transaction failures at crucial moments.

Fundamentally, the main cause of this problem is rooted in the digital innovation transition phase undertaken by Bank Syariah Indonesia through the launch of the Byond by BSI SuperApp. (Fasya et al., 2025) Although this innovation was planned to replace the previous application to provide a more modern and integrated transaction experience, the implementation process faced serious technical obstacles. There was a clear difference in performance comparison between the stability of the BSI system and the stability of the BSI system. Old mobile with the Byond by BSI application. (Septianingrum et al., 2025) characterized by repeated service disruptions so that customers cannot perform basic banking functions such as transfers and payments.

This operational failure is categorized as a cyber impact that causes fundamental inconvenience to customers. (Rizal & Ardhian, 2023) Trust is crucial in the banking ecosystem. Therefore, repeated service disruptions risk eroding customer confidence in the professionalism of digital system management and negatively impacting the institution's reputation. As a further implication, banks are required to prioritize ethical standards in their interactions with customers to restore credibility, an integral part of sound business ethics (Hasibuan, 2024).

Previous Research

Previous research conducted by Aditya Nugraha Putra and Siti Puspitasari (2024) entitled "Crisis Communication in the Digital Era: A Case Study of Handling a Reputation Crisis at Brand X on Social Media" used a qualitative approach with a case study design. The results showed that transparency, speed of response, and appropriate narratives were the main factors in mitigating reputation crises on social media. The study concluded that a responsive and engagement-based crisis communication approach proved effective in helping restore brand reputation. (Putra, Aditya Nugraha, Puspitasari, 2024).

Previous research conducted by Hasyim, Dhea Annisa Siregar, Lia Damayanti Sinaga, Rory Jelika Rani Br Barus, and Wantryni Parhusip (2025) entitled "The Effect of Mobile Banking Service Quality on Generation Z Customer Loyalty" used the Systematic Literature Review (SLR) method by analyzing empirical articles from 2019–2025. The results of the study show that the quality of mobile banking services has a significant effect on the loyalty of Generation Z customers both directly and through the mediation of satisfaction and trust, with the dimensions of security and ease of use as dominant factors. (Hasyim et al., 2025).

Previous research conducted by Nadiaika Purnama (2024) entitled "The Effect of Mobile Banking Service Quality and Trust on Customer Loyalty Mediated by Customer Satisfaction at PT Bank Syariah Indonesia KCP Medan Pulo Brayan" used a quantitative approach with an accidental sampling technique on 100 respondents and was analyzed using Smart PLS. The results showed that the quality of mobile banking services had a significant effect on customer loyalty. Customers, trust has an impact on customer satisfaction, and customer satisfaction has been proven to mediate the relationship between service quality and trust on BSI customer loyalty. (Purnama, 2024).

Previous research conducted by Devianty Milania Tannavaro and Sidi Ahyar Wiraguna (2025) entitled "Public Relations Communication Strategy in Cyber Crisis: Case Study of BPJS Kesehatan and Bank Syariah Indonesia" used literature study and case analysis methods with reference to crisis communication theory, public relations code of ethics, and Law No. 27 of 2022 concerning Personal Data Protection. The results of the study showed that the success of public relations in dealing with a digital trust crisis is largely determined by the

ability to convey information quickly, openly, and ethically, as well as collaboration with internal divisions such as IT and legal in an effort to restore reputation and maintain public trust. (Tannavaro, Devianty Milania, 2025).

Objective

1. To analyze the impact of service disruptions (downtime) on the Byond by BSI application on the level of customer trust of Bank Syariah Indonesia.
2. To determine customer perceptions of the quality of BSI digital services after system disruptions and transaction errors occurred.
3. To analyze the impact of digital service disruptions on image and BSI's social media reputation.
4. To formulate recommendations for strategies to restore customer trust post service disruption.

1. METHODOLOGY

This research uses a qualitative approach with a descriptive method for a descriptive study (Research et al., 2018), namely analyzes crisis communication strategies and efforts to restore customer trust following the disruption of BYOND by BSI digital banking services in 2025. A qualitative approach was chosen because this study seeks to understand in depth how companies respond to crises through public communication and how these responses are received and responded to by customers in the digital space. Descriptive research is used to systematically describe the forms of crisis communication carried out and the dynamics of public responses that emerge during and after service disruptions.

Research data was obtained through BSI's official social media platforms, such as Instagram, Twitter, and the website, as well as public comments related to the service disruption. Data was also collected from online media coverage of the incident. Information from news reports and official statements. The company's crisis events were then compiled into a chronology of events as the basis for analysis. The data collection method used secondary data obtained through online media coverage discussing the disruption of BYOND digital banking services, official company statements, and scientific journal articles relevant to crisis communication theory and customer trust restoration.

2. RESULTS AND DISCUSSION

2.1. Results

Based on the results of observations and secondary data collection from online media and official social media of PT Bank Syariah Indonesia Tbk, it was found that service disruptions

(downtime) of the Byond by BSI application occurred repeatedly throughout 2025 in three main periods, namely, February, June, and September.

In the first period (February 8-11, 2025), as quoted from kompas.com, the disruption not only occurred in the Byond by BSI application, but also impacted ATM services and QRIS or EDC transactions, especially in the Aceh region. This disruption caused disruption to people's economic activities because most transactions depend on the BSI banking system. Management stated that the disruption was caused by the system update process and ensuring customer funds and data remain secure. (Respati, 2025). In the second period (early June 2025), as quoted from detikfinance, the disruption occurred at the beginning of the month, when people's transaction needs increased. Customers reported that the application could not be accessed, error notifications appeared, or only displayed a white screen. The bank stated that technical problems and a surge in user fees were the main causes. (Andi, 2025) In the third period (September 2025), as quoted from CNBC Indonesia, the disruption lasted more than 24 hours and again caused widespread complaints from customers. Management stated that these obstacles were part of the system recovery and improvement process. The bank also emphasized the security of customer funds and urged customers not to provide personal data to parties claiming to represent BSI. (Zefanya, 2025).

Of these three incidents, a pattern emerged indicating that recurring system disruptions occurred in the context of system updates or increased digital service capacity. Several customer comments generally included complaints about transaction failures, as well as some frustration due to the prolonged and repeated disruptions over several months, and the bank's response with a relatively consistent communication pattern (Khoirunnisa et al., 2024).

Table 1. Bank Syariah Indonesia's Instagram and Twitter comments

Category Comment	Customer Comments Content	Bank Response Pattern
Complaint Technical	The system error occurred when BSI used the new application, namely Byond by BSI.	Submit an apology for the problems and services experienced and provide an explanation.
	The transfer had already been made but when checked, there was no error.	Submit an apology and explain that the byond by bsi application is currently undergoing quality improvements.
	The system is undergoing quality improvement but there is no change	Offer an apology and provide an explanation of the maintenance of the Byond by BSI system

Category Comment	Customer Comments Content	Bank Response Pattern
Disappointment	Loss of trust so that you don't want to use BSI anymore	Submit an apology and inform customers that Byond by BSI is undergoing system upgrades.
	Customers ask that bank workers be more effective in their work	Submit an apology and provide information that using Byond by BSI periodically
	Complaining that the downtime is too long	Submit an apology and DM invitation for further information
Request Compensation	Transaction failed but balance decreased and asked where the money was	Submit an official apology and DM invitation for further confirmation
	Asking where the money is, transferred to BSI but it didn't come in	Submit an apology and provide information that use Byond by BSI regularly

Source: Bank Syariah Indonesia's Instagram and Twitter comments

Customer comments and responses from the bank itself can be seen in a relatively uniform or similar pattern, namely conveying an apology as a form of communication to customers (Syam, 2024), explaining that the system is undergoing maintenance or capacity improvement, and encouraging customers to contact customer service via direct message or call center. Therefore, in some cases, customers still express dissatisfaction due to the response given is considered to be a template and does not provide a direct concrete solution. This shows that the crisis communication strategy has been implemented, but its effectiveness in restoring the perception of service reliability still needs to be improved.

2.2. Discussion

2.2.1. Digital Service Disruption as an Operational and Reputational Crisis

A digital banking service disruption is a form of operational crisis that has the potential to escalate into a reputational crisis if not addressed through appropriate communication strategies. In the banking industry, customer trust is the primary foundation of business continuity because the products offered are intangible and heavily dependent on the perceived security and credibility of the institution. Therefore, a service disruption on a digital platform like Byond by BSI not only impacts the technical aspects but also impacts public perception of the company's competence and integrity.

The disruption of digital services to the Byond by BSI app that occurred in September 2025 demonstrates this. Issues such as login difficulties, transaction failures, and lack of access to various features impacted customers' perceptions of the bank's professionalism and

responsibility (Liddiana et al., 2026). This situation was exacerbated by the context of digital transformation, namely the migration of services from BSI Mobile to Byond, where technical challenges and user adaptation also impacted customer satisfaction and loyalty (Nusantara, 2025).

2.2.2. Theoretical Framework: SCCT as a Foundation for Crisis Response

To understand how organizations should respond to crises, this study utilizes Situational Crisis Communication Theory (SCCT) developed by Timothy J. Coombs (2007). This theory focuses on how organizations should respond to crises to protect their reputation, emphasizing that communication strategies must be tailored to the organization's level of responsibility for the crisis (Maulana & Nasrulloh, 2024).

In the context of digital banking service disruptions, the public tends to attribute system failures to weaknesses in internal technology management. This means that public perception of corporate responsibility is quite high, requiring organizations to provide a response that goes beyond mere technical explanations. Such a response must include acknowledgment of the impact on customers, transparency of information, and a concrete commitment to improvement.

2.2.3. The Role of Crisis Communication in the Digital Age

The rise of digital media has transformed the way organizations manage communications in crisis situations. Information about service disruptions can spread quickly and widely through social media platforms, allowing public narratives to form before organizations have a chance to issue official clarification. This emphasizes the importance of two-way communication in a crisis (Online et al., 2025), allowing organizations to demonstrate concern while controlling the public narrative.

A quick and empathetic response to customer complaints has been shown to help reduce negative perceptions and reinforce the perception that the company is actively involved in resolving issues (Pelayanan et al., 2024). Conversely, a response that is too slow or perceived as unconvincing can actually increase public dissatisfaction (Multidisipit & Vol, 2025). This is reflected in the cyberattack incident experienced by BSI in May 2023. The initial, minimal response, simply referring to the incident as "system maintenance" (Suteja & Munggaran, 2020), created the impression that the bank was not transparent with customers and damaged the company's image.

Besides speed, communication strategies also need to pay attention to the delivery approach. Direct Theory Communication strategy emphasizes that communication messages must be delivered directly and clearly to achieve specific strategic objectives (Julian & Puspitaningrum, 2025). Therefore, crisis communication in the digital era serves not only to

convey information but also as a tool to rebuild emotional bonds between banks and their customers (Prilaku et al., 2024).

2.2.4. Restoring Customer Confidence Post-Crime

a) Dimension of Trust

Trust is defined as the willingness of one party to be sensitive to another party in a social reality (Anjani & Novianto, 2024) (Triwardhani, 2024). In banking operations, trust is a crucial element, especially in digital services, where data security is a major customer concern (Sentral et al., 2020).

Research explains that trust is built on three main dimensions: competence, integrity, and benevolence (Wong et al., 2017). Digital system disruptions generally have a direct impact on perceptions of competence, so organizations need to demonstrate increased technological capacity, strengthened security systems, and a commitment to protecting customer data. Furthermore, the Commitment Trust Theory from Morgan and Hunt assert that trust is key to building long-term, mutually beneficial relationships (Wulandari & Pratama, 2025), and in digital banking, this trust is highly dependent on the stability of technology, where one major incident can shake the trust that has been built over years (Zahra & Rafif, 2025).

b) Factors Influencing Trust Restoration

Some important factors that influence the recovery of customer confidence after the crisis are as follows:

- **Perceived Risks of Digital Services:** Customer trust is significantly influenced by how banks manage risks in using digital services. The higher a customer's perception of risk, the lower their willingness to use e-banking (Bisnis et al., 2025). Therefore, proactive communication regarding data security and customer protection measures is crucial. BSI needs to explain the security systems implemented while educating customers on how to protect their data (Hussainy et al., 2025).
- **Sharia Financial Literacy:** Customers' financial literacy levels also influence their response to crises. Higher levels of literacy increase the likelihood that customers will understand the benefits and risks of Sharia financial products, making them more rational in responding to service disruptions (Publikasi et al., 2025). Conversely, in a crisis, low literacy levels can worsen the public's response (Amala, 2025), as was the case with the Byond by BSI disruption.
- **Institutional Image:** A positive image of Islamic banks, built on reputation, service quality, and results that meet expectations, will increase public trust and interest in joining as customers (Handinisari & Muhlisin, 2023). However, when a crisis occurs,

this image can be quickly damaged. The success of BSI's image recovery lies in the integration of mass communication and interpersonal communication, where both approaches must work synergistically.

- **Tangible Corrective Actions:** Research findings confirm that system security, communication, and reputation do not always directly influence post-crisis trust but must be mediated by tangible and verifiable recovery actions (Efendi et al., 2024). Concrete corrective actions, such as system updates, independent audits, or technological infrastructure improvements, serve as concrete evidence of a company's commitment to improving service quality.

2.2.5. Integrated Crisis Communication Strategy

Based on the entire description above, the crisis communication strategy in the case of Byond by BSI service disruption must be understood as an integrated process, encompassing four main elements.

Element	Description
Quick response	Provide an honest and comprehensive official statement as soon as possible through various communication channels.
Information Transparency	Provide accurate information regarding the causes of disturbances, impacts, and handling steps.
Social Media Management	Actively conversations on social media to control the public narrative monitor and respond
Real Corrective Action	Implementing possible technical improvements, accompanied by two-way communication and ongoing support to customers

High service quality, namely the ability to meet customer needs beyond their expectations (M. Komunikasi & Indonesia, 2024), must be a standard to be re-established post-crisis. Therefore, crisis communication serves not merely as a reputation mitigation tool but as a strategic instrument in maintaining the sustainability of bank-customer relationships (S. Komunikasi et al., nd).

3. CONCLUSION

Repeated disruptions to the Byond by BSI app in 2025 became a digital crisis that demonstrated the mismatch between technical failures and customers' high expectations of BSI's credibility. Management's seemingly reactive and repetitive communication strategy, citing the need to maintain the system, actually raised public doubts about the bank's ability to manage the surge in transactions, especially at the crucial beginning of the month. Repeating the same excuses amidst the ongoing crisis left customers feeling digitally trapped, as they felt their access to their funds was no longer secure.

Restoring trust cannot be achieved through words alone, but requires consistent service, clear honesty and openness. The role of institutions is also needed to guarantee deposits to protect customer funds in the event of a bank system failure (Dana et al., nd). This issue is very likely to trigger a reaction in areas that are highly dependent on Islamic banking, such as Aceh, because a disruption to the system could cause a massive collapse in the local economy. This crisis shows the stark difference between the aggressive marketing tactics of SuperApps and the unprepared supporting infrastructure.

BSI needs to continuously focus on transparency of information regarding service conditions actively, as a form of moral responsibility, in order to maintain the basis of customer trust in the Islamic banking ecosystem.

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THE INFLUENCE OF SUSTAINABLE MARKETING STRATEGY ON CUSTOMER TRUST AND LOYALTY OF GENERATION Z CONSUMERS FROM THE PERSPECTIVE OF SHARIA BUSINESS MANAGEMENT

(STUDY ON BUN COFFEE UNILA BANDAR LAMPUNG)

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Abstract

Increasing business competition requires companies to implement marketing strategies that focus not only on short-term profits but also on sustainability and long-term customer relationships. Generation Z, as a dominant consumer segment, shows high concern for environmental issues, business ethics, and transparency. Therefore, the implementation of sustainable marketing strategies plays an important role role in building customer trust and consumer loyalty. This study aims to analyze the development of sustainable marketing research and its relationship with customer trust and Generation Z loyalty from an Islamic business management perspective, particularly in the context of Bun Coffee Unila, Bandar Lampung. This research employed a Systematic Literature Review (SLR) method using the OSPORIS framework, which consists of Objective, Search, Process, Output, Review, Interpretation, and Synthesis stages. The analysis was strengthened using bibliometric techniques with VOSviewer to map research trends and topics relationships. The findings indicate that sustainable marketing is closely related to green marketing, consumer behavior, ethical marketing, and sustainable development. The implementation of sustainable marketing strategies enhances positive consumer perceptions, builds trust, and encourage long-term loyalty. From an Islamic perspective, these practices align with the principles of honesty, trustworthiness, and social responsibility. This study implies that the integration of sustainability strategies, digital technology utilization, and Islamic values can become competitive advantage for SMEs in attracting and retaining Generation Z consumers.

Keywords: Sustainable Marketing, Customer Trust, Customer Loyalty, Generation Z, Islamic Business Management

INTRODUCTION

The increasingly competitive development of the business world requires business actors to not only focused on increasing sales, but on building long-term relationships with consumers. Changes in people's consumption patterns, especially in the digital era, which requires encourage companies to implement more adaptive, responsible marketing strategies, and oriented towards sustainability (Fathoni et al., 2025). The concept of sustainable marketing is present as a strategic approach which not only pays attention to economic benefits, but also pays attention to social and environmental aspects environment, so as to be able to create long-term value for the company and society (Nadanyiova, 2023).

Generation Z as a consumer group born between 1997 and 2012 has different characteristics compared to the previous generation. This generation is known to be more concerned on environmental issues, business ethics, transparency, and corporate social responsibility (Wibowo & Ayuningtyas, 2024). Generation Z considering product quality and paying attention to the company's values and commitment to sustainable and responsible business practices (Belz et al., 2025). Therefore, the implementation of the strategy sustainable marketing is an important factor in building trust (customer trust) and drive consumer loyalty in the Generation Z segment.

One of the culinary businesses that is growing in the campus environment is Bun Coffee. located at the University of Lampung (Unila), Bandar Lampung. As a business targeting the students, the majority of whom come from Generation Z, Bun Coffee is faced with the demands to implementing marketing strategies that are in line with consumer values and preferences. Efforts such as use of quality materials, reduction of plastic waste, honest and transparent service, and Responsible marketing communications can be an effective strategy in increasing customer trust and loyalty (Zafarinah, 2024).

With sustainable marketing, companies are required to avoid practices that are detrimental. consumers, such as information manipulation, excessive exploitation of resources, and activities that damaging the environment. Islam strictly prohibits all forms of fraud (gharar), cheating (tadlis), and actions that cause harm to other parties. This principle shows that sustainability In marketing, the aim is not only to maintain the company's reputation, but also to reflect ethical responsibility to Allah SWT and to society as part of the mandate that must be carried out accountable (Alserhan, 2017).

The concept of sustainable marketing is increasingly being applied in business practices as an effort creating long-term value through attention to economic, social and environmental aspects. Various studies show that sustainable marketing strategies have a positive impact on consumer perception, trust, and customer loyalty (Sari, 2020). However, research that specifically specifically analyzes the influence of sustainable marketing on customer trust and

consumer loyalty in the Generation Z segment is still relatively limited, especially when examined from a Business Management perspective. Sharia. The Sharia approach emphasizes the importance of honesty, transparency, responsibility, and a focus on the common good, which aligns with the principles of sustainability (Sabrina & Rialdy, 2024).

Research limitations are also seen in the local culinary business sector, especially those operating in a campus environment with the majority of consumers from Generation Z. Therefore, this study aims to analyze the influence of sustainable marketing strategies on customer trust and Generation Z consumer loyalty and review its implementation based on Business Management principles Sharia at Bun Coffee Unila Bandar Lampung. The results of this study are expected to provide theoretical contributions in the development of sharia-based sustainable marketing studies, as well as provides implications for culinary business actors in designing marketing strategies that are capable of increase consumer trust and loyalty in a sustainable manner. This research is also expected to can be a reference for further research that examines the relationship between business sustainability, consumer trust and customer loyalty in various business sectors.

1. RESEARCH METHODS

This research was conducted using **the Systematic Literature Review (SLR)** approach. to systematically identify, evaluate, and synthesize various research results previous studies related to **sustainable marketing, customer trust,** Generation Z consumer loyalty, and the perspective of Islamic Business Management. This method is also widely used in research in the field of management and business to develop conceptual understanding and identify research gap (Xiao & Watson, 2019). In this study, through bibliometric analysis, reinforced by the application of visualization similarity mapping (VOS) techniques using the device VOSviewer software.

The research process was carried out with reference to the OSPORIS framework which includes the following stages: **Objective, Search, Process, Output, Review, Interpretation**, and **Synthesis.** At the **Objective stage**, the goal research was established to examine the concept and implementation **of sustainable marketing**, analyze its influence on **customer trust** and loyalty of Generation Z consumers, and examine its suitability with the principles of Sharia Business Management.

In the **Search stage**, literature searches are carried out through several scientific databases, namely Google Scholar, Scopus, ScienceDirect, Garuda, and Sinta. Keywords used include "sustainable marketing", "green marketing", "customer trust", "customer loyalty", "Generation Z", as well as “Islamic marketing.” The literature used was limited to the publication period 2015–2024 to ensure the relevance and currency of the information (Kitchenham & Charters, 2007).

At the **Process stage,** the articles obtained are selected based on inclusion and exclusion criteria. Inclusion criteria include national and international journal articles that are relevant to the topic. research, available in **full text form**, and has a clear research method. Meanwhile, articles that are duplicates, irrelevant to the research focus, or do not come from scientific sources excluded from the selection process. The screening process is carried out in stages through initial identification, review of titles and abstracts, and evaluation of suitability based on the article's content (Moher et al., 2009).

Articles that meet the criteria are then analyzed at the Output stage through the process data extraction. The information collected includes the author's name, year of publication, research object, research methods, variables used, and key findings. The data is then organized into a literature matrix to facilitate analysis and comparison between studies (Snyder, 2019).

At the Review stage, the quality of each article is evaluated based on the level of relevance to the topic. research, clarity of methodology, and its contribution to the development of theory and practice.

Next, at the Interpretation stage, an analysis is carried out to identify the relationship patterns between sustainable marketing, customer trust, and consumer loyalty of Generation Z, and their relationship with Sharia Business Management values. The final stage, namely Synthesis, is carried out by integrating all research findings to produce comprehensive conclusions and identify research gap as a basis for research development (Tranfield et al., 2003) in the business context local culinary, especially Bun Coffee Unila Bandar Lampung.

2. RESULTS AND DISCUSSION

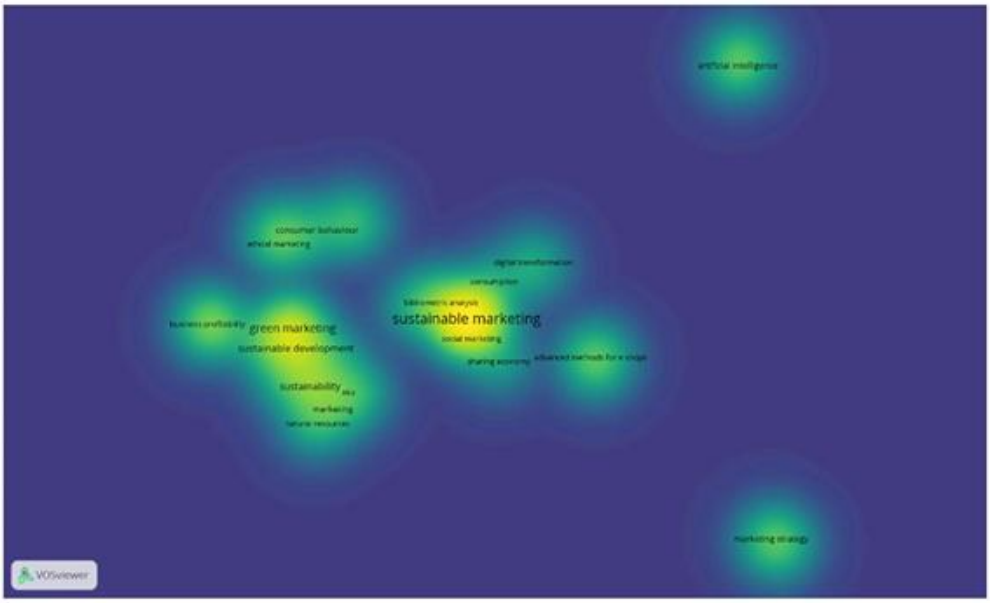
The results of this study were obtained through bibliometric analysis using software VOSviewer on articles related to the topic of **sustainable marketing**. Analysis was carried out to identify research trends, relationships between topics, and the direction of research development relevant to **customer trust** and loyalty of Generation Z consumers.

2.1. Research Topic Trends and Density

Based on the **density visualization**, it can be seen that the keyword "sustainable marketing" is the main topic with the highest density level. This shows that the research regarding sustainable marketing has become a major focus and has continued to grow in recent years Lastly. Around the main topic, several keywords emerged that had a strong connection, such as **green marketing, sustainability, consumer behavior, ethical marketing,** and **sustainability development**. These findings show that the concept of sustainable marketing does not stand alone, but closely related to consumer behavior, business ethics, and efforts to maintain environmental sustainability and social. In addition, a fairly high density is also seen in the keywords **green marketing** and **consumer behavior**. This indicates that research

places a lot of emphasis on how environmentally friendly strategies influence consumer perceptions and behavior. In this study, the findings This supports the assumption that sustainable marketing strategies have the potential to build consumer trust and encourage loyalty.

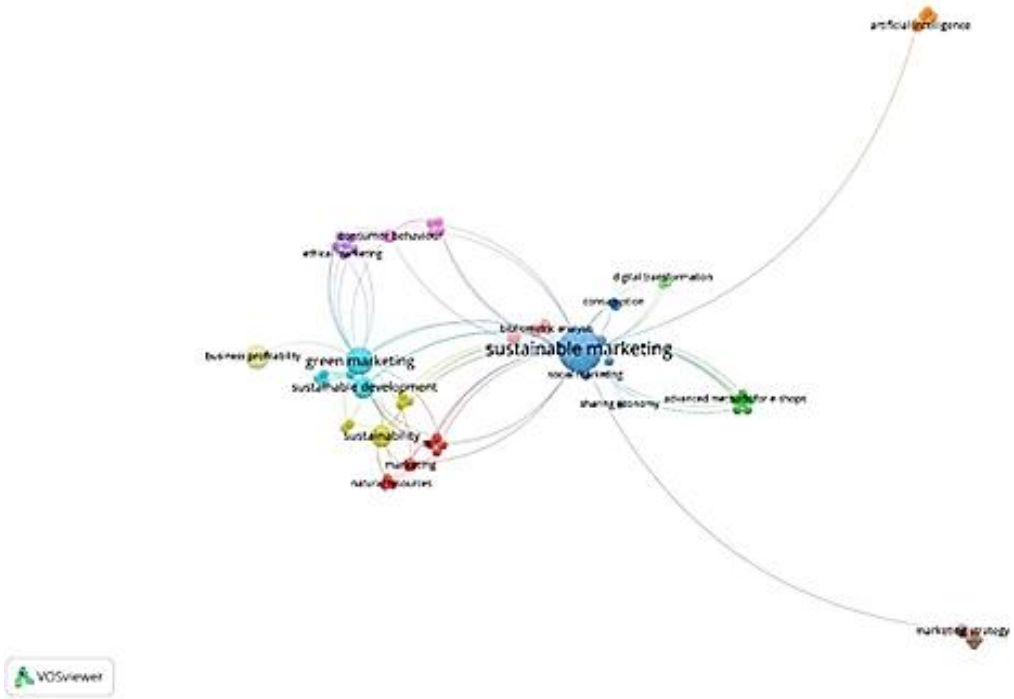
Figure 1. Trends and Density of Research Topics



2.2. Network Visualization

The results of **the network visualization** show a strong relationship between **sustainable marketing** with several research clusters. The first cluster relates to sustainability issues environment, such as **green marketing, natural resources,** and **sustainable development**. The second cluster related to consumer aspects, namely **consumer behavior** and **ethical marketing**. The third cluster covers technological developments and digitalization, such as **digital transformation, e-commerce methods**, and **sharing economy**. The interconnectedness between clusters shows that the development of **Sustainable marketing** today not only focuses on environmental aspects, but also includes digital transformation and changing consumption patterns. This is relevant to the characteristics of Generation Z. which is greatly influenced by digital technology in the decision-making process. There are topics relatively separate areas such as **artificial intelligence** and **marketing strategy**. Positions that are far apart shows that studies on the integration of advanced technology with **sustainable marketing** are still limited. and become a research opportunity in the future.

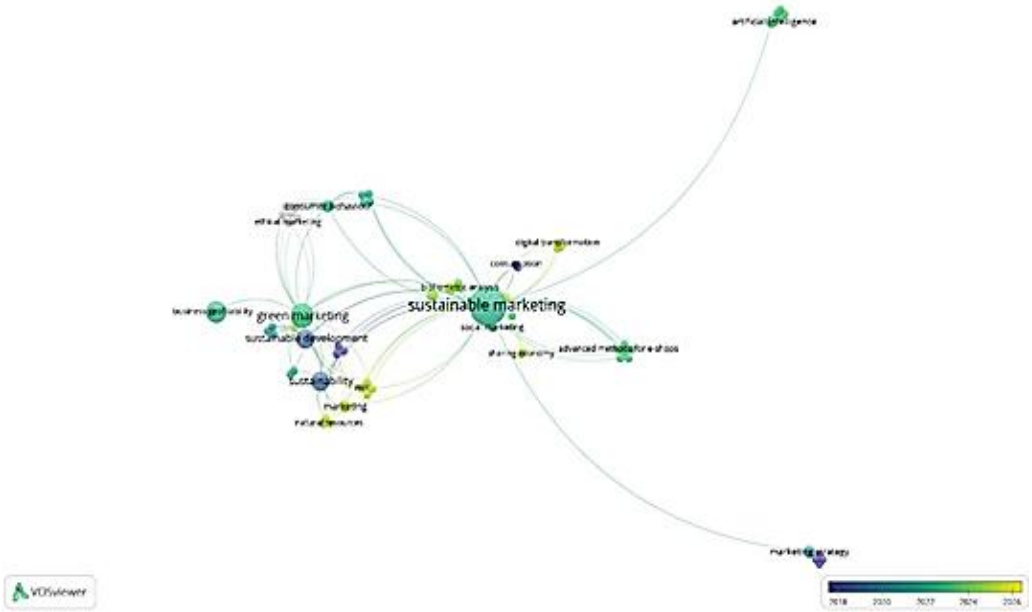
Figure 2. Research Topic Network Analysis



2.3. Time Development Analysis (Overlay Visualization)

The results of **the overlay visualization** show that initial research focused more on basic concepts such as **sustainability, marketing**, and **natural resources**. Meanwhile, research that more recently started to move towards the topics of **digital transformation, consumer behavior**, and integration technologies such as **artificial intelligence**. Brighter colors on some keywords shows that research in this area is relatively new and is still developing. The existence of shift in research focus from traditional environmental approaches to more holistic approaches Modern and technology-based. This is in line with the development of Generation Z consumer behavior. which is more digital-oriented and demands transparency and social responsibility from companies.

Figure 3. Time Development Analysis (Overlay Visualization)



2.4. Implications for Customer Trust and Loyalty

*The relationship between **sustainable marketing, ethical marketing,** and **consumer behavior** shows that sustainable marketing strategies play a role in shaping positive perceptions Consumers. Transparent, environmentally responsible, and consumer-oriented business practices on ethical values can increase the level of consumer trust. This trust will then become the basis for forming loyalty through repeat purchases, recommendations, and emotional attachment towards the brand. From the perspective of Sharia Business Management, this finding is in line with the principles honesty **(shiddiq)**, trustworthiness, and social responsibility which emphasize the importance of business practices ethical and sustainable.*

3. CONCLUSIONS AND MANAGERIAL IMPLICATIONS

Based on the results of **the Systematic Literature Review** analysis and bibliometric mapping using VOSviewer, it can be concluded that research on **sustainable marketing** showed significant development and became one of the main focuses in the study modern marketing. The concept of **sustainable marketing** is known to be closely related to **green marketing, consumer behavior, ethical marketing,** and **sustainable development,** which shows that sustainable marketing strategies are not only oriented towards environmental aspects, but also

on changes in consumer behavior and the application of ethical values in business activities. The results of the study shows that the implementation of **sustainable marketing** plays a role in building positive perceptions consumers, which then increases **customer trust**. This trust is an important factor in building loyalty through repeat purchases, recommendations, and long-term engagement towards brands. In addition, the latest research trends also point towards the integration of digital technologies such as **digital transformation** that is in line with the characteristics of Generation Z as adaptive consumers towards technology.

From the perspective of Islamic Business Management, **sustainable marketing** practices are in line with the principles of honesty **(shiddiq)**, trustworthiness, transparency, and social and environmental responsibility. Therefore, the implementation of sustainable marketing strategies not only provides economic benefits, but also reflects moral and spiritual values in business activities. In the context of the culinary business Like Bun Coffee Unila Bandar Lampung, a **sustainable marketing** strategy can be an approach which is effective in increasing the trust and loyalty of Generation Z consumers.

The managerial implications of this study indicate that business actors, especially MSMEs in culinary sector, needs to implement operational practices that support sustainability, such as use of environmentally friendly packaging, waste reduction, and sustainable resource management efficient in order to improve business image and customer trust. In addition, transparency and honesty in conveying information regarding product quality, price, and production processes, it is necessary to be priority to strengthen **customer trust**, especially for Generation Z consumers who have a high level of high concern for business ethics. The use of digital media also needs to be optimized as marketing communications tools to convey sustainability values and build engagement customers more effectively.

4. LIMITATIONS AND SUGGESTIONS OF RESEARCH

This study has several limitations that need to be considered in interpreting the research results. First, this research uses a **systematic** approach **Literature Review** (SLR) and bibliometric analysis so that the findings produced are conceptual and synthesis of previous research, and has not been supported by direct empirical data from the object research. Second, the literature used is limited to the period 2015–2024 and only comes from from certain databases, so there is likely still relevant research that has not been accommodated. Third, the analysis conducted through VOSviewer mapping focuses on the relationship keywords and research trends, so that it is not yet able to describe the relationship in depth causal relationship between the variables **of sustainable marketing, customer trust,** and consumer loyalty in the context of specifically local culinary businesses. In addition, studies from the perspective of Sharia Business Management are still limited to a conceptual approach and has not directly measured the level of application of values sharia in business practices.

Based on these limitations, further research is recommended to conduct research empirically using quantitative methods or mixed methods to test the direct influence of **sustainable marketing** on **customer trust** and consumer loyalty, especially for Generation Z consumers. Further research can also expand the research object to various MSME sectors or other industries to obtain more general and comprehensive results. Further research is recommended to develop additional variables such as satisfaction. customers, brand image, or perceived value as mediating or moderating variables. Further studies in-depth understanding of the implementation of Sharia Business Management principles in marketing practices Sustainable development also needs to be carried out using measurable indicators. In addition, wider use of databases and more in-depth bibliometric analysis can be carried out to obtain a more comprehensive picture of future research trends.

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THE ROLE OF CUSTOMER RELATIONSHIP MANAGEMENT (CRM) IN INCREASING CUSTOMER SATISFACTION AND LOYALTY FROM A SHARIA BUSINESS PERSPECTIVE IN LOCAL MSMES

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Abstract

The increasingly dynamic business competition requires Micro, Small, and Medium Enterprises (MSMEs) not only focus on increasing sales but also to build long-term relationships with customers. Customer Relationship Management (CRM) is one of the strategic approaches that can be implemented to improve customer satisfaction and loyalty. In the context of Islamic business, the implementation of CRM is not solely oriented toward economic profit but must also be based on Islamic ethical values such as honesty, trustworthiness, transparency, and fairness. This study aims to examine the role of CRM in enhancing customer satisfaction and loyalty from the perspective of Islamic business in local MSMEs. The research employed a Systematic Literature Review (SLR) method following the PRISMA guidelines. Data were collected from journal articles indexed in Google Scholar, Scopus, ScienceDirect, Garuda, and SINTA within the period 2019–2024. The selection process resulted in 50 relevant articles for analysis. The findings indicate that key CRM dimensions influencing customer satisfaction include service quality, effectiveness communication, service personalization, responsiveness to customer complaints, customer data management, and the utilization of digital technology. Customer satisfaction was found to significantly influence customer loyalty, as reflected in repeat purchases, customers retention, and positive word-of-mouth recommendations. The integration of CRM with Islamic business principles enhance customer trust and strengthen long-term loyalty. These findings suggest that Sharia-based CRM can serve as an effective strategy to improve the competitiveness and sustainability of MSMEs.

Keywords: Customer Relationship Management, Islamic Business, MSMEs, Systematic Literature Review

INTRODUCTION

The increasingly dynamic development of business competition requires business actors not to... only sales oriented, but also on efforts to build long-term relationships with customers. Customer satisfaction and loyalty are important factors in maintaining business sustainability, especially for Micro, Small and Medium Enterprises (MSMEs) which have limited resources and market access.

One of the strategic approaches that can be used to improve quality relationship with customers is Customer Relationship Management (CRM) which is a business strategy that focuses on systematically managing interactions with customers in order to increase satisfaction, retain customers, and create long-term loyalty (Nursaidah et al., 2025).

Implementation of Customer Relationship Management (CRM) makes business actors understand customer needs, preferences and behavior so that they can provide services which is more personal and responsive. According to Pradanis & Andriani's research, 2024 shows that effective CRM implementation has a significant impact on increasing customer satisfaction customers, which further drives loyalty through repeat purchases and recommendations. to other customers (Pradanis & Andriani, 2024).

For local Micro, Small and Medium Enterprises (MSMEs), a close relationship with Customers are one of the competitive advantages that can be utilized to maintaining business continuity amidst increasingly competitive market competition. Customer loyalty is an important asset for Micro, Small and Medium Enterprises (MSMEs) because loyal customers tend to make repeat purchases, have a high level of lower price sensitivity, as well as the potential to become a promotional medium through communication word of mouth (Andriani, 2021).

Close relationships with customers are one of our competitive advantages. which can be utilized to improve business sustainability. Emotional closeness, direct communication, as well as more personal service are factors that can strengthen relationship between business actors and customers. However, there are still many Micro, Small, and Medium Enterprises Medium Enterprises (SMEs) that have not implemented Customer Relationship Management (CRM) effectively systematic and still manage customer relationships in a traditional way. This condition causes the potential for increasing customer satisfaction and loyalty has not been optimally utilized (Lestari & Suwitho, 2018).

From a sharia business perspective, managing customer relationships is not only oriented towards economic gain, but also based on Islamic ethical values such as honesty, trustworthiness, justice, transparency, and services that provide benefits for all parties. These principles emphasize the importance of building trust and fair relations between business

actors and customers as part of their responsibility moral and spiritual. In the application of Customer Relationship Management (CRM) in the context of Sharia business not only aims to increase customer satisfaction and loyalty, but also creating sustainable business relationships that comply with sharia principles.

Sharia business emphasizes the concept of blessing and social responsibility in running a business. Business actors are expected not only to pursue profits, but also paying attention to the interests of customers, society, and the environment. In sharia business, implementation of Customer Relationship Management (CRM) in line with sharia values can strengthen customer trust and create more sustainable loyalty (Hasan et al., 2023). Trust built through honesty and fair service will increase customer satisfaction and foster long-term, mutually beneficial relationships. Various studies in Indonesia show that the application of sharia principles in business practices have a positive influence on customer satisfaction and loyalty. Customers tend to feel more comfortable and trust businesses that adhere to the principles of honesty, transparency, and services that are in accordance with Islamic values (Mufarrochah et al., 2025). Research on the influence Customer Relationship Management (CRM) on customer satisfaction and loyalty has many studies have been conducted that specifically integrate the concept of Customer Relationship Management (CRM) with a sharia business perspective in the context of Micro, Small and Medium Enterprises Local MSMEs are still relatively limited. Previous research shows that mixed results regarding the most important Customer Relationship Management (CRM) factors. influence customer satisfaction and loyalty. Some studies emphasize the importance of service quality, while other studies highlight the role of communication, trust, or use of digital technology (Wardati et al., 2024).

Based on this, this research uses the Systematic Literature method. Review (SLR) to systematically examine various studies related to the role of Customer Relationship Management in increasing customer satisfaction and loyalty in perspective of sharia business on local MSMEs. Through this approach, the research aims to identify research trends, key factors for successful implementation of Customer Relationship Management (CRM), and its implications for the development of business practices sharia in Micro, Small, and Medium Enterprises (MSMEs). The results of the study are expected to provide theoretical contributions to the development of sharia business management literature as well as provide practical recommendations for Micro, Small and Medium Enterprises (MSMEs) in manage customer relationships effectively and sustainably.

Based on the problems that have been described, this research aims to to conduct a systematic review of various studies related to the implementation of Customer Relationship Management in increasing customer satisfaction and loyalty in Business Local Micro, Small, and Medium Enterprises (MSMEs) with a sharia business approach. Through the method Systematic Literature Review (SLR), this study attempts to identify research trends, key

factors for successful CRM implementation, as well as their implications for development Sharia business practices in Micro, Small, and Medium Enterprises (MSMEs). Research results It is hoped that it can provide theoretical contributions to the development of business management literature. sharia and provide practical recommendations for MSMEs in managing customer relationships effectively, sustainably, and in accordance with sharia principles.

1. RESEARCH METHODS

This research uses a Systematic Literature Review (SLR) approach to systematically review various research results related to the role of Customer Relationships Management (CRM) in increasing customer satisfaction and loyalty from a customer perspective Sharia business in Micro, Small, and Medium Enterprises (MSMEs). Systematic Literature Method Review (SLR) was chosen because it provides a comprehensive, objective, and structured synthesis. to previously published research findings (Snyder, 2019).

This research is a qualitative research with a systematic literature study approach. Systematic Literature Review (SLR) is conducted through a process of identification, evaluation, and synthesis. relevant research to obtain a comprehensive picture of developments research and the main factors that influence the success of CRM implementation in MSMEs in the perspective of sharia business with several articles as the main articles in compile a framework to answer the research questions in Table 1.

Table 1. Research Questions

ID	Research Questions	Identify Answers
RQ_1	How development research on Customer Relationship Management (CRM) in MSMEs?	Identifying research trends based on year, number of articles, and number of research topic development.
RQ_2	What are the dimensions or factors of CRM that impacts customer satisfaction in customer relationship management, MSMEs?	Identifying CRM variables such as quality service, communication, service personalization, and utilization of technology.
RQ_3	How does CRM influence customer loyalty in MSMEs?	Identifying loyalty indicators such as repeat purchases, customer retention, commitment to customers, and word of mouth recommendations (word of mouth).
RQ_4	How are the roles of sharia business principle values implemented in the implementation of CRM in MSMEs?	Identifying sharia principles which implemented, such as honesty (shiddiq), trustworthiness, transparency, justice and service ethical.
RQ_5	What is the impact of implementing sharia based CRM?	Identifying increased customer trust, satisfaction, long-term loyalty, loyalty and business sustainability.
RQ_6	What research methods and dominant analysis techniques in sharia business perspective?	Identifying the most commonly used types of research methods (quantitative, qualitative, or mixed methods).

In Table 1 there are 6 research questions which include identification. answers based on the results and discussion. In this study, bibliometric analysis will strengthened by the application of visualization similarity mapping (VOS) techniques using VOSviewer software (van Eck & Waltman, 2010).

The data used is secondary data obtained from scientific journal articles.

National and international indexed in several databases, namely:

- Google Scholar
- Scopus
- ScienceDirect
- Garuda (Digital Reference Garuda)
- SINTA Portal

The articles used are limited to publications within the 2019–2024 period so that reflect the latest research developments. The literature search process is carried out using a combination of keywords such as:

- “Customer Relationship Management” OR “CRM”
- “Customer Satisfaction”
- “Customer Loyalty”
- “MSMEs” or “SMEs”
- “Islamic Business” OR “Sharia Business”

The article selection process is carried out with reference to the PRISMA (Preferred Reporting) guidelines. Items for Systematic Reviews and Meta-Analyses), which includes the stages of identification, screening (screening), eligibility assessment, and determination of the final articles to be analyzed.

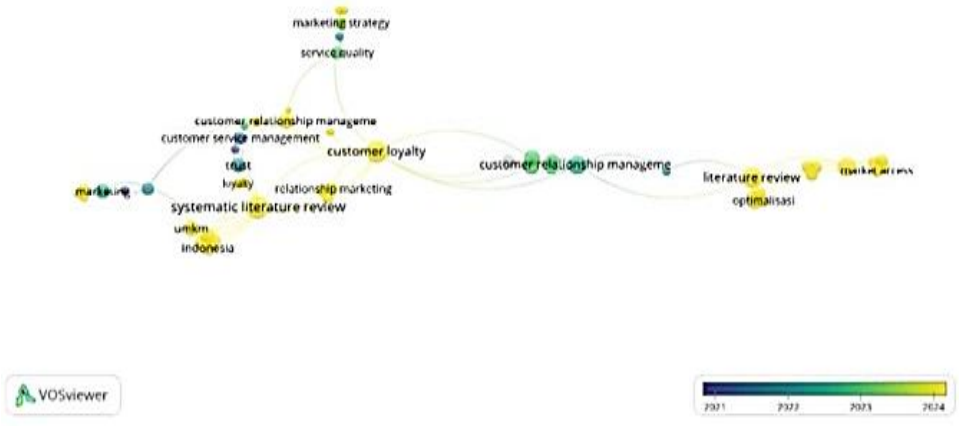
2. RESULTS AND DISCUSSION

Based on the literature search process in the Google Scholar and Scopus databases, ScienceDirect, Garuda, and SINTA with a period of 2019–2024, obtained as many as 520 articles at the identification stage. After the process of removing duplication and filtering based on titles and abstracts, the number of articles was reduced to 150 articles. Next, an assessment was carried out eligibility (full-text review) based on inclusion and exclusion criteria. The final results show that as many as 50 articles were declared relevant and used in

the analysis. The results of this selection shows that research on Customer Relationship Management (CRM) is quite much has been done, but research that specifically links CRM with the perspective Sharia business in MSMEs is still limited.

Analysis of selected articles, research on CRM in MSMEs shows an increasing trend in the last five years. The majority of studies published in the 2021–2024 period, which shows the increasing attention of academics towards the importance of customer relationship management in increasing the competitiveness of MSMEs.

Figure 1. Distribution of Customer Relationship Management (CRM) Dimensions Research By Year of Publication



The results of the literature synthesis show that several dimensions of Customer Relationship Management (CRM) which has the most influence on customer satisfaction in Micro Enterprises, Small and Medium Enterprises (SMEs) such as service quality, effective communication, personalization service, speed in responding to complaints, customer data management, and utilization digital technology. Among these factors, service quality is the most dominant factor in increasing customer satisfaction. Customers tend to feel satisfied when they receive friendly, fast service that meets their needs, as well as good communication and a personal approach can also increase customers' positive perceptions of the business.

Furthermore, the results of the analysis show that the implementation of CRM has a positive influence. on customer loyalty. Customer loyalty is reflected in repeat purchasing behavior, long-term commitment to a product or service, as well as the customer's willingness to recommending a business to others through word of mouth communication mouth). In the context of MSMEs, customer loyalty has a very important role because the cost of retaining customers is relatively lower compared to the cost of acquiring them. acquiring new

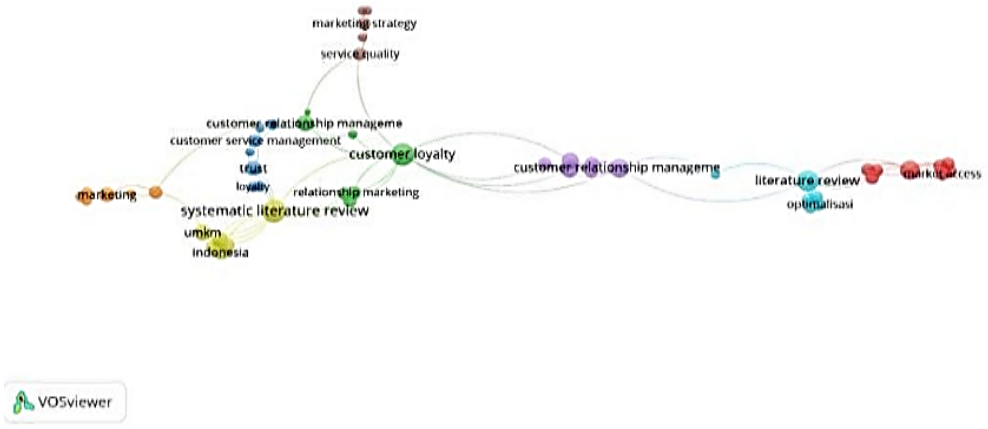
customers. Therefore, effective CRM implementation can be a strategy appropriate to maintain business continuity.

From a sharia business perspective, customer relationship management is not only oriented on the economic aspect, but also on Islamic ethical values. The results of the study show that The sharia principles most widely applied in business practices include honesty (shiddiq), trust, transparency, justice, and services oriented towards the public interest. These values play an important role in building customer trust, which is the main factor in creating long-term relationships between business actors and customers.

The integration between CRM and sharia business principles has been proven to have a positive impact on customer satisfaction and loyalty. Customers tend to feel more comfortable and confident towards businesses that implement the principles of honesty and transparency in transactions. Trust is formed through fair and responsible service. increase customer satisfaction, which ultimately drives long-term loyalty. In addition, the implementation of sharia-based CRM can also improve business image and support sustainability of MSME businesses.

Based on the results of bibliometric analysis using VOSviewer, it shows that there is several main research clusters. The first cluster focuses on the relationship between CRM, customer satisfaction, and customer loyalty. The second cluster relates to MSMEs, quality service, and customer trust. Meanwhile, the third cluster connects the business concept sharia, sharia marketing, and Islamic business ethics. This mapping shows that the integration between CRM and the perspective of sharia business is still a developing topic and has broader research opportunities in the future.

Figure 2. Customer Relationship Management (CRM) Clusters by Year Publication



The results of the vosviewer show that Customer Relationship Management has a role strategic in increasing customer satisfaction and loyalty in MSMEs. However, CRM implementation in MSMEs is still not optimal due to limited resources, understanding of technology, and customer management systems that are still traditional. Therefore, the implementation of CRM that is integrated with sharia business values can be effective strategies in increasing competitiveness, building customer trust, and creating business sustainability. In addition, the development of digital technology also opens up opportunities for MSMEs to develop digital-based CRM that is in line with the principles of sharia principles.

3. CONCLUSIONS AND MANAGERIAL IMPLICATIONS

Based on the results of the Systematic Literature Review (SLR) of the articles published in the period 2019–2024, it can be concluded that Customer Relationship Management (CRM) has a strategic role in increasing customer satisfaction and loyalty. customers in Micro, Small, and Medium Enterprises (MSMEs). The results show that Research on CRM in MSMEs has increased in recent years, but research that specifically integrates CRM with a sharia business perspective is still relatively limited. This shows that the topic of sharia-based CRM still has wide opportunities to be developed in further research.

The CRM dimensions that have the most influence on customer satisfaction include quality. service, effective communication, personalization of service, speed in handling complaints, customer data management, and the use of digital technology. Among these factors, the quality of service and communication are the most dominant factors in increasing satisfaction Customer satisfaction has a positive impact on customer loyalty. customers demonstrated through repeat purchases, long-term commitment, as well recommendations to others.

From a sharia business perspective, CRM implementation is not only oriented towards improving business performance, but it must also be based on Islamic ethical values such as honesty (shiddiq), trustworthiness, transparency, justice, and service that provides welfare. The integration between CRM and sharia principles has been proven to be able to increase customer trust, which is a key factor in building satisfaction and loyalty long term. Thus, the implementation of sharia-based CRM can be a strategy that effective in increasing the competitiveness and sustainability of MSME businesses.

The results of this study provide several managerial implications that can be applied by MSME actors. Namely:

1. Business actors need to manage customer relationships more systematically by implementing CRM concepts, both simple and digital-based, such as the use of

customer databases, social media, or communication applications for maintain ongoing interactions.

2. Improving the quality of service needs to be a top priority, because the quality of service is which has been proven to be a dominant factor in increasing satisfaction and loyalty. customers. MSMEs need to provide responsive, friendly, and reliable service. able to adapt to customer needs through a more personalized approach personal.
3. Business actors need to strengthen communication with customers through delivery clear information, fast response to complaints, and building relationships positive emotions.
4. In sharia business, MSME actors need to apply the values of honesty, transparency, justice and responsibility in every business activity. The application of these values not only increase customer trust, but also build business image positive and sustainable.
5. Business actors need to start utilizing digital technology in CRM management, such as the use of social media, marketplaces, and customer recording systems. CRM digitalization can help improve customer management efficiency. while expanding market reach.

4. LIMITATIONS AND SUGGESTIONS OF RESEARCH

This study has several limitations that need to be considered in interpret the results of the study because this research uses a systematic approach Literature Review (SLR) which relies entirely on secondary data from articles that have been published published. With the number of studies that specifically examine Customer Integration Relationship Management (CRM) with a sharia business perspective in the context of Micro Enterprises, Small and Medium Enterprises (SMEs) are still relatively limited. Most of the research analyzed more discussion of CRM in general without explicitly linking it to value sharia values, so the scope of analysis on sharia aspects is still limited. This research did not conduct empirical testing directly in the field, so the results obtained conceptual and a synthesis of previous research.

Based on the limitations, several suggestions for further research can be put forward. Further research is expected to be able to conduct empirical studies directly on MSMEs. to test the influence of sharia-based Customer Relationship Management on customer satisfaction and customer loyalty in more depth. Future research can expand the variables research by adding other relevant factors, such as customer trust, quality digital services, customer experience , and technology adoption in CRM management. Further research is recommended to examine more specifically regarding implementation of sharia-based digital CRM, considering the

development of digital technology that increasingly rapid and its role is increasingly important in managing customer relations in MSMEs.

Future research can be conducted with a more methodological approach. diverse, such as mixed methods or longitudinal studies, so that they can provide a more comprehensive picture of CRM effectiveness in the long term. long.

Fifth, further research can also broaden the research context to the business sector. particular area or area to gain a more specific understanding of implementation of sharia-based CRM on various characteristics of MSMEs. With the existence of research development on these aspects, it is hoped that studies on Customer Relationship Management from a sharia business perspective can provide greater contributions strong both theoretically and practically in supporting the sustainability and competitiveness of MSMEs in the future.

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PROTEAN CAREER ORIENTATION, LIFELONG LEARNING, AND HUMAN RESOURCE DEVELOPMENT STRATEGIES FOR A FUTURE-READY WORKFORCE IN HIGHER EDUCATION

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Abstract

The transformation of work driven by digitalisation, globalisation, and the expansion of knowledge-based economies has reshaped career development in higher education. Knowledge workers, including academics and professional staff, are increasingly expected to manage their careers proactively, engage in continuous learning, and adapt to rapidly changing institutional and technological demands. However, many universities still rely on traditional, hierarchical career structures that are largely institution-driven and may not sufficiently support self-directed career growth. In this context, protean career orientation has emerged as an important concept for understanding how individuals navigate contemporary career challenges. Protean career orientation emphasises personal values, self-direction, and responsibility for career management, making it highly relevant to the development of lifelong learning and career sustainability.

This conceptual paper examines the role of protean career orientation in promoting lifelong learning among knowledge workers in higher education and explores human resource development strategies for building a future-ready workforce. Drawing on the literature on protean career orientation, lifelong learning, career adaptability, and career sustainability, the paper develops a conceptual framework that explains how self-directed career attitudes may encourage continuous learning and strengthen employees' ability to respond to changing career demands. It is argued that knowledge workers with stronger protean career orientation are more likely to pursue learning opportunities, update their competencies, and demonstrate greater career adaptability, which in turn contributes to long-term career sustainability.

The paper further proposes several HRD strategies to support this process, including continuous professional development, mentoring, learning culture initiatives, competency-based training, and institutional policies that encourage self-directed growth. These strategies may help higher education institutions create an environment that supports adaptability, employability, and future-ready workforce development. The paper contributes a conceptual model that links protean career orientation with lifelong learning and sustainable career development in higher education, offering practical implications for policymakers, university leaders, and HRD practitioners seeking to prepare knowledge workers for the evolving demands of the knowledge economy.

Keywords: Protean Career Orientation, Lifelong Learning, Human Resource Development, Knowledge Workers, Higher Education, Career Adaptability

THE GREEN PREMIUM: INVESTIGATING GEN Z'S WILLINGNESS TO PAY FOR SUSTAINABILITY

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Abstract

Purpose: This study examines Gen Z's purchase intentions regarding green products due to growing concerns over economic collapse, epidemic lockdowns, and climatic calamity. It investigates the influence of independent variables like environmental concern, environmental knowledge, green perceived value, green perceived quality, green trust, and willingness to pay on green purchase behaviour among Pakistani youth.

Novelty: While prior research has explored green the consumption of green products in general, this study uniquely focuses on Gen Z in Pakistan, a developing market which is underrepresented in sustainability literature. A comprehensive model is tested integrating six key predictors, revealing how global climate crises shape environmentally conscious behaviours in emerging economies.

Methodology: A quantitative research design, recommended by prior consumer behaviour studies, was employed. Online questionnaires targeted Gen Z respondents (born 1997–2012). Data analysis utilized SPSS 22.0 for descriptives and Smart PLS-4.0 for structural equation modelling, testing all six hypotheses.

Findings: All hypotheses were supported. Gen Z demonstrates strong environmental consciousness, with significant positive effects from environmental concern, knowledge, perceived value, quality, trust, and willingness to pay on green purchase intentions. They prioritize sustainability and accept green premiums when supported by honest marketing.

Implications: Marketers should leverage Gen Z's eco-awareness by designing genuine, sustainable products with transparent strategies and communication. These insights guide tailored marketing in Pakistan, fostering green behaviours and contributing to national sustainability goals.

Keywords: Green Products, Environmental Concerns, Environmental Knowledge, Green Perceived Value, Green Perceived Quality, Green Trust, Purchase Intention, Green Premium.

TÜRKİYE'DE İŞLETMELERİN DİJİTAL DÖNÜŞÜM KAPASİTESİ: TÜİK VERİLERİ ÜZERİNDEN BETİMSEL BİR DEĞERLENDİRME

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Özet

Dijital dönüşüm, işletmelerin operasyonel verimlilik, pazara erişim, müşteri ilişkileri, veri temelli karar alma ve sürdürülebilir rekabet gücü oluşturma kapasitelerini doğrudan etkileyen stratejik bir dönüşüm alanıdır. Bu çalışmanın amacı, Türkiye'de işletmelerin dijital dönüşüm kapasitesini TÜİK tarafından yayımlanan güncel istatistikler üzerinden işletme büyüklüğü temelinde betimsel olarak değerlendirmektir. Çalışmada ikincil veri analizi yöntemi benimsenmiş; TÜİK Girişimlerde Bilişim Teknolojileri Kullanım Araştırması 2025 ve TÜİK Yapay Zekâ İstatistikleri 2025 verileri esas alınmıştır. Analiz kapsamında web sitesi sahipliği, sosyal medya kullanımı, e-satış, web satış, kurumsal kaynak planlaması, müşteri ilişkileri yönetimi, iş zekâsı yazılımı, ücretli bulut bilişim ve yapay zekâ kullanımı göstergeleri çalışan sayısı büyüklük gruplarına göre incelenmiştir. Bulgular, dijital teknolojilerin kullanım oranının işletme büyüklüğü arttıkça yükseldiğini göstermektedir. Örneğin 2025 yılında web sitesi sahipliği 10-49 çalışanlı girişimlerde %52,4, 50-249 çalışanlı girişimlerde %73,1 ve 250 ve üzeri çalışanlı girişimlerde %92,5'tir. Benzer biçimde yapay zekâ kullanımı 10-49 çalışanlı girişimlerde %6,6 iken, 250 ve üzeri çalışanlı girişimlerde %24,1'e ulaşmaktadır. Bulgular, Türkiye'de dijital dönüşüm kapasitesinin işletme büyüklüğüne göre belirgin biçimde farklılaştığını; özellikle küçük ve orta ölçekli girişimlerin ileri dijital teknolojiler, bulut bilişim, iş zekâsı ve yapay zekâ kullanımı açısından büyük işletmelere kıyasla daha sınırlı bir kapasiteye sahip olduğunu ortaya koymaktadır.

Anahtar Kelimeler: İşletmeler, Dijital Dönüşüm, TÜİK, Yapay Zekâ, E-Satış.

DIGITAL TRANSFORMATION CAPACITY OF ENTERPRISES IN TÜRKİYE: A DESCRIPTIVE ASSESSMENT BASED ON TURKSTAT DATA

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Abstract

Digital transformation is a strategic transformation area that directly affects enterprises' operational efficiency, market access, customer relations, data-driven decision-making, and capacity to build sustainable competitive advantage. The aim of this study is to descriptively evaluate the digital transformation capacity of enterprises in Türkiye based on recent statistics published by TurkStat, with a particular focus on enterprise size. The study adopts a secondary data analysis approach and uses data from TurkStat's Survey on Information and Communication Technology Usage in Enterprises 2025 and Artificial Intelligence Statistics 2025. Within the scope of the analysis, indicators such as website ownership, social media usage, e-sales, web sales, enterprise resource planning, customer relationship management, business intelligence software, paid cloud computing, and artificial intelligence usage are examined according to employee-size groups. The findings indicate that the use of digital technologies increases as enterprise size grows. For instance, in 2025, website ownership was 52.4% among enterprises with 10-49 employees, 73.1% among enterprises with 50-249 employees, and 92.5% among enterprises with 250 or more employees. Similarly, artificial intelligence usage was 6.6% among enterprises with 10-49 employees, while it reached 24.1% among enterprises with 250 or more employees. These findings reveal that digital transformation capacity in Türkiye differs substantially by enterprise size, and that small and medium-sized enterprises have a more limited capacity than large enterprises, particularly in advanced digital technologies, cloud computing, business intelligence, and artificial intelligence usage.

Keywords: Enterprises, Digital Transformation, TurkStat, Artificial Intelligence, E-Sales

GİRİŞ

Dijital dönüşüm, günümüzde işletmelerin yalnızca bilgi teknolojilerini kullanma düzeyini değil; iş modellerini, değer yaratma biçimlerini, müşteri ilişkilerini, operasyonel süreçlerini ve karar alma mekanizmalarını yeniden şekillendiren stratejik bir dönüşüm alanı olarak ele alınmaktadır. Dijital teknolojiler, işletmelerin pazara erişim kapasitesini artırmakta, veri temelli karar alma süreçlerini güçlendirmekte, operasyonel verimliliği desteklemekte ve rekabet avantajı oluşturma potansiyelini yükseltmektedir. Bu nedenle dijital dönüşüm, yalnızca teknik bir modernizasyon süreci değil; işletme stratejisi, organizasyonel yapı, yetenekler ve performans göstergeleriyle ilişkili bütüncül bir değişim süreci olarak değerlendirilmektedir (Bharadwaj et al., 2013; Vial, 2019; Verhoef et al., 2021).

Dijital dönüşümün işletmelerdeki yansımaları çok boyutlu göstergeler üzerinden izlenebilmektedir. Web sitesi sahipliği ve sosyal medya kullanımı işletmelerin dijital görünürlüğünü ortaya koyarken; e-satış ve web satış uygulamaları dijital pazara erişim kapasitesini göstermektedir. Bunun yanında kurumsal kaynak planlaması, müşteri ilişkileri yönetimi, iş zekâsı yazılımları, bulut bilişim ve yapay zekâ kullanımı gibi göstergeler, dijital dönüşümün daha ileri aşamalarını temsil etmektedir. Bu göstergeler, işletmelerin yalnızca çevrim içi varlık gösterme düzeyini değil, aynı zamanda veri, süreç, müşteri ve kaynak yönetimini dijital teknolojiler aracılığıyla ne ölçüde bütünleştirebildiğini de ortaya koymaktadır.

Dijital dönüşüm kapasitesi işletme büyüklüğüne göre önemli ölçüde farklılaşmaktadır. Büyük işletmeler çoğu zaman daha güçlü finansal kaynaklara, uzman insan kaynağına, gelişmiş teknolojik altyapılara ve daha kurumsallaşmış yönetim sistemlerine sahip oldukları için ileri dijital teknolojileri daha hızlı benimseyebilmektedir. Buna karşılık küçük ve orta ölçekli işletmeler, sınırlı kaynaklar, dijital beceri eksikliği, yatırım maliyetleri ve stratejik dijitalleşme kapasitesindeki yetersizlikler nedeniyle dijital dönüşüm sürecinde daha kırılgan bir konumda yer alabilmektedir. OECD, KOBİ'lerin dijital dönüşümde büyük işletmelere kıyasla geride kalabildiğini ve dijital uçurumun özellikle veri analitiği, kurumsal kaynak planlaması, bulut bilişim ve yapay zekâ gibi daha karmaşık teknolojilerde belirginleştiğini vurgulamaktadır (OECD, 2021). Benzer şekilde, Eller et al. (2020) da KOBİ dijitalleşmesinde bilgi teknolojileri kaynakları, çalışan becerileri ve dijital stratejinin önemli belirleyiciler olduğunu ortaya koymaktadır.

Türkiye açısından işletmelerin dijital dönüşüm kapasitesinin incelenmesi, hem işletme rekabetçiliği hem de ulusal kalkınma politikaları bakımından önem taşımaktadır. Türkiye'de küçük ve orta ölçekli işletmeler ekonomik yapının önemli bir bölümünü oluşturmakta; istihdam, üretim, girişimcilik ve bölgesel kalkınma açısından kritik bir rol üstlenmektedir. Bu nedenle dijital dönüşüm kapasitesinin yalnızca büyük işletmeler düzeyinde değil, farklı

büyüklük grupları arasında karşılaştırmalı olarak analiz edilmesi gerekmektedir. İşletme büyüklüğüne göre ortaya çıkan dijital kapasite farkları, dijitalleşme politikalarının hangi alanlara odaklanması gerektiğine ilişkin önemli ipuçları sunmaktadır.

Bu çalışmada, Türkiye'de işletmelerin dijital dönüşüm kapasitesi TÜİK tarafından yayımlanan güncel ve resmi istatistikler üzerinden betimsel olarak değerlendirilmektedir. Çalışmanın veri kaynaklarını TÜİK Girişimlerde Bilişim Teknolojileri Kullanım Araştırması 2025 ve TÜİK Yapay Zekâ İstatistikleri 2025 oluşturmaktadır. Bu kapsamda web sitesi sahipliği, sosyal medya kullanımı, e-satış, web satış, kurumsal kaynak planlaması, müşteri ilişkileri yönetimi, iş zekâsı yazılımı, ücretli bulut bilişim ve yapay zekâ kullanımı göstergeleri çalışan sayısına göre işletme büyüklüğü grupları temelinde incelenmektedir (TÜİK, 2025a; TÜİK, 2025b).

Çalışmanın temel amacı, Türkiye'de işletmelerin dijital dönüşüm kapasitesinin işletme büyüklüğüne göre nasıl farklılaştığını ortaya koymaktır. Bu doğrultuda çalışma, nedensel ilişkiler kurmayı değil, TÜİK'in güncel verileri üzerinden işletmelerin dijitalleşme görünümünü betimsel olarak değerlendirmeyi amaçlamaktadır. Elde edilen bulguların, özellikle küçük ve orta ölçekli işletmelerin dijital görünürlükten ileri dijital teknolojilere uzanan dönüşüm sürecinde hangi alanlarda desteklenmesi gerektiğine ilişkin politika yapıcılar, işletme yöneticileri ve araştırmacılar için açıklayıcı bir çerçeve sunması beklenmektedir.

1. KAVRAMSAL ÇERÇEVE

Dijital dönüşüm, işletmelerin dijital teknolojileri yalnızca destekleyici araçlar olarak kullanmasından daha geniş bir anlam taşımaktadır. Bu süreç; işletmenin değer yaratma biçimini, iş modelini, operasyonel süreçlerini, müşteri ilişkilerini ve karar alma mekanizmalarını yeniden yapılandıran stratejik bir değişim alanı olarak değerlendirilmektedir. Vial (2019), dijital dönüşümü dijital teknolojilerin örgütlerde önemli değişimleri tetiklediği ve değer yaratma süreçlerini dönüştürdüğü bir süreç olarak ele almaktadır. Benzer biçimde Verhoef et al. (2021), dijital dönüşümü dijitalleşme ve iş modeli yeniliğiyle ilişkili çok aşamalı bir dönüşüm süreci olarak değerlendirmektedir.

İşletmeler açısından dijital dönüşüm kapasitesi, farklı dijital teknolojilerin benimsenme ve iş süreçlerine entegre edilme düzeyiyle ilişkilidir. Web sitesi ve sosyal medya kullanımı dijital görünürlüğü artırırken; e-satış ve web satış uygulamaları işletmelerin dijital pazarlara erişim kapasitesini güçlendirmektedir. ERP, CRM, iş zekâsı yazılımları, bulut bilişim ve yapay zekâ gibi daha ileri dijital teknolojiler ise işletmelerin veri temelli karar alma, süreç entegrasyonu, müşteri yönetimi ve operasyonel verimlilik kapasitesini desteklemektedir. Bu nedenle dijital dönüşüm, yalnızca çevrim içi varlık göstermekten ibaret olmayıp, işletme stratejisinin dijital

teknolojilerle bütünleşmesini gerektiren kapsamlı bir yönetim alanıdır (Bharadwaj et al., 2013).

Dijital dönüşüm kapasitesi işletme büyüklüğüne göre farklılaşabilmektedir. Büyük işletmeler genellikle daha güçlü finansal kaynaklara, uzman insan kaynağına ve gelişmiş teknolojik altyapılara sahip oldukları için ileri dijital teknolojileri daha kolay benimseyebilmektedir. Buna karşılık küçük ve orta ölçekli işletmeler, sınırlı kaynaklar, dijital beceri eksikliği ve yatırım maliyetleri nedeniyle dijital dönüşüm sürecinde daha fazla desteğe ihtiyaç duyabilmektedir. Eller et al. (2020), KOBİ dijitalleşmesinde bilgi teknolojileri kaynakları, çalışan becerileri ve dijital stratejinin önemli belirleyiciler olduğunu ortaya koymaktadır. OECD (2021) de küçük işletmelerin dijital dönüşümde çoğu zaman büyük işletmelere kıyasla daha yavaş ilerlediğini ve bu nedenle dijitalleşme politikalarının KOBİ'lerin kapasite geliştirme ihtiyaçlarını dikkate alması gerektiğini vurgulamaktadır.

2. YÖNTEM

Bu çalışma, ikincil verilere dayalı betimsel bir araştırma olarak tasarlanmıştır. Araştırmada, Türkiye'de işletmelerin dijital dönüşüm kapasitesini güncel ve resmi istatistikler üzerinden değerlendirmek amacıyla TÜİK tarafından yayımlanan Girişimlerde Bilişim Teknolojileri Kullanım Araştırması 2025 ve Yapay Zeka İstatistikleri 2025 verileri kullanılmıştır (TÜİK, 2025a; TÜİK, 2025b).

Çalışmanın analiz birimini 10 ve daha fazla çalışanı olan girişimler oluşturmaktadır. Girişim büyüklüğü, TÜİK'in ilgili araştırmalarda kullandığı çalışan sayısı gruplandırmasına uygun biçimde 10-49 çalışan, 50-249 çalışan ve 250 ve üzeri çalışan olmak üzere üç kategori üzerinden ele alınmıştır. Bu kapsamda web sitesi sahipliği, sosyal medya kullanımı, e-satış, web satış, ERP, CRM, iş zekâsı yazılımı, ücretli bulut bilişim ve yapay zekâ kullanımı göstergeleri girişim büyüklüğü temelinde karşılaştırmalı olarak incelenmiştir.

Veriler yüzde değerleri üzerinden düzenlenmiş, tablo haline getirilmiş ve girişim büyüklüğü grupları arasında karşılaştırmalı olarak yorumlanmıştır. Bu yönüyle çalışma, nedensel ilişkileri test etmeyi amaçlayan açıklayıcı bir araştırma değil; Türkiye'de işletmelerin dijital dönüşüm kapasitesine ilişkin güncel ve betimsel bir görünüm sunan bir değerlendirme niteliğindedir.

Çalışmanın temel sınırlılığı, kullanılan TÜİK verilerinin 10 ve daha fazla çalışanı olan girişimleri kapsamasıdır. Bu nedenle mikro ölçekli işletmeler araştırma kapsamı dışında kalmaktadır. Ayrıca çalışma ikincil verilere dayandığı için işletmelerin dijital dönüşüm sürecindeki yönetsel, kültürel, finansal ve sektörel dinamiklerini doğrudan açıklamamaktadır. Buna karşın, TÜİK'in güncel ve resmi verileri üzerinden yapılan karşılaştırmalı

değerlendirme, Türkiye'de işletme büyüklüğüne göre dijital dönüşüm kapasitesindeki farklılıkların görünür hale getirilmesine olanak sağlamaktadır.

3. BULGULAR

3.1. Dijital Görünürlük ve Dijital Pazara Erişim Göstergeleri

TÜİK Girişimlerde Bilişim Teknolojileri Kullanım Araştırması 2025 verileri, Türkiye'de işletmelerin dijital görünürlük ve dijital pazara erişim düzeylerinin işletme büyüklüğüne göre belirgin biçimde farklılaştığını göstermektedir. Web sitesi sahipliği, sosyal medya kullanımı, e-satış ve web satış göstergeleri birlikte değerlendirildiğinde, çalışan sayısı arttıkça dijital teknolojilerin kullanım oranının yükseldiği görülmektedir. Bu durum, dijitalleşmenin yalnızca teknolojiye erişimle değil, aynı zamanda işletmelerin ölçek, kaynak, insan sermayesi ve kurumsal kapasite düzeyiyle de ilişkili olduğunu göstermektedir.

Web sitesi sahipliği, işletmelerin dijital görünürlüğünü yansıtan temel göstergelerden biridir. 2025 yılında web sitesi sahipliği oranı 10-49 çalışanlı girişimlerde %52,4 iken, 50-249 çalışanlı girişimlerde %73,1'e, 250 ve üzeri çalışanı olan girişimlerde ise %92,5'e ulaşmaktadır. Bu bulgu, küçük işletmelerin yaklaşık yarısının web sitesi aracılığıyla dijital görünürlük sağladığını; buna karşılık büyük işletmelerde web sitesi sahipliğinin neredeyse standart bir uygulama haline geldiğini göstermektedir.

Sosyal medya kullanımı açısından da benzer bir ölçek farkı görülmektedir. 2025 yılında sosyal medya kullanımı 10-49 çalışanlı girişimlerde %52,8, 50-249 çalışanlı girişimlerde %64,2 ve 250 ve üzeri çalışanı olan girişimlerde %83,4 olarak gerçekleşmiştir. Sosyal medya kullanım oranlarının web sitesi sahipliğine kıyasla küçük işletmelerde görece yakın düzeyde olması, sosyal medyanın daha düşük maliyetli ve erişilebilir bir dijital görünürlük aracı olarak kullanıldığını düşündürmektedir. Ancak büyük işletmelerin sosyal medya kullanımında da daha yüksek oranlara ulaşması, dijital iletişim kapasitesinin işletme büyüklüğüyle birlikte güçlendiğini göstermektedir.

Dijital pazara erişim göstergeleri olan e-satış ve web satış oranlarında ise daha sınırlı bir yaygınlık göze çarpmaktadır. 2024 yılında e-satış yapma oranı 10-49 çalışanlı girişimlerde %12,9, 50-249 çalışanlı girişimlerde %15,1 ve 250 ve üzeri çalışanı olan girişimlerde %26,5'tir. Web satış yapma oranı ise aynı büyüklük gruplarında sırasıyla %11,9, %13,3 ve %21,3 olarak gerçekleşmiştir. Bu bulgular, işletmelerin dijital görünürlük göstergelerinde belirli bir yaygınlığa ulaşmış olmasına rağmen, dijital satış kanallarını kullanma düzeyinin özellikle küçük ve orta ölçekli işletmelerde hâlen sınırlı kaldığını göstermektedir.

Tablo 1. Girişim Büyüklüğüne Göre Dijital Görünürlük ve Dijital Satış Göstergeleri

Gösterge	10-49 çalışan	50-249 çalışan	250+ çalışan
Web sitesi sahipliği, 2025	%52,4	%73,1	%92,5
Sosyal medya kullanımı, 2025	%52,8	%64,2	%83,4
E-satış yapma oranı, 2024	%12,9	%15,1	%26,5
Web satış yapma oranı, 2024	%11,9	%13,3	%21,3

Kaynak: TÜİK Girişimlerde Bilişim Teknolojileri Kullanım Araştırması 2025 verilerinden derlenmiştir. E-satış oranları internet, web sitesi/mobil uygulama veya Elektronik Veri Alışverişi (EDI) aracılığıyla yapılan satışları kapsamakta; web satış oranları ise web sitesi veya mobil uygulamalar üzerinden yapılan satışları ifade etmektedir (TÜİK, 2025a).

Tablo 1'de yer alan bulgular genel olarak değerlendirildiğinde, Türkiye'de işletmelerin dijital görünürlük kapasitesinin dijital satış kapasitesine kıyasla daha gelişmiş olduğu görülmektedir. Başka bir ifadeyle, işletmeler web sitesi ve sosyal medya gibi araçlarla dijital ortamda varlık göstermekte; ancak bu görünürlüğü e-satış ve web satış kanallarına dönüştürme konusunda daha sınırlı bir performans sergilemektedir. Bu farklılık özellikle 10-49 çalışanlı girişimlerde daha belirgindir. Küçük işletmelerde web sitesi sahipliği %52,4 ve sosyal medya kullanımı %52,8 düzeyindeyken, e-satış oranının %12,9 ve web satış oranının %11,9'da kalması, dijital görünürlük ile dijital ticaret kapasitesi arasında önemli bir boşluk bulunduğunu göstermektedir.

Bu bulgular, Türkiye'de dijital dönüşüm politikalarının yalnızca işletmelerin çevrim içi görünürlüğünü artırmaya değil, aynı zamanda dijital satış kanallarını etkin kullanma, e-ticaret altyapısı geliştirme, ödeme ve lojistik süreçlerini dijitalleştirme ve dijital müşteri ilişkileri yönetimi kapasitesini güçlendirme alanlarına da odaklanması gerektiğine işaret etmektedir. Özellikle küçük ve orta ölçekli işletmelerin dijital pazarlara erişim kapasitesinin desteklenmesi, dijital dönüşümün daha kapsayıcı biçimde yaygınlaşması açısından önem taşımaktadır.

3.2. Dijital İş Yazılımları, Bulut Bilişim ve Yapay Zekâ Kullanımı

Dijital dönüşümün ileri aşamaları, işletmelerin yalnızca web sitesi veya sosyal medya kullanımıyla sınırlı değildir. Kurumsal kaynak planlaması (ERP), müşteri ilişkileri yönetimi (CRM), iş zekâsı yazılımları, bulut bilişim ve yapay zekâ kullanımı; işletmelerin süreç entegrasyonu, veri temelli karar alma, müşteri yönetimi, operasyonel verimlilik ve dijital rekabet kapasitesini göstermesi bakımından daha derin göstergeler sunmaktadır. Bu nedenle söz konusu teknolojiler, işletmelerin dijital dönüşüm sürecinde temel dijital görünürlükten ileri dijital yetkinliklere geçiş düzeyini değerlendirmek açısından önem taşımaktadır.

TÜİK verileri, dijital iş yazılımları ve ileri dijital teknolojilerin kullanımında da işletme büyüklüğüne göre belirgin farklılıklar olduğunu göstermektedir. ERP kullanımı 2025 yılında 10-49 çalışanlı girişimlerde %23,6 iken, 50-249 çalışanlı girişimlerde %46,0'a, 250 ve üzeri çalışanı olan girişimlerde ise %76,5'e yükselmektedir. Bu bulgu, büyük işletmelerde iş süreçlerinin dijital sistemlerle bütünleştirilme düzeyinin küçük işletmelere kıyasla çok daha yüksek olduğunu göstermektedir.

CRM kullanımında da benzer bir farklılaşma görülmektedir. 2025 yılında CRM kullanımı 10-49 çalışanlı girişimlerde %9,9, 50-249 çalışanlı girişimlerde %18,4 ve 250 ve üzeri çalışanı olan girişimlerde %42,0 olarak gerçekleşmiştir. Bu sonuç, müşteri verilerinin sistematik biçimde yönetilmesi ve müşteri ilişkilerinin dijital araçlarla desteklenmesi konusunda büyük işletmelerin daha yüksek bir kapasiteye sahip olduğunu ortaya koymaktadır.

İş zekâsı yazılımı kullanımı, dijital dönüşüm kapasitesindeki ölçek farkını en açık gösteren göstergelerden biridir. 2025 yılında iş zekâsı yazılımı kullanımı 10-49 çalışanlı girişimlerde yalnızca %4,9 düzeyindeyken, 50-249 çalışanlı girişimlerde %10,7'ye ve 250 ve üzeri çalışanı olan girişimlerde %35,1'e ulaşmaktadır. Bu bulgu, küçük ve orta ölçekli işletmelerde veri analitiği ve karar destek sistemlerinin kullanımının hâlen oldukça sınırlı olduğunu göstermektedir.

Ücretli bulut bilişim kullanımı da işletme büyüklüğü arttıkça yükselmektedir. 2025 yılında ücretli bulut bilişim kullanımı 10-49 çalışanlı girişimlerde %17,3, 50-249 çalışanlı girişimlerde %31,8 ve 250 ve üzeri çalışanı olan girişimlerde %54,3 olarak gerçekleşmiştir. Bulut bilişim, işletmelere ölçeklenebilir dijital altyapı, veri depolama, yazılım hizmetleri ve esnek çalışma olanakları sunduğu için dijital dönüşümün önemli bileşenlerinden biridir. Ancak bulgular, küçük işletmelerin bulut tabanlı altyapılardan yararlanma düzeyinin büyük işletmelere kıyasla daha düşük kaldığını göstermektedir.

Yapay zekâ kullanımı ise dijital dönüşümün en yeni ve ileri göstergelerinden biri olarak dikkat çekmektedir. TÜİK Yapay Zekâ İstatistikleri 2025 verilerine göre yapay zekâ kullanımı 10-49 çalışanlı girişimlerde %6,6, 50-249 çalışanlı girişimlerde %9,6 ve 250 ve üzeri çalışanı olan girişimlerde %24,1 olarak raporlanmıştır. Bu sonuç, yapay zekâ kullanımının Türkiye'de henüz tüm işletme gruplarında sınırlı düzeyde olduğunu; ancak büyük işletmelerin küçük ve orta ölçekli işletmelere kıyasla yapay zekâ teknolojilerini daha yüksek oranda benimsediğini göstermektedir.

Tablo 2. Girişim Büyüklüğüne Göre Dijital İş Yazılımları ve İleri Teknoloji Kullanımı

Gösterge	10-49 çalışan	50-249 çalışan	250+ çalışan
ERP kullanımı, 2025	%23,6	%46,0	%76,5
CRM kullanımı, 2025	%9,9	%18,4	%42,0
İş zekâsı yazılımı kullanımı, 2025	%4,9	%10,7	%35,1
Ücretli bulut bilişim kullanımı, 2025	%17,3	%31,8	%54,3
Yapay zekâ kullanımı, 2025	%6,6	%9,6	%24,1

Kaynak: TÜİK Girişimlerde Bilişim Teknolojileri Kullanım Araştırması 2025 ve TÜİK Yapay Zekâ İstatistikleri 2025 verilerinden derlenmiştir (TÜİK, 2025a; TÜİK, 2025b).

Tablo 2'de yer alan bulgular genel olarak değerlendirildiğinde, Türkiye'de ileri dijital teknolojilerin kullanımında işletme büyüklüğüne bağlı güçlü bir farklılaşma olduğu görülmektedir. Web sitesi ve sosyal medya gibi temel dijital görünürlük göstergelerine kıyasla ERP, CRM, iş zekâsı, bulut bilişim ve yapay zekâ kullanımında küçük ve orta ölçekli işletmeler ile büyük işletmeler arasındaki kapasite farkı daha belirgin hale gelmektedir. Özellikle iş zekâsı yazılımı ve yapay zekâ kullanımı göstergeleri, küçük işletmelerde dijital dönüşümün hâlen sınırlı ve daha temel düzeylerde ilerlediğine işaret etmektedir.

Bu bulgular, Türkiye'de dijital dönüşüm politikalarının yalnızca dijital görünürlük veya e-ticaret kapasitesini artırmaya odaklanmasının yeterli olmayacağını göstermektedir. Küçük ve orta ölçekli işletmelerin veri analitiği, süreç entegrasyonu, müşteri ilişkileri yönetimi, bulut tabanlı altyapılar ve yapay zekâ temelli çözümlerden daha etkin yararlanabilmesi için finansal desteklerin, dijital beceri geliştirme programlarının, danışmanlık hizmetlerinin ve teknolojiye erişim mekanizmalarının güçlendirilmesi gerekmektedir. Bu açıdan ileri dijital teknolojilere erişim, işletmeler arasında dijital kapasite farkını azaltmanın ve dijital dönüşümü daha kapsayıcı hale getirmenin temel koşullarından biri olarak değerlendirilebilir.

4. SONUÇ VE DEĞERLENDİRME

Bu çalışma, Türkiye'de işletmelerin dijital dönüşüm kapasitesini TÜİK'in güncel verileri üzerinden işletme büyüklüğü temelinde betimsel olarak değerlendirmiştir. Bulgular, web sitesi sahipliği ve sosyal medya kullanımı gibi temel dijital görünürlük göstergelerinde belirli bir yaygınlığa ulaşıldığını; ancak e-satış, web satış, iş zekâsı yazılımı, bulut bilişim ve yapay zekâ kullanımı gibi daha ileri dijitalleşme göstergelerinde işletme büyüklüğüne bağlı belirgin kapasite farkları bulunduğunu göstermektedir (TÜİK, 2025a; TÜİK, 2025b).

Araştırma sonuçları, dijital dönüşümün yalnızca teknolojik araçların kullanımıyla sınırlı olmadığını; işletmelerin iş modeli, müşteri ilişkileri, veri temelli karar alma, operasyonel

verimlilik ve rekabet gücüyle doğrudan ilişkili stratejik bir dönüşüm alanı olduğunu ortaya koymaktadır. Bu bulgu, dijital dönüşümü işletme stratejisinin temel bileşenlerinden biri olarak ele alan çalışmalarla uyumludur (Bharadwaj et al., 2013; Vial, 2019; Verhoef et al., 2021).

Çalışmanın bulguları özellikle küçük ve orta ölçekli işletmeler açısından dikkat çekicidir. KOBİ'lerin dijital görünürlük göstergelerinde ilerleme kaydetmesine karşın, veri analitiği, bulut bilişim, iş zekâsı ve yapay zekâ gibi ileri dijital teknolojilerde büyük işletmelere kıyasla daha sınırlı bir kapasiteye sahip olduğu görülmektedir. Bu sonuç, KOBİ dijitalleşmesinde bilgi teknolojileri kaynakları, çalışan becerileri ve dijital stratejinin kritik rolünü vurgulayan araştırmalarla ve KOBİ'lerin dijital dönüşüm sürecinde özel politika desteğine ihtiyaç duyduğunu belirten OECD değerlendirmeleriyle örtüşmektedir (Eller et al., 2020; OECD, 2021).

Sonuç olarak, Türkiye'de dijital dönüşüm politikalarının yalnızca işletmelerin çevrim içi görünürlüğünü artırmaya değil; dijital satış kapasitesi, veri analitiği, bulut tabanlı altyapılar, dijital beceriler ve yapay zekâ farkındalığı gibi alanlara da odaklanması gerekmektedir. Çalışmanın temel katkısı, Türkiye'de işletmelerin dijital dönüşüm görünümünü güncel ve resmi istatistikler üzerinden bütüncül biçimde sunmasıdır. Bununla birlikte çalışma ikincil verilere dayalı betimsel bir analiz olduğu için nedensel ilişkiler kurmamaktadır. Gelecek araştırmalarda dijital dönüşüm kapasitesi; sektör, bölge, ihracat durumu, inovasyon kapasitesi ve sürdürülebilirlik performansı gibi değişkenlerle birlikte daha ayrıntılı biçimde incelenebilir.

Beyan: Bu çalışmanın hazırlanması sürecinde, metnin dilsel tutarlılığını desteklemek ve Türkçe-İngilizce ile İngilizce-Türkçe çeviri süreçlerine yardımcı olmak amacıyla ChatGPT'den yararlanılmıştır.

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İŞLETME BÜYÜKLÜĞÜNE GÖRE ÇEVRESEL SÜRDÜRÜLEBİLİRLİK FAALİYETLERİ: TÜİK VERİLERİ ÜZERİNDEN BETİMSEL BİR DEĞERLENDİRME

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Özet

Çevresel sürdürülebilirlik, işletmelerin çevresel etkilerini azaltma çabalarının yanı sıra enerji verimliliği, kaynak kullanımı, dijital teknolojilerin çevresel amaçlarla kullanımı ve atık yönetimi uygulamalarıyla da yakından ilişkilidir. Bu çalışmanın amacı, Türkiye'de işletme büyüklüğüne göre çevresel sürdürülebilirlik faaliyetlerinin nasıl farklılaştığını TÜİK tarafından yayımlanan güncel veriler üzerinden betimsel olarak değerlendirmektir. Çalışmada ikincil veri analizi yöntemi benimsenmiş; TÜİK Girişimlerde Bilişim Teknolojileri Kullanım Araştırması 2025 verileri temel alınmıştır. Analiz kapsamında enerji tüketimini azaltmaya yönelik bilgi ve iletişim teknolojileri kullanımı ile kullanılmayan bilgi ve iletişim teknolojileri ekipmanlarının yönetim biçimleri çevresel sürdürülebilirlik ve döngüsel ekonomi bağlamında incelenmiştir.

Bulgular, enerji tüketimini azaltmak amacıyla bilgi ve iletişim teknolojileri sistemleri veya çözümleri kullanan girişimlerin oranının işletme büyüklüğüne göre belirgin biçimde farklılaştığını göstermektedir. Bu oran 10-49 çalışanlı girişimlerde %15,0, 50-249 çalışanlı girişimlerde %24,3 ve 250 ve üzeri çalışanlı girişimlerde %45,0'dır. Ayrıca 10 ve daha fazla çalışanı olan girişimlerin %37,5'i kullanılmayan bilişim teknolojileri ekipmanlarını elektronik atık toplamaya verdiğini veya geri dönüşüme gönderdiğini belirtmiştir. Bulgular, büyük işletmelerin çevresel sürdürülebilirlik faaliyetlerinde daha yüksek bir kapasiteye sahip olduğunu; küçük ve orta ölçekli işletmelerin ise dijital destekli enerji verimliliği ve döngüsel ekonomi uygulamaları açısından daha fazla desteklenmesi gerektiğini göstermektedir.

Anahtar Kelimeler: Çevresel Sürdürülebilirlik, İşletme Büyüklüğü, Enerji Verimliliği, Döngüsel Ekonomi, TÜİK.

ENVIRONMENTAL SUSTAINABILITY PRACTICES BY ENTERPRISE SIZE: A DESCRIPTIVE ASSESSMENT BASED ON TURKSTAT DATA

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Abstract

Environmental sustainability is closely associated not only with firms' efforts to reduce their environmental impacts but also with energy efficiency, resource use, the use of digital technologies for environmental purposes, and waste management practices. The aim of this study is to descriptively examine how environmental sustainability practices differ by enterprise size in Türkiye based on recent data published by TurkStat. The study adopts a secondary data analysis approach and uses data from TurkStat's Survey on Information and Communication Technology Usage in Enterprises 2025. Within the scope of the analysis, the use of information and communication technologies to reduce energy consumption and the management of unused information and communication technology equipment are examined in relation to environmental sustainability and circular economy.

The findings indicate that the proportion of enterprises using information and communication technology systems or solutions to reduce energy consumption differs substantially by enterprise size. This rate is 15.0% among enterprises with 10-49 employees, 24.3% among enterprises with 50-249 employees, and 45.0% among enterprises with 250 or more employees. In addition, 37.5% of enterprises with 10 or more employees reported that they sent unused information and communication technology equipment to electronic waste collection or recycling. The findings suggest that large enterprises have a higher capacity for environmental sustainability practices, whereas small and medium-sized enterprises need stronger support in digitally enabled energy efficiency and circular economy-oriented practices.

Keywords: Environmental Sustainability, Enterprise Size, Energy Efficiency, Circular Economy, TurkStat

GİRİŞ

Çevresel sürdürülebilirlik, günümüzde işletmelerin yalnızca çevreye verdikleri zararı azaltmaya yönelik bir sorumluluk alanı değil; aynı zamanda rekabet gücü, kurumsal dayanıklılık, kaynak verimliliği ve uzun vadeli değer yaratma kapasitesiyle ilişkili stratejik bir yönetim konusu haline gelmiştir. Kurumsal sürdürülebilirlik yaklaşımı, işletmelerin ekonomik performans hedeflerini çevresel ve sosyal sorumluluklarla birlikte ele almasını gerektirmektedir (Dyllick & Hockerts, 2002). Bu bağlamda enerji tüketiminin azaltılması, kaynakların daha verimli kullanılması, atıkların yönetilmesi, ürün ve ekipman yaşam döngüsünün uzatılması ve çevresel etkilerin sistematik biçimde izlenmesi, işletmelerin sürdürülebilirlik kapasitesinin önemli göstergeleri arasında yer almaktadır.

Çevresel sürdürülebilirlik tartışmalarında döngüsel ekonomi yaklaşımı giderek daha fazla önem kazanmaktadır. Döngüsel ekonomi, geleneksel "al-üret-tüket-at" anlayışının yerine kaynakların daha uzun süre sistem içinde tutulmasını, atık oluşumunun azaltılmasını, yeniden kullanım ve geri dönüşüm uygulamalarının güçlendirilmesini hedeflemektedir. Geissdoerfer et al. (2017), döngüsel ekonomiyi kaynak girdilerinin, atıkların, emisyonların ve enerji kayıplarının azaltılmasına odaklanan bir sürdürülebilirlik paradigması olarak ele almaktadır. Bocken et al. (2016) ise döngüsel ekonomi stratejilerinin ürün ömrünü uzatma, kaynak döngülerini kapatma ve kaynak kullanımını daraltma yoluyla işletmelerin sürdürülebilirlik performansına katkı sağlayabileceğini vurgulamaktadır. Bu çerçevede kullanılmayan bilgi ve iletişim teknolojileri ekipmanlarının geri dönüşüme yönlendirilmesi, yeniden kullanılması, satılması, bağışlanması ya da uygun biçimde yönetilmesi, işletmeler açısından çevresel sürdürülebilirlik ve döngüsel ekonomi uygulamalarının somut göstergeleri arasında değerlendirilebilir.

Dijitalleşme ile çevresel sürdürülebilirlik arasındaki ilişki, özellikle ikiz dönüşüm yaklaşımı bağlamında daha görünür hale gelmiştir. İkiz dönüşüm, dijital dönüşüm ile yeşil dönüşümün birbirinden bağımsız değil, birbirini destekleyen iki stratejik dönüşüm alanı olarak ele alınması gerektiğini ifade etmektedir. Muench et al. (2022), yeşil ve dijital dönüşümlerin birçok alanda birbirini güçlendirebileceğini, ancak bu iki dönüşümün otomatik olarak uyumlu hale gelmediğini vurgulamaktadır. Dijital teknolojiler enerji tüketiminin izlenmesi, süreçlerin optimize edilmesi, kaynak kullanımının kontrol edilmesi, atık yönetiminin iyileştirilmesi ve veriye dayalı karar alma süreçlerinin güçlendirilmesi yoluyla çevresel sürdürülebilirlik uygulamalarını destekleyebilmektedir. Bu nedenle bilgi ve iletişim teknolojileri, yalnızca dijital dönüşümün değil, aynı zamanda çevresel performansın ve kaynak verimliliğinin geliştirilmesinde de önemli bir araç olarak değerlendirilebilir (George et al., 2021).

Bununla birlikte, işletmelerin çevresel sürdürülebilirlik faaliyetlerini benimseme düzeyi işletme büyüklüğüne göre farklılaşabilmektedir. Büyük işletmeler daha güçlü finansal

kaynaklara, gelişmiş teknik altyapılara, uzman insan kaynağına ve kurumsallaşmış yönetim sistemlerine sahip oldukları için çevresel sürdürülebilirlik uygulamalarını daha hızlı ve sistematik biçimde hayata geçirebilmektedir. Buna karşılık küçük ve orta ölçekli işletmeler, sınırlı kaynaklar, bilgi ve beceri eksiklikleri, teknolojiye erişim güçlükleri ve yatırım maliyetleri nedeniyle yeşil dönüşüm sürecinde daha kırılgan bir konumda yer alabilmektedir. OECD (2021), KOBİ'lerin toplam çevresel etkileri nedeniyle net sıfır hedefleri açısından kritik öneme sahip olduğunu, ancak yeşil dönüşüm sürecinde finansman, bilgi, kapasite ve politika desteğine ihtiyaç duyduklarını belirtmektedir. Benzer şekilde, KOBİ'lerin dijitalleşme düzeyinde bilgi teknolojileri kaynakları, çalışan becerileri ve dijital stratejinin belirleyici olması, dijital destekli çevresel sürdürülebilirlik uygulamalarında da kurumsal kapasitenin önemini göstermektedir (Eller et al., 2020).

Bu çalışmanın amacı, Türkiye'de işletme büyüklüğüne göre çevresel sürdürülebilirlik faaliyetlerinin nasıl farklılaştığını TÜİK tarafından yayımlanan güncel veriler üzerinden betimsel olarak değerlendirmektir. Bu kapsamda TÜİK Girişimlerde Bilişim Teknolojileri Kullanım Araştırması 2025 verileri temel alınmakta; enerji tüketimini azaltmaya yönelik bilgi ve iletişim teknolojileri kullanımı ile kullanılmayan bilgi ve iletişim teknolojileri ekipmanlarının yönetim biçimleri çevresel sürdürülebilirlik ve döngüsel ekonomi bağlamında incelenmektedir (Türkiye İstatistik Kurumu [TÜİK], 2025). Çalışmada işletme büyüklüğü 10-49 çalışan, 50-249 çalışan ve 250 ve üzeri çalışan grupları üzerinden ele alınmaktadır.

Bu çalışma, çevresel sürdürülebilirlik faaliyetleri ile işletme büyüklüğü arasındaki görünümü betimsel düzeyde ortaya koymayı amaçlamaktadır. Bu nedenle çalışma nedensel bir ilişki testi sunmamakta; mevcut resmi istatistikler üzerinden karşılaştırmalı bir değerlendirme yapmaktadır. Bununla birlikte, elde edilen bulgular Türkiye'de küçük, orta ve büyük ölçekli işletmelerin dijital destekli enerji verimliliği ve döngüsel ekonomi uygulamaları bakımından ne ölçüde farklılaştığını görünür kılmaktadır. Bu yönüyle çalışma, KOBİ'lerin yeşil dönüşüm sürecinde dijital teknolojilerle nasıl desteklenebileceğine ilişkin politika ve araştırma tartışmaları için betimsel bir başlangıç noktası sunmaktadır.

1. KAVRAMSAL ÇERÇEVE

Çevresel sürdürülebilirlik, işletmelerin ekonomik amaçlarını çevresel ve sosyal sorumluluklarla birlikte ele almasını gerektiren çok boyutlu bir yönetim yaklaşımıdır. Dyllick ve Hockerts (2002), kurumsal sürdürülebilirliği işletmelerin ekonomik, çevresel ve sosyal sermayeyi birlikte koruyarak uzun vadeli değer yaratma kapasitesiyle ilişkilendirmektedir. Bu bağlamda enerji tüketiminin azaltılması, kaynak verimliliğinin artırılması ve atıkların yönetilmesi, işletmelerin çevresel sürdürülebilirlik performansının temel bileşenleri arasında değerlendirilebilir.

Döngüsel ekonomi yaklaşımı, çevresel sürdürülebilirliğin işletme uygulamalarına yansıyan önemli boyutlarından biridir. Bu yaklaşım, ürünlerin, ekipmanların ve kaynakların kullanım süresinin uzatılmasını; atık oluşumunun azaltılmasını; yeniden kullanım, geri dönüşüm ve kaynak döngülerinin güçlendirilmesini öne çıkarmaktadır (Bocken et al., 2016; Geissdoerfer et al., 2017). Bu nedenle kullanılmayan bilgi ve iletişim teknolojileri ekipmanlarının geri dönüşüme gönderilmesi, satılması, bağışlanması veya yeniden kullanıma yönlendirilmesi, işletmeler açısından döngüsel ekonomiyle ilişkili çevresel sürdürülebilirlik uygulamaları olarak değerlendirilebilir.

Dijitalleşme ise çevresel sürdürülebilirlik uygulamalarını destekleyen önemli bir araçtır. İkiz dönüşüm yaklaşımı, dijital dönüşüm ile yeşil dönüşümün birlikte ele alınması gerektiğini vurgulamakta; dijital teknolojilerin enerji tüketimini izleme, süreçleri optimize etme, kaynak kullanımını kontrol etme ve çevresel performansı iyileştirme potansiyeline dikkat çekmektedir (George et al., 2021; Muench et al., 2022). Ancak bu kapasite işletme büyüklüğüne göre farklılaşabilmektedir. Büyük işletmeler daha güçlü kaynaklara ve teknik altyapılara sahipken, KOBİ'ler dijital ve yeşil dönüşüm süreçlerinde daha fazla desteğe ihtiyaç duyabilmektedir (Eller et al., 2020; OECD, 2021). Bu çalışma da TÜİK verileri üzerinden işletme büyüklüğüne göre dijital destekli çevresel sürdürülebilirlik kapasitesini betimsel olarak değerlendirmektedir (TÜİK, 2025).

2. YÖNTEM

Bu çalışma, ikincil verilere dayalı betimsel bir araştırma olarak tasarlanmıştır. Araştırmada temel veri kaynağı olarak TÜİK tarafından yayımlanan Girişimlerde Bilişim Teknolojileri Kullanım Araştırması 2025 kullanılmıştır. Çalışmanın analiz birimini 10 ve daha fazla çalışanı olan girişimler oluşturmaktadır.

İşletme büyüklüğü, TÜİK'in çalışan sayısına dayalı sınıflandırmasına uygun biçimde 10-49 çalışan, 50-249 çalışan ve 250 ve üzeri çalışan grupları üzerinden ele alınmıştır. Çevresel sürdürülebilirlik faaliyetleri ise iki temel göstergeyle incelenmiştir: enerji tüketimini azaltmaya yönelik bilgi ve iletişim teknolojileri sistemleri veya çözümleri kullanımı ile kullanılmayan bilgi ve iletişim teknolojileri ekipmanlarının elektronik atık toplama veya geri dönüşüme yönlendirilmesi.

Veriler yüzde değerleri üzerinden düzenlenmiş, tablo haline getirilmiş ve işletme büyüklüğüne göre karşılaştırmalı olarak yorumlanmıştır. Bu nedenle çalışma nedensel ilişki testi sunmamakta; Türkiye'de işletme büyüklüğüne göre dijital destekli çevresel sürdürülebilirlik kapasitesine ilişkin güncel ve betimsel bir görünüm ortaya koymaktadır. Verilerin toplulaştırılmış resmi istatistiklere dayanması ve mikro işletmeleri kapsamaması çalışmanın temel sınırlılıklarıdır.

3. BULGULAR

Bu bölümde, işletme büyüklüğüne göre çevresel sürdürülebilirlik faaliyetleri betimsel olarak değerlendirilmektedir. Analiz kapsamında öncelikle enerji tüketimini azaltmaya yönelik bilgi ve iletişim teknolojileri kullanımı incelenmekte; ardından kullanılmayan bilgi ve iletişim teknolojileri ekipmanlarının yönetim biçimleri e-atık yönetimi ve döngüsel ekonomi bağlamında ele alınmaktadır.

3.1. Enerji Tüketimini Azaltmaya Yönelik Bilgi ve İletişim Teknolojileri Kullanımı

TÜİK Girişimlerde Bilişim Teknolojileri Kullanım Araştırması 2025 verileri, enerji tüketimini azaltmaya yönelik bilgi ve iletişim teknolojileri kullanımının işletme büyüklüğüne göre belirgin biçimde farklılaştığını göstermektedir. En az 10 çalışanı olan girişimlerin genelinde bu oran %17,1 iken, çalışan sayısı arttıkça kullanım düzeyi yükselmektedir.

Tablo 1. İşletme Büyüklüğüne Göre Enerji Tüketimini Azaltmaya Yönelik BİT Kullanımı, 2025

İşletme büyüklüğü	Enerji tüketimini azaltmak için BİT sistemleri/çözümleri kullanımı
10-49 çalışan	%15,0
50-249 çalışan	%24,3
250 ve üzeri çalışan	%45,0
10 ve üzeri çalışanlı girişimler genel oranı	%17,1

Kaynak: TÜİK Girişimlerde Bilişim Teknolojileri Kullanım Araştırması, 2025 verilerinden derlenmiştir.

Tablo 1'de görüldüğü üzere, enerji tüketimini azaltmaya yönelik BİT sistemleri veya çözümleri kullanımı 10-49 çalışanlı girişimlerde %15,0 iken, 50-249 çalışanlı girişimlerde %24,3'e ve 250 ve üzeri çalışanı olan girişimlerde %45,0'a yükselmektedir. Bu bulgu, işletme büyüklüğü arttıkça dijital destekli enerji verimliliği uygulamalarının daha yaygın hale geldiğini göstermektedir.

Özellikle küçük ve büyük işletmeler arasındaki fark dikkat çekicidir. Büyük işletmelerde enerji tüketimini azaltmaya yönelik BİT kullanımı, küçük işletmelere göre 30 yüzde puan daha yüksektir. Başka bir ifadeyle, büyük işletmelerin bu tür uygulamaları kullanma oranı küçük işletmelerin üç katına ulaşmaktadır. Bu sonuç, çevresel sürdürülebilirlik faaliyetlerinde

işletme ölçeğinin teknolojik altyapı, finansal kaynak ve kurumsal kapasite bakımından önemli bir farklılaşma yarattığını göstermektedir.

Genel olarak değerlendirildiğinde, küçük ve orta ölçekli işletmelerin enerji verimliliği amacıyla dijital teknolojilerden yararlanma düzeyinin büyük işletmelere kıyasla daha sınırlı kaldığı görülmektedir. Bu nedenle KOBİ'lerin enerji izleme, süreç optimizasyonu, otomasyon ve veri temelli karar alma gibi dijital destekli çevresel sürdürülebilirlik uygulamalarında daha fazla desteklenmesi önem taşımaktadır.

3.2. Kullanılmayan BİT Ekipmanlarının Yönetimi ve E-Atık Uygulamaları

Çevresel sürdürülebilirlik açısından bir diğer önemli gösterge, işletmelerin kullanılmayan bilgi ve iletişim teknolojileri ekipmanlarını nasıl yönettikleridir. Bilgisayar, monitör, cep telefonu ve benzeri ekipmanların kullanım dışı kalması, elektronik atık yönetimi ve kaynak verimliliği açısından önemli bir konu oluşturmaktadır. Bu nedenle kullanılmayan BİT ekipmanlarının geri dönüşüme gönderilmesi, yeniden kullanılması, satılması, kiralanması veya bağışlanması döngüsel ekonomiyle ilişkili uygulamalar olarak değerlendirilebilir.

Tablo 2. Girişimlerde Kullanılmayan BİT Ekipmanlarının Yönetim Biçimleri, 2025

Kullanılmayan BİT ekipmanlarının yönetim biçimi	10 ve üzeri çalışanlı girişimlerin oranı
Elektronik atık toplamaya verme veya geri dönüşüme gönderme	%37,5
Yedek parça olarak kullanmak veya bilgi güvenliği gibi nedenlerle işletmede muhafaza etme	%39,6
Satma, kiralama veya bağışlama	%32,3

Kaynak: TÜİK Girişimlerde Bilişim Teknolojileri Kullanım Araştırması, 2025 verilerinden derlenmiştir.

Tablo 2'de yer alan bulgular, 10 ve daha fazla çalışanı olan girişimlerin %37,5'inin kullanılmayan BİT ekipmanlarını elektronik atık toplamaya verdiğini veya geri dönüşüme gönderdiğini göstermektedir. Bu oran, işletmelerde e-atık yönetimi ve geri dönüşüm farkındalığının belirli bir düzeye ulaştığını göstermekle birlikte, uygulamanın girişimlerin yarısından daha düşük bir düzeyde kaldığını da ortaya koymaktadır.

Bulgular ayrıca girişimlerin %39,6'sının kullanılmayan BİT ekipmanlarını yedek parça olarak kullanmak veya bilgi güvenliği gibi nedenlerle işletmede muhafaza ettiğini; %32,3'ünün ise bu ekipmanları sattığını, kiraladığını veya bağışladığını göstermektedir. Bu sonuçlar, kullanılmayan BİT ekipmanlarının yalnızca atık olarak değil, yeniden kullanım ve ürün

ömrünü uzatma açısından da değerlendirildiğini göstermektedir. Ancak e-atık yönetimi ve geri dönüşüm uygulamalarının daha yaygın hale getirilmesi, işletmelerde döngüsel ekonomi ve çevresel sürdürülebilirlik kapasitesinin güçlendirilmesi açısından önem taşımaktadır.

3.3. İşletme Büyüklüğüne Göre Çevresel Sürdürülebilirlik Kapasite Farkı

Enerji tüketimini azaltmaya yönelik BİT kullanımı göstergesi, işletme büyüklüğüne göre çevresel sürdürülebilirlik kapasitesinde belirgin bir farklılaşma olduğunu göstermektedir. Bu farklılaşma yalnızca yüzde değerleri üzerinden değil, küçük, orta ve büyük işletmeler arasındaki kapasite açığı açısından da değerlendirilebilir.

Tablo 3. İşletme Büyüklüğüne Göre Dijital Destekli Enerji Verimliliği Kullanım Farkı, 2025

Karşılaştırma	Enerji verimliliği için BİT kullanımı	Farkın yorumu
Orta ölçekli işletme / Küçük işletme	%24,3 / %15,0	Orta ölçekli işletmelerde kullanım oranı küçük işletmelere göre 9,3 yüzde puan daha yüksektir.
Büyük işletme / Küçük işletme	%45,0 / %15,0	Büyük işletmelerde kullanım oranı küçük işletmelerin 3 katıdır.
Büyük işletme / Orta ölçekli işletme	%45,0 / %24,3	Büyük işletmelerde kullanım oranı orta ölçekli işletmelere göre yaklaşık 1,85 kat daha yüksektir.

Kaynak: TÜİK Girişimlerde Bilişim Teknolojileri Kullanım Araştırması, 2025 verilerinden hesaplanmıştır.

Not: Küçük işletme 10-49 çalışanlı, orta ölçekli işletme 50-249 çalışanlı, büyük işletme ise 250 ve üzeri çalışanlı girişimleri ifade etmektedir. Oransal fark, karşılaştırılan ilk grubun enerji tüketimini azaltmaya yönelik BİT kullanımı oranının ikinci grubun oranına bölünmesiyle hesaplanmıştır.

Tablo 3'te görüldüğü üzere, orta ölçekli işletmelerin enerji tüketimini azaltmaya yönelik BİT kullanımı küçük işletmelere göre 9,3 yüzde puan daha yüksektir. Büyük işletmeler ile küçük işletmeler arasındaki fark ise 30 yüzde puana ulaşmaktadır. Bu sonuç, büyük işletmelerin dijital destekli enerji verimliliği uygulamalarında küçük işletmelere göre çok daha ileri bir konumda olduğunu göstermektedir.

Genel olarak değerlendirildiğinde, çevresel sürdürülebilirlik kapasitesinin yalnızca çevresel farkındalıkla değil, aynı zamanda teknolojik altyapı, işletme ölçeği, finansal kaynaklar ve

kurumsal kapasiteyle de ilişkili olduğu görülmektedir. Bu nedenle KOBİ'lerde çevresel sürdürülebilirlik kapasitesinin artırılması için enerji verimliliği odaklı dijital teknoloji yatırımları, e-atık yönetimi farkındalığı, geri dönüşüm altyapısına erişim ve döngüsel ekonomi uygulamalarına yönelik destek mekanizmalarının güçlendirilmesi önem taşımaktadır.

4. SONUÇ VE DEĞERLENDİRME

Bu çalışma, Türkiye'de işletme büyüklüğüne göre çevresel sürdürülebilirlik faaliyetlerinin nasıl farklılaştığını TÜİK Girişimlerde Bilişim Teknolojileri Kullanım Araştırması 2025 verileri üzerinden betimsel olarak değerlendirmiştir. Bulgular, enerji tüketimini azaltmaya yönelik BİT sistemleri veya çözümleri kullanımının işletme büyüklüğü arttıkça belirgin biçimde yükseldiğini göstermektedir. Bu oran 10-49 çalışanlı girişimlerde %15,0 iken, 50-249 çalışanlı girişimlerde %24,3'e ve 250 ve üzeri çalışanı olan girişimlerde %45,0'a ulaşmaktadır. Bu sonuç, çevresel sürdürülebilirlik kapasitesinin yalnızca çevresel farkındalıkla değil; aynı zamanda teknolojik altyapı, finansal kaynaklar ve kurumsal kapasiteyle de ilişkili olduğunu göstermektedir (TÜİK, 2025).

Araştırma bulguları, kullanılmayan BİT ekipmanlarının yönetimi açısından da önemli sonuçlar sunmaktadır. Girişimlerin %37,5'inin kullanılmayan ekipmanları elektronik atık toplamaya verdiği veya geri dönüşüme gönderdiği; %32,3'ünün ise bu ekipmanları sattığı, kiraladığı veya bağışladığı görülmektedir. Bu göstergeler, işletmelerde e-atık yönetimi ve yeniden kullanım uygulamalarının belirli bir düzeye ulaştığını göstermektedir. Bununla birlikte, geri dönüşüm oranının girişimlerin yarısından daha düşük düzeyde kalması, döngüsel ekonomi uygulamalarının daha fazla yaygınlaştırılması gerektiğine işaret etmektedir. Bu bulgu, ürün ömrünün uzatılması, yeniden kullanım ve kaynak döngülerinin güçlendirilmesini vurgulayan döngüsel ekonomi yaklaşımıyla uyumludur (Bocken et al., 2016; Geissdoerfer et al., 2017).

Genel olarak değerlendirildiğinde, çalışma büyük işletmelerin dijital destekli çevresel sürdürülebilirlik uygulamalarında daha güçlü bir konumda bulunduğunu; küçük ve orta ölçekli işletmelerin ise özellikle enerji verimliliği, e-atık yönetimi ve döngüsel ekonomi uygulamalarında desteklenmeye ihtiyaç duyduğunu ortaya koymaktadır. Bu sonuç, KOBİ'lerin dijital ve yeşil dönüşüm süreçlerinde finansman, bilgi, beceri ve teknolojiye erişim açısından daha fazla desteğe ihtiyaç duyduğunu belirten çalışmalarla örtüşmektedir (Eller et al., 2020; OECD, 2021). Bu nedenle KOBİ politikalarının dijitalleşme ve çevresel sürdürülebilirliği ayrı ayrı değil, ikiz dönüşüm yaklaşımı çerçevesinde birlikte ele alması önem taşımaktadır (George et al., 2021; Muench et al., 2022).

Çalışmanın temel katkısı, Türkiye'de işletme büyüklüğüne göre dijital destekli çevresel sürdürülebilirlik kapasitesini güncel ve resmi istatistikler üzerinden görünür kılmasıdır.

Bununla birlikte çalışma, toplulaştırılmış ikincil verilere dayandığı için işletme düzeyinde nedensel ilişki testi sunmamaktadır. Gelecekte yapılacak araştırmalarda çevresel sürdürülebilirlik göstergeleri; sektör, bölge, ihracat, Ar-Ge, yenilikçilik kapasitesi, katma değer ve finansal performans gibi değişkenlerle birlikte incelenebilir. Sonuç olarak, KOBİ'lerin rekabet gücünü, kaynak verimliliğini ve çevresel sürdürülebilirlik kapasitesini artırmak için dijital ve yeşil dönüşümü bütüncül biçimde destekleyen politika mekanizmalarına ihtiyaç bulunmaktadır.

Beyan: Bu çalışmanın hazırlanması sürecinde, metnin dilsel tutarlılığını desteklemek ve Türkçe-İngilizce ile İngilizce-Türkçe çeviri süreçlerine yardımcı olmak amacıyla ChatGPT'den yararlanılmıştır.

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ANALYZING THE RELATIONSHIP BETWEEN ENVIRONMENTAL SOCIAL GOVERNANCE (ESG) AND CORPORATE PERFORMANCE: A SYSTEMATIC LITERATURE REVIEW AND META-SYNTHESIS

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Abstract

This study aims to dissect the relationship between Environmental, Social, and Governance (ESG) and company performance through a systematic and integrative approach. Although ESG has received increasing attention in recent years, previous research has shown inconsistent results regarding the direction and magnitude of its influence on corporate performance, necessitating a comprehensive synthesis. This study employed a Systematic Literature Review (SLR) method combined with a meta-synthesis approach, following PRISMA guidelines and employing a structured search strategy across various academic databases to ensure broad coverage of the literature. Relevant, reputable journal articles were critically analyzed, focusing on ESG dimensions, corporate performance indicators, and mediating and moderating variables that influence these relationships. The results indicate that ESG generally has a positive influence on corporate performance, including financial performance, firm value, and market performance. However, this relationship is heterogeneous and strongly influenced by context, such as differences in ESG measurement, research methods, and institutional environments. The governance dimension proved to be the most dominant, while the environmental and social dimensions tended to vary across sectors. Furthermore, ESG also plays a role in reducing risk and enhancing long-term resilience, although its effects are often indirect and complex. The novelty of this research lies in the meta-synthesis approach that is able to reveal the non-linear ESG relationship mechanism, while its contribution is to provide a comprehensive conceptual framework and practical implications for academics, investors, and policymakers, while also offering directions for further research.

Keywords: ESG, Corporate Performance, Systematic Literature Review, Meta-Synthesis, Sustainability, Corporate Governance

INTRODUCTION

In the last decade, the concept of Environmental, Social, and Governance (ESG) has undergone a significant transformation from a mere non-financial reporting instrument to a strategic framework that plays a crucial role in determining a company's sustainability and competitiveness. This change was driven by increasing pressure from institutional investors, regulators, and the public demanding transparency, accountability, and socially and environmentally responsible business practices. ESG is now viewed as a key indicator in evaluating the quality of corporate governance, management's ability to manage non-financial risks, and the potential for long-term value creation. In line with these developments, academic literature on ESG has grown rapidly, particularly in examining the relationship between ESG and various dimensions of company performance, including financial performance, firm value, and corporate risk (Nguyen, n.d.).

The relationship between ESG and corporate performance has been a major focus in numerous empirical studies and literature reviews. Numerous studies have shown that effective ESG implementation can enhance corporate value through improved reputation, operational efficiency, and investor confidence. Furthermore, integrating ESG into corporate strategy can strengthen business sustainability and create long-term competitive advantage. Furthermore, ESG also plays a role in mitigating risk.

Companies, particularly reputational and operational risks, ultimately impact the stability of financial performance. However, existing research findings are inconsistent, with some studies finding a significant positive relationship, while others show weak or insignificant results. (Bani-Khaled et al., nd; Li et al., nd; Nian & Said, nd).

These inconsistent results indicate fragmentation in the ESG literature, both conceptually and methodologically. Previous research tends to develop separately across various subtopics such as ESG risk, ESG disclosure, and ESG-based investment, without strong integration within a comprehensive theoretical framework. Furthermore, many literature reviews are still descriptive in nature and fail to systematically connect various empirical findings. This situation leads to a lack of in-depth understanding of the mechanisms of the relationship between ESG and company performance and the factors that moderate this relationship. (Nguyen, nd; Seow, nd).

Furthermore, there are several significant research gaps in the ESG and firm performance literature. First, most previous studies have focused on the direct relationship between ESG and firm performance without exploring the mechanisms of this relationship in depth, including the interactions between ESG dimensions that may actually have different impacts on performance. Second, previous research has been dominated by quantitative approaches using secondary data, while integration with qualitative approaches and theoretical

perspectives has been limited. Third, differences in ESG measurement and firm performance indicators lead to high heterogeneity in the results, making it difficult to draw general conclusions. Fourth, most literature reviews have not conducted an in-depth synthesis of the research content and are limited to bibliometric or descriptive analysis (Nian & Said, nd; Supratno et al., 2021).

Furthermore, the lack of cross-context integration is a major limitation of the existing literature. Many studies focus on specific geographic regions or industry sectors, making their results difficult to generalize broadly. ESG determinants have been shown to be strongly influenced by contextual factors such as regulation, governance structure, and industry characteristics. Furthermore, the relationship between social responsibility and financial performance is also significantly influenced by external pressures and market expectations, indicating that the relationship between ESG and corporate performance is dynamic and contextual. Therefore, a research approach is needed that is able to integrate these various contexts to produce a more comprehensive understanding (Martiny et al., nd; Supratno et al., 2021).

Based on this gap, this study offers a significant contribution by adopting a systematic literature review approach combined with meta-synthesis to deeply examine the relationship between ESG and corporate performance. This approach allows for the systematic and interpretive integration of empirical findings from various studies, thus generating a deeper understanding.

This study provides a comprehensive overview of the ESG–performance nexus. Furthermore, this study integrates various theoretical perspectives, such as stakeholder theory, legitimacy theory, and agency theory, to explain the relationship between ESG and company performance in greater depth.

The main novelty of this research lies in the integration of systematic literature review and meta-synthesis approaches in analyzing the relationship between ESG and company performance holistically. This research not only summarizes existing empirical findings but also identifies the sources of heterogeneity in research results and develops a more integrated conceptual framework. Furthermore, this research outlines a future research agenda focused on developing more standardized ESG measurements, integrating research methodologies, and exploring ESG relationships across various industrial and geographic contexts. Therefore, this research is expected to make significant theoretical and practical contributions to the development of ESG literature and its implementation in the business world.

1. RESEARCH METHODOLOGY

This study uses a Systematic Literature Review (SLR) approach combined with meta-synthesis to comprehensively analyze the relationship between Environmental, Social, and Governance (ESG) and company performance. The SLR approach was chosen because it allows for systematic, transparent, and replicable identification, evaluation, and synthesis of literature, thereby enhancing the validity and reliability of the research findings. Furthermore, meta-synthesis is used to integrate research findings from diverse methodological approaches, both quantitative and qualitative, to generate a deeper conceptual understanding of the ESG performance nexus. This approach is highly relevant given that the ESG literature exhibits a high degree of heterogeneity in empirical findings and fragmentation in theoretical frameworks (Bani-Khaled et al., n.d.; Mengist et al., n.d.; Nguyen, n.d.).

In its implementation, this study adopted the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) protocol as the primary guideline for the literature selection process. PRISMA was used to ensure that every stage of the research, from article identification to inclusion, was conducted systematically and transparently. In addition, this research also integrates the SALSA (Search, Appraisal, Synthesis, Analysis) framework to strengthen the literature analysis process, especially in the research stage. quality evaluation and synthesis of findings. The combination of these two approaches allows research not only to identify the literature broadly but also to produce an in-depth and structured synthesis (Mengist et al., nd; Sharma et al., nd).

The literature search strategy was conducted systematically, utilizing reputable academic databases to ensure comprehensive coverage. The search focused on articles published in reputable journals, particularly those indexed by Scopus Q1 and Q2, to ensure high academic quality. The search string was constructed using a combination of Boolean operators to identify literature relevant to the topic of ESG and corporate performance. Operationally, the search string included terms such as ESG, environmental social governance, or sustainability performance combined with firm performance, financial performance, or firm value, and supported by methodological terms such as systematic literature review, meta-analysis, or meta-synthesis. The search process was conducted on titles, abstracts, and keywords to ensure a high level of relevance to the research focus. (Aggarwal et al., nd).

Furthermore, the literature selection process is carried out through several stages that follow the PRISMA flow, namely identification, screening, feasibility evaluation, and inclusion. In the identification stage, all articles obtained from the database were collected and documented. The next stage was screening, where duplicate articles were removed and an initial selection was made based on the title and abstract to eliminate irrelevant studies. In the eligibility evaluation stage, articles that passed the initial screening were analyzed in full (full

text review) to ensure their suitability for the research objectives. The final stage was inclusion, which involved selecting articles that met all criteria for further analysis. This process was carried out systematically to minimize selection bias and ensure the quality of the literature used in the study (Saini et al., n.d.).

Strict inclusion and exclusion criteria were established to maintain the consistency and quality of the analyzed data. Articles included in this study were those that explicitly addressed the relationship between ESG and company performance, whether in terms of financial performance, firm value, or risk. Furthermore, articles had to be empirical studies, systematic reviews, or meta-analyses published in reputable scientific journals and in English. The publication period was limited to the most recent period, from 2015 to 2026, to ensure relevance to recent developments in ESG research. Conversely, articles that had not undergone peer-review, were not directly related to the topic, or had incomplete data were excluded from the analysis. This approach ensured that only relevant and high-quality literature was used in the synthesis process (Narula et al., n.d.).

After the selection process was completed, data from the selected articles was systematically extracted using a structured template. The collected information included article identifiers such as author, publication year, and journal, as well as methodological aspects such as research design, ESG variables used, company performance indicators, and key findings. Furthermore, research context, such as geographic region and industry sector, was recorded to support comparative analysis. The data extraction process was conducted carefully and iteratively to ensure the accuracy and consistency of the information collected. Next, the extracted data was coded using a thematic approach to identify patterns in the relationship between ESG and company performance.

In the quality evaluation stage, each article is assessed based on several key criteria: clarity of research objectives, appropriateness of methodology, validity of analysis, and contribution to ESG literature. This assessment aims to ensure that only studies of adequate methodological quality that serve as the basis for the synthesis. Quality evaluation also helps identify potential bias in the analyzed literature, so that research results can be interpreted more carefully and accurately (Mengist et al., nd).

The final stage of this research is data synthesis and analysis using a meta-synthesis approach. Unlike meta-analysis, which focuses on statistical aggregation, meta-synthesis allows for interpretive integration of findings to generate deeper conceptual understanding. The analysis is conducted through several steps: identifying key themes, comparing findings across studies, and developing a conceptual framework explaining the relationship between ESG and company performance. This approach allows researchers to identify moderating and mediating factors influencing the relationship and explain the heterogeneity of results found

in previous literature. Thus, meta-synthesis provides a richer contribution to understanding the complexity of the ESG performance nexus (Mengist et al., n.d.).

To ensure the reliability and validity of the research, the entire process was conducted transparently and well-documented. The use of the PRISMA protocol, clear selection criteria, and a systematic data extraction and analysis process were crucial steps in enhancing the research's credibility. Furthermore, cross-checking was performed during the data extraction and coding stages to mitigate potential subjective bias. With this approach, the research is expected to produce robust, replicable findings and make a significant contribution to the development of the ESG and corporate performance literature (Saini et al., n.d.).

2. RESEARCH RESULTS/RESEARCH FINDINGS

2.1. Positive Relationship of ESG to Company Performance

Findings from various studies analyzed in this systematic literature review consistently show that the implementation of Environmental, Social, and Governance (ESG) is positively related to company performance across various dimensions, including financial performance, firm value, and market performance. This relationship is explained by improved corporate reputation, operational efficiency, and strengthened investor and stakeholder trust. Recent studies confirm that companies with better ESG practices tend to have greater access to funding sources, lower costs of capital, and greater resilience to external risks (Bani-Khaled et al., n.d.; Cai et al., n.d.; Nian & Said, n.d.).

Furthermore, ESG also serves as a mechanism for creating long-term value through the integration of sustainability practices into business strategy. The environmental dimension contributes to resource efficiency and cost reduction, the social dimension enhances customer loyalty and stakeholder relationships, while the governance dimension enhances transparency and the quality of corporate decision-making. This is in line with stakeholder theory and legitimacy theory which explains that Companies that are able to meet social and environmental expectations will gain higher legitimacy and have an impact on improving performance (Zairis, nd). However, the strength of this positive relationship is not universal. Various research results indicate that the influence of ESG on company performance is strongly influenced by the industry context, company characteristics, and the institutional environment. Companies in developed countries with strict regulations and high levels of ESG awareness tend to show a stronger relationship than those in developing countries (Jayne et al., 2010; Parra-Domínguez, J., 2026). Furthermore, industrial sectors such as energy and manufacturing exhibit a more significant ESG impact than other sectors due to higher environmental pressures.

Table 1. Synthesis of Key Studies on ESG and Corporate Performance

Authors	Title and Year	Country	Aim	Methodology	Finding	Journal
Bani-Khaled et al.	ESG factors and firm value (2025)	Global	Analyzes influence ESG on company value	SLR	ESG matters uh significantly positive on firm value	AMS Review
Li et al.	ESG performance and corporate success (2024)	Global	Review of relationships ESG and company values	SLR	ESG increase the value company n and sustainability business tan	Business Strategy & Development
Nian & Said	ESG, risk and financial performance (2025)	Global	Testing ESG on risk and performance	SLR	ESG increase performance decrease an risk	Journal of Scientific Research
Coelho et al.	CSR and financial performance (2023)	Global	Assessment impact CSR on performance	SLR	CSR (part ESG) impact k positive on performance	CSR & Environmental Management
Yingzhao & Hizam Hanafiah	ESG and financial performance nce (2024)	Malaysia	Analysis connection ESG and performance	SLR	ESG bewitched uh positive but varies	Malaysia an Journal of Consumer Economistics
Godinez-Reyes et al.	CSR and financial performance nce (2025)	Latin America ca	Analysis CSR and performance	SLR	Positive relationship with variation regional	Analysis Econom ico
Parra Domínguez et al.	CSR in emerging markets (2026)	Emergencies markets	Evaluation CSR and performance	SLR	Positive impact ESG depending context	Social Sciences & Humanities Open
Da Cunha et al.	ESG indicator s and performance nce (2025)	Global	Carry gan framework ESG	SLR	ESG increase right performance through indicators structured	Future Business Journal

Based on the synthesis table above, there is a consistent pattern that ESG plays a role as a value driver in improving company performance. However, ESG's contribution is not only direct, but also through indirect mechanisms such as risk reduction, reputation enhancement, and operational efficiency. This demonstrates that ESG is not simply a reporting tool but has evolved into an integrated business strategy.

Further analysis shows that the positive relationship between ESG and corporate performance is multidimensional and contextual. Cross-country studies indicate that institutional factors

such as regulation, market pressure, and ESG awareness are key determinants in strengthening or weakening this relationship. Furthermore, variations in ESG measurement methods and performance indicators contribute to differences in results across studies, indicating the need for a more integrated, synthesized approach.

Furthermore, the findings also show that ESG has a more significant impact in the long term than in the short term. This indicates that investing in ESG is a sustainable strategy that requires time to generate optimal benefits. Thus, ESG can be viewed as a form of strategic investment that creates both economic and social and environmental value.

This research makes a major contribution by synthesizing various empirical findings on the relationship between ESG and corporate performance through an integrated systematic literature review and meta-synthesis approach. Unlike previous studies, which tend to be fragmented, this research offers a more comprehensive understanding by identifying common patterns, inconsistencies, and contextual factors influencing the relationship. The main novelty of this research lies in:

a. Integration across studies to reveal the relationship patterns between ESG and performance in general holistic

b. Emphasis on the multidimensional and contextual nature of the ESG–performance nexus

c. Development of a conceptual basis for further meta-synthesis-based research

Thus, this study not only strengthens the empirical evidence regarding the positive relationship between ESG and firm performance, but also provides a new direction for the development of ESG theory and practice in the future.

2.2. Heterogeneity of Research Results (Inconsistent Findings)

Although the majority of the literature indicates a positive relationship between ESG and company performance, the findings of this systematic literature review also reveal significant heterogeneity and inconsistency in research findings. Some studies found a strong and significant relationship, while others showed a weak, insignificant, or even negative relationship in some cases.

This variation in results confirms that the relationship between ESG and company performance is not universal, but is strongly influenced by the methodological approach, variable measurement, and research context (Kumar & Shah, nd).

One of the main sources of inconsistency is differences in ESG measurements. Some studies use ESG scores from data providers like Refinitiv or MSCI, while others use proxy indicators like CSR disclosure or sustainability reporting. These differences result in variations in the

presentation of ESG quality (Aggarwal et al., n.d.; Mukhtar et al., n.d.), which ultimately impacts the empirical results. Furthermore, differences in corporate performance measures, such as the use of ROA, ROE, Tobin's Q, or market-based indicators, contribute to the heterogeneity of the findings (Clément et al., n.d.; Supratno et al., 2021).

From a methodological perspective, inconsistencies are also influenced by variations in research approaches, such as the use of panel regression models, cross-sectional analysis, and meta-analysis. Quantitative studies often produce different findings than qualitative studies or systematic reviews due to differences in research design and analysis techniques. Furthermore, there is the potential for Endogeneity and selection bias in empirical ESG research are also important factors influencing the results (Aggarwal et al., nd; Mukhtar et al., nd).

Contextual factors such as country, industrial sector, and level of economic development also plays a significant role in explaining the inconsistencies in findings. Studies conducted in developed countries tend to show a stronger relationship between ESG and corporate performance compared to those in developing countries, which still face limitations in ESG regulation and implementation. Furthermore, industrial sectors with high environmental pressures, such as energy and manufacturing, show a more consistent relationship than the service sector (Godinez-Reyes, NL, 2025; Waldau, n.d.).

Table 2. Synthesis of Studies Related to ESG Inconsistency and Performance

Authors	Title and Year	Country	Aim	Methodology	Finding	Journal
Nian & Said	ESG, risk and financial performance (2025)	Global	Impact Assessment ESG on risk and performance	SLR	Results varies depending on the indicator	Journal of Scientific Research
Yingzhao & Hizam-Hanafiah	ESG and financial performance (2024)	Malaysia	Relationship analysis ESG and performance	SLR	Relationship is not consistent between studies	Malaysian Journal of Consumer Economics
Clement et al.	ESG scores in literature (2025)	Global	Evaluation use ESG scores	SLR	Difference measurement ESG trigger inconsistency	Journal of Enterprise Communications
Yes Cunha et al.	ESG indicators and performance (2025)	Global	Developmen t gan framework ESG	SLR	Variation of indicators causes results different	Future Business Journal

Authors	Title and Year	Country	Aim	Methodology	Finding	Journal
Aggarwal et al.	ESG investing using ADO model (2025)	Global	Analysis ESG investing	SLR	Research methods influence hi results	Journal of Accounting Literature
Mukhtar et al.	ESG research trends (2025)	Global	Analysis SLR & ESG trends	SLR & Bibliometric	Inconsistent si consequence differences in approach	IJPPM
Godinez-Reyes et al.	CSR and performance (2025)	Latin America	Evaluation CSR and performance	SLR	Results varies between country	Analysis Economy co
Waldau	ESG in family firms (2025)	Global	Analysis ESG in family firms	SLR	Context influential companies hi results	Management Review Quarterly

Analysis of the synthesis table shows that the heterogeneity of the results is not simply an anomaly, but rather reflects the inherent complexity of the relationship between ESG and corporate performance. ESG is a multidimensional construct encompassing environmental, social, and governance aspects, making it difficult to reduce to a single, uniform measure. This inconsistency indicates that the relationship between ESG and performance is context-dependent and measurement-sensitive.

Furthermore, differences in the theoretical frameworks used, such as stakeholder theory, agency theory, and the resource-based view, also influence the interpretation of the relationship between ESG and performance. Studies using stakeholder theory tend to find a positive relationship, while the agency theory approach sometimes finds weaker or insignificant results due to consideration of potential conflicts of interest between management and shareholders.

Furthermore, this heterogeneity also indicates the existence of a non-linear relationship. There's a strong correlation between ESG and company performance. In some cases, early ESG investments can increase operational costs, thus reducing short-term performance, but provide long-term benefits. This explains why some studies find a negative or insignificant relationship.

This research makes an important contribution by not only identifying inconsistencies in the ESG literature but also systematically categorizing the sources of heterogeneity into three key dimensions: measurement, methodology, and context. The meta-synthesis approach employed allows for the integration of previously fragmented findings into a more comprehensive analytical framework.

The main novelty of this research is:

a. Revealing the heterogeneity of the ESG–performance nexus as a structural phenomenon, not just differences in research results.

b. Integrate various sources of inconsistency into one conceptual framework.

c. Provide a basis for the development of more advanced future research models. robust and contextual

Thus, this study broadens the understanding of ESG not only as a factor influencing performance, but also as a complex construct that requires a more integrated analytical approach.

2.3. The Asymmetrical Role of ESG Dimensions (E, S, and G)

The results of a systematic literature review indicate that the Environmental, Social, and Governance dimensions do not have a uniform impact on company performance. Instead, each dimension has a distinct influence mechanism and varying levels of significance depending on the industry context, company characteristics, and institutional environment. This finding confirms that an aggregate approach to ESG has the potential to obscure the specific dynamics of each dimension, which actually contribute differently to company performance (Martiny et al., n.d.).

The governance dimension has consistently been found to be the most powerful factor influencing company performance. This is due to its role in ensuring the quality of decision making, the effectiveness of internal oversight, and transparency in reporting. Good governance practices can reduce agency conflicts, increase operational efficiency, and strengthen investor confidence, thus directly impacting financial performance and company value. (Bani-Khaled et al., nd; Supratno et al., 2021).

Meanwhile, the environmental dimension shows a more significant influence in industries with high environmental impacts, such as energy, manufacturing, and mining. Implementing environmentally friendly practices, such as energy efficiency and waste management, can reduce operational costs and improve regulatory compliance. However, in industries with low environmental pressure, the influence of this dimension tends to be more limited (Kumar & Shah, nd).

On the other hand, the social dimension contributes to company performance by enhancing reputation, customer loyalty, and improving stakeholder relationships. The impact of this dimension tends to be indirect and more visible in the long term, particularly through improved corporate image and social legitimacy. Therefore, the influence of the social

dimension is often more difficult to measure quantitatively than other dimensions (Zairis, n.d.).

Table 3. Synthesis Table of the Impact of ESG Dimensions on Performance

Authors	Title and Year	Country	Aim	Methodology	Finding	Journal
Martiny et al.	Determination of ESG performance (2024)	Global	Analysis of ESG factors	SLR	Every dimension of ESG own different impacts	Journal of Cleaner Production
Li et al.	ESG and firm value (2024)	Global	Relations of ESG and corporate value	SLR	Governance is the most dominant factor	Business Strategy & Development
Bani-Khaled et al.	ESG and firm value (2025)	Global	Evaluation of ESG and values	SLR	Governance has the strongest impact	AMS Review
Yes Cunha et al.	ESG indicators framework (2025)	Global	Development of ESG indicator	SLR	Impact of ESG depending on dimensions	Future Business Journal
Yingzhao & Hizam-Hanafiah	ESG and financial performance (2024)	Malaysia	Analysis of ESG and performance	SLR	Environment is significant in the sector certain	Malaysian Journal
Sitompul et al.	Renewable energy and firm performance (2024)	Global	Impact of green energy	SLR	Environment is important in the energy sector	Sustainable Utility
Coelho et al.	CSR and financial performance (2023)	Global	Impact of CSR	SLR	Social impact through reputation	CSR & Environment Management
Tan et al.	ESG and consumer behavior (2025)	Global	ESG and consumer behavior	SLR	Social increase customer loyalty	International Journal of Consumer Studies

Analysis of the findings shows that the differences in impact across ESG dimensions reflect the multidimensional nature of the ESG concept itself. The governance dimension has the most direct impact because it relates to a company's internal structure and control mechanisms, which influence all operational activities. This explains why governance is often a key determinant of consistently improving company performance across various research contexts.

In contrast, the environmental and social dimensions exhibit more contextual and indirect patterns of influence. The environmental dimension is highly dependent on a company's level of exposure to environmental issues, making its impact more pronounced in industries with

high resource intensity. Meanwhile, the social dimension operates through reputation and legitimacy mechanisms, which take longer to impact financial performance.

These findings also indicate that the use of aggregate ESG scores can lead to bias in interpreting the relationship between ESG and company performance. Combining all three dimensions in a single index obscures the varying contributions of each dimension. Therefore, an analytical approach that separates ESG dimensions is crucial for generating more accurate and in-depth insights.

This research contributes by highlighting that the relationship between ESG and corporate performance is not only heterogeneous but also differential across ESG dimensions. The meta-synthesis approach used allows for the identification of dominant patterns of governance dimensions, as well as the contextual role of environmental and social dimensions.

The main novelties of this research include:

a. Separation of ESG analysis into three main dimensions to avoid bias aggregation
b. Identification of different influence mechanisms on each ESG dimension
c. Strengthening the argument that governance is the main driver of performance, while environmental and social are contextual.

Thus, this study provides a stronger conceptual basis for further research to develop more specific and dimension-based ESG models.

2.4. ESG as a Risk Reduction Mechanism

A systematic literature review shows that ESG plays a strategic role in reducing various types of corporate risk, including reputational risk, operational risk, and financial risk. Companies with high ESG performance tend to have greater stability, lower volatility, and greater resilience to external shocks such as economic crises or market uncertainty. These findings confirm that ESG serves not only as a value-creating tool but also as an effective risk mitigation mechanism in the context of modern corporate management (Cai et al., n.d.).

The governance dimension plays a crucial role in mitigating financial and agency risks by improving the quality of oversight and transparency. A sound governance structure can minimize opportunistic management practices and improve the accuracy of financial reporting, thereby reducing the risk of asymmetric information and increasing investor confidence. This has a direct impact on the stability of a company's financial performance (Ellili & Seow, n.d.).

Furthermore, environmental and social dimensions contribute to reducing reputational and operational risks. Companies with good environmental practices tend to be more compliant

with regulations and avoid legal sanctions and environmental costs. Meanwhile, good social practices strengthen stakeholder relationships and reduce the potential for social conflict, ultimately enhancing the sustainability of a company's operations (Bel Oms, n.d.; Supratno et al., 2021).

In the context of economic uncertainty, ESG has been shown to function as a shock absorber that enhances corporate resilience. Studies show that companies with high ESG scores are able to maintain more stable performance during periods of crisis than companies with low ESG scores. This suggests that ESG plays a crucial role in enhancing corporate resilience in the face of complex business dynamics (Alahdal et al., n.d.; Singhania & Gupta, n.d.).

Table 4. ESG Synthesis Table and Corporate Risk Reduction

Authors	Title and Year	Country	Aim	Methodology	Finding	Journal
Nian & Said	ESG, Risk and Financial Performance (2025)	Global	Analysis ESG and risk	SLR	ESG lower n risk and increase stability	Journal of Scientome trick Research
Nguyen	ESG Risk Review (2025)	Global	ESG risk assessment	SLR & Bibliometric	ESG reduce various types of risks	Business Strategy & Development
Bani-Khaled et al.	ESG and Firm Value (2025)	Global	ESG and company values	SLR	Governance lower risk finance	AMS Review
Ellili & Seow	ESG controversy ice and performance (2025)	Global	Analysis ESG controversy ice	Bibliometric & Content Analysis	ESG reduces risk reputation	Business Strategy & Development
Bell-Oms	ESG controversy ice (2025)	Global	Evaluation ESG and risk	Review	ESG reduces risk operational	CSR & Environment frond Management ent
Coelho et al.	CSR and financial performance (2023)	Global	Impact CSR	SLR	CSR reduce reputational risk	CSR & Environment frond Management ent
Alahdal et al.	ESG and Earnings management (2023)	Global	ESG and earnings management	Review	ESG lower risk of report manipulation	Accounting Research Journal
Singhania & Gupta	ESG disclosure and firm risk (2024)	Global	ESG and corporate risk	Meta-analysis	ESG lower n volatility	CSR & Environment frond Management

The analysis of the findings shows that ESG functions as a comprehensive risk management mechanism, encompassing various dimensions of corporate risk. The governance dimension plays a role in mitigating internal risks by improving control quality and transparency, while the environmental and social dimensions play a role in managing external risks arising from regulatory and stakeholder pressures.

Furthermore, ESG also contributes to reducing systematic risk and Idiosyncratic risk. By increasing transparency and accountability, ESG helps reduce information uncertainty in the market, thereby lowering the cost of capital and increasing investor confidence. Furthermore, companies with strong ESG practices tend to have more proactive risk management strategies, enabling them to anticipate and respond more effectively to changes in the business environment.

These findings also indicate that the role of ESG in risk mitigation is becoming increasingly important in a global context characterized by high volatility, regulatory changes, and increasing pressure on sustainability. Therefore, ESG can is seen as an integral part of enterprise risk management that focuses not only on protecting value, but also on creating long-term value. This research contributes by confirming that ESG functions not only as a determinant of corporate performance but also as a multidimensional and strategic risk mitigation instrument. Using a meta-synthesis approach, this research integrates previously scattered findings into a more systematic framework. The key novelties of this research include:

1. Integration of ESG roles in reducing various types of corporate risks
2. Affirmation of ESG as part of modern enterprise risk management
3. Identification of ESG as a key factor in increasing corporate resilience

Thus, this study extends the ESG literature by positioning ESG not only as a performance factor, but also as a mechanism for stabilizing and protecting corporate value.

2.5. The Role of Mediating and Moderating Variables

The results of a systematic literature review indicate that the relationship between Environmental, Social, and Governance (ESG) and company performance is not direct, but rather influenced by various mediating and moderating variables that form a complex and non-linear relationship mechanism. This finding confirms that ESG operates through an indirect pathway involving internal and external factors of the company, resulting in varying impacts on company performance (Salem et al., n.d.; Truant et al., n.d.). Corporate governance emerges as one of the most dominant moderating variables in strengthening the relationship between ESG and company performance. An effective governance structure can improve the

quality of ESG implementation and ensure that sustainability practices are integrated into business strategy. This strengthens the impact of ESG on financial performance and company value (Supratno et al., 2021; Tamasiga et al., n.d.).

Furthermore, ownership structure also acts as a significant moderating factor. Institutional and managerial ownership can influence a company's level of commitment to ESG, which ultimately impacts its performance. Companies with strong institutional ownership tend to have better ESG implementation due to investor pressure to increase transparency and accountability (Fitria Widiyani Roosinda, Ninik Sri Lestari, AA Gde Satia Utama, Hastin Umi Anisah, Albert Lodewyk Sentosa Siahaan, Siti Hadiyanti Dini Islamiati, Kadek Ayu Astiti, Nurul Hikmah, 2021).

Company size was also found to be an important factor in determining the strength of the ESG-performance relationship. Large companies generally have the resources Larger companies have greater resources to effectively implement ESG practices, resulting in a more significant impact on performance. Conversely, smaller companies face resource constraints that can hinder optimal ESG implementation (Seow, nd; Waldau, nd).

On the other hand, digitalization and innovation act as mediating variables that strengthen the relationship between ESG and corporate performance. Digital transformation enables companies to improve operational efficiency, transparency, and manage ESG data more effectively. This accelerates the integration of ESG into business processes and enhances its impact on corporate performance.

Sustainability reporting also serves as an important mediating mechanism in the relationship between ESG and corporate performance. Transparent sustainability reporting increases stakeholder trust and reduces information asymmetry, ultimately positively impacting firm value and financial performance (Tamasiga et al., n.d.).

Table 5. Synthesis Table of ESG Mediating and Moderating Variables

Authors	Title and Year	Country	Aim	Methodology	Finding	Journal
Salem et al.	ESG and bank performance e (2024)	Global	Analysis mediation ESG	Scoping Review	Mediation influence hi relationship ESG	Journal of Risk & Financial Management
Kumar & Shah	Digital ESG (2025)	Global	ESG and digitalization	SLR	Digitalization strengthens ESG performance	Sustainability Futures
Bani-Khaled et al.	ESG and Firm Value (2025)	Global	ESG and company values	SLR	Governance strengthen relationships ESG	AMS Review

Authors	Title and Year	Country	Aim	Methodology	Finding	Journal
Yong et al.	ESG committee (2024)	Global	Role committee ESG	SLR	Governance increase an effectiveness ESG	Int. Journal of Business & Society
Hadi et al.	Ownership and sustainability (2025)		Ownership and ESG	SLR	Ownership moderates the relationship ESG	JoHDeC
Waldau	ESG in Family Firms (2025)	Global	ESG and characteristics company	SLR	Size company influence hi ESG	Manage ment Review Quarterly
Seow	ESG disclosure determinants (2024)	Global	ESG disclosure	SLR	Reporting as a mediator important	Business Strategy & Environment
Tamasiga et al.	ESG disclosure and performance e (2024)	Global	ESG disclosure	Review	Transparent increase performance	SN Business & Economics

Analysis of the findings indicates that the relationship between ESG and corporate performance is non linear and mechanism-driven, with mediating and moderating variables playing a significant role in determining the direction and strength of the relationship. ESG does not operate as an independent factor directly influencing performance, but rather through complex interactions with various organizational and environmental factors.

Corporate governance and ownership structure serve as enabling factors which determines the effectiveness of ESG implementation. Without strong governance and a supportive ownership structure, ESG practices tend to be symbolic and have no significant impact on company performance. This underscores the importance of integrating ESG into corporate governance systems.

Meanwhile, digitalization, innovation, and sustainability reporting act as transmission mechanisms that bridge the relationship between ESG and corporate performance. These factors increase the visibility, efficiency, and credibility of ESG practices, thereby strengthening their impact on corporate performance.

These findings also suggest that the relationship between ESG and corporate performance must be understood within a more complex framework, one that considers the interactions between multiple variables. Thus, a simple linear approach is no longer adequate to explain ESG dynamics in the modern business context.

This research makes an important contribution by identifying that the relationship between ESG and firm performance is a relationship mediated and moderated by various key factors, rather than a simple direct relationship. Through a meta-synthesis approach, this study

integrates various variables previously studied separately into a single, comprehensive conceptual framework. The main novelties of this study include:

1. Development of an ESG–performance framework based on mediation and moderation
2. Identification of the key roles of governance, ownership, and digitalization as factors amplifier
3. Affirmation that ESG relationships are non-linear and contextual

Thus, this study extends the ESG literature by providing a deeper understanding of the mechanisms underlying the relationship between ESG and firm performance.

2.6. Influence of Geographic and Industrial Context

A systematic literature review shows that the relationship between Environmental, Social, and Governance (ESG) and company performance is highly contextual and significantly influenced by geographic factors and industry characteristics. The literature consistently emphasizes that variations in regulatory systems, market maturity, and investor and stakeholder pressure are key determinants of the strength and direction of this relationship (Bani-Khaled et al., n.d.; Salem et al., n.d.).

In developed countries, ESG implementation tends to have a stronger and more consistent impact on company performance. This is driven by the existence of strict regulations, more transparent reporting standards, and increasing investor awareness of sustainability issues. A strong institutional environment enables companies to strategically integrate ESG into their business operations, thus contributing directly to increased company value and financial performance (Wang et al., nd).

In contrast, in developing countries, the relationship between ESG and corporate performance shows more mixed and inconsistent results. Limited regulations, weak enforcement mechanisms, and low reporting standards often result in ESG implementation being symbolic. Furthermore, limited resources and low market pressure also limit companies' ability to leverage ESG as a source of competitive advantage (Godinez-Reyes, NL, 2025; Kogi et al., n.d.).

Beyond geographic differences, industry context also plays a crucial role in determining the effectiveness of ESG on company performance. Resource-based industries such as energy and manufacturing tend to exhibit higher sensitivity to the environmental dimension due to its direct link to environmental impacts and emissions regulations. Meanwhile, the financial sector is more influenced by the governance dimension, particularly regarding transparency, risk management, and investor confidence. The social dimension also shows a greater

influence in consumer-oriented industries because it relates to reputation and stakeholder relationships (Truant et al., nd; Waldau, nd).

Table 6. Geographic and Industrial Context Synthesis Table

Authors	Title and Year	Country	Aim	Methodology	Finding	Journal
Bani-Khaled et al.	ESG and Firm Value (2025)	Global	Analysis ESG and corporate value	SLR	Impact ESG is stronger in developed countries	AMS Review
Seow	ESG review research (2025)	Global	Analysis development ESG	SLR & Bibliometric	Regulations determine strength ESG	Journal of Economic Surveys
Cai et al.	ESG disclosure and firm value (2024)	Global	ESG disclosure and performance	SLR & Bibliometric	High transparency increases performance	Sustainability
Godinez-Reyes et al.	CSR in Latin America (2025)	Latin America	CSR and performance	SLR	ESG results vary across developing country	Analysis Economic
Kogi et al.	ESG in Africa (2025)	Africa	ESG in developing country	SLR	Implementation ESG is still limited	Meditate Account Research
Truant et al.	ESG in supply chains (2024)	Global	ESG in industry	SLR	Response ESG different inter-sectoral	Journal of Cleaner Production
Waldau	ESG in Family Firms (2025)	Global	ESG and company characteristics	SLR	Industrial factors influence hi impact ESG	Management Review Quarterly

Further analysis shows that geographic and industry factors not only moderate the relationship between ESG and firm performance but also determine the transmission mechanism of ESG itself. In environments with high institutional quality, ESG functions as an effective value creation mechanism by improving operational efficiency, reducing the cost of capital, and enhancing investor confidence. Conversely, in contexts with low institutional quality,

ESG tends to function merely as a legitimacy tool without providing significant economic impact. Furthermore, the heterogeneity of industry sectors suggests that an ESG approach cannot be universal. Industries with high environmental exposure require a focus on the environmental dimension, while the financial and services sectors rely more on governance and social aspects. This emphasizes that effective ESG implementation must consider industry-specific characteristics to achieve optimal impact on company performance.

This research makes an important contribution by confirming that ESG performance nexus is contextual and cannot be universally generalized. Unlike previous studies, which tended to examine ESG relationships in aggregate, this research integrates geographic and sectoral dimensions into a more comprehensive analytical framework. Key novelties of this research include:

1. Emphasis on the role of geographic context as a key determinant of ESG strength
2. Integration of cross-industry analysis in understanding variations in ESG impacts
3. Development of the perspective that ESG is a mechanism that depends on the quality of institutions and sector characteristics

Thus, this research provides strategic implications for academics and practitioners in designing more contextual and effective ESG policies and strategies.

2.7. ESG Measurement Issues

One of the key findings of this systematic literature review is the lack of a uniform ESG measurement standard, resulting in high variation in research findings regarding the relationship between ESG and company performance. The literature shows that the use of various ESG rating providers, such as MSCI, Bloomberg, Refinitiv, and Sustainalytics produces different ESG scores for the same company, creating comparability issues between studies (Clément et al., n.d.; Devianti, 2023).

Differences in ESG measurement methodology are a major source of this inconsistency. Each rating agency uses different indicators, weightings, and assessment approaches to evaluate environmental, social, and governance dimensions. As a result, ESG scores reflect not only company performance but also the methodological biases of data providers. This makes empirical results related to the relationship between ESG and company performance unstable and difficult to generalize (Clément et al., n.d.; Narulita et al., 2025).

Furthermore, several studies show that differences in ESG measurements also affect the statistical significance of the relationship between ESG and firm performance. Research using ESG disclosure tends to find a positive relationship. weaker than studies using aggregate score-based ESG ratings. Furthermore, variations in definitions of corporate performance, such as ROA, ROE, Tobin's Q, and market return, further exacerbate the heterogeneity of research findings (Nian & Said, nd; Saini et al., nd).

This lack of uniformity also has significant methodological implications for ESG research. Without consistent measurement standards, it is difficult to conduct accurate meta-analyses and build solid ESG theory. performance nexus. Therefore, a number of recent literatures emphasize the importance of developing an integrated ESG measurement framework and

harmonizing global reporting standards to improve the reliability and validity of research in this area (Mengist et al., n.d.; Zairis, n.d.).

Table 7. Synthesis Table of ESG Measurement Inequality

Authors	Title and Year	Country	Aim	Methodology	Finding	Journal
Cleme nt et al.	ESG scores in literature (2025)	Global	Analysis use ESG score	SLR	The difference in Journal Journal of ESG ratings causing bias	Journal of Enterprise Communion ties
Rubino et al.	ESG rating divergence (2026)	Global	Analysis difference ESG rating	SLR	Different ESG scores between provider	Review of Management al Science
Yes Cunha et al.	ESG indicators framework (2025)	Global	Developers an indicator ESG	SLR	There isn't any standard measurement ESG	Future Business Journal
Nian & Said	ESG and performance ce (2025)	Global	ESG and performance	SLR	Results depending on the method measurement	Journal of Scientometric Research
Saini et al.	ESG and financial variables (2023)	Global	ESG and variables finance	SLR	Variation indicator glue consistency	International Journal of Law and Management
Cai et al.	ESG disclosure and firm value (2024)	Global	ESG disclosure	SLR	Disclosure and rating the results different	Sustainability

Further analysis shows that the non-uniformity of ESG measurements is one of the main sources of heterogeneity in the ESG–performance literature. Differences between ESG rating providers are not only technical but also conceptual, as each agency has a different definition and focus on ESG dimensions. This makes ESG not a homogeneous construct, but rather a multidimensional and interpretive construct.

Furthermore, the use of diverse company performance indicators complicates the analysis of the relationship between ESG and performance. The combination of varying ESG measures and performance indicators yields a wide range of potentially different empirical results, making it difficult to draw consistent conclusions. Therefore, it is important to consider the appropriateness of the types of ESG measures and performance indicators used in research.

These findings also highlight the importance of methodological transparency in ESG research. Researchers need to explicitly explain data sources, measurement methods, and the inherent limitations of the ESG indicators used. Without such transparency, interpretation of research results can be potentially biased and misleading.

This study makes an important contribution by identifying the heterogeneity of ESG measurement as a major source of inconsistency in the ESG–performance nexus literature. Unlike previous studies that only highlight the relationship between ESG and performance, this study positions measurement issues as a key factor influencing empirical results. The key novelties of this study include:

1. Affirmation that ESG rating divergence is the main determinant of heterogeneity research result
2. Integration of methodological issues in the analysis of the relationship between ESG and company performance
3. Emphasis on the need for global harmonization of ESG measurement standards

Thus, this study provides a stronger conceptual basis for the development of future ESG research, particularly in improving the consistency and validity of empirical findings.

2.8. ESG as a Long-Term Competitive Advantage Strategy

Literature shows that Environmental, Social, and Governance (ESG) not only impacts short-term company performance but also plays a long-term role in creating sustainable competitive advantage. Integrating ESG into business strategy enables companies to improve operational efficiency, strengthen their reputation, and build relationships long-term relationships with stakeholders. Thus, ESG functions as a sustainability-oriented value creation mechanism (Ellili & Seow, nd; Zahra et al., nd).

Over the long term, companies that consistently implement ESG tend to be more resilient to external pressures such as economic crises, regulatory changes, and market dynamics. ESG helps companies proactively manage risks, including environmental, social, and governance risks, thereby improving performance stability and reducing volatility. This makes ESG a crucial factor in enhancing corporate resilience (Narula et al., nd).

Furthermore, ESG also contributes to the creation of competitive advantage through innovation and differentiation. Companies that adopt ESG practices are often more innovative in developing environmentally friendly products, improving energy efficiency, and creating sustainable business models. This innovation not only increases company competitiveness but also opens up new sustainability-oriented market opportunities (Martiny et al., n.d.; Zairis, n.d.).

Furthermore, ESG strengthens a company's legitimacy in the eyes of stakeholders, including investors, consumers, and regulators. Companies with strong ESG performance tend to have easier access to funding, have a lower cost of capital, and enjoy higher levels of market trust. This demonstrates that ESG creates not only economic value but also social value,

strengthening a company's strategic position in the long term (Bani-Khaled et al., n.d.; Zahra et al., n.d.).

Table 8. ESG Synthesis Table as Competitive Advantage

Authors	Title and Year	Country	Aim	Methodology	Finding	Journal
Li et al.	ESG and firm value (2024)	Global	ESG and continuityan	SLR	ESG increase long-term performance	Business Strategy & Development
Zahra et al.	Sustainable e-business practices (2025)	Global	Practice ongoingan	SLR	ESG createn competitive advantage	Cogent Business & Management
Nian & Said	ESG and risk (2025)	Global	ESG and risk	SLR	ESG increase stability research company	Journal of Scientome trick
Narula et al.	ESG investing & performance ce (2025)	Global	ESG investment	Review	ESG increasean resilience	CSR & Environment frond Management
Martiny et al.	ESG determinants (2024)	Global	Determinants ESG	SLR	ESG encourage innovation	Journal of Cleaner Production
Zairis et al.	Sustainable e-finance (2024)	Global	ESG and finance	SLR	ESG open new market opportunities	Sustainability
Bani Khaled et al.	ESG and firm value (2025)	Global	ESG and mark company	SLR	ESG an increase value company	AMS Review
Tamasi ga et al.	ESG disclosure (2024)	Global	ESG disclosure	Review	ESG increases an investor confidence	SN Business & Economics

Analysis shows that ESG has evolved from a mere compliance obligation to a strategic instrument in creating long-term competitive advantage. Within the resource-based view, ESG can be viewed as an intangible resource that is difficult for competitors to imitate, particularly in the form of reputation, stakeholder trust, and innovation capabilities. This makes ESG a source of sustainable competitive advantage.

Furthermore, ESG also serves as an adaptation mechanism to changes in the business environment. Companies that strategically integrate ESG are better able to respond to regulatory changes and market demands, thus gaining greater flexibility in the face of uncertainty. Thus, ESG not only improves performance but also strengthens organizational resilience.

These findings also indicate that ESG benefits are cumulative and more visible in the long term than in the short term. Therefore, research that focuses solely on short-term impacts may potentially overlook ESG's strategic contribution to corporate sustainability.

This research contributes by shifting the perspective of ESG from a mere performance factor to a long-term competitive advantage strategy. Unlike previous studies that focused on the direct relationship between ESG and financial performance,

This research emphasizes the role of ESG as a strategic mechanism for creating sustainable value. The key novelties of this research include:

1. Affirmation of ESG as a source of sustainable competitive advantage
2. Integration of long-term perspectives in ESG-performance analysis
3. Strengthening the role of ESG in increasing corporate resilience and innovation

Thus, this study provides theoretical and practical contributions in understanding ESG as a business strategy that not only improves performance, but also ensures the long-term sustainability of the company.

2.9. Integration of ESG with Management Theory

The results of a systematic literature review indicate that the relationship between Environmental, Social, and Governance (ESG) and corporate performance is explained through various theoretical perspectives, particularly stakeholder theory, legitimacy theory, and agency theory. These three theories provide a strong conceptual foundation for understanding how and why ESG can influence corporate performance. However, the literature still shows theoretical fragmentation and the absence of an integrative framework capable of explaining the ESG–performance nexus comprehensively (Bani-Khaled et al., 2025; Aggarwal et al., 2025).

Stakeholder theory explains that companies that effectively manage relationships with various stakeholders will gain greater support, ultimately improving company performance. In the ESG context, practices that address environmental and social concerns will increase stakeholder trust, strengthen the company's reputation, and create long-term value (Freeman, 1984 in Bani-Khaled et al., 2025).

Meanwhile, legitimacy theory emphasizes that companies strive to gain social legitimacy by aligning their activities with societal norms and expectations. ESG implementation provides a means for companies to demonstrate social and environmental responsibility, thereby increasing public acceptance and mitigating reputational risk. Thus, ESG serves as a legitimacy tool that impacts corporate sustainability and performance (Seow, 2024; Cai et al., 2024).

On the other hand, agency theory views ESG as a mechanism to mitigate conflicts of interest between management and shareholders. Good governance practices within ESG, particularly in the governance dimension, can increase transparency and accountability, thereby reducing agency costs and improving corporate efficiency. This ultimately has a positive impact on financial performance (Aggarwal et al., 2025; Clément et al., 2025).

Although these three theories are widely used, the literature shows that the theoretical approaches used are still partial. Most studies rely on a single theoretical perspective without integrating various existing approaches. As a result, explanations of the relationship between ESG and company performance are incomplete and tend to be fragmented. This indicates the need to develop a more comprehensive and integrative theoretical framework to understand the ESG-performance nexus (Mukhtar et al., 2025; Seow, 2025).

Table 9. ESG Theoretical Perspective Synthesis Table

Authors	Title and Year	Country	Aim	Methodology	Finding	Journal
Bani Khaled et al.	ESG and firm value (2025)	Global	Analysis ESG theory	SLR	Stakeholder dominant theory	AMS Review
Aggarwal et al.	ESG investing (2025)	Global	ESG and investment	SLR (ADO model)	Agency theory is relevant For governance	Journal of Accounting Literature
Seow	ESG disclosure determinant ts (2024)	Global	Determinants ESG	SLR	Dominant legitimacy theory	Business Strategy and the Environment
Cai et al.	ESG disclosure and firm value (2024)	Global	ESG disclosure	SLR	ESG as a tool of legitimacy	Sustainability
Clement et al.	ESG scores (2025)	Global	ESG measurement	SLR	Governance related agency theory	Journal of Enterprise Communion ties
Mukhtar et al.	ESG research trends (2025)	Global	ESG Trends	SLR & Bibliometric	The theory still fragmented	IJPPM
Seow	ESG research review (2025)	Global	Integration ESG research	SLR	Need for theory integration	Journal of Economic Surveys

Analysis shows that no single theory can comprehensively explain the relationship between ESG and corporate performance. Stakeholder theory emphasizes value creation through external relationships, legitimacy theory focuses on social acceptance and reputation, while agency theory focuses on internal corporate mechanisms. These three theories complement each other, but in research practice, they are often used separately.

This theoretical fragmentation limits understanding the complexity of the ESG performance nexus. ESG is a multidimensional concept encompassing economic, social, and

environmental aspects, requiring a multidimensional theoretical approach. Therefore, integrating various theories is essential to achieve a more comprehensive understanding.

Furthermore, the lack of theoretical integration also contributes to inconsistent research findings. Without a unified theoretical framework, it is difficult to explain why ESG has varying impacts across contexts. This reinforces the need to develop conceptual models that combine multiple theoretical perspectives within a single analytical framework.

This research makes an important contribution by identifying theoretical fragmentation in the ESG–performance nexus literature and emphasizing the need for theoretical integration. Unlike previous studies that tend to use a single theoretical perspective, this research proposes a multi-theoretical approach to understanding ESG more comprehensively. The key novelties of this research include:

1. Identification of gaps in the form of theoretical fragmentation in ESG literature
2. Integration of stakeholder, legitimacy, and agency theory in one analytical framework
3. Strengthening the perspective that ESG is a multidimensional phenomenon requires a holistic theoretical approach

Thus, this study provides a significant theoretical contribution in developing a more comprehensive and relevant ESG–performance conceptual model.

2.10. Research Gaps and Future Directions

A systematic literature review identified several significant research gaps in the study of the relationship between Environmental, Social, and Governance (ESG) and corporate performance. Despite the rapid growth of the ESG literature in recent years, methodological and conceptual limitations hamper a comprehensive understanding of the ESG performance nexus.

This gap is primarily related to the lack of a longitudinal approach, minimal use of mixed methods, limited integration across contexts, and the lack of optimal use of meta-synthesis as an analysis approach (Seow, 2025; Mukhtar et al., 2025).

One major gap is the predominance of cross-sectional research, which only captures the relationship between ESG and company performance in the short term. This approach fails to explain the long-term dynamics of ESG implementation, even though ESG benefits are often cumulative and only become apparent over a longer time horizon. Therefore, longitudinal research is needed to uncover the causal relationship and evolution of ESG's impact on company performance over time (Li et al., 2024; Nian & Said, 2025).

Furthermore, the ESG literature is still dominated by quantitative approaches, while the use of mixed-methods approaches, which combine quantitative and qualitative analysis, remains very limited. However, the complexity of ESG as a multidimensional phenomenon requires a more holistic approach to understand the underlying mechanisms of the relationship between ESG and company performance. A mixed-methods approach can provide deeper insights, particularly in explaining the context and process of ESG implementation (Aggarwal et al., 2025; Seow, 2025).

Another gap is the lack of cross-country and cross-sector integration in ESG research. Most studies still focus on specific contexts, either developed countries or specific industrial sectors, making the results difficult to generalize. However, the relationship between ESG and company performance is strongly influenced by institutional factors and industry characteristics. Therefore, comparative research across countries and sectors is needed to generate a more comprehensive understanding (Kogi et al., 2025; Bani-Khaled et al., 2025).

In addition, the use of meta-synthesis in ESG research is still not optimal. Most systematic literature reviews are merely descriptive and fail to conceptually integrate the findings. Meta synthesis allows researchers to combine various research findings into a more structured and theoretical conceptual framework. Therefore, this approach has great potential to address the fragmentation of the ESG literature and develop a more integrative model (Seow, 2025; Ed-Dafali et al., 2025).

Table 10. ESG Research Gaps Synthesis Table

Authors	Title and Year	Country	Aim	Methodology	Finding	Journal
Seow	ESG research review (2025)	Global	Analysis ESG research	SLR & Bibliometric	Lack of methodological integration	Journal of Economic Surveys
Mukhtar et al.	ESG research trends (2025)	Global	ESG Trends	SLR	Dominance of cross sectional studies	IJPPM
Li et al.	ESG and firm value (2024)	Global	ESG long-term	SLR	Need study longitudinal	Business Strategy & Development
Nian & Said	ESG and risk (2025)	Global	ESG and performance	SLR	Impact ESG long term is not optimal	Journal of Scientometric Research
Aggarwal et al.	ESG investing (2025)	Global	ESG and investment	SLR (ADO model)	Mixed method	Journal of Accounting Literature

Authors	Title and Year	Country	Aim	Methodology	Finding	Journal

Kogi et al.	ESG in Africa (2025)	Africa	ESG developing countries	SLR	Lack of cross-study country	Meditate Accountantcy Research
Bani Khaled et al.	ESG and firm value (2025)	Global	ESG and mark company	SLR	Need cross sector integration	AMS Review
Ed-Dafali et al.	ESG practices review (2025)	Global	ESG framework	SLR (PRISM)	Meta-synthesis still limited	Business Strategy and the Environment

The analysis shows that the research gap in the ESG–performance nexus is not only methodological but also conceptual. The dominance of cross-sectional approaches has limited understanding of causal relationships and the long-term dynamics of ESG. Furthermore, the lack of use of mixed-methods research limits the research's ability to capture the complexity of ESG as a multidimensional phenomenon.

Limited integration across countries and sectors also reinforces the fragmentation of the literature. ESG cannot be separated from institutional context and industry characteristics, so isolated research in a single context tends to produce findings that cannot be generalized. Therefore, a comparative approach is crucial in the development of the ESG literature.

Furthermore, the minimal use of meta-synthesis indicates that the literature ESG is still in the exploratory stage and has not yet reached the level of theoretical integration mature. Meta-synthesis has the potential to bring together fragmented findings into a more comprehensive and systematic conceptual framework.

This research contributes by comprehensively identifying and systematizing various research gaps in the ESG–performance nexus literature. Unlike previous studies that only partially highlighted limitations, this research integrates methodological and conceptual gaps within a single analytical framework. The main novelties of this research include:

1. Identifying multidimensional ESG research gaps
2. Emphasizing the importance of longitudinal and mixed-method approaches
3. Strengthening the role of meta-synthesis in integrating ESG literature
4. Developing a basis for a more integrated ESG conceptual model

Thus, this study opens up opportunities for further research to develop a more comprehensive approach to understanding the relationship between ESG and company performance.

3. DISCUSSION

The results of this study indicate that the relationship between Environmental, Social, and Governance (ESG) and company performance is complex and non-linear. This finding is

consistent with recent literature that positions ESG as a multidimensional construct that simultaneously influences various aspects of company performance. From a stakeholder theory perspective, ESG serves as a mechanism to meet increasing stakeholder expectations, thereby enhancing company legitimacy and strengthening investor and customer trust. A study by Li et al. (2024) showed that high ESG performance contributes to increased company value by enhancing reputation and the quality of stakeholder relationships (Li et al., 2024).

However, findings regarding the heterogeneity of research results indicate that the relationship between ESG and company performance is not always consistent. Within the framework of agency theory, this situation can be explained by the conflict of interest between management and shareholders. ESG implementation, which requires long-term investment, often does not yield immediate results in the short term, which can lead to negative perceptions of a company's financial performance. Nian and Said (2025) found that the impact of ESG on financial performance is highly dependent on the company's time horizon and risk management mechanisms (Nian & Said, 2025).

Furthermore, the differences in influence between ESG dimensions reinforce the relevance of the resource-based view in explaining this relationship. The governance dimension tends to have the most significant influence because it is directly related to decision-making structures and the effectiveness of internal controls. Meanwhile, the Environmental dimensions are more dominant in industries with high environmental impacts, and the social dimension plays a role in building reputation and long-term relationships with stakeholders. This finding aligns with research by Martiny et al. (2024), which shows that each ESG dimension has a distinct influence mechanism on company performance (Martiny et al., 2024).

Furthermore, this study found that ESG plays a significant role in reducing corporate risk. From a legitimacy theory perspective, companies that adopt sound ESG practices tend to gain stronger social legitimacy, thereby reducing reputational and operational risks. Wang et al. (2025) demonstrated through a meta-analysis that ESG disclosure significantly reduces corporate risk and improves performance stability under conditions of economic uncertainty (Wang et al., 2025).

Other findings indicate that the relationship between ESG and company performance is not direct, but rather influenced by various mediating and moderating variables such as corporate governance, company size, digital innovation, and sustainability reporting. This suggests that ESG operates through complex and complex mechanisms. Aggarwal et al. (2025) emphasized that integrating ESG into corporate strategy requires the support of a strong organizational system to achieve optimal performance (Aggarwal et al., 2025).

In geographic and industry contexts, this study shows that the influence of ESG is highly dependent on the institutional environment. In developed countries, ESG implementation

tends to be more effective due to strong regulatory support and high investor awareness. Conversely, in developing countries, research results show greater variation due to limited reporting standards and institutional infrastructure. Bani Khaled et al. (2025) showed that institutional factors play a significant role in determining the effectiveness of ESG on company performance (Bani Khaled et al., 2025).

In addition, this study identified that the absence of uniform ESG measurement standards is one of the main causes of inconsistency in research results. Differences in the use of ESG indicators and data providers make direct comparisons difficult. Clément et al. (2025) assert that variation in ESG ratings is a major challenge in developing a consistent ESG literature (Clément et al., 2025).

From a long-term perspective, ESG plays a role not only in improving company performance but also as a strategy for creating sustainable competitive advantage. Integrating ESG into business strategy enables companies to increase resilience to changes in the business environment and create long-term value. This aligns with research by Coelho et al. (2023), which shows that corporate social responsibility has a positive impact on the company's long-term performance (Coelho et al., 2023).

4. CONCLUSION

This study aims to examine the relationship between Environmental, Social, and Governance (ESG) and corporate performance through a systematic literature review and meta-synthesis approach. Based on a comprehensive synthesis of the current literature, this study found that ESG generally has a positive relationship with corporate performance, including financial performance, firm value, and market performance. However, the strength and direction of this relationship are not uniform.

The findings show that the impact of ESG is significantly influenced by the dimensions measured, industry context, geographic conditions, and mediating and moderating variables such as corporate governance, company size, and innovation level. Furthermore, the study found that ESG plays a significant role in reducing corporate risk and enhancing long-term stability, thus strengthening ESG's position as a sustainability-oriented business strategy. These findings challenge the long-held assumption that ESG is merely an additional cost, and instead demonstrate that ESG can be a source of long-term competitive advantage.

In terms of scientific contribution, this research provides several important contributions. First, this study strengthens previous findings showing a positive relationship between ESG and firm performance, while also revealing heterogeneity in the results that has not been fully explained in previous literature. Second, this study integrates various theoretical perspectives such as stakeholder theory, agency theory, legitimacy theory, and the resource based view

into a more comprehensive analytical framework. Third, this study introduces a meta-synthesis approach as an effort to address the fragmentation of the ESG literature and generate a deeper conceptual understanding. Thus, this study not only confirms previous findings but also enriches the scholarly discussion by providing an integrative perspective on the ESG-performance nexus.

However, this study has several limitations. First, it relies on studies available in the literature, and is therefore heavily influenced by variations in the quality and research methods used in those studies. Second, differences in ESG measurement and company performance indicators limit direct comparisons between studies. Third, this study fails to fully capture the dynamics of the long-term relationship between ESG and company performance because most of the literature analyzed uses a cross-sectional approach. Therefore, the results of this study require careful interpretation and cannot be absolutely generalized to all contexts.

Based on these limitations, this study provides several recommendations for further research. Future research is recommended to use a longitudinal approach is needed to understand long-term ESG dynamics and identify stronger causal relationships. Furthermore, the use of mixed methods is also needed to capture the complexity of ESG in greater depth, both quantitatively and qualitatively. Cross-country and cross-sector research is also needed to increase the generalizability of findings and understand differences in institutional contexts. Furthermore, efforts are needed to develop more uniform ESG measurement standards so that research results can be compared more consistently. Thus, further research is expected to produce a more integrated ESG conceptual model capable of explaining the relationship between ESG and company performance more comprehensively.

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INTEGRATION OF MAQASID SHARIAH IN ESG REPORTING: A SYSTEMATIC LITERATURE REVIEW ON SHARIA ENVIRONMENTAL ACCOUNTING

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Abstract

This study aims to analyze the integration of maqasid shariah (Islamic principles) in Environmental, Social, and Governance (ESG) reporting through a Systematic Literature Review (SLR) approach in the context of Islamic environmental accounting. The background of this study is based on the increasing attention to sustainability reporting and the need to integrate Islamic values within a global ESG framework. The SLR method used follows the PRISMA steps, which include identification, screening, eligibility, and inclusion. A total of 20 relevant articles that met the inclusion criteria were systematically analyzed. The results show that ESG has emerged as the dominant framework in sustainability reporting and has a significant influence on company performance and investor perceptions. However, this influence is not uniform across all ESG dimensions. On the other hand, Islamic Social Reporting (ISR) and maqasid shariah play an important role in building values-based reporting, but their implementation remains suboptimal and unstandardized. This study also found a gap between ESG and maqasid shariah, caused by differences in their value foundations and the lack of a clear integrative framework. Furthermore, challenges such as suboptimal regulations and the phenomenon of greenwashing continue to hinder sustainability reporting. This study's conclusion confirms that the integration of ESG and maqasid shariah holds significant potential for creating a more comprehensive and ethical sustainability reporting system. However, the development of an integrated, measurable, and sharia-compliant reporting framework is necessary for optimal implementation.

Keywords: ESG, Maqasid Sharia, Islamic Social Reporting, Sustainability Reporting, Sharia Accounting

INTRODUCTION

In recent years, sustainability issues have increasingly gained attention in the business and financial worlds. Companies are no longer solely judged by their profits, but also by their regard for the environment, society, and good governance. This concept is known as Environmental, Social, and Governance (ESG). ESG is now widely used as a benchmark for assessing company performance more comprehensively, including in attracting investors who are starting to consider sustainability aspects in their investment decisions (Berg et al., 2022; Gillan et al., 2021). In Indonesia, attention to sustainability practices has also increased, particularly since the introduction of regulations from the Financial Services Authority (OJK) encouraging financial institutions to prepare sustainability reports (OJK, 2017).

From an Islamic economic perspective, the concept of sustainability is not new. Values such as justice, balance, and social responsibility have long been part of the fundamental principles of the Islamic economic system. This is reflected in the concept of maqasid shariah, the primary objective of sharia, which focuses on safeguarding human well-being, such as protecting religion, life, intellect, posterity, and property (Chapra, 2008; Dusuki & Bouheraoua, 2021). Therefore, conceptually, ESG is closely linked to sharia principles, although the two developed from different backgrounds.

With the growing need for transparency, Islamic financial institutions have begun developing various reporting methods that reflect social and environmental responsibility. One such approach is Islamic Social Reporting (ISR), designed to disclose corporate social information based on Islamic values (Haniffa, 2021; Rahman et al., 2022). Furthermore, there is the application of green accounting, which seeks to incorporate environmental aspects into financial reports as a form of corporate responsibility for the impacts of its activities (Larrinaga & Bebbington, 2021). In Indonesia, this reporting practice is gaining ground, although it has not yet been consistently implemented across all Islamic financial institutions (Khairunnisa et al., 2025).

However, the implementation of ESG in Islamic financial institutions still faces various obstacles. One prominent one is the lack of clear integration between ESG standards and the concept of maqasid sharia. ESG generally emphasizes aspects that are material and relevant to investors, while maqasid sharia encompasses broader dimensions, including moral and spiritual values (Hassan et al., 2022; Khan, 2021). This difference indicates that there is still a gap that needs to be understood and bridged, especially in the context of Sharia-based sustainability reporting.

On the other hand, many previous studies have addressed ESG, ISR, or green banking separately. Studies that combine these three aspects within a single framework based on the maqasid sharia are still relatively limited. Consequently, a complete picture of how

sustainability reporting in Islamic finance should be conducted remains unclear. This indicates a research gap that warrants further exploration.

Based on this, this study focuses on understanding the development of ESG reporting in Islamic financial institutions, how the concept of maqasid shariah is integrated into these practices, and identifying any remaining gaps between the two. This study was conducted using a Systematic Literature Review (SLR) approach to provide a more comprehensive picture based on previous research.

Through this research, it is hoped that a clearer understanding can be obtained regarding the direction of development of ESG reporting from a sharia perspective, as well as contributing to formulating a reporting framework that is more in line with maqasid sharia values.

1. LITERATURE REVIEW

1.1. Environmental, Social, and Governance (ESG)

The concept of Environmental, Social, and Governance (ESG) has experienced rapid development in recent years and has become a key approach to assessing corporate sustainability. ESG emerged as a response to the limitations of conventional financial reporting, which focuses solely on profitability without considering the social and environmental impacts of a company's activities. With ESG, company assessments become more comprehensive, encompassing three main dimensions: environmental , social , and governance (Friede et al., 2020).

The environmental aspect of ESG encompasses various aspects such as waste management, carbon emissions, energy efficiency, and the sustainable use of natural resources. Meanwhile, the social aspect relates to a company's relationship with employees, consumers, and the surrounding community, including issues such as employee welfare and corporate social responsibility. The governance aspect focuses on transparency, accountability, and a sound corporate management structure (Anam et al., 2023).

As global awareness of climate change and sustainability issues increases, ESG has become not only a tool for internal corporate evaluation, but also a key consideration for investors in making investment decisions. Investors tend to choose companies with good ESG performance because they are perceived to have lower risks and more stable long-term prospects. This shows that ESG has a strategic role in increasing company value and competitiveness in the global market (Kholid, & Bachtiar, 2023).

In Indonesia, ESG implementation has been further strengthened by the Financial Services Authority's regulation, POJK No. 51/POJK.03/2017, which requires financial institutions to prepare sustainability reports. This regulation represents a crucial step in encouraging

transparency and increasing corporate awareness of the importance of sustainable business practices (Financial Services Authority, 2017).

1.2. Maqasid Shariah in Sustainable Finance

Maqasid shariah is a concept that explains the primary objective of Islamic sharia, namely to achieve welfare and prevent harm in human life. In an economic context, maqasid shariah serves as the basis for determining whether an economic activity is in accordance with Islamic principles. This concept does not only focus on profit, but also on the balance between individual and societal interests (Chapra, 2008).

Over time, the maqasid sharia (Islamic principles) have begun to be integrated into the modern financial system as a framework for assessing sustainability. This is because maqasid sharia shares similarities with the concept of sustainability, emphasizing a balance between economic, social, and environmental aspects. Research shows that implementing maqasid sharia in financial institutions can increase public trust and strengthen the institution's legitimacy (Kamali, 2021).

Furthermore, maqasid shariah also has broader dimensions than ESG, as it encompasses spiritual and moral aspects not included in the ESG framework. This makes maqasid shariah a more comprehensive concept for assessing sustainability, particularly in the context of Islamic economics. (Nabila Salvia, 2023).

1.3. Islamic Social Reporting (ISR)

Islamic Social Reporting (ISR) is a form of social reporting developed to meet reporting needs in Islamic financial institutions. ISR encompasses not only social and environmental aspects but also incorporates ethical and spiritual values that are characteristic of Islamic economics. This concept emerged in response to the limitations of conventional CSR, which was deemed not to fully reflect Sharia principles (Yunita et al., 2025).

In practice, ISR is used as a tool to measure the extent to which a company has carried out its social responsibilities in accordance with Islamic principles. ISR covers various aspects, such as Sharia compliance, fairness in profit distribution, and contribution to society. Research shows that companies that implement ISR tend to have higher levels of transparency and better relationships with stakeholders (Mukhlis et al., 2022).

However, ISR still has limitations, particularly in addressing broader environmental aspects. This necessitates its combination with other approaches, such as ESG, to provide a more comprehensive picture of corporate sustainability.

1.4. Green Accounting from a Sustainability Perspective

Green accounting is an accounting approach that aims to incorporate environmental impacts into a company's financial statements. This concept developed in response to increasing environmental damage caused by industrial activities industry. With green accounting, companies are expected to be more transparent in disclosing their environmental impacts and taking steps to mitigate them (Iyer, 2024).

In the Indonesian context, the application of green accounting is still in its infancy. However, this concept is becoming increasingly relevant with increasing attention to environmental and sustainability issues (Sujarweni, 2024). Several studies have shown that implementing green accounting can improve company performance and strengthen the company's public image (Sari & Astari, 2023).

From a sharia perspective, green accounting aligns with the principle of human responsibility as a caliph on earth. This means that every economic activity must consider environmental sustainability as part of a trust that must be safeguarded.

1.5. Integration of ESG and Maqasid Shariah in Sustainability Reporting

The integration of ESG and maqasid shariah (objectives of sharia) is a crucial issue in the development of modern Islamic finance. ESG provides a globally standardized framework, while maqasid shariah provides a deeper and more comprehensive value base. The combination of the two is expected to produce a reporting system that not only meets global standards but also aligns with Islamic values (Widiyanti, 2025).

However, there are fundamental differences between ESG and maqasid shariah. ESG is more oriented towards investor interests and materiality, while maqasid shariah encompasses broader dimensions, including moral and spiritual aspects. This difference means that integrating the two still faces various challenges in practice (Umar & Wahab, 2025).

Therefore, it is necessary to develop a reporting framework that can combine these two concepts in a more integrated manner. This approach is expected to contribute to creating a more sustainable and equitable financial system.

2. RESEARCH METHODOLOGY

This study uses a Systematic Literature Review (SLR) approach to systematically examine the integration of maqasid shariah (obligations of sharia) into Environmental, Social, and Governance (ESG) reporting in the context of sharia environmental accounting. This approach was chosen because it allows researchers to collect and synthesize previous research findings in a structured manner, thus providing a more comprehensive picture and identifying existing research patterns and gaps (Kitchenham, 2004).

The research process was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, which serve as the standard for reporting systematic reviews (Page et al., 2021). These guidelines aim to ensure that the literature search, screening, and selection process is conducted systematically, transparently, and responsibly.

The data used in this study is secondary data obtained from scientific journal articles relevant to the research topic. The literature search process was conducted through several scientific databases, namely Google Scholar and SINTA by using a combination of keywords related to ESG, Islamic Social Reporting (ISR), green accounting, and maqasid sharia in the context of sustainability. The use of this combination of keywords aims to obtain articles that are in accordance with the research focus.

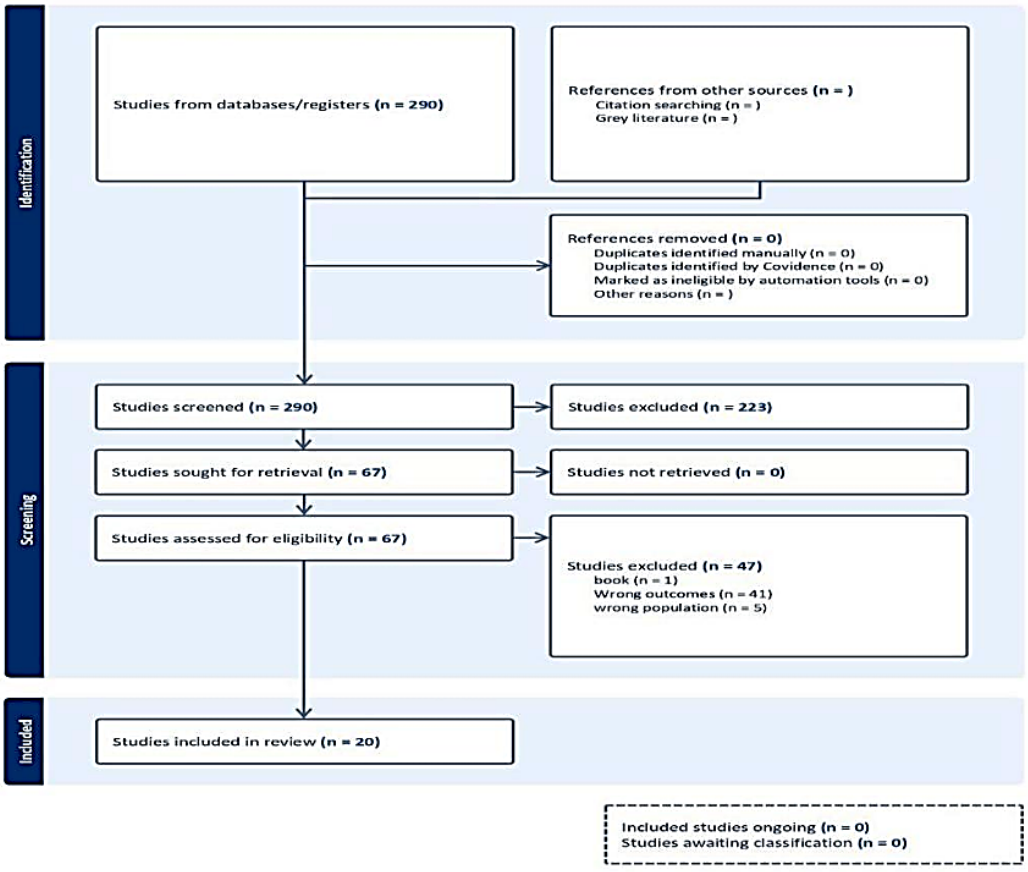
The article selection process used inclusion and exclusion criteria to ensure the quality and relevance of the literature. Selected articles were scientific journal articles discussing ESG, ISR, green accounting, or sustainability in the context of Islamic finance, published between 2021 and 2026, and available in full text. Meanwhile, articles that are not relevant to the research topic, are not available in full, or are not scientific publications are eliminated from the selection process.

The article selection process was carried out according to the PRISMA process. During the identification stage, 290 articles were obtained from searches in predetermined databases. Furthermore, at the screening stage based on the title and abstract, 223 articles were eliminated because they were not relevant to the research topic, leaving 67 articles which were then analyzed further at the full text review stage.

During the eligibility evaluation stage , a comprehensive review of the 67 articles was conducted. As a result, 47 articles were eliminated due to not meeting the inclusion criteria, such as inappropriate research focus, irrelevant populations, and results that did not align with the research objectives. Thus, 20 articles met all criteria and were used as primary sources in this study.

The article selection process is presented visually through the PRISMA flowchart shown in Figure 1.

Figure 1. PRISMA Flowchart



The diagram describes in detail the stages of article selection from identification to determining the final articles used in the research.

Data analysis in this study was carried out using a descriptive qualitative approach. Each selected article was analyzed to identify the research objectives, methods used, and key findings. The analysis results were then classified into several key themes related to ESG, Islamic Social Reporting, green accounting, and integration with maqasid sharia. This approach was used to gain a deeper understanding of the patterns of relationships between studies and to identify remaining research gaps.

To ensure the validity of the research, the articles used were only from peer-reviewed scientific journals. Furthermore, the selection process was conducted systematically using

clear criteria to ensure the research results were accountable. Research reliability was maintained by ensuring that all data collection and analysis processes were conducted consistently according to the procedures established in the SLR method.

The results of data extraction from articles that have met the inclusion criteria are presented in Table 1 below.

Table 1. Research Article Data Extraction Results

No	Writer (Year)	Research Title	Method	Object /Sample	Main Outcome	Variable/Focus
1	Fitranty Adirestuty et al. (2024)	Report Analysis Sustainability of Study Bank Comparison Sharia Indonesia and Maybank Islamic Berhad 2019–2022	Comparative qualitative	Bank Sharia Indonesia & Maybank Islamic	ESG, sharia compliance	Sustainability reporting has been implemented, However ESG integration and sharia compliance are not yet fully optimal
2	Anggita Caesar Septyaningrum & Fetria Eka Yudiana (2025)	Islamic influence Social Reporting, Good Corporate Governance, and Stakeholder Pressure on Sustainability Report with Profitability as Moderation	Quantitative (panel regression)	40 financial sector companies	ISR, GCG, stakeholders pressure	ISR has no significant effect, whereas GCG and stakeholder pressure have a positive influence
3	Ni Luh Ayu Anggraeni & Eka Ardhani Sisdyani (2025)	Green Accounting, Commissioner Independent, Media Exposure and Disclosure Report Sustainability	Quantitative (panel regression)	Company SRI-HEART	Green accounting	Green accounting has a positive influence on sustainability report disclosure
4	Arini (2026)	Islamic Corporate Governance and Sustainability Report as a Value Determinant Islamic Commercial Bank	Quantitative (regression & path)	Islamic general bank Indonesia	ICG, sustainability report	ICG has a negative effect while sustainability reports have a positive effect on company value

No	Writer (Year)	Research Title	Method	Object /Sample	Main Outcome	Variable/Focus
5	Naufal Rizqullah Al Banjari (2023)	Green Influence Accounting and Carbon Emission Disclosure of Company Values through Maqasid Sharia	Quantitative (SEM-PLS)	State-Owned Enterprises (BUMN) ISSI	Green accounting, maqasid	Maqasid sharia has a significant effect, while environmental variables do not
6	Rizqi Anfanni Fahmi (2025)	Reporting Sustainability in Financial institutions Sharia: Analysis Literature on Practice, Standards, and The challenge	Narrative literature review	International literature	ESG, maqasid	ESG is developing, but it is not yet integrated with maqasid and does not yet have standards
7	Alifia Fitriani & Luciana Luthan (2025)	Influence ESG Disclosures on Reactions Investors, Performance Finance, and Costs Compliant Company Capital Sharia Principles	Quantitative (regression)	Jakarta Islamic Index	ESG	ESG has a significant impact on investors and performance
8	Vira Inriani et al. (2026)	Corporate Influence Sharia Governance, ESG Disclosure, and Leadership Sharia against Financial performance Islamic Bank Indonesia in Bone Regency	Quantitative (regression)	BSI	ESG, CSG	All variables have a significant positive effect
9	Siti Khomsatun et al. (2025)	Disclosure Green Banking and Performance of Islamic Banks in Indonesia: Exploration of Relationships and Moderating Roles Regulation	Quantitative (MRA)	16 Islamic banks	Green banking	The impact of green banking varies depending on the dimension

No	Writer (Year)	Research Title	Method	Object /Sample	Main Outcome	Variable/Focus
10	Deli Maharani et al. (2025)	Systematic Literature Top review Islamic Implementation Social Reporting (ISR) at the Institution Islamic Finance in Indonesia	SLR (PRISM)	Literature 2014–2025	ISR	ISR increases transparency but is not yet standardized
11	Yuni Mayanti et al. (2025)	The Impact of Intellectual Assets, Islamic Sustainability Reporting, and Green Performance on Sharia-Based Corporate Value	Quantitative (panel regression)	JII	ISR, green performance	Not significant partial, but simultaneous significance
12	Noufal Muksalmina & Risk Maulana (2026)	Beyond Philanthropy: Decoupling and Greenwashing in CSR Reporting and Comparative Institutionalism Perspectives between Indonesia and Malaysia	Comparative quantitative	Indonesia & Malaysia	CSR, ESG	Greenwashing and symbolic reporting found
13	Devina Kansa Mutia (2025)	Analysis of the Adequacy of POJK 51/2017 as a Regulatory Framework for ESG Reporting in Indonesian Financial Sector Issuers	Qualitative (content analysis)	Financial sector issuers	ESG, regulation	High formal compliance but low quality
14	Aulia Putri et al. (2026)	Interpretation of Islamic Social Reporting (ISR) Practices and Managers' Perceptions of Their Impacts on the Performance of Bank Syariah Indonesia (2022–2024)	Qualitative (case study)	BSI	ISR	ISR serves as a compliance and legitimacy strategy

No	Writer (Year)	Research Title	Method	Object /Sample	Main Outcome	Variable/Focus
15	Aina Salsabila & Muhammad Hafizh (2025)	The Influence of Islamic Corporate Governance, Profitability, and Corporate Social Responsibility on Islamic Sustainability Report Disclosure in the Jakarta Islamic Index	Quantitative (panel regression)	JII	ISR	ICG and significant profits, CSR does not
16	Dedek Saripah et al. (2024)	Is ESG Disclosure Important for Investors?	Quantitative (regression)	BEI Sharia Companies	ESG	Inconsistent results across dimensions
17	Sabrina & Ersi Sisdianto (2024)	Analysis of the Implementation of Social Responsibility Accounting in Increasing Transparency of Bank Syariah Indonesia (BSI) Sustainability Reports	Qualitative	BSI	ESG, maqasid	Integration of ESG and maqasid has a positive impact
18	Wahid Wachyu Adi Winarto et al. (2021)	The Influence of Green Banking Disclosure on Corporate Value in Islamic Commercial Banks in Indonesia	Quantitative (regression)	Green banking	Islamic bank	Has a significant positive impact
19	Jhody Wiraputra et al. (2024)	The Influence of The Global Reporting Initiative, Sustainability Accounting Standard Board and Carbon Emission Disclosure on the Sustainable Development Goals in Southeast Asia in the Islamic Perspective	ASEAN	Quantitative	ESG	ESG has an impact on SDGs
20	Delia Zara Zaneta & Mukhtarudd in n (2026)	Islamicity Performance Index in the ESG Era: Convergence, Competition, or Gap in Sharia Sustainability Reporting?	Literature review	Literature	ESG, IPI	Relationship dominated by gap

3. RESEARCH RESULTS AND DISCUSSION

Based on the extraction results of 20 articles presented in Table 1. Research Article Data Extraction Results, the findings of this study are classified into five main themes, namely: (1) the influence of ESG on the performance of sharia companies, (2) the role and limitations of Islamic Social Reporting (ISR), (3) the position of maqasid shariah in sustainability, (4) the integration of ESG and maqasid shariah, and (5) implementation challenges that include regulations and the phenomenon of greenwashing. This grouping allows for consistent pattern analysis, differences in findings, and identification of research gaps.

3.1. ESG as a Dominant Framework in Sustainability

Most studies (approximately 9 out of 20 articles) indicate that ESG positively impacts company performance and investor perceptions. Fitriani and Luthan (2025) found that ESG disclosure improves investor reaction, financial performance, and lowers the cost of capital; these findings align with Winarto et al. (2021) who demonstrated a significant positive effect of green banking disclosure on firm value. Furthermore, Anggraeni and Sisdyani (2025) confirmed that green accounting improves the quality of sustainability disclosures, while Wiraputra et al. (2024) extended the evidence to the macro level that global ESG standards (GRI and SASB) contribute to the achievement of the SDGs. Overall, this evidence indicates that ESG has become a dominant framework, positively responded to by markets and stakeholders.

However, the influence of ESG is not homogeneous across dimensions. Saripah et al. (2024) showed that only the social dimension had a positive effect on firm value, while the environmental dimension had no effect, and the governance dimension had a negative effect. This finding is consistent with Khomsatun et al. (2025) who found that green banking disclosure influences maqasid shariah performance . varies across dimensions (e.g., customer/employee aspects tend to be positive, while daily operations can be negative). Thus, although ESG is significant in aggregate, partially each component (E, S, G) has a different direction and strength of influence.

3.2. ISR: Important but Not Operationally Strong

Five articles discuss ISR as a Sharia-based reporting approach. In general, ISR has been shown to enhance transparency and reputation. Maharani et al. (2025) demonstrated that ISR increases public trust, while Putri et al. (2026) emphasized the dual role of ISR as both Sharia compliance and a legitimacy strategy. These findings strengthen ISR's position as a medium for communicating the values of maqasid sharia to stakeholders.

On the other hand, the effectiveness of ISR is inconsistent. Septyaningrum and Yudiana (2025) found that ISR had no significant effect on sustainability reporting, which contrasts

with previous positive findings. Furthermore, Salsabila and Hafizh (2025) showed that ISR was more influenced by internal factors such as ICG and profitability, while CSR had no significant effect. This means that ISR performance still depends on internal conditions and has not yet become an established standard across entities.

Another limitation is the lack of standardization. Maharani et al. (2025) emphasized that the lack of uniform indicators causes ISR implementation to vary across institutions. Thus, while strong normatively, ISR remains weak operationally, in terms of consistency, and comparability.

3.3. Maqasid Shariah as a Strong Foundation of Values

Maqasid shariah serves as the normative foundation for sharia sustainability. Al Banjari (2023) showed that maqasid shariah significantly influences firm value, even when environmental variables (green accounting and carbon disclosure) have no effect. This finding demonstrates the difference between the value approach (maqasid) and technical indicators (ESG).

Furthermore, Sabrina and Sisdianto (2024) found that integrating ESG with maqasid sharia improves performance across economic, social, and environmental dimensions. This indicates that maqasid sharia has strategic potential as an ethical basis that enriches the ESG framework.

However, most studies emphasize that maqasid shariah is still conceptual and has not been translated into measurable and standardized indicators. The lack of standardized metrics is a major obstacle to integration into a comparable reporting system.

3.4. Integration of ESG and Maqasid Shariah: Between Potential and Gaps

A total of seven articles discuss the integration of ESG and maqasid shariah. Generally, there are two strands of findings: (i) the existence of conceptual gaps, and (ii) the potential for positive integration.

Regarding gaps, Fahmi (2025) stated that there is no standard framework capable of comprehensively integrating ESG and maqasid. This is reinforced by Zaneta and Mukhtaruddin (2026), who found that the relationship between ESG and the Islamicity Performance Index (IPI) is dominated by structural gaps, with convergence limited to social and governance aspects and fundamental differences in value foundations. These findings confirm that ESG and sharia concepts are not identical and are not yet fully compatible.

Conversely, on the potential side, Inriani et al. (2025) showed that the combination of corporate sharia governance, ESG disclosure, and sharia leadership had a positive effect on financial performance. This finding aligns with Sabrina and Sisdianto (2024) and Mayanti et al. (2025), who showed that the effect becomes significant when sustainability and sharia

variables are tested simultaneously, although it is weak partially. Thus, the integration of ESG and maqasid sharia is possible and effective, but requires an integrated (rather than partial) approach and a clear operational framework.

3.5. Implementation Challenges: Regulation, Formality, and Greenwashing

Four articles highlight implementation challenges. Mutia (2025) shows that although POJK 51/2017 encourages reporting compliance, ESG quality remains variable and tends to be formalistic, marked by a lack of quantitative indicators and independent assurance . This finding is consistent with Muksalmina and Maulana (2026), who identified the phenomena of greenwashing and decoupling, where reporting serves as a legitimacy tool rather than a reflection of actual practices.

Cross-country comparisons reinforce these findings: Malaysia, with its Value-Based Intermediation approach , demonstrates higher ESG maturity, but still poses the risk of greenwashing; while Indonesia is stronger in its social aspects based on maqasid (obligatory obligations), but is often administrative in nature. This means that regulation is necessary but not sufficient to ensure the quality, depth, and integrity of reporting.

3.6. Synthesis and Affirmation of Research Gap

Overall, ESG has become the dominant framework and has proven to be influential. on company performance and investor perceptions. However, its integration with the maqasid sharia is still suboptimal due to three main issues:

(1) conceptual gap between ESG and sharia values (Zaneta & Mukhtaruddin, 2026; Fahmi, 2025),
(2) operational limitations in the form of the absence of measurable and standardized maqasid indicators (Maharani et al., 2025), and
(3) implementation challenges such as ineffective regulations and greenwashing practices. (Mutia, 2025; Muksalmina & Maulana, 2026).
On the other hand, empirical evidence shows that when ESG and sharia principles are integrated simultaneously, the impact is significant (Inriani et al., 2025; Mayanti et al., 2025; Sabrina & Sisdianto, 2024). Therefore, the research gap lies in the absence of an integrated reporting framework capable of operationalizing maqasid sharia into ESG-compatible indicators (measurable, comparable, and auditable).

The implication is that this study emphasizes the need to develop an integrated sharia sustainability reporting framework that combines the strengths of ESG (global standards, measurability) with maqasid sharia (ethical foundations and benefit), so that reporting not only meets global standards but is also substantively aligned with Islamic values.

4. CONCLUSION AND SUGGESTIONS

4.1. Conclusion

Based on a systematic literature review of 20 articles, it can be concluded that Environmental, Social, and Governance (ESG)-based sustainability reporting has emerged as the dominant framework in corporate sustainability practices, including in the Islamic finance sector. Most studies show that ESG has a positive impact on company performance, firm value, and investor perceptions. This confirms that ESG has become a recognized global standard for promoting transparency and accountability.

However, research also shows that the influence of ESG is not homogeneous. Some studies find that only certain dimensions, such as social aspects, have a positive impact, while others, such as governance, can have a negative impact. This suggests that ESG implementation is still partial and not fully consistent.

On the other hand, Islamic Social Reporting (ISR) as a sharia-based reporting approach has an important role in increasing corporate transparency and reputation. However, the effectiveness of ISR remains suboptimal due to the lack of uniform standards and its reliance on internal company factors. This prevents ISR from becoming a robust and consistent reporting framework like ESG.

Furthermore, maqasid shariah has been proven to play a significant role as a foundation for values in sustainability, particularly in creating welfare oriented towards economic, social, and environmental aspects. However, the values of maqasid shariah remain conceptual and have not been systematically integrated into measurable reporting indicators.

The results of this study also show that the integration between ESG and maqasid shariah still faces significant gaps. Differences in values and approaches mean the two concepts are not yet fully aligned. However, several studies have shown that integration can have a positive impact when implemented comprehensively and simultaneously.

Furthermore, implementation challenges such as weak regulations and the emergence of greenwashing indicate that sustainability reporting does not fully reflect actual practices. In many cases, reporting remains a formality and is used as a means of legitimacy.

Thus, it can be concluded that although ESG has emerged as a primary framework in sustainability reporting, its integration with maqasid shariah remains suboptimal. It is necessary to develop a reporting framework that integrates both concepts comprehensively, measurably, and in accordance with sharia values.

4.2. Suggestion

Based on these conclusions, some suggestions that can be given are as follows: First, regulators need to strengthen sustainability reporting policies and standards, oriented not only toward formal compliance but also toward promoting the quality and substance of reporting. Regulations such as the Financial Services Authority Regulation (POJK) need to be developed to accommodate the integration of ESG and the maqasid sharia principles.

Second, Islamic financial institutions need to improve the implementation of sustainability reporting, focusing not only on technical ESG aspects but also on concretely integrating the values of maqasid sharia into operational practices. This is crucial to ensure that reporting is not merely symbolic but reflects a commitment to sustainability grounded in Islamic values.

Third, academics and future researchers need to develop indicators and a conceptual framework capable of integrating ESG and maqasid sharia in a systematic and measurable manner. Further research is also recommended to employ a broader empirical approach to test the effectiveness of this integration in various industry contexts.

Fourth, it is crucial for companies to increase transparency and avoid greenwashing by ensuring that sustainability reporting reflects actual conditions and practices. This can be achieved through improving data quality, using quantitative indicators, and providing independent assurance.

Thus, the development of sharia-based sustainability reporting in the future is expected to not only follow global ESG standards, but also be able to integrate the values of maqasid sharia in a substantial and sustainable manner.

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ANALYSIS OF THE ROLE OF ARTIFICIAL INTELLIGENCE IN DIGITALIZING ZAKAT MANAGEMENT TOWARDS TRANSPARENCY AND ACCOUNTABILITY: A SYSTEMATIC LITERATURE REVIEW

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Abstract

This study aims to analyze the role of Artificial Intelligence in support the digitalization of zakat management and its impact on transparency and accountability. The approach used is qualitative with the Systematic method Literature Review, namely reviewing various journals and scientific publications that are relevant to research topic. Data were collected through scientific database searches and selected based on the suitability of the theme, then analyzed descriptively to find patterns and the relationship between concepts.

The results of the study show that digitalization has increased efficiency in the process of collecting, managing, and distributing zakat. Artificial Intelligence plays a role in processing data, assisting decision making, and improving accuracy of fund distribution to mustahik. In addition, the use of technology also encourage increased transparency through information disclosure and strengthen accountability through an integrated recording system. However, the implementation technology still faces obstacles such as limited infrastructure, resources human, and data security aspects. Overall, the integration of Artificial Intelligence in digitalizing zakat management, it makes a positive contribution to strengthening the governance more transparent and accountable management.

Keywords: Artificial Intelligence, Digitalization of Zakat, Transparency, Accountability

INTRODUCTION

The development of digital technology in recent years has begun to change the way public and financial institutions work, including in zakat management. The emergence of Artificial Intelligence (AI), big data, and fintech are driving previously manual processes. become faster, more measurable, and more integrated. In the context of zakat, digitalization is not only facilitate fundraising, but also open up opportunities to increase transparency and accountability of zakat management institutions (Muharromi, Basori, and Zahid 2025; Siregar and Abd Majid 2025). This is important because zakat is not only related to economic aspects, but also public trust and institutional responsibility towards muzakki and mustahik.

However, conditions on the ground show that transparency and accountability are still lacking. become the main problem. The transparency of financial reports is not optimal, the system reporting that is not yet real-time, as well as limited access to information, makes trust community's understanding of zakat institutions is not yet optimal (Cahyani 2024; Risky and Tania 2024). In addition, zakat management does not fully reflect the principle of accountability. from a sharia perspective which emphasizes honesty and accountability (Basri, Nabiha, and Majid 2016). If this condition is allowed to continue, the large potential for zakat will not be realized optimal and the trust of the muzakki can decrease.

On the other hand, technologies like AI are starting to be seen as promising solutions can help process zakat data automatically, improve reporting accuracy, and support more appropriate decision making in the distribution of funds (Shamsuddin, Karim, and Yunus 2025; Syahrizal 2025). Integration with technologies such as blockchain also can increase transparency because the data is more open and difficult to manipulate (Handarini et al. 2024; Ningsih et al. 2024; Akther et al. 2025). In addition, the use of digital platforms and fintech has been proven to increase efficiency and ease of access for the public in paying zakat (Kasri and Yuniar 2021; Malik, Utami, and Setiawati 2025; Sulaeman and Fahrezy 2025).

The motivation for this research arises from the gap between technological potential and implementation in the field. Although the digitalization of zakat has developed, the utilization of AI to increase transparency and accountability is still uneven and not widely used. studied in depth. In fact, this technology has great potential to strengthen governance manage zakat more reliably and based on data (Sanusi and Hija 2025; Nugroho and Al giffari 2026). Without a comprehensive study, the use of technology risks not being optimal or not in accordance with sharia principles.

A number of previous studies have discussed the digitalization of zakat from various sources. point of view. Several studies focus on the impact of digitalization on improving collection of zakat funds and the effectiveness of the payment system (Aini, Putra, and Husniah 2025; Verdianti and Puja 2023). Other research discusses the implementation of digitalization in

increasing the transparency and quality of zakat institution services (Oktaviani 2025; Saputra and Kamal 2025). In addition, there is also a study that reviews the development of digital zakat research. in general and the use of technologies such as blockchain and AI in the zakat system (Rafiki, Syahrial, and Andika 2024; Islami et al. 2025; Laylo 2023; Sasmita, Khafidhoh, and Najikha 2025). Most of the research uses a quantitative approach, studies case, or simple literature review.

Even though it has been discussed a lot, there are still some things that have not been addressed in detail. in-depth. Most studies still look at digitalization in general and have not placing AI as a primary focus in increasing transparency and accountability. In addition, the relationship between AI, zakat governance, and sharia principles is still rare. discussed in an integrated manner. The systematic literature review approach is capable of mapping overall research development is also still limited (Rafiki, Syahrial, and Andika 2024; Khulataini 2025).

Based on this, the research gap in this study lies in the fact that it has not yet been there is a study that integrates Artificial Intelligence, digitalization of zakat management, and transparency and accountability within a comprehensive analytical framework. This research also offers a combination of variables that are still rarely researched and using a systematic literature review approach to provide an overview more intact.

The novelty of this research lies in the focus of the analysis on the role of AI in digitalization of zakat by emphasizing the aspects of transparency and accountability. This research also trying to connect modern technological developments with the principles of zakat governance sharia-based so as to produce a more integrative perspective.

The implications of this research include two things. Theoretically, this research can enrich the literature on digital zakat and the role of AI in Islamic finance. In practice, the results of this study can be a reference for zakat management institutions in develop a system that is more transparent, accountable, and in accordance with sharia principles so that it can increase public trust (Alfatah and Abdulloh 2024; Anisah et al. 2025; Fatima 2024).

Based on this background, the aim of this study is to analyze systematically the role of Artificial Intelligence in the digitalization of zakat management as well as its impact on the transparency and accountability of zakat institutions through an approach systematic literature review.

1. LITERATURE REVIEW

This study discusses the relationship between digitalization of zakat management, utilization technology, especially Artificial Intelligence (AI), as well as the role of transparency and accountability in increasing public trust in zakat institutions. These three aspects are

interconnected related and become the basis for understanding the transformation of zakat management in the digital era.

Digitalization of zakat management is a process of changing the system from manual become technology-based which includes collection, management, to fund distribution. Utilization of digital platforms, payment applications, and integration with a modern financial system, the zakat process becomes more efficient and easier accessible to the public. Several studies show that the use of the platform digital is able to increase the effectiveness of zakat collection and expand the reach zakat institution services (Akbarillah 2025; Kholimah, Adinugraha, and Sain 2025). In addition, digitalization also encourages the formation of a zakat ecosystem that is connected to the system broader Islamic finance, thereby supporting social and economic development sharia-based (Cheumar et al. 2025).

This digital transformation also changes the role of zakat management institutions to become more... strategic. The institution not only functions as a fund collector, but also as a information management must be accurate, transparent and accountable. Digitalization enables institutions to manage data more systematically and structured, so as to support more appropriate decision making (Fajri 2025; Oktavendi and Mu'ammal 2022). This development also encourages the emergence of the model more adaptive zakat management, including digital asset-based zakat management increasingly relevant to modern economic conditions (Rosele et al. 2025).

Along with these developments, the use of Artificial Intelligence is starting to... become an important part of the zakat management system. AI is used to process large amounts of data, identifying patterns, and assisting the prediction process in distribution of zakat funds to be more targeted. With a data-driven approach, AI is able to increase efficiency and accuracy in decision making (Shamsuddin, Karim, and Yunus 2025). In addition, the integration of AI with Islamic social financial instruments also opens up opportunities to develop more innovative and sustainable financing models (Putri, Mardiah, and Setyanor 2025).

The use of technology in zakat is not only limited to AI, but also involving big data and fintech which complement each other. Big data enables information management on a large scale, while fintech provides convenience in transactions and service access. This combination of technologies has been proven to increase inclusion finance and expanding community participation in paying zakat (Ahmad and Yahaya 2023; Fuad, Alim, and Hakim 2025). However, the use of technology also needs to be balanced with good risk management, especially regarding data security and protection of user information (Alsaghir 2023).

In the context of governance, transparency and accountability are the main indicators. in assessing the performance of zakat institutions. Transparency is related to the openness of information to the public, while accountability emphasizes the institution's ability to be

accountable for the management of funds in a clear and measurable manner. These two aspects have an important role in building the trust of muzakki in zakat institutions (Syifa and Anggraini 2024; Sunarsih et al. 2025). This trust is a key factor in increasing community participation in distributing zakat through official institutions.

In addition, the quality of information presented by zakat institutions is also a part important in supporting transparency and accountability. Accurate, relevant, and timely information easily accessible will help the public understand how zakat funds are managed and distributed. This has a direct impact on increasing legitimacy and credibility zakat institutions in the public eye (Alfindo 2024; Zaharah and Fauzi 2024). On the other hand, regulations which regulates the management of zakat also plays a role in ensuring that the practices carried out in accordance with sharia principles and applicable legal provisions (Zaharah and Fauzi 2024).

Technological developments also strengthen the implementation of transparency and accountability. in zakat management. Technology enables a more open reporting system, real-time, and easy to audit, so it can minimize the potential for deviations in fund management (Sari and Asrianti 2025; Wahyudi, Amalia, and Rini 2024). In addition, ease of access and clarity of information provided through digital platforms as well increasing the community's motivation to distribute zakat through official institutions.

Overall, the existing literature shows that digitalization and the use of technology has an important role in improving the quality of zakat management, especially in aspects of efficiency, transparency, and accountability. Integration between technologies such as AI, big data, and fintech with a zakat management system as the basis for building good governance which is more modern and reliable. Thus, strengthening the role of technology in Zakat management is not only a necessity, but also a strategic step in increasing public trust and optimizing zakat potential in the digital era.

2. METHODOLOGY

This research uses a qualitative approach with a systematic literature method. review (SLR). This method is used to systematically review various studies regarding the role of Artificial Intelligence in the digitalization of zakat management and its impact towards transparency and accountability.

The research process is carried out in several stages. First, determining the focus and research questions. Second, collect literature from scientific journals through databases such as Google Scholar and Scopus with relevant keywords, such as digitalization of zakat, Artificial Intelligence, transparency, and accountability. Third, conducting article selection. based on inclusion criteria, namely research that is relevant, recent, and of good quality clear scientific.

Next, the data was analyzed using content analysis techniques with identify themes, main concepts, and important findings from each study. The analysis is then compiled to see the patterns, trends and developments of the study. related to the use of AI in zakat management.

Through this method, research can provide a systematic and comprehensive picture. comprehensive overview of the role of AI in enhancing transparency and accountability zakat institutions in the digital era.

3. RESULTS AND DISCUSSION

Based on the results of the literature review, digitalization has brought changes in zakat management, especially in the aspects of collection, management and distribution funds. A number of studies show that the use of digital technology makes the zakat management process becomes more efficient, structured, and easily accessible to community. This change also broadens the reach of zakat institutions in capturing muzakki, so that fund collection becomes more optimal compared to the method conventional. Not only that, digitalization also changes the pattern of interaction between institutions zakat and the community become faster and more responsive, so that the service process becomes more adaptive to user needs.

At the collection stage, digitalization provides convenience in payments. zakat through various platforms such as mobile banking, e-wallet, and online-based services others. This convenience encourages increased community participation because the process more practical and flexible. In addition, the digital system allows for the recording of muzakki data automatically and integrated, so that zakat institutions can manage information easily more systematic. The collected data not only functions as an archive, but can also be used for analysis of muzakki behavior, such as payment frequency, preferences payment channels, to the potential for future donations. In this way, zakat institutions can designing more precise and data-driven collection strategies.

The role of Artificial Intelligence is starting to be seen at the data management stage and decision-making. Based on the results of the study, AI is used to process deep data large numbers, identifying patterns of mustahik needs, and helping to determine priority of fund distribution. With this approach, zakat management no longer depends on on estimates, but based on more accurate and objective data analysis. AI also allows the mustahik segmentation process to be more detailed, for example based on economic conditions, location, and level of vulnerability. This helps zakat institutions in designing programs that are more effective and have a direct impact on improving welfare of beneficiaries.

In addition, AI also plays a role in increasing the operational efficiency of zakat institutions. Processes that were previously done manually, such as data verification or classification zakat recipients, can be done automatically with the help of an AI-based system. This not only saves

time, but also reduces the potential for human error in data processing. With a more structured system, zakat institutions can work more efficiently focus on program planning and impact evaluation, not just on the process administrative.

In the distribution process, the use of AI also plays a role in ensuring that zakat funds are distributed more precisely to the target. The system is able to group mustahik based on the level of need and economic conditions, so that distribution becomes more focused and in line with the objectives of zakat. In addition, the use of technology This allows the distribution monitoring process to be carried out continuously. Zakat institutions can track whether the assistance provided has been received well, as well as assess its impact over a certain period of time. With this monitoring system, evaluation programs become more objective and data-driven.

From the transparency side, the results of the study show that digitalization provides significant contribution in increasing information transparency. Zakat institutions can presenting information related to the collection and distribution of funds more openly through digital platforms. This easy access to information allows the public to directly monitor zakat management. In addition, transparency is also strengthened through presentation of more detailed and structured financial reports. The public not only know the amount of funds collected, but also how these funds are used. This condition helps build public trust in zakat institutions.

Furthermore, from the accountability aspect, the use of digital systems and AI strengthens accountability mechanism of zakat institutions. Every transaction is recorded automatically and can be traced back, thus facilitating the audit process. In addition, financial reports can be compiled more quickly and accurately because it is supported by an integrated system. Accountability is not only seen from the reporting aspect, but also from the institution's capabilities. in showing the impact of the program being implemented. With the data that structured, zakat institutions can show real results from the distribution of funds, so that increase legitimacy in the eyes of the public.

Furthermore, the integration of technologies such as AI, big data, and other digital systems encourage the formation of a more modern zakat ecosystem. This ecosystem allows there is collaboration between zakat institutions, the government and the financial sector in managing funds more optimally. Integrated data opens up opportunities for decision-making broader policies, for example in poverty alleviation or empowerment community economy. Thus, zakat management is not only administrative, but also be part of a larger social development system.

However, the results of the study also show that the implementation of AI in Zakat management still faces several challenges. Not all zakat institutions have adequate

infrastructure and human resource readiness. Limitations in mastering technology and implementation costs are the main obstacles. In addition, there is still a digital literacy gap in society which can influence effectiveness of using digital platforms. On the other hand, data security aspects are also a important attention, considering that the data being managed is sensitive and related to personal information.

Apart from technical challenges, there are also challenges from the regulatory and compliance side. with sharia principles. The use of technology, especially AI, must be ensured not to contradicts sharia values in zakat management. Therefore, it is necessary a clear regulatory framework and adequate oversight to ensure the implementation of technology remain in accordance with the principles of justice and welfare. This is important so that the innovation that carried out not only technically effectively, but also legally and sharia-compliant.

Overall, the results of this discussion show that Artificial Intelligence has a strategic role in supporting the digitalization of zakat management. This role seen in the improvement in the quality of data management, accuracy of distribution, and openness information to the public. AI not only functions as a technological tool, but also as instruments that encourage the transformation of zakat governance to be more modern, transparent, and accountable. This finding is in line with the discussion in the introduction and review. literature that emphasizes that technology integration, especially AI, is an important factor in increasing transparency and accountability of zakat institutions in the digital era.

4. CONCLUSION

Based on the results of the study, digitalization has changed zakat management to be more efficient. efficient, structured, and easily accessible. This change is visible in the collection process, data management, to the distribution of funds which is now supported by a data-based system technology. Artificial Intelligence plays an important role in strengthening this process, especially in data processing, decision making, and determining distribution priorities zakat. With the help of AI, zakat management no longer depends on estimates, however based on more accurate data analysis. As a result, transparency increases because information is more open, and accountability is also stronger because every transaction can be recorded and well researched.

However, the implementation of this technology still faces several obstacles, such as infrastructure limitations, lack of human resources who understand technology, and data security risks. Therefore, the successful implementation of digitalization and AI is very important. depends on the readiness of the institution in managing technology and increasing capacity resources owned. Overall, the integration of Artificial Intelligence in zakat management provides a positive direction in strengthening transparency and accountability, while encouraging better zakat governance in the digital era.

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UTILIZATION OF ARTIFICIAL INTELLIGENCE IN SHARIA BUSINESS PRACTICES IN THE FIELD OF E-COMMERCE: BIBLIOMETRIC ANALYSIS AND SYSTEMATIC LITERATURE REVIEW

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Abstract

The development of digital technology has transformed business practices, including Sharia-compliant e-commerce. This study aims to analyze the use of artificial intelligence (AI) in Sharia-compliant business practices in the e-commerce sector through a Systematic Literature Review (SLR) approach. The study identifies four main domains of AI utilization: halal product verification and certification, Muslim-preference-based service personalization, halal supply chain optimization, and Sharia compliant risk management. Findings indicate that previous research has focused on the development of decision support systems, chatbot implementation, transaction fraud detection, and optimization of halal product recommendations. However, research gaps remain, particularly regarding the ethical framework of AI from an Islamic perspective, algorithmic audit standards for Sharia compliance, and the socio-economic implications of automation. This study provides a comprehensive synthesis of the development of AI utilization in Sharia e-commerce and proposes future research directions.

Keywords: Artificial Intelligence, Sharia Business, Halal E-Commerce, Systematic Literature Review, Halal Technology, Digital Islamic Economy

INTRODUCTION

The development of digital technology has driven significant changes in modern business practices, particularly in the e-commerce sector. The integration of artificial intelligence (AI) has become an increasingly dominant phenomenon in improving operational efficiency, service quality, and customer experience. AI has been recognized as a strategic technology transforming business models across various industries (Kaplan, Andreas 2019). In the e-commerce context, AI applications include recommendation systems, chatbots, consumer behavior analysis, and transaction fraud detection (Huang and Rust 2018).

This issue is crucial to discuss because the growth of the sharia economy and the halal industry is showing rapid development globally. Digital transformation in the Islamic economic ecosystem is driving the emergence of various innovative business models, including halal-based e-commerce. Sharia businesses are not solely oriented toward profitability but also emphasize adherence to ethical principles, transparency, and the halal nature of products and transactions (Dusuki 2008). Furthermore, the development of AI technology presents both opportunities and challenges in maintaining a balance between technological efficiency and sharia compliance.

Artificial intelligence has transformed the operational paradigm of modern business. Kaplan and Haenlein (2019) assert that AI enables organizations to increase efficiency, personalize services, and optimize business processes. In the e-commerce sector, AI is used in recommendation systems, chatbots, predictive analytics, and fraud detection (Davenport and Ronanki 2018). The use of AI has a significant impact on improving customer experience, consumer loyalty, and company competitive advantage.

In line with these developments, the halal industry is experiencing rapid growth as a strategic sector of the global economy. (Sidlo 2017) notes that the halal economy encompasses various sectors, including food, finance, pharmaceuticals, cosmetics, and e-commerce. The halal industry is not only concerned with consumption aspects but also reflects ethical values, transparency, and sustainability (Wilson, n.d.). This growth demands technological innovation capable of supporting an increasingly broad market scale.

Previous research has extensively examined the role of AI in business and e-commerce. These studies highlight how AI can enhance organizational performance, improve decision-making, and create competitive advantage (Davenport and Ronanki 2018). In the e-commerce sector, AI has been shown to contribute to improving customer experience and optimizing business processes (Huang and Rust 2018). Furthermore, other literature discusses the development of the halal industry, including the importance of halal assurance, the halal supply chain, and halal certification (Tieman 2011).

Scientific studies on Artificial Intelligence in sharia business are still relatively developing. A bibliometric approach is needed to understand the intellectual structure, research trends, and conceptual relationships in academic literature (Donthu et al. 2021). Systematic literature review complements this analysis by providing a comprehensive synthesis of empirical findings (David Tranfield, David Denyer, nd). Therefore, this study seeks to fill the academic gap through bibliometric analysis and systematic literature review.

However, there are differences in focus within existing research. AI studies are generally positioned within a conventional business framework, emphasizing technical and economic aspects. Meanwhile, research on Islamic business focuses more on normative, ethical, and adherence to Islamic principles (Dusuki 2008). Consequently, the integration of intelligent technologies such as AI and Islamic business practices, particularly in the context of e-commerce, remains relatively limited and scattered across various research themes.

To address this gap, this study employs a Systematic Literature Review (SLR) approach to analyze the use of artificial intelligence in sharia business practices in the e-commerce sector. The SLR approach allows for the identification of research trends, mapping of AI implementation areas, and systematic analysis of research gaps (Barbara Kitchenham 2004). This approach allows the study not only to summarize the literature but also to provide a more comprehensive conceptual synthesis.

The research findings indicate that the use of AI in Islamic e-commerce can be classified into several key domains, including halal product verification, personalized service based on Muslim preferences, halal supply chain optimization, and Islamic compliance risk management. These findings provide a comprehensive overview of the direction of AI research in Islamic business and its implications for future studies and business practices.

1. FORMULATION OF THE PROBLEM

This research is designed to answer fundamental questions related to the dynamics of research and technology implementation in sharia business. The research questions address the development of research trends on Artificial Intelligence in sharia business practices in e commerce, the conceptual cluster structure formed in the scientific literature, and the implications of AI utilization for efficiency, sharia compliance, and the sustainability of halal businesses.

2. MATERIALS AND METHODS

This research employs a mixed-methods approach that integrates bibliometric analysis and a systematic literature review (SLR). This approach was chosen to gain a comprehensive understanding of research developments related to the use of Artificial Intelligence in Sharia business practices in e-commerce. Bibliometric analysis is used to map conceptual structures,

inter-theme relationships, and research trends, while the systematic literature review serves to in-depth examine empirical findings and theoretical frameworks developed in the academic literature.

Research data was obtained from relevant scientific databases, namely Scopus, Web of Science, and Google Scholar, taking into account the broad scope of the literature and the quality of the indexed publications. The search process was conducted systematically using a combination of keywords such as "Artificial Intelligence," "Islamic Business," "Halal E-Commerce," "Digital Transformation," and other related terms. The analyzed literature was limited to the 2021–2026 period to capture the latest research developments. Document selection was carried out using inclusion and exclusion criteria to ensure academic relevance and source quality.

Bibliometric analysis was carried out with the help of VOSviewer software through the co-occurrence analysis technique on keywords to identify research theme clusters. Next, a systematic literature review was conducted using a thematic approach to interpret academic discourse patterns, the contribution of Artificial Intelligence to halal business, and its ethical implications from a sharia economic perspective. The combination of these two methods allows the research to produce both a structural overview and a substantive understanding of the phenomenon under study.

3. BIBLIOMETRIC ANALYSIS RESULTS

The results of the VOSviewer mapping show the existence of several main clusters that reflect the conceptual structure of the research.

Figure 1. Bibliometric Analysis Result



The bibliometric analysis in this study provides an overview of the intellectual structure and conceptual evolution of research related to the use of Artificial Intelligence in Sharia business practices in e commerce. The bibliometric approach allows researchers to identify patterns of relationships between concepts, the intensity of keyword associations, and the direction of academic discourse development (Donthu et al., 2021). Through co-occurrence mapping using VOSviewer, a thematic network visualization is obtained that reflects the multidimensional interactions between technology, the halal industry, and the Sharia economy.

The mapping results show that Artificial Intelligence serves as a central concept connecting various research domains. This indicates that AI is no longer positioned as a mere technological instrument, but rather as a strategic variable influencing economic systems, market behavior, and modern business structures (Dwivedi et al., 2021). The cluster structure that is formed reflects that research is developing in an interdisciplinary approach that integrates technological, management, economic and ethical perspectives.

3.1. Technology Cluster and Digital Transformation

The first cluster demonstrates the dominance of technology and digital transformation themes. Keywords such as technology, digital transformation, and big data demonstrate that the discourse on AI in Islamic business is firmly rooted in the general digital transformation literature. Schwab (2016) asserts that the fourth industrial revolution is characterized by the integration of intelligent digital systems that are redefining how organizations create value.

Digital transformation in the modern business context involves more than just technology adoption, but also reflects fundamental changes in business models, organizational structures, and competitive strategies (Vial, 2021). Recent literature confirms that AI is a key catalyst for digital transformation due to its capabilities in automation, adaptive learning, and predictive analytics (Verhoef et al., 2021). In this context, big data is a key element enabling AI to generate strategic insights based on consumer behavior patterns (Bag et al., 2021).

Recent research shows that organizations that integrate AI into their digital transformation strategies tend to have higher operational performance (Wamba et al., 2021). AI enables increased process efficiency, reduced transaction costs, and optimized decision-making (Ransbotham et al., 2022). In the context of e-commerce, this technology plays a role in recommendation systems, personalized customer experiences, and market demand prediction (Huang & Rust, 2021).

From a sharia economic perspective, digital transformation has strategic implications for transparency and accountability. Digital technology enables increased transaction visibility, reduced information asymmetry, and strengthened market trust (Zhang et al., 2022). This

aligns with sharia principles, which emphasize fairness, clarity of contracts, and the prohibition of gharar (Chapra, 2000).

3.2. Halal Industry Cluster

The second cluster highlights the halal industry. Keywords such as "halal industry" reflect the close relationship between AI research in Islamic business and the growth of the global halal economy. The halal industry is developing as a strategic economic sector driven not only by religious demand but also by consumer preferences for quality, safety, and ethical standards (Razzaq et al., 2021).

Recent literature shows that the complexity of the halal supply chain demands technological innovations that can improve transparency and traceability (Khan et al., 2021). AI plays a crucial role in optimizing halal logistics, predicting demand, and managing supply chain risks (Ali et al., 2022). AI-based technologies are also used in data-driven halal verification systems, enabling increased accuracy and efficiency of the certification process (Tieman & Darun, 2021).

Recent research confirms that digitalization of the halal industry increases consumer trust through transparency of product information (Haleem et al., 2022). AI enables real-time analysis of halal market data, enabling businesses to respond more adaptively to changing consumer preferences (Rahman et al., 2023).

Furthermore, the integration of AI in the halal industry is also related to business sustainability. AI supports energy efficiency, resource optimization, and waste reduction in the halal supply chain (Khan & Khan, 2022). This perspective aligns with the maqasid sharia values, which emphasize balance, sustainability, and the benefit (Dusuki, 2022).

3.3. Halal E-Commerce Cluster

The third cluster demonstrates the relationship between halal e-commerce and the digital economy. Digital platforms enable the expansion of halal product distribution across regions, reducing geographic barriers, and increasing market accessibility (Laudon & Traver, 2021). However, the dynamics of halal e-commerce cannot be separated from the issue of consumer trust.

Gefen et al. (2003) emphasized that trust is a key determinant of e-commerce adoption. Recent literature reinforces that trust in halal e-commerce has additional dimensions, namely sharia compliance, halal product authenticity, and information transparency (Sulaiman et al., 2021). AI plays a role in strengthening trust through intelligent recommendation systems, interactive chatbots, and fraud detection (Chong et al., 2022).

Recent research shows that AI-driven personalization improves customer experience and consumer loyalty (Huang & Rust, 2022). In the halal context, AI-based recommendation systems enable consumers to find products that match their preferences. religious and consumption ethics (Rahman et al., 2022).

AI also plays a crucial role in digital transaction security. Anomaly detection, fraud pattern identification, and algorithm-based risk management enhance the stability of the halal e-commerce ecosystem (Bélanger et al., 2021). This is crucial for maintaining transaction integrity in line with Sharia-compliant principles of honesty and fairness.

3.4. Artificial Intelligence Cluster

The fourth cluster focuses on the concept of Artificial Intelligence itself. The literature in this cluster highlights machine learning, automation, predictive analytics, and decision support systems. Russell and Norvig (2021) explain that AI reflects systems that are able to learn, adapt, and make data based decisions.

Recent research shows that AI improves organizational operational efficiency through the automation of routine tasks and predictive decision-making (Raisch & Krakowski, 2021). AI also contributes to digital business model innovation (Iansiti & Lakhani, 2022).

However, the development of AI also raises critical issues related to ethics and governance. Floridi et al. (2022) emphasize the importance of the principles of fairness, accountability, transparency, and ethics (FATE). Recent literature highlights explainable AI as an approach to increasing algorithmic transparency (Arrieta et al., 2021).

3.5. Sharia Economic Cluster

The fifth cluster highlights Islamic economics as a normative framework. Islamic economics emphasizes a balance between economic efficiency and moral values (Chapra, 2000). Recent literature suggests that modern technology should be evaluated based on its compliance with the maqasid of Islamic law (Abojeib & Habib, 2022).

From a sharia perspective, AI is assessed not only from an efficiency perspective but also from an ethical perspective, distributive justice, and social impact (Dusuki, 2022). Academic discourse emphasizes the importance of Islamic ethical AI governance (Khan et al., 2023).

4. DISCUSSION

The findings of this study demonstrate that Artificial Intelligence plays a strategic role in transforming Sharia business practices, particularly in the halal e-commerce ecosystem. The bibliometric analysis reveals that AI does not develop as a single variable but is closely integrated with discourses on digital transformation, the halal industry, consumer behavior, and the normative framework of the Sharia economy. The resulting cluster structure indicates

that modern research increasingly emphasizes a multidisciplinary approach to understanding the impact of intelligent technology on value-based economic systems.

Artificial Intelligence has been proven to significantly contribute to the operational efficiency of digital businesses. Recent literature confirms that AI-driven automation enables organizations to increase productivity by reducing manual activities, optimizing business processes, and increasing service speed (Raisch & Krakowski, 2021; Ransbotham et al., 2022). In the context of halal e-commerce, this efficiency is reflected in the increased accuracy of recommendation systems, personalization of customer experiences, and the ability to predict market demand. AI enables businesses to respond to the dynamics of consumer preferences with a data-driven approach, thereby reducing uncertainty in business decision-making.

Furthermore, AI plays a vital role in improving the quality of customer experience. Huang and Rust (2021, 2022) assert that Artificial Intelligence enables organizations to create more adaptive, responsive, and personalized interactions. In halal e-commerce, AI-based systems help consumers find products that align with their religious preferences and ethical consumption values. This personalization not only increases customer satisfaction but also strengthens consumer loyalty and trust in digital platforms. From a digital marketing perspective, AI serves as a strategic instrument in creating added value based on relevance and user convenience.

Another dimension that emerged strongly in this research is the contribution of AI to risk management and the security of digital transactions. The e-commerce ecosystem is highly vulnerable to fraud, data manipulation, and uncertain market behavior. AI-based anomaly detection systems enable organizations to identify risk patterns more quickly and accurately (Bélanger et al., 2021). In the context of Islamic business, transaction stability and security have a broader meaning, as they are directly related to the principles of honesty, fairness, and transparency of contracts. Thus, the use of AI in digital security systems aligns with the goal of maintaining the integrity of sharia economic transactions.

However, this research also identifies critical challenges in the integration of Artificial Intelligence. Recent literature consistently highlights ethical issues in AI, particularly regarding algorithmic bias, model opacity, and the accountability of automated systems (Mehrabi et al., 2021; Floridi et al., 2022). Bias in training data can lead to unfair decisions, potentially affecting access distribution, product recommendations, and risk assessment. In the context of Islamic economics, this issue is crucial because technology must uphold the principles of justice (adl) and moral responsibility (amanah).

The lack of transparency of algorithms is also a major concern. Complex AI models often operate as black boxes, making them difficult for users and regulators to understand. Arrieta

et al. (2021) emphasized that explainable artificial intelligence (XAI) is a crucial approach to improving system transparency. In Islamic business practices, transparency is not merely a technical aspect, but rather a fundamental principle related to clarity of contracts, openness of information, and the reduction of gharar. Therefore, the integration of AI into the Islamic economy requires a system design that is not only efficient but also ethically accountable.

Research also shows that Artificial Intelligence (AI) is influencing organizational decision-making structures. AI enables organizations to shift from managerial intuition to algorithmic prediction-based decisions (Raisch & Krakowski, 2021). This shift improves analytical accuracy, but also raises questions about the role of humans in the decision-making process. From a sharia perspective, moral responsibility remains with human actors, so AI should be positioned as a tool, not a substitute for human ethical judgment.

In the context of the halal industry, AI plays a role as a driver of transparency and traceability. The complexity of the halal supply chain demands a system capable of ensuring product integrity from upstream to downstream. AI-based digitalization allows for increased visibility of production, distribution, and halal verification processes (Haleem et al., 2022). This strengthens consumer trust and increases the efficiency of the halal certification system. Thus, AI contributes to the stability of an increasingly digitalized halal ecosystem.

Conceptually, this research demonstrates that Artificial Intelligence plays a dual role in Islamic business. On the one hand, AI improves organizational efficiency, innovation, and competitiveness. On the other hand, AI raises ethical, regulatory, and normative challenges that require serious attention. The integration of intelligent technology into a values-based economy demands a balance between innovation and ethics. This perspective reinforces the view that digital transformation in the Islamic economy cannot be separated from moral and social dimensions.

5. CONCLUSION

This study concludes that Artificial Intelligence plays an increasingly strategic role in sharia business practices, particularly in the halal e-commerce sector. The bibliometric analysis shows that research is developing within a multidisciplinary framework reflecting the integration of digital technology, the halal industry, consumer behavior, and sharia economics. Artificial Intelligence is positioned as a central concept that connects various modern research domains.

The use of AI has been proven to contribute significantly to improving operational efficiency, customer experience quality, and risk management in the halal e-commerce ecosystem. AI enables organizations to improve productivity, decision-making accuracy, and digital business competitiveness. Furthermore, this technology supports transparency and stability in

transaction systems, aligning with the principles of honesty and fairness in the Islamic economy.

However, this research also confirms that the integration of Artificial Intelligence into Islamic business presents significant ethical challenges. Algorithmic bias, system opacity, and accountability issues are key concerns in current academic discourse. From a sharia economic perspective, technology must be evaluated not only from the aspect of efficiency, but also from its compliance with the principles of justice, transparency, and moral responsibility.

Thus, this study emphasizes that the successful implementation of Artificial Intelligence in Sharia business practices depends on an organization's ability to integrate technological innovation with the ethical framework and normative values of Sharia. Artificial Intelligence should be positioned as a strategic instrument that strengthens the sustainability, fairness, and integrity of the halal economic system in the digital era.

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ESG RESEARCH TRENDS IN ISLAMIC BUSINESS MANAGEMENT: BIBLIOMETRIC ANALYSIS AND SYSTEMATIC LITERATURE REVIEW USING VOSVIEWER

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Abstract

The development of the Environmental, Social, and Governance (ESG) concept has become a major concern in modern business management practices, including in the Islamic business realm. This study aims to map ESG research trends in the context of Islamic business management using a Systematic Literature Review (SLR) approach and bibliometric analysis using VOSviewer. Data were obtained through Publish or Perish from Google Scholar and SINTA, using relevant keywords for the period 2015 to 2025. After a selection process based on inclusion and exclusion criteria, 40 journal articles were selected for analysis. The VOSviewer visualization results indicate several main clusters covering environmental performance, corporate governance, aspirations, Islamic finance, and Maqasid Syariah. The keywords "ESG" and "Maqasid Syariah" emerged as dominant nodes, indicating a high degree of interconnectedness between research topics. This analysis indicates that ESG integration in Islamic business management is gaining increasing attention, while also opening up opportunities for further research on the practical implementation and governance of Islamic principles.

Keywords: ESG, Islamic Business Management, Maqasid Syariah, Systematic Literature Review, VOSviewer

INTRODUCTION

The digital era and global pressure to implement sustainable business practices have pushed companies across various sectors to align their management strategies with ESG (Environmental, Social, and Governance) principles. ESG integration is no longer simply an option, but rather a key indicator of a company's success in facing global competition and meeting the demands of a society increasingly concerned with sustainability, ethics, and social responsibility. In the context of Islamic business, ESG implementation is becoming increasingly relevant because companies are not only required to achieve operational efficiency and profitability but also must ensure that all their business practices are aligned with Islamic principles. This includes fulfilling the objectives of Maqasid Syariah, such as justice, social welfare, environmental protection, and economic sustainability, so that companies can contribute optimally to society and stakeholders.

Although extensive research on ESG has been conducted globally, studies specifically integrating ESG with Sharia-compliant business management remain relatively limited and scattered throughout the literature. Many studies focus solely on one aspect, such as corporate governance or environmental sustainability, without integrating it within the overall framework of Sharia principles. Furthermore, much of the existing literature tends to be descriptive and lacks a clear understanding of the interrelationships between key concepts, making it difficult to obtain a comprehensive picture of research trends and the direction of development of ESG studies in the Sharia context.

This study aims to fill this gap by employing a Systematic Literature Review (SLR) approach, which allows researchers to systematically identify, evaluate, and synthesize relevant literature. To strengthen the analysis, this study also utilizes VOSviewer, a bibliometric tool capable of mapping the relationships between keywords, identifying research clusters, and visualizing conceptual networks emerging from the literature. In this way, the study not only provides an overview of current study focuses and publication trends but also demonstrates the interrelationships between themes, such as the relationship between ESG, corporate governance, sustainability, Islamic finance, and Maqasid Syariah.

This approach allows the research to uncover areas that have been extensively researched while highlighting aspects that have received less attention. Thus, this research is expected to not only provide theoretical contributions to the development of Islamic business management literature but also provide practical guidance for stakeholders, including Islamic banks, Islamic-oriented companies, and Islamic financial institutions, in designing ESG implementation strategies that align with the principles of Maqasid Syariah. Overall, this research seeks to bridge the gap between modern sustainable business practices and the demands of Islamic principles, so that Islamic business management can develop ethically,

efficiently, and sustainably. In addition to providing a conceptual foundation for the importance of ESG integration in Islamic business, this research also emphasizes the need for systematic literature mapping to understand existing research trends and patterns. Using a Systematic Literature Review (SLR) approach, the research can identify key themes, relationships between concepts, and research gaps that still need to be explored. This is important because without clear mapping, the development of sustainable sharia-based business theories and practices will tend to be fragmented and less integrated.

Furthermore, this study uses VOSviewer as a bibliometric analysis tool to visualize the relationships between keywords and research clusters that appear in the literature. This visualization allows researchers and readers to understand how ESG themes interrelate with environmental, social, and governance aspects, as well as the Maqasid Shariah principles in Islamic business practices. In this way, the study not only presents quantitative information on publication trends but also provides qualitative insights into research focus, interrelationships between topics, and priorities for future study development.

This approach also facilitates the identification of areas that have received insufficient attention, such as the integration of ESG into operational decisions, the development of innovative Islamic financial instruments, and the measurable evaluation of social and environmental impacts. These findings can serve as a guide for academics in designing further research and can also assist practitioners in developing effective, measurable ESG implementation strategies that align with the principles of Maqasid Shariah.

1. RESEARCH METHODOLOGY

This research uses a qualitative approach through the Systematic Literature Review method. The primary data sources were Google Scholar and SINTA databases, with the support of the Publish or Perish application to extract bibliographic data, including citation counts, h-index, and publication trends. Keywords used included combinations of "ESG," "Sustainability," "Shariah," "Islamic Finance," and "Maqasid Shariah."

The article selection process was carried out through several stages. The first stage was the identification of initial articles based on relevant keywords, resulting in 120 potential articles. Next, title and abstract screening was conducted, resulting in 75 articles. Full-text articles were then examined in depth, resulting in 52 articles, and finally, 40 articles met the inclusion criteria for analysis. Inclusion criteria included journal articles relevant to ESG topics in Islamic business, published between 2015 and 2025, and available in Indonesian or English. Articles without full text availability, undergraduate theses, dissertations, or non-indexed proceedings were excluded from this study.

Data from the selected articles was then analyzed using VOSviewer to map keyword co occurrence, research clusters, and node strengths. This analysis identified dominant themes and relationships between concepts emerging in the literature, clearly visualizing research trends and key focuses.

2. RESULTS AND DISCUSSION

The analysis of 40 journal articles that met the criteria shows that publications on ESG in the context of Islamic business management have increased significantly since 2019. This increase indicates that the topic of ESG is increasingly becoming a key concern for Islamic academics, practitioners, and financial institutions, as global awareness of sustainable and ethical business practices grows. Specifically, the peak number of publications occurred between 2022 and 2024, reflecting a surge in research interest in recent years. The articles with the highest number of citations highlight the integration of ESG with the Maqasid Shariah principles, particularly in the context of Islamic financial management and corporate governance practices. This demonstrates that academic attention goes beyond environmental or social aspects alone, but also emphasizes the alignment of ESG implementation with Islamic principles that underlie economic sustainability and societal well-being.

Further analysis using VOSviewer revealed complex interrelationships between keywords in the analyzed literature. This keyword network visualization reveals several key research clusters, each with a specific focus but systematically interconnected. The first cluster focuses on environmental aspects, with the most dominant nodes including keywords such as ESG, environmental performance, green finance, and sustainability reporting. This keyword dominance indicates that most research emphasizes environmentally friendly sustainability practices, including corporate strategies for reducing negative environmental impacts and the implementation of green finance in Islamic businesses. These nodes demonstrate a close relationship with social and governance aspects, confirming that ESG research does not stand alone but is integrated with other dimensions of Islamic business management.

The second cluster focuses on corporate governance, where keywords such as corporate governance, ethical management, risk management, and transparency emerge as important nodes. The strong interconnectedness between these keywords indicates that the implementation of good governance principles is a fundamental aspect of ESG integration. Research in this cluster emphasizes that compliance with Sharia principles, transparency, and ethical management practices not only enhance a company's reputation but also contribute to the achievement of overall sustainability goals. These findings align with the concept of Maqasid Shariah, which emphasizes the importance of justice, welfare, and the protection of stakeholder rights in all business activities.

The third cluster highlights social aspects and Maqasid Shariah. Prominent keywords in this cluster include social responsibility, Maqasid Shariah, community welfare, and ethical investment. This demonstrates that ESG research in Islamic business management addresses not only environmental sustainability and governance but also social welfare and broader Islamic objectives. The relationships between nodes in this cluster demonstrate that social aspects and Islamic principles are closely intertwined with practice. corporate governance and ESG implementation, so that every policy or strategy that implemented, companies must consider social, economic and sharia impacts simultaneously.

A literature synthesis of the 40 articles analyzed also revealed that most studies emphasize the importance of integrating ESG with Islamic finance practices, risk management, and corporate governance based on Maqasid Shariah. These results indicate that implementing ESG in Islamic businesses can improve transparency, accountability, and sustainable corporate performance. Furthermore, this study confirms that companies that consistently implement ESG principles not only meet regulatory and ethical demands but also strengthen their position in global competition by demonstrating a commitment to sustainability and societal well-being.

However, research also found gaps in ESG implementation at the operational and strategic decision-making levels. Several articles highlighted that although Islamic companies have formally adopted ESG, the implementation of these practices in daily operations remains limited and has not been fully integrated into internal management processes. This indicates the need for further research to develop an ESG implementation model that is not only conceptually based but also practical, measurable, and able to be consistently implemented by Islamic companies.

Furthermore, VOSviewer's bibliometric analysis reveals several emerging keywords that have emerged in recent years, such as "ethical investment," "green sukuk," and "sustainable reporting," indicating that ESG research in the context of Islamic finance is shifting toward concrete products and instruments. This opens up opportunities for further research to explore the effectiveness of ESG strategies in improving corporate performance, minimizing risk, and enhancing stakeholder satisfaction in accordance with the principles of Maqasid Shariah.

Overall, the results of this study confirm that ESG integration in Islamic business management is an increasingly relevant topic and has received significant attention from the academic community. This study not only highlights existing research trends and focuses but also identifies areas requiring further exploration, including the development of a Sharia-based ESG implementation framework, integrated social and environmental impact measurement, and evaluation of corporate governance effectiveness in supporting sustainability goals. Thus, this paper provides important theoretical and practical contributions to the development of

ethical, transparent, and sustainable Islamic business management. This analysis also reveals that although many Islamic companies have begun to formally adopt ESG principles, the level of implementation on the ground remains variable.

Several studies have shown that companies often face obstacles in implementing comprehensive sustainability practices, whether due to limited resources, a lack of internal understanding, or challenges in integrating ESG into operational decision-making processes. This indicates that ESG implementation requires not only strategic commitment from top management but also structural support, staff training, and systematic monitoring and evaluation mechanisms to consistently achieve sustainability goals.

Furthermore, the literature synthesis indicates a shift in the focus of ESG research from mere concepts and theory to more practical and innovative aspects. Several recent studies have begun to highlight the development of ESG-based Islamic financial instruments, such as green sukuk and ethical investment products, that can support the funding of sustainable projects while adhering to the Maqasid Shariah principles. This phenomenon demonstrates that the integration of ESG into Islamic business is not merely normative but also opens up real opportunities for responsible financial innovation that positively impacts society and the environment.

Furthermore, keyword analysis using VOSviewer shows a close relationship between environmental, governance, and social aspects in the analyzed literature. This confirms that ESG implementation in Islamic business is multidimensional and cannot be viewed in isolation. Companies that successfully integrate these three dimensions in a balanced manner are more likely to achieve long-term strategic goals, enhance their reputation, and build trust with stakeholders. Therefore, this study emphasizes the importance of a holistic approach to ESG implementation, combining environmental, ethical, governance, and social welfare aspects while ensuring compliance with the Maqasid Shariah principles.

Furthermore, the analyzed literature highlights the importance of measurable sustainability monitoring and reporting. Transparency and accountability are key aspects in ensuring that any ESG initiative truly has a positive impact, rather than simply being a formality. The implementation of clear performance indicators, consistent internal audits, and stakeholder engagement in sustainability evaluations are essential parts of ESG- and Sharia-compliant management practices.

Overall, the findings from these 40 articles demonstrate that ESG integration into Islamic business management is a complex yet essential process. It encompasses not only the application of environmental, governance, and social principles but also requires alignment with the Islamic values underlying business practices. This research confirms that Islamic companies that are able to manage all three ESG dimensions in an integrated manner and in

alignment with the Maqasid Shariah (the principles of Islamic law) have the potential to simultaneously create economic, social, and environmental value, thereby strengthening competitiveness and long-term sustainability.

Figure 1. VOSviewer Result

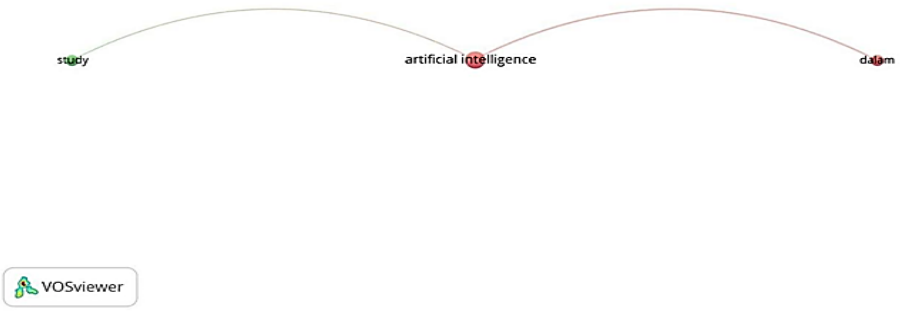


Figure 1 shows the VOSviewer visualization of the ESG research keyword network in Islamic business management, divided into several main clusters. The "ESG" node appears as the largest node, indicating that this topic is a primary focus in the analyzed literature. The first cluster, which highlights environmental aspects, includes keywords such as environmental performance, sustainability, and green finance. This indicates that most research emphasizes sustainability practices, environmental reporting, and the application of green finance in Islamic business.

The second cluster focuses on corporate governance, with keywords such as corporate governance, ethical management, and risk management. These nodes are strongly interconnected, indicating that the implementation of good governance principles is a crucial focus in ESG integration, while also supporting transparency and accountability in Islamic companies.

The third cluster highlights social aspects and Maqasid Sharia, with keywords such as social responsibility, Maqasid Sharia, and community welfare. The interconnectedness of nodes in this cluster demonstrates that ESG research addresses not only environmental and governance aspects but also social welfare and the fulfillment of Sharia objectives.

The connecting lines between clusters indicate significant interrelationships between environmental, governance, and social aspects, confirming that ESG research in Islamic business management is multidimensional and interconnected. Overall, this visualization demonstrates research trends that emphasize the integration of ESG with the principles of Maqasid Syariah, show that ESG implementation must consider the environment, governance, and social welfare holistically.

3. RESEARCH IMPLICATIONS

The results of this study have significant implications, both theoretically and practically, for the development of sharia business management that focuses on the integration of ESG and the Maqasid Sharia principles. Theoretically, this study makes an important contribution to enriching the currently limited academic literature on the integration of ESG concepts with sharia principles in business practices. Bibliometric analysis using VOSviewer reveals clear research trends, including key topics receiving significant attention, interrelated keyword clusters, and emerging keywords emerging in the latest literature. These findings not only map the focus of existing research but also assist academics in identifying research gaps that still need to be explored, such as the application of ESG in operational decision making, the development of ESG-based sharia financial instruments, and the quantitative evaluation of social and environmental impacts.

Thus, this study broadens the theoretical understanding of how the Maqasid Syariah principles can be systematically integrated into ESG strategies, thereby enriching the conceptual framework of sustainable Islamic business management.

Practically, this research has broad implications for stakeholders in the Islamic business world. First, for Islamic business institutions and Islamic banks, the findings can serve as a guide for designing and implementing ESG practices that are in accordance with Islamic principles. For example, companies can adjust their investment policies, risk management, and sustainability reporting by considering the provisions of Maqasid Syariah, so that every strategic decision pursues not only profitability but also sustainability and societal welfare. Second, information regarding research clusters and dominant keywords can help practitioners identify the most relevant areas for development, such as the implementation of green finance, ethical risk management, Sharia-based corporate governance, and social responsibility programs that align with Maqasid Syariah. This enables companies to develop more structured, effective, and sustainable ESG implementation strategies, while enhancing the reputation and public trust in Islamic companies.

Furthermore, practical implications also include developing the capacity of academics and professionals to understand ESG research trends in the Sharia context. This research can be used as a reference for developing training programs, workshops, or educational modules for managers, auditors, and other stakeholders, enabling them to optimally apply ESG principles in daily business practices. With a deeper understanding of clusters and the relationships between keywords, practitioners can design strategies that do not focus solely on one aspect but simultaneously integrate the environment, governance, and social welfare, in accordance with the objectives of Maqasid Shariah.

Furthermore, this study emphasizes the importance of continuous evaluation of ESG implementation in Islamic companies. The analysis shows that although numerous studies highlight the integration of ESG with Islamic principles, practical implementation at the operational level still requires strengthening. Therefore, companies need to develop concrete ESG performance measurement indicators, transparent reporting systems, and internal oversight mechanisms capable of ensuring that every business practice is not only economically profitable but also aligned with Islamic principles and has a positive impact on society and the environment.

Overall, this study offers comprehensive theoretical and practical guidance for the development of ESG-based Islamic business management. By mapping research trends, keyword clusters, and interrelationships between various themes, this study provides strategic insights for academics, practitioners, and policymakers. Implementation of these findings is expected to encourage Islamic companies to develop more ethical, transparent, and sustainable business practices, while strengthening their contribution to achieving the objectives of Maqasid Shariah, namely justice, social welfare, and environmental sustainability. Practical implications of this study also include the importance of innovation in products and services that align with ESG principles and Maqasid Shariah. For example, the development of Islamic financial instruments such as green sukuk, ethical investments, or sustainable project financing programs can be an effective strategy to encourage companies not only to achieve profitability but also to provide tangible benefits to the environment and society. This approach enables Islamic companies to take an active role in building a greener and more equitable economy, while strengthening their position in a market that increasingly prioritizes sustainability and social responsibility.

Furthermore, this study demonstrates that education and internal capacity building are crucial for effective ESG implementation. Managers and staff need to be equipped with a thorough understanding of ESG principles and Maqasid Shariah, including how to integrate them into strategy, operations, and daily decision-making. This includes training on sustainability reporting, ethical risk management, and socio-environmental impact assessment, so that every company policy and action can make a tangible contribution to Sharia objectives and sustainable development.

This research emphasizes the importance of collaboration between various stakeholders, including regulators, academics, practitioners, and the public. This collaboration can help ensure that ESG implementation in Islamic companies is not merely a formality but actually produces measurable positive impacts. With the involvement of various parties, companies can gain a broader perspective on sustainability priorities, social and environmental risk management, and product innovation in accordance with Islamic principles.

Strategically, this research finding also encourages Islamic companies to develop more comprehensive ESG performance indicators, encompassing environmental, social, and governance aspects, as well as alignment with Maqasid Shariah. These indicators serve not only as a measure of ESG implementation success but also as a basis for ongoing evaluation, transparent reporting, and corporate accountability to stakeholders.

Thus, the implementation of appropriate performance indicators can be an effective internal monitoring mechanism, while supporting the achievement of broader sustainability goals.

Taking all these aspects into account, this study confirms that ESG implementation in Islamic businesses should be viewed as a sustainable long-term strategy. The resulting theoretical and practical implications not only strengthen the academic literature on the integration of ESG and Maqasid Shariah but also provide concrete guidance for developing Sharia business practices capable of simultaneously creating economic, social, and environmental value. This is ultimately expected to create Sharia companies that are not only financially superior but also ethical, contribute to community welfare, and care about environmental sustainability.

4. CONCLUSION

Based on the Systematic Literature Review (SLR) analysis and bibliometric visualization using VOSviewer, it can be concluded that research on ESG in sharia business management has experienced significant growth and shows an increasingly integrated trend. Bibliometric results show that the keywords ESG and Maqasid Shariah emerged as dominant nodes, confirming that the research focus is not only on sustainability practices and corporate governance, but also on compliance with sharia principles. This indicates that the integration of ESG in the context of sharia business cannot be separated from the objectives of Maqasid Shariah, namely ensuring the achievement of justice, social welfare, and environmental sustainability through ethical and responsible business practices.

The research findings also confirm that ESG integration in Islamic business management is multidimensional, encompassing environmental, social, and governance aspects, which are interrelated and influence each other. The environmental cluster highlights the importance of environmentally friendly practices, sustainability reporting, and green finance; the governance cluster emphasizes ethical management, corporate governance, and risk management; while the social and Maqasid Shariah clusters emphasize social responsibility and community welfare. The interrelationships between these clusters confirm that effective ESG implementation in Islamic business requires a holistic approach that integrates all these dimensions while ensuring alignment with Islamic principles.

Furthermore, this study provides insights into gaps or areas requiring further research. Although numerous studies have emphasized the conceptual and theoretical aspects of ESG,

their application at the operational level, strategic decision-making, and concrete sustainability impact measurement remains limited. Therefore, this study emphasizes the importance of developing a practical, measurable, and consistently applicable ESG implementation model within Islamic companies, ensuring that the results not only comply with ethical and Islamic principles but also contribute significantly to societal well-being and environmental preservation.

Theoretically, the results of this study enrich the literature on the integration of ESG and Maqasid Shariah in business management, providing a clearer understanding of trends, focuses, and relationships between research themes. Practically, these findings can serve as guidance for Sharia business institutions, Islamic banks, and companies that wish to implement Sharia-based ESG practices, including in designing strategies, risk management, performance measurement, and sustainability reporting in accordance with the objectives of Maqasid Shariah.

Overall, this study confirms that ESG integration in Islamic business is a relevant and strategic topic, which continues to grow with increasing academic and practical attention to sustainability, ethical governance, and Islamic compliance. These findings not only provide a strong theoretical basis, but also serve as a practical reference for the development of more ethical, transparent, and sustainable sharia business management, while also opening up opportunities for further research related to holistic ESG implementation, monitoring, and impact evaluation strategies based on Maqasid Shariah.

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UTILIZING FINTECH TECHNOLOGY TO INCREASE THE COMPETITIVENESS OF ISLAMIC BANKING IN THE DIGITAL ERA

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Abstract

Digital transformation through the adoption of artificial intelligence, big data, and blockchain has transformed the financial industry's business models and encouraged digital ecosystem-based bank-fintech collaboration. In a dual banking system, Islamic banks face limitations in efficiency, technological capacity, and the complexity of Sharia compliance, making fintech integration a crucial strategy for enhancing competitiveness. This study aims to analyze the role of fintech integration in shaping the competitive advantage of Islamic banks. Using an exploratory qualitative approach through a multi-institutional case study, data were obtained from interviews, documents, and observations, then analyzed using coding and thematic analysis. The results show that fintech integration improves operational efficiency, service innovation, financial inclusion, and customer loyalty. This integration forms dynamic organizational capabilities that strengthen Sharia-based digital competitiveness, with Sharia regulation and compliance as key determinants. This study formulates an Islamic Digital Competitive Advantage model as a theoretical and strategic contribution to strengthening the Sharia-compliant fintech ecosystem.

Keywords: Islamic Fintech, Digital Transformation, Dynamic Capabilities, Competitiveness, Islamic Banking

INTRODUCTION

In recent years, the financial sector has become a driving force behind digital transformation through the adoption of AI, big data, blockchain, cloud computing, mobile banking, and contactless payments, fundamentally changing the structure, processes, and models of financial services. The COVID-19 pandemic has accelerated digitalization through a massive migration to digital banking applications, online investment services, and electronic payment systems, making information technology a key source of efficiency, cost reduction, and improved quality of financial services.

The rapid expansion of fintech with products such as digital wallets, fast payments, P2P lending, robo-advisors, crowdfunding, and neobanks has shifted the way customers interact with financial services, reducing reliance on traditional bank payment infrastructure and forcing banks to change the way they operate. Fintech leverages cutting-edge technologies such as open APIs, blockchain, artificial intelligence, and data analytics to offer faster, cheaper, and more user-friendly services, thus encouraging banks to transform from the classic competitive model to a collaborative fintech bank model and develop new business models such as open banking.

Amidst global competition and a dual banking system, Islamic banks face various structural constraints such as lower efficiency, limited business scale, immature regulations (particularly for Islamic fintech), and complex governance and Sharia compliance, which add to operational burdens. Various studies show that regulatory fragmentation, limited technical capacity, and the suboptimal utilization of Sharia-compliant competitive advantages have left Islamic banks lagging behind conventional banks and fintech players, necessitating the strengthening of policy frameworks, infrastructure, and more adaptive operational strategies.

Sharia business development and strategic management in the digital era requires the integration of technologies such as fintech, blockchain, digital banking, and digital marketing. to increase efficiency, financial inclusion, and market reach, while remaining based on the values of honesty, fairness, social responsibility, and sharia compliance. Recent research emphasizes the importance of sharia-based digital planning, collaboration between Islamic banks and fintech, strengthening technological and human resource infrastructure, and utilizing strategic analysis (SWOT, strategic management) so that digital innovation does not merely follow trends, but becomes a source of sustainable competitive advantage that is consistent with maqashid al-syariah.

1. LITERATURE REVIEW

1.1. The Concept of Banking Competitiveness

Bank competitiveness is now understood as the ability to maintain superior performance through a combination of service quality, speed, flexibility, innovation, cost efficiency, and a reputation that is difficult for competitors to imitate (A. AL-Azzam & Gursoy, 2025). Modern competitiveness models also incorporate customer orientation, social responsibility, and the ability to build a business partner ecosystem (Alizadeh et al., 2024).

Competitive advantage in banking is often explained through Porter (cost leadership, differentiation, focus) and the resource-based view (RBV), namely the utilization of Unique resources and capabilities that are valuable, rare, and difficult to imitate (Ogalo & Rugami, 2023). This practice is evident in product differentiation, pricing strategies, agency banking, service innovation, and targeted brand positioning to dominate specific market segments (Kinoti & Bett, 2023).

Dynamic capabilities are a bank's ability to detect (sensing) digital opportunities/threats, seizing them through investment and innovation, and transforming structures and processes (Abdurrahman et al., 2024b). Research shows that sensing, digital ecosystems, and GRC capabilities are crucial for the success of digital transformation and improved bank performance. (Abdurrahman et al., 2024a).

1.2. Islamic Banking and the Challenges of Digitalization

A literature review confirms that all digital innovations in Islamic banking must remain subject to the following core principles: the prohibition of usury, gharar, and maysir (risk of betting), the obligation to ensure the existence of a lawful and clear object, and a legitimate and fair contract-based relationship pattern (Haerunnisa & Sugitanata, 2024). Islamic banking operations, both in fundraising (wadi'ah, mudharabah) and financing distribution (murabahah, ijarah, musyarakah), must adhere to the pillars and conditions of the contract, including clarity on pricing, risks, and profit-sharing mechanisms (Cintya & Fauzatul Laily Nisa, 2024).

In the digital context, this principle translates into the design of digital banking services (mobile banking, internet banking, Islamic fintech, even AI and blockchain) that must avoid hidden interest practices, contractual uncertainty, or excessive speculation (Safriatullah et al., 2025). A maqashid sharia-based approach is used to assess that digitalization must safeguard religion, life, intellect, descendants, and property, while maximizing public welfare through efficiency, transparency, and financial inclusion (Nur Aisyah & Anggara, 2025).

Qualitative literature shows that the intermediary function of Islamic banks (collecting capital owner funds and channeling them to the real sector) has shifted from face-to-face to digital

channels, but the contract structure remains the same: buying and selling, leasing, and profit sharing (Lestari, 2025). Digital banking allows account opening, financing, and investment to be carried out entirely online, including real-time savings and investments that still refer to the mudharabah or wakalah bil ujrah scheme. At the specific contract level, the need for a digital risk management model that aligns with the contract's characteristics has emerged. A study on ijarah financing at Bank Syariah Indonesia, for example, designed a risk dashboard, digital traceability, and automated credit scoring to manage asset risk and moral hazard without changing the rights and obligations of the parties as stipulated in Sharia (M. Masrukhan & Setya Pramono, 2025). Similarly, the use of blockchain is portrayed as a means of increasing transparency and contract security, with the caveat that the technical design must be aligned with the provisions of muamalah fiqh (Aminin, 2024).

Literature studies consistently find gaps in technology and institutional readiness in the digitalization of Islamic banking. Various studies highlight uneven IT infrastructure, suboptimal cybersecurity, and high technology investment costs. At the human resources level, many practitioners have banking backgrounds conventional and limited digital-sharia competencies; this makes the innovation and design process for digital sharia products slow and carries the risk of miscommunication with customers (Dz., 2018).

Regulatory frameworks for Sharia-compliant digital services, including digital banking, AI, and blockchain, are still evolving. Bank Indonesia and the Financial Services Authority (OJK) have responded by developing a more adaptive regulatory framework for Islamic Sharia Banks (BUS), Islamic Sharia Business Units (UUS), and Islamic Sharia Rural Banks (BPRS). However, the literature still notes gaps in data protection, technology governance, and the certainty of Islamic jurisprudence (fiqh) regarding digital contracts. The recommended institutional adaptations are comprehensive and structured: strengthening IT capital, developing a digital-oriented organizational culture, enhancing financial and digital literacy among the public, and fostering close collaboration between regulators, Islamic banks, and technology providers (A'yun & Dwi Aprilia Putri, 2022). This approach is seen as a prerequisite for digitalization to become a source of improved performance and inclusion, rather than a new source of Sharia non-compliance and operational risk (Hasanah et al., 2024).

1.3. Fintech as an Agent of Disruption and Collaboration

The literature defines fintech as technology-based financial innovation that creates new business models, applications, and processes with a material impact on financial markets and institutions (Alshater et al., 2022). Historically, fintech development has been depicted as moving from the use of communication technology and electronic banking to a post-2008 digital-intensive phase with the internet, mobile, big data, AI, and blockchain triggering systemic changes in the financial industry (Hornuf et al., 2021).

Bibliometric studies show that fintech was initially positioned as a disruptive force against traditional banking, particularly through digital payments, P2P lending, crowdfunding, robo-advisors, and DeFi, offering cheaper, faster, and customer-centric services (Chatterjee, 2025). However, recent trends highlight a shift in the narrative: from "disruptor" to an integral component of the financial ecosystem, with an emphasis on integration, financial inclusion, and regulatory challenges such as cybersecurity and compliance (Faour & Al-Sowaidi, 2023).

Qualitative and empirical research highlights that bank–fintech interactions are evolving from a competitive pattern to a spectrum of coopetition (competition + cooperation), with a dominant collaborative strategy (Costa et al., 2025). Some frequently discussed forms of collaboration are:

- Partnership / product-related collaboration: the use of fintech solutions (e.g., payments, lending, digital KYC) embedded within bank services; this pattern is common in Europe, Asia, and Turkey, particularly among large banks that choose product collaboration over direct acquisition (Gafarovna, 2025).
- Investment / equity stake & acquisition: banks invest in fintech to access technology, secure licenses or exclusive rights, and control the direction of product development; usually done in smaller fintechs (Drasch et al., 2018).
- Ecosystem & open banking model: banks build digital ecosystems through APIs, innovation labs, accelerators, and banking platforms so that fintech becomes a partner in a complementary digital financial ecosystem (Judijanto et al., 2025).

Banks' primary motives are business model innovation, efficiency improvements, customer experience improvements, and expansion of distribution channels; while fintechs pursue access to banks' customer bases, reputation, infrastructure, and regulatory expertise (Ao & Ji, 2025). Empirical evidence from several countries suggests that diverse bank fintech collaborations can improve banking efficiency and risk-adjusted returns, although the effects differ across segments (e.g., positive in the benchmark sector, but negative in certain payments and digital wallets) (Le et al., 2024).

Literature review on Islamic fintech shows rapid research growth since 2017, but still lags behind conventional fintech 2. Islamic fintech is defined as a financial technology application that complies with sharia principles (prohibition of usury, gharar, maysir) and focuses on Muslim institutions and markets (KILIÇ, 2023).

Literature review finds huge opportunities for fintech integration in finance Islam for:

- increasing financial inclusion for the unbanked and MSMEs, especially through profit sharing-based P2P, sharia crowdfunding, and digital microfinance (Kasmon et al., 2025);
- expanding Islamic social finance (zakat, waqf, alms) with crowdfunding platforms, blockchain for waqf transparency, and more efficient social digital banking services;
- utilizing AI, big data, and blockchain for operational efficiency, service personalization, and transaction transparency and security in the Islamic financial ecosystem (Emelda Sari, 2025).

However, various studies also emphasize structural barriers: a lack of specific regulations, a Sharia-compliant governance framework for new technologies, low financial and digital literacy, and issues of standardization across jurisdictions. Therefore, the development of Islamic fintech is seen as requiring close collaboration between regulators, Islamic financial institutions, and technology providers, as well as an adaptive regulatory framework that maintains Sharia compliance (Ruhland & Wiese, 2023).

1.4. Initial Conceptual Framework

Recent literature describes fintech as more than just an operational tool, but a strategic enabler transforming the way financial institutions design business models, manage risk, and build competitive advantage (Bhat et al., 2023). Fintech integration enables process automation (lending, verification, fraud detection, credit scoring), data driven decision-making, and the expansion of service reach to previously unbanked segments. In the context of Islamic finance, fintech is positioned as an enabler of LKS transformation to address the pressures of globalization, technological disruption, and efficiency demands, while adhering to Sharia principles. Fintech helps LKS develop more inclusive financing products, crowdfunding, and online solutions without compromising Sharia contracts and ethics (Abdullah et al., 2024).

This integration can be conceptually understood as a triggering variable that drives changes in the service structure and competitive strategies of financial institutions (conventional and sharia) (Muhibban & Hasan, 2025).

Empirical studies show that the use of fintech increases operational efficiency, lowers costs, accelerates transactions, improves risk control, and encourages product innovation, which in turn strengthens the competitiveness of banks and financial service providers. This increased efficiency is reflected in real-time processes, more accurate credit risk management, and more personalized services through AI, big data, and IoT technologies (Anifa et al., 2022). In Islamic financial institutions, fintech-based service innovations such as Islamic peer-to-peer (P2P) financing, crowdfunding, e-wallets, and online business solutions are considered capable of increasing inclusion, accelerating the distribution of halal financing, and providing added value to MSMEs. Regulations and fatwas supporting these innovations enable Islamic

financial institutions (IFIs) to offer a wider variety of products (factoring, bespoke financing, digital platforms) while increasing efficiency and competitiveness compared to conventional institutions. Thus, conceptually, service innovation and efficiency serve as mediating mechanisms linking fintech integration with improved performance and competitive advantage (Nuri, 2025).

Various studies confirm that Sharia regulation and compliance are contextual factors that significantly determine the direction and quality of fintech integration, particularly in Islamic fintech (Muryanto, 2023). Strong, clear, and technology-adaptive regulations serve a dual role: ensuring consumer protection and Sharia compliance, while simultaneously encouraging or inhibiting innovation if they are too fragmented or rigid (Asyiqin et al., 2024). Comparative research on Indonesia, Malaysia, and the UK and studies of Islamic economic law indicate that a mature Sharia fintech ecosystem requires specific Sharia fintech regulations, a supervisory framework, a regulatory sandbox, and standardized Sharia governance. A Sharia Supervisory Board and internal audit mechanisms are considered crucial in designing products, verifying contracts, and monitoring ongoing compliance (Fikriawan et al., 2025). Other findings position Sharia compliance as a contextual filter that moderates the relationship between fintech adoption and competitiveness: without strong compliance, technological advantages are not readily accepted by the Muslim market and can undermine trust (Alkasasbeh et al., 2024). Fragmentation of sharia standards, differences in regulations between countries, and weak oversight are cited as the main sources of uncertainty and reputational risk in Islamic fintech (Suswanto et al., 2025).

2. RESEARCH METHODOLOGY

This research uses an exploratory qualitative approach with a multi-institutional case study design to deeply explore the dynamics of Sharia fintech integration across various types of institutions (BUS, UUS, and Sharia fintech) in a real-world context (Yarmanti A. et al., 2025). The qualitative approach allows researchers to understand the perceptions, strategies, and experiences of key actors related to digital innovation and Sharia compliance, rather than simply measuring the relationship between variables quantitatively.

Research locations include:

- Sharia Commercial Banks (BUS) that have developed digital services/collaboration fintech;
- Sharia Business Unit (UUS) in conventional banks that are undergoing transformation digital;
- Sharia fintech companies that partner with BUS/UUS (for example in payments, financing, or social finance).

Case selection was done purposively based on the intensity of integration. fintech and relevance to the theme of Sharia innovation (Ascarya & Sakti, 2022). Informants were selected purposively and snowball-based to obtain strategic and operational perspectives, including:

- Strategic management (board of directors/executives) that determines the direction of fintech integration and collaboration models.
- IT/digital banking managers who understand technical aspects, system architecture, and digital projects (Estrela et al., 2025).
- Sharia Supervisory Board (DPS) which oversees the conformity of products and platforms with Sharia principles (Mohd Haridan et al., 2023).
- Industry regulators/supervisors (e.g. OJK/Bank Indonesia/KNEKS) to obtain policy, regulatory, and sandbox insights (Malik & Shahzad, 2025).

Data collection technique:

1. Semi-structured in-depth interviews Used to explore the experiences, strategies and views of informants in a flexible but focused manner (Given, 2012).
2. Document analysis This includes annual reports, sustainability reports, digital roadmaps, internal policies, and regulations and fatwas related to Sharia fintech (Ammanda, 2025). A systematic approach such as READ (ready, extract, analyze, distill) can be used to maintain the rigor of document analysis (Dalglish et al., 2020).
3. Observation

Non-participant observation of digital banking policies, displays and features, fintech applications, and sharia compliance implementation mechanisms (e.g., DPS approval flow in digital products) (Hambali, 2025).

The analysis is carried out iteratively through:

1. Coding process
   - Open coding: identifying initial concepts from interview transcripts and document.- Axial coding: grouping codes into interrelated categories (e.g. strategic enablers, innovation mechanisms, regulatory barriers) (Bingham, 2023).
   - Selective coding: developing core categories that support the conceptual framework on fintech integration, innovation/efficiency, and Sharia regulation. (Richards & Hemphill, 2018).
2. Thematic analysis
   - Identifying and formulating cross-case strategic themes (BUS, UUS, fintech), such as collaboration patterns, the role of DPS, and strategies for dealing with regulations (Kazanskaia, 2025).

3. Triangulation

- Source triangulation: comparing the perspectives of management, IT, DPS, and regulator.
- Triangulation method: confirming interview findings with documents and observations, to increase the credibility and reliability of the results.

3. RESULTS AND DISCUSSION

The digitalization of financing products and services is evident in the development of mobile banking, sharia e-wallets, digital payments, and online financing (P2P, digital financing) which facilitate access and accelerate transactions (Nur Ainia, 2025). The use of AI and big data supports customer behavior analytics, sharia credit scoring, fraud detection, and service personalization, thereby improving efficiency and decision quality (Meero, 2025). Strategic partnership models with fintech startups have emerged in the form of product marketing collaboration, channeling/joint financing, payment gateways, data sharing, and fintech bank consortiums (bin Shaharudin et al., 2025).

Fintech integration improves operational efficiency through automation, reduced transaction costs, and real-time processing, although it incurs initial technology investment costs (Masrina et al., 2024). In terms of service differentiation, Islamic banks offer Sharia compliant digital experiences (zakat, waqf, halal financing, and Sharia e-wallet features), distinguishing them from conventional banks (Nurbaidah, 2025). Digitalization expands Islamic financial inclusion, particularly in the unbanked/MSME segment and remote areas, with access to services via smartphones. This contributes to the growth of assets and the customer base of Islamic financial institutions (Pajaria, 2025). Improved customer experience and loyalty occur through fast service, AI-based personalization, 24/7 convenience, and the ease of a digital payment ecosystem.

The complexity of digital Sharia compliance arises from smart contracts, crypto, and blockchain; a digital Sharia governance framework and clearer regulatory standards are needed. Cybersecurity and data protection risks are key issues: the risk of fraud, data breaches, and system disruptions, necessitating the strengthening of infrastructure and consumer protection regulations. Barriers to organizational culture, human resources, and digital literacy (both within customers and within banks) hinder the full adoption of fintech.

The study findings confirm that fintech integration creates dynamic capabilities (rapid innovation, organizational agility, and information system quality) that subsequently enhance digital competitiveness (efficiency, differentiation, inclusion, and loyalty). The Islamic Digital Competitive Advantage (IDCA) model can be formulated as a causal relationship: Fintech Integration ÿ Dynamic Capabilities (innovativeness, agility, information systems) ÿ

Islamic digital competitive advantage, with regulation and sharia compliance as key moderators (Maryam et al., 2025).

4. CONCLUSION

Research shows that fintech integration in Islamic banking acts as a catalyst for competitiveness, particularly through increased operational efficiency, expanded financial inclusion, and strengthened the quality and reach of digital services. Islamic fintech and bank-fintech collaboration can open broader financial access for MSMEs and previously unaffordable communities, while simultaneously strengthening the national Islamic economic ecosystem.

Successful integration is largely determined by organizational capabilities (digital infrastructure readiness, human resources, governance, and innovation) as well as strong Sharia compliance, including the role of the Sharia Supervisory Board and clear regulations to underpin trust and legitimacy in digital services. These findings align with literature emphasizing that internal institutional readiness and an adequate Sharia regulatory framework are key prerequisites for fintech utilization to truly generate sustainable competitive advantage for Islamic financial institutions.

This study's institutional scope is limited to a select number of Islamic Sharia-compliant Islamic banks (BUS), Islamic Sharia-compliant Islamic banks (UUS), and fintech companies. Therefore, generalizing the results to the entire Indonesian Islamic banking industry requires caution. Furthermore, the findings rely heavily on interview data and informant perceptions, which are potentially subject to subjective bias and do not fully capture long-term quantitative evidence on competitive performance.

Further research is recommended to: Conduct cross-country comparative studies to see how variations in regulations, organizational capabilities, and bank–fintech collaboration models affect the competitiveness of Islamic financial institutions in various jurisdictions.

Using a longitudinal and/or mixed methods approach to observe the long-term impact of fintech integration on financial performance, inclusion, and customer loyalty, so that testing of the Islamic Digital Competitive Advantage model can be carried out more robustly and empirically.

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THE ROLE OF SHARIA ECONOMIC INSTRUMENTS IN SUPPORTING A MAQASID SHARIA-BASED GREEN ECONOMY IN INDONESIA: A SYSTEMATIC LITERATURE REVIEW

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Abstract

Sharia economics holds significant potential for supporting sustainable development through integration with the green economy concept, which emphasizes a balance between economics growth, social justice, and environmental sustainability. This study aims to analyze the role of sharia economic instruments in supporting a green economy based on the maqÿÿid sharia in Indonesia. The methodology used is a qualitative-descriptive approach using a systematic literature review (SLR) of various indexed scientific literature relevant to Islamic economics, sustainability, and Islamic finance. The results show that sharia economic instruments such as zakat, waqf, and green sukuk contribute significantly to financing sustainable development, particularly in the renewable energy sector, environmental management, and community economics empowerment. Furthermore, profit-sharing systems and sharia fintech also play a role in increasing financial inclusion and encouraging green investment. However, several challenges remain, such as limited regulations, low public literacy, and the lack of optimal integration of ESG standards with sharia principles. In conclusion, the integration of sharia economics and the green economy has a strong normative and empirical foundation and has the potential to become a strategic solution for realizing sustainable development in Indonesia. Strengthening policies, innovating financial instruments, and cross-sector collaboration are needed to optimize the role of Islamic economics in supporting the transformation towards a green economy based on the principles of Islamic law.

Keywords: Islamic Economics, Green Economy, Maqasid Syariah, Sustainable Finance, Green Sukuk, Islamic Social Finance, Sustainable Development

INTRODUCTION

Sharia Economics, with its principles of ethics and social responsibility, has great potential to contribute to realizing green-based sustainable development economy (A'ini et al., 2024). In Islamic economics, values such as justice, balance, and responsibility towards nature is an important foundation in every economic activity (Abyan, 2025). Sharia economics also emphasizes the principle of maslahah (public interest). and ihsan (goodness), which underlines the importance of maintaining the balance of the ecosystem and protecting the environment (Romli, 2024). A green economy is defined as an economic model which results in increased human well-being and social equality, while simultaneously significantly reduce environmental risks and ecological scarcity (Fauzi et al., 2025). The Agency United Nations (UN) Environment Programme, United Nations Environment Programme or UNEP for short, in its report entitled Towards a Green Economy defines Green Economy as an economic concept that able to improve welfare and social justice (Tippa & Amodekar, 2024). There are three things What is considered in this concept is low carbon, socially inclusive, and resource efficient (Iskandar & Aqbar, 2019). The concept of a green economy emerged due to human behavior. which tends to be profit oriented when compared to sustainable oriented (Vita & Soehardi, 2022). If the green economy is based on the perspective of Islamic economics, then this This is in accordance with the principles of maqashid sharia (Septiarini & Ayu Firawati, 2025). In general In terminology, Maqashid al-Syari'ah is the intention of Allah as the creator of sharia to provide benefits (maslahah) to humans, namely by fulfilling their needs daruriyah (primary), hajiyah (secondary), and tahsiniyah (tertiary) needs so that humans can live in goodness and can be a good servant of Allah (Yunia Fauzia, 2016). Islam emphasizes its people in preserving and protecting the environment as written in the Al-Quran surah al-Anbiya verses 35-39 (Maulida, 2023).

Seeing Indonesia's geographical conditions which are rich in Natural Resources (SDA), makes Indonesia dependent on the use of natural resources as a factor of production produce output (P. Rany et al., 2020). In this context, Islam offers a paradigm a theocentric alternative. Islam views all human activities, including religious activities, as economy, as part of worship and a form of devotion to Allah SWT (Wardani, 2025). In addition to theoretical support for the relationship between Islamic economics and development sustainable, various modern empirical studies confirm the relevance of Islamic economic principles with the needs of a green economy (Permana & Wahyu, 2023). For example, research in Indonesia shows that the green economy concept not only supports resource efficiency power and green technology investment but also in line with the principles of maqashid sharia such as maintenance of religion, life, property and descendants which is the main goal of Islamic law; This shows that there is a strong normative foundation for integration between Islamic economics and sustainable development (Septiarini & Ayu Firawati, 2025). Furthermore, contemporary

studies towards Islamic financial instruments such as green sukuk emphasizes the role of this instrument in capital mobilization for environmental projects that comply with sharia principles, while at the same time provide a positive impact on sustainable development targets (Blanchard, 2016). However, there are still significant obstacles such as regulatory fragmentation, limitations investor awareness, as well as the lack of a comprehensively integrated ESG-Sharia standards framework. systematic, so that research that comprehensively analyzes the relationship between sharia economic instruments and the development of a green economy based on maqashid sharia have not yet been widely conducted (Rafiqi et al., 2025). This creates a need for research that is not not only theoretical but also synthesizes empirical evidence of the existence and suitability Islamic financial instruments with the global agenda of sustainable financing in Indonesia (Masruroh, 2025).

In addition, the dynamics of global climate change have encouraged countries to adopt a more sustainable and low-carbon development model. In this context, the financial sector has a strategic role in directing investment towards activities that environmentally friendly. Sharia economy, with the principle of prohibiting usury, gharar, and maysir, inherently encourages stable and long-term oriented economic practices, making them relevant in supporting the transformation towards a green economy (Iqbal & Mirakhor, 2011a). On the other hand, the development of sustainable finance shows there is an increasing need for a financial system that does not only pursue profit financial, but also pay attention to social and environmental impacts. The principles in Islamic economics such as justice ('adl) and balance (tawazun) provide an ethical foundation strong in building a sustainable and inclusive financial system (Chapra, 2008b).

Indonesia as a country with the largest Muslim population in the world has great potential in developing a sustainable Islamic economy. This is supported by increasing public awareness of environmental issues and the government's commitment to achieve the Sustainable Development Goals (SDGs) targets. In this context, economic integration Sharia and green economy can be an effective and sustainable development strategy. contextual (Finance, 2021).

Furthermore, Islamic financial instruments such as zakat, waqf, and sukuk have unique characteristics in supporting inclusive and sustainable development. Instruments This instrument not only functions as a wealth distribution tool, but can also be directed to finance environmentally friendly projects such as renewable energy, waste management, and conservation of natural resources (Obaidullah, 2018a). However, the implementation of integration between sharia economy and green economy still facing various challenges, such as limited supporting regulations, lack of public literacy, as well as the less than optimal synergy between the public and private sectors. Therefore Therefore, a more comprehensive

study is needed to identify potential, challenges, and strategy for developing sharia economic instruments to support a green economy based on maqÿÿid sharia in Indonesia (Board, 2023).

1. LITERATURE REVIEW

The concept of green economy from an Islamic perspective cannot be separated from the framework of the Qur'an. Qur'an and Hadith as the main normative sources. Islam views humans as caliphs ardh who has the responsibility to maintain environmental balance (hifz al-bi'ah). In economic context, production, distribution and consumption activities are not only oriented towards profit (profit oriented), but also on sustainability and long-term welfare. This is in line with the principle of maqÿÿid sharia which places benefit as the main goal Islamic law (Al-Ghazali, 1997) (Al-Syatibi, 2004)

Maqÿÿid sharia classically includes five main safeguards (al-dharuriyyat al khams), namely protecting religion (hifz al-din), soul (hifz al-nafs), reason (hifz al-'aql), descendants (hifz al-nasl), and wealth (hifz al-mal). In contemporary developments, scholars such as (Chapra, 2008a) and (Kamali, 2011) expand the dimensions of maqÿÿid into the development context sustainable development, including environmental protection. (A'ini et al., 2025) Islamic economic instruments such as zakat, waqf, sukuk, and profit-sharing-based financing have great potential in Supporting the transition to a green economy. According to (Obaidullah, 2018b) Islamic social finance can be directed to financing environmentally friendly projects and community empowerment Sustainability-based. Green sukuk is an important innovation in financing. renewable energy projects and low-carbon infrastructure, (Haneef & others, 2020). Indonesia itself has issued Green Sukuk as a form of commitment to development sustainable.

In addition, the Islamic economic approach emphasizes the principle of la darar wa la dirar (not allowed to borrow). endanger oneself and others). This principle is in line with the concept of externalities in environmental economics, where economic activities that damage the environment are contrary to the value of justice and balance (mizan)(Amsari & Others, 2025). Thus, green economy based on maqÿÿid sharia is not just an adaptation of Western concepts, but rather a manifestation Islamic values in the modern economic system (Miswanto & Tasrif, 2024).

Empirical literature shows that the integration of Islamic economics and green economy contribute to sustainable development by improving social welfare, poverty reduction, and environmental conservation (Beik & Arsyianti, 2016) (Dusuki & Abdullah, 2007). This strengthens the argument that Islamic economics has relevance strategic in supporting the Sustainable Development Goals (SDGs) agenda.

The development of modern literature also shows that the integration between Islamic economics and the green economy can be analyzed through an institutional economics approach. In this perspective In this context, Islamic financial institutions act as a mechanism that not only regulates financial activities economy but also shape sustainable economic behavior. North (1990) emphasized that strong institutions are able to create long-term economic efficiency, which in This context is in line with the principle of maqÿÿid sharia in maintaining a balance between economic growth and environmental sustainability. This strengthens the argument that Islamic economic instruments are not only normative in nature, but also have structural relevance in the modern economic system (North, 1990).

Furthermore, the concept of circular economy is also starting to be associated with Islamic economics as part of the development of a green economy. Circular economy emphasizes efficient use of resources. resources through the principles of reduce, reuse, and recycle, which are substantially in line with Islamic values in avoiding waste (israf) and damage (fasad). Study by Geissdoerfer et al. (2017) showed that the implementation of a circular economy can increase efficiency. resources while reducing environmental impact. From an Islamic perspective, this is related closely related to the principle of balance (mizan) which has become the basis of economic ethics as described in previous literature (Geissdoerfer et al., 2017).

In addition, the development of Islamic financial technology (fintech) also opens up new opportunities. in supporting green economy financing. Sharia-based fintech enables access broader and more inclusive financing, especially for small and medium projects environmentally oriented. According to Haddad and Hornuf (2019), fintech can improve efficiency of financial intermediation and accelerating the distribution of financing, which in this context can be utilized to support sharia-based green investments. This complements the role of traditional instruments such as zakat, waqf, and sukuk which have been explained in the literature previously (Haddad & Hornuf, 2019).

On the other hand, the integration between the Environmental, Social, and Governance (ESG) principles with Islamic finance has also received significant attention in recent literature. ESG provides a systematic evaluation framework for the social and environmental impacts of an investment. In the context of Islamic economics, ESG principles are in accordance with maqÿÿid sharia values, especially in the aspects of social justice and environmental sustainability. According to Friede et al. (2015), ESG-based investments empirically show more stable performance in the long term. long, thus strengthening the relevance of integration between Islamic finance and green economy (Friede et al., 2015).

Thus, this literature enrichment shows that the integration of Islamic economics and green economy is not only supported by theological and normative foundations, but also by

developments in modern economic theory and global empirical evidence. This further strengthens the position Islamic economics as an adaptive and relevant system in responding to challenges sustainable development, while complementing the previous discussion regarding the role of Islamic financial instruments in supporting environmental sustainability and welfare social (Sachs, 2015).

2. RESEARCH METHODS

This research uses a qualitative-descriptive approach with a systematic method. literature review (SLR). This method was chosen because it is able to provide a comprehensive synthesis on the concept of green economy from the perspective of maqÿÿid sharia and its relevance to Islamic economic instruments. According to Tranfield, Denyer, and Smart, a systematic review is structured and transparent methods for identifying, evaluating, and interpret all research findings relevant to a particular topic. This approach is widely used in indexed sustainable economic and financial research. Scopus (Tranfield et al., 2003).

The data collection process is carried out by searching for articles in scientific databases. reputable sources such as Scopus, ScienceDirect, SpringerLink, and Emerald Insight with keywords: Islamic economics, green economy, maqasid al-shariah, Islamic finance and sustainability, as well green sukuk. Inclusion criteria include: (1) Scopus indexed articles, (2) published in 2000–2025 period, (3) discussing the relationship between Islamic economics and environmental sustainability, and (4) using a conceptual or empirical approach. Articles that are irrelevant or not having peer-reviewed were excluded from the analysis.

In analyzing the data, this study uses content analysis techniques as follows: developed by Krippendorff (2018), namely by identifying the main themes that related to maqÿÿid sharia and sustainable development. The theme then categorized based on five dimensions of maqÿÿid (hifz al-din, al-nafs, al-'aql, al-nasl, al-mal) to see the contribution of each Islamic economic instrument to the sustainability aspect.

In addition, this research also uses a normative-analytical approach, namely by examine the basic principles of Islamic economics which are sourced from the Qur'an and Hadith as well classical maqÿÿid literature such as the works of Al-Syatibi and Al-Ghazali. This approach is combined with public policy analysis to assess the implementation of green sukuk and green economic policies in Indonesia.

To increase the validity of the research, source triangulation was carried out with comparing findings from conceptual literature and empirical studies. As emphasized by (Creswell, 2014), triangulation strengthens the credibility of qualitative research through convergence various data sources. With this method, research is not only normative but also based on empirical evidence that has been published in reputable international journals.

3. RESULTS AND DISCUSSION

The results of the analysis show that the integration of sharia economic instruments with the concept The green economy has a strong normative and empirical foundation. Conceptually, maqÿÿid Sharia emphasizes the achievement of public welfare (maslahah 'ammah) which is not only oriented towards economic welfare, but also social and ecological sustainability (Dusuki & Abdullah, 2008). Development in Islam must maintain a balance between growth and distributive justice as explained by Chapra within the development framework based on maqÿÿid (Chapra, 2008b). Islamic social financial instruments such as zakat and productive waqf have great potential. in supporting environmentally friendly projects and green economic empowerment (Kholiq, 2025). A study in the Journal of Islamic Accounting and Business Research shows that Islamic social finance can be directed to support the achievement of the Sustainable Development Goals (SDGs), especially clean energy and poverty reduction. (Haneef & others, 2020) This in line with the objectives of hifz al-nafs and hifz al-mal in maqÿÿid sharia.

The implementation of green sukuk is concrete evidence of the contribution of the Islamic capital market to Low-carbon development financing. Indonesia as a pioneer in global green sukuk issuance shows that Islamic finance is able to compete in the financial system international (Supriyadi et al., 2023). Research in the Journal of Financial Economics and Energy Economics found that green bonds have a positive impact on market stability and renewable energy financing (Flammer, 2021).

Profit sharing systems such as mudharabah and musyarakah offer financing models based on risk-sharing which is more stable than the interest-based system (Annizar & Junarsin, 2025). Empirical research in the institutional economics literature shows that the system partnerships encourage long-term investment and reduce excessive speculation. (Iqbal & Mirakhor, 2011b) This is relevant to the principle of sustainability because it avoids exploitation. resources for short-term gain. Macroeconomically, the integration of a green economy based on maqÿÿid sharia has the potential increasing national economic resilience (Nasr & Bhatti, 2021). Literature in the Journal of Cleaner Production shows that the success of the transition to a green economy is very depends on strong governance, transparency and regulatory support.(Taghizadeh-Hesary & Yoshino, 2020) In the normative perspective of Islam, the principle of balance (mizan) as emphasized in the Qur'an as the basis for sustainable development ethics.

Thus, the synthesis between maqÿÿid sharia and green economy shows that Islam has a holistic and long-term oriented development paradigm. The integration of spiritual, social and ecological values is the main differentiation compared to the system conventional economics.

A study in the Pacific-Basin Finance Journal confirms that investment Green also contributes to financial stability and climate risk mitigation (Bouri et al., 2019).

Findings from various empirical studies show that Indonesia is one of the a pioneering country in the issuance of global green sukuk, with total issuance reaching more than USD 5 billion since it was first launched in 2018. Data from the Ministry of Finance The Republic of Indonesia shows that the funds raised through green sukuk are mostly allocated to the renewable energy sector, sustainable transportation, and waste management. This shows that Islamic financial instruments do not only function as a tool financing, but also as a policy instrument capable of directing development towards a low carbon economy (Indonesia, nd).

Interpretation of these findings indicates that green sukuk have a strategic role. In bridging the need for sustainable development financing with the principles of sharia. In the maqÿÿid sharia perspective, this is closely related to the protection of the soul (hifz al-nafs) through reducing the impact of climate change, as well as protecting property (hifz al-mal) through productive and sustainable investments. Thus, green sukuk is not only provide economic benefits, but also create social and ecological value in a sustainable manner. simultaneous(W. Bank, nd).

In addition, data from the Islamic Development Bank (IsDB) shows that the potential Islamic social finance (zakat, waqf, and alms) globally is estimated to reach more than USD 1 trillion per year. However, the realization of its use for the environmental sector is still relatively low small. This fact shows that there is a gap between the potential and implementation of the instrument. Islamic social finance in supporting the green economy (ID Bank, nd). Analysis of This condition indicates that one of the main factors is that integration is not yet optimal. between Islamic financial institutions and national environmental policies. In addition, the lack of operational standards that combine ESG principles and maqÿÿid sharia are also becoming obstacles in optimizing these instruments. Therefore, strengthening regulations is necessary and institutional innovation so that Islamic social finance can be more effective in supporting sustainable development (Board, 2023).

On the other hand, the development of the sharia fintech sector in Indonesia also shows a trend positive, with user growth increasing significantly over the past five years. Data OJK shows that sharia fintech lending has experienced quite significant annual growth. high, especially in financing MSMEs. This is a great opportunity for integrating technology-based financing with green economy projects, such as sustainable agriculture and small-scale renewable energy (Finance, nd). Interpretation of These findings indicate that sharia fintech can be a catalyst in expanding access. green financing, especially for sectors that have not been reached by conventional banking. From the perspective of maqÿÿid sharia, this supports

the principle of distributive justice (al-'adl) and social welfare (maslahah), while strengthening financial inclusion based on sustainability (AD Bank, nd).

Overall, the results of the analysis show that the integration of Islamic economics and The green economy in Indonesia has enormous potential, but still requires strengthening of regulations, instrument innovation, and collaboration between institutions. These findings emphasizes that the maqÿÿid sharia-based approach is not only normatively relevant, but also has practical implications in creating a sustainable and equitable economic system. inclusive. Thus, the Islamic economy can become one of the main pillars in supporting the transformation towards a green economy in Indonesia (Programme, nd).

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ANALYSIS OF THE POTENTIAL ELEMENTS OF GHARAR AND USURY IN ELECTRONIC MONEY MECHANISMS AND THEIR IMPLICATIONS FOR THE VALIDITY OF TRANSACTIONS FROM THE PERSPECTIVE OF ISLAMIC ECONOMICS IN INDONESIA

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Abstract

This study aims to examine the potential elements of gharar and riba in the electronics money (e-money) system and their impact on the validity of transactions from the perspective of Islamic economics in Indonesia. The research employs a qualitative method with a descriptive analytical approach through a literature review of DSN-MUI fatwas, regulations, and various relevant academic sources. The findings indicate that e-money is a digital payment system innovation that offers convenience, efficiency, and speed in transactions. However, in practice, there is still a potential presence of gharar caused by unclear contractual agreements, lack of cost transparency, and system risks that are not fully understood by users. In addition, the potential for usury may arise from additional charges that do not have a clear contractual basis or from fund management by issuers that do not comply with Sharia principles. The existence of these elements affects the validity of transactions, where a transaction is considered valid if it fulfills the pillars and conditions of a contract and is free from prohibited elements. This study concludes that the use of e-money is generally permissible (mubah) as long as it complies with Sharia principles, such as transparency, clarity of contracts, and the absence of gharar and usury. Therefore, the role of regulators, service providers, and Sharia supervisory institutions is essential in ensuring that e-money practices align with Islamic economic principles.

Keywords: Electronic Money, Gharar, Riba, Islamic Economics, Transaction Validity

INTRODUCTION

The development of information and communication technology has brought major changes in various aspects of human life, including the financial system. Innovation in the field of Financial technology known as financial technology (fintech) has created a system transactions that are faster, more efficient, and more accessible to the wider community. In Indonesia, fintech progress shows a very significant trend in recent years, marked by the increasing number of fintech companies and the diversification of financial services digital services offered to the public (Adji et al. 2023). Fintech not only provides convenience in transactions, but also plays an important role in increasing financial inclusion, especially for micro, small and medium enterprises (MSMEs) which previously had difficulty access formal financial services (Muzdalifa et al. 2018). In addition, the regulations that are starting to development also shows that the government and related authorities are trying to accommodate fintech progress to remain within clear legal corridors.

One real example of fintech progress is the use of electronic money (e-money). money). Electronic money is a means of payment that is stored in digital form and used to carry out various transactions without using cash. The use of e Money in Indonesia continues to increase, along with the development of lifestyles a society that is moving towards a cashless society. The millennial generation and society urban is the most active group using e-money in daily activities, such as transportation payments, online shopping, and transactions at various merchants (Abiba and Indrarini 2021). This shows that e-money has become an important part of the system modern payments in Indonesia.

Furthermore, the digitalization of payment systems through e-money also has an impact. to changes in people's consumption attitudes. Ease of conducting transactions without cash tends to increase consumption intensity because the payment process becomes more practical and faster (Achir and Kusumaningrum 2021). In addition, the use of e-money also contribute to the formation of a cashless society ecosystem supported by infrastructure increasingly developing digital (Manik 2019). In the macroeconomic context, the increase the use of e-money can even affect the amount of money in circulation and the stability of the system finance, especially when linked to interest rate factors and economic conditions such as COVID-19 pandemic (Wijaya, Mukhlis, and Seprillina 2021).

Even though it provides various conveniences and benefits, the use of electronic money also poses its own challenges, especially from a sharia economic perspective. As As a country with a Muslim majority population, Indonesia has a great need for a financial system that is not only efficient, but also in accordance with sharia principles. Sharia economics emphasizes the importance of justice, transparency and balance in every transaction. financial transactions, as well as prohibiting practices that contain elements of gharar (uncertainty), usury (prohibited

additions), and maysir (speculation) (Pusvisasari, Bisri, and Suntana 2023). By therefore, every innovation in the financial system, including e-money, needs to be assessed for its suitability. with these principles.

In practice, electronic money mechanisms can have elements of gharar. refers to the ambiguity or uncertainty in a transaction that could be detrimental one party. In the e-money system, the potential for gharar can arise from a lack of transparency regarding administration fees, how to manage balances, or the risk of losing funds due to system disruptions or technical errors. In addition, users are often not fully understand the contracts underlying e-money transactions, thus creating ambiguity in legal relationship between users and service providers (MZ Muttaqin 2024). This situation of course, this is contrary to the basic principles of Islamic economics which require clarity and transparency in every transaction.

Apart from gharar, the potential for usury elements is also a concern in the use of money. electronic. Riba is an additional requirement in a transaction without any reward equivalent, which is clearly prohibited in Islam. In the context of e-money, the potential for usury can appear in various forms, such as the existence of certain additional costs for which the basis is unclear the agreement, or management of funds held by the e-money issuer that does not comply with sharia principles. In some cases, funds deposited by users can be used by the publisher for certain interests, thus raising questions about the validity use of these funds according to a sharia perspective (I Kamaluddin and Islami 2025).

Furthermore, the complexity of the electronic money system involves various parties, such as users, publishers, merchants, and financial institutions, further increasing the potential the emergence of sharia issues. Every interaction between these parties is basically a a contract that must fulfill the pillars and requirements of Islamic law. If there are elements that are not If it is not in accordance, then the transaction can be considered invalid or even haram. Therefore, it is important to conduct an in-depth analysis of the e-money mechanism to ensure that all transaction processes that occur are in accordance with sharia principles (Savitri and Muchlis 2024).

In an effort to maintain compliance with sharia principles, the role of institutions such as the Sharia Supervisory Board National Sharia of the Indonesian Ulema Council (DSN-MUI) and the Sharia Supervisory Board (DPS) becomes very important. These two institutions are responsible for ensuring that the product and financial services in the community have complied with sharia provisions. Supervision Effective implementation of DSN-MUI and DPS is expected to reduce the potential for violations of the principles sharia in digital financial practices, including the use of e-money (Dianto, Arif, and Majid 2025). In addition, transparency and accountability in financial management are also important aspects that must be considered, as emphasized in the study of Islamic accounting (Sagala and Nurlaila 2025).

The development of increasingly complex financial technology, including the use of blockchain and cryptocurrency, also shows that the digital financial system continues to experiencing rapid development. This requires a more comprehensive approach comprehensive in understanding the impact of this technology on Islamic economic law (Hidayat, Sujianto, and Asiyah 2023). In this context, an analysis of electronic money be an important part of the effort to ensure that financial innovation remains within the corridor of sharia.

Based on this description, it can be concluded that even though electronic money provides various conveniences and benefits in a modern payment system, there are the possibility of the emergence of elements of gharar and usury which need to be studied in depth. The ambiguity in the transaction mechanism and the possibility of additional unforeseen costs in accordance with sharia principles can affect the validity of e-money transactions from a financial perspective Islamic economic perspective. Therefore, this research is important to conduct in order to provide a more complete understanding of the legal status of the use of money electronics in Indonesia.

This study aims to analyze the electronic money mechanism in Indonesia, identify the possible elements of gharar and riba in the system, and assess its implications for the validity of transactions from a sharia economic perspective. With Thus, the results of this study are expected to contribute to the development Islamic economics, especially in the context of fintech, as well as being a reference for society, financial institutions, and regulators in developing a payment system that not only efficient, but also in accordance with Islamic values.

1. LITERATURE REVIEW

1.1. The Concept of Electronic Money (E-Money)

Electronic money is a digital payment instrument which allows users to make transactions without using cash, with values stored electronically in a system. The development of e money is inseparable from the progress of financial technology (fintech) which encourages transaction efficiency and expanding public financial access. In the literature, e Money is classified into several forms, such as server-based and network-based. chips, each of which has advantages in terms of flexibility and security usage. The adoption of e-money is also influenced by factors of trust, ease of use usage, and the benefits perceived by users (Dahlberg, Guo, and Ondrus 2018)(Shaikh, Glavee-Geo, and Karjaluoto 2020).

In the Indonesian context, the use of electronic money is regulated by the authorities. monetary regulations to ensure the security and stability of the payment system. This not only covers technical aspects, but also consumer protection and supervision of service providers.

This is important considering The rapid development of digital payments can give rise to various risks if not well regulated. Studies show that effective regulation plays a role important in increasing public trust in the payment system digital (Rahman 2022)(Slozko and Pelo 2018).

The working mechanism of e-money involves the process of storing value, filling balances, and use in transactions connected to digital systems. Although While providing convenience and speed, the complexity of these systems is often not fully understood by the user. This has the potential to cause ambiguity in transactions, especially regarding fees, balance deduction systems, and fund management by service providers (Ernawati and Nugroho 2021) (Banna, Hassan, and Rashid 2021).

1.2. The Concept of Gharar in Islamic Economics

Gharar is a concept in Islamic economics which refers to the existence of elements of uncertainty, ambiguity, or speculation in a transaction. In From an Islamic perspective, every transaction must be carried out clearly and transparently so that it does not harm one of the parties. Therefore, excessive gharar (gharar fahish) is prohibited because it can create injustice and inequality in economic relations (Muneeza, Mustapha, and Nasution 2020)(Rabbani 2021).

Conceptually, gharar can be divided into several types, such as unclear transaction objects, price uncertainty, and unclear timing submission. In modern practice, the forms of gharar are becoming more complex as the development of digital financial technology. Technology-based systems often difficult to fully understand by users, thus increasing the potential for the occurrence of uncertainty in transactions (Alaeddin et al. 2018) (Hasan, Ashfaq, and Saleem 2020).

In the context of e-money, elements of gharar can appear if they are present lack of transparency in operational mechanisms, such as hidden fees or systems that are not explained in detail to users. This shows that Even though technology provides convenience, clear information is still needed so that transactions in accordance with sharia principles (Bashir 2022) (Ernawati and Nugroho 2021).

1.3. The Concept of Usury in Sharia Economics

Riba is an addition obtained illegally in transactions finance, either in the form of loans or usurious exchange of goods. In Islam, usury is strictly prohibited because it is contrary to the principles of justice and balance in the economy. This prohibition aims to prevent exploitation and ensure that every transaction provides fair benefits to all parties (Narayan 2019)(Hasan, Ashfaq, and Saleem 2020).

The most commonly discussed types of riba are riba fadhl and riba nasi'ah. Fadhl occurs in the exchange of similar goods in unequal quantities, whereas riba nasi'ah occurs because of the addition resulting from delayed payment. In the modern financial system, the potential for usury can appear in various forms, included in the additional fee or fine mechanism in the payment system digital (Firmansyah and Anwar 2019) (Rabbani 2021).

The impact of usury in the economic system is very broad, starting from inequality distribution of wealth to economic instability. Therefore, Islamic economics emphasizes the importance of a usury-free financial system by prioritizing principles of fairness, transparency, and cooperation (Banna et al., 2021; Hasan et al., 2020).

1.4. Principles of Validity of Transactions in Islam

In Islamic economics, the validity of a transaction is determined based on fulfillment of the pillars and conditions of the contract. A contract is an agreement between the parties. be the basis of transactions and must be based on the principles of honesty, justice, and transparency (Budiwati 2018). The pillars of the contract include the parties to the transaction, the object which is traded, as well as the existence of ijab and qabul. In addition, conditions such as competence legal requirements, clarity of object, and absence of coercion must also be met so that the transaction is valid. considered valid (Hasanah 2024).

The validity of transactions in Islam is also related to the principles of halal and thayyib, which means that transactions must be permitted according to sharia and provide benefits. without harming other parties (Ramdan and Purnamasari 2020). Therefore, transactions which contains elements of gharar (uncertainty), usury, or unfair practices can be considered valid.

In the development of modern transactions such as online buying and selling, contracts can still be considered valid even if done digitally, as long as it meets the requirements and conditions that has been determined. Ijab and qabul can be done through electronic media as long as there is a clear agreement between the parties (Siregar 2019). However, the practices New things like cashback or promos still need to be checked to ensure there are no elements that are contrary to sharia principles (Hidayah 2023). Thus, the principle The validity of transactions in Islam emphasizes clarity of contracts, justice, and free from prohibited elements. This principle remains relevant in dealing with development of the digital economy, including in assessing the validity of money transactions electronic.

1.5. Previous Research

Several previous studies have discussed the development of electronic money. (e-money) and its relationship with Islamic economics, both in terms of technology and behavior users, as well as aspects of compliance with Islamic principles. Studies by (Dahlberg, Guo, and Ondrus 2018) and (Shaikh, Glavee-Geo, and Karjaluoto 2020) shows that the use of digital payments

is influenced by factors convenience, trust, and benefits felt by users. This confirms that e-money has become an important part of the modern payment system, but aspects of trust and transparency remain important factors in its use.

Furthermore, research by (Rahman 2022) and (Slozko and Pelo 2018) emphasizes the importance of regulation in digital payment systems to reduce risks and improving consumer protection. Good regulation can create stability financial system and increase public confidence in the use of e money. On the other hand, (Ernawati and Nugroho 2021) analyzed e-money from the perspective of Islamic economic perspective and found that e-money is sharia acceptable as long as it does not contain prohibited elements, such as gharar and usury.

Other research by (Muneeza, Mustapha, and Nasution 2020) and (Rabbani 2021) identify various sharia issues in fintech, including the potential for gharar due to the lack of transparency of the digital system. Meanwhile, (Alaeddin et al. 2018) and (Hasan, Ashfaq, and Saleem 2020) explains that the complexity of technology in digital transactions can increase the risk of confusion for users, especially if the information provided is incomplete or difficult to understand.

In this context, (Bashir 2022) also emphasized that compliance with Sharia principles in digital payment systems are highly dependent on clarity mechanisms and transparency of information. In terms of usury, research (Narayan 2019) and (Firmansyah and Anwar 2019) shows that the modern financial system, including fintech, has the potential to contain elements of usury if there are additions that are not in accordance with the principle of justice. This is reinforced by research (Banna, Hassan, and Rashid 2021) which states that fintech-based financial inclusion must continue to comply with sharia principles so as not to cause economic inequality.

Meanwhile, in the context of transaction validity, research (Budiwati 2018), (Hasanah 2024), and (Ramdan and Purnamasari 2020) emphasized that a A transaction is valid if it meets the terms and conditions of the contract and does not contain any elements prohibited. Research (Siregar 2019) shows that digital transactions remain legal according to sharia if it fulfills the principles of the contract, while (Hidayah 2023) highlights the importance of analyzing new practices such as cashback so as not to deviate from sharia provisions.

Although various studies have discussed e-money and the economy sharia, there is still a research gap. Most of the research previously only focused on aspects of technology adoption, regulation, or general concepts sharia fintech, without analyzing more deeply the potential elements of gharar and usury specific in the operational mechanisms of e-money. In addition, research that directly connecting the potential for gharar and usury with legitimacy transactions from a sharia economic perspective in Indonesia are still limited.

Therefore, this research exists to fill this gap by carry out a more comprehensive analysis regarding the potential elements of gharar and usury in the electronic money mechanism, and examine its implications for the validity transactions based on the principles of Islamic economics. Thus, this research is expected to provide a more in-depth contribution to the development Sharia fintech studies, especially in the context of e-money use in Indonesia.

2. RESEARCH METHODS

This research uses a qualitative research type with a descriptive approach. analytical. The qualitative approach was chosen because this research aims to understand and analyze in depth the phenomena related to the potential elements of gharar and riba in the electronic money system, as well as its impact on the validity of transactions in the view of Islamic economics. The descriptive-analytical nature is used to systematically explain the facts and characteristics of the objects being studied, while simultaneously conducting an analysis of the suitability of the practice with the principles of Islamic law.

In its implementation, this research uses two main approaches, namely normative approach and conceptual approach. The normative approach is used to studying the provisions of Islamic law originating from the Qur'an, hadith, and fatwas of scholars, especially the fatwa of the National Sharia Council of the Indonesian Ulema Council (DSN-MUI) which is related with electronic money. Meanwhile, a conceptual approach is used to understand basic concepts in sharia economics, such as gharar, usury, and the principle of contract validity, which then used as a basis for analyzing electronic money practices in Indonesia.

The data sources in this study consist of primary data and secondary data. Primary data obtained from official documents in the form of DSN-MUI fatwas relating to electronic money and digital financial transactions from a sharia perspective. While secondary data was obtained from various relevant literature, such as scientific journals, textbooks, previous research results, as well as regulations from Bank Indonesia and related authorities that regulate payment systems and electronic money in Indonesia. The use of these two types of data aims to obtain comprehensive understanding of the research object.

The data collection technique used in this research is literature study. (library research). Researchers collect various references related to the topic research, then conduct in-depth reviews and studies of the sources The literature study was chosen because this research is conceptual and normative, so that does not require field data collection, but rather emphasizes analysis to written documents and sources.

Furthermore, the data analysis technique used in this study is analysis. descriptive and comparative analysis. Descriptive analysis is used to explain in detail electronic money mechanisms and the potential elements of gharar and usury that may exist within them.

Meanwhile, comparative analysis is carried out by comparing money practices. existing electronics with the principles of Islamic economics, particularly in relation to the validity of the contract and the prohibition of gharar and usury. Through these two analysis techniques, It is hoped that this research can produce objective and comprehensive conclusions. regarding the validity of electronic money transactions from the perspective of Islamic economics in Indonesia.

3. RESULTS AND DISCUSSION

3.1. Electronic Money Mechanism in Indonesia

Its use is influenced by financial literacy, security, access, and government support (Akbar and Rachmawati 2023). Electronic money aims expanding financial access, but not yet fully reaching all groups (Mahardika 2025). This system stores balances digitally, is prepaid, and its use is increasing, especially during the COVID-19 pandemic, and has an impact on the amount of money in circulation and economic stability in Indonesia (Sari and Winarni 2024).

Electronic money top-up mechanism in Indonesia, specifically for Go-Pay, involves four methods: bank transfer (ATM or Mobile Banking), payment in minimarkets or retail partners, the Gojek app, and transfers between GoPay users. stored electronically, allowing for various transactions within the GO- application. JEK. Issuers, such as Gojek, facilitate the service, while users engage in transactions, ensuring compliance with Islamic economic law in accordance with the Fatwa DSN No. 116/DSN-MUI/IX/2017 (Rafaldini, Saripudin, and Maulida 2024).

The fee structure for top-ups is also subject to Islamic financial principles. According to DSN-MUI Fatwa No. 28/DSN-MUI/III/2002, the conversion of physical money into cash electronics must remain the same value, and any additional costs must be justified as service fees, not interest, to comply with Islamic law (Nadzir 2018). Money Electronic documents in Indonesia are stored digitally, and publishers are responsible for maintain the equivalent value of the balance stored. This storage mechanism is subject to supervision under Islamic law, which requires funds to be held in a safe manner which avoids interest (riba) and ensures the security of user funds (Nengsih 2019).

Transactions using electronic money are facilitated by infrastructure that provided by the issuer or third-party operator. These transactions are designed to be secure and in accordance with conventional and Islamic financial principles. Contracts such as Sales Purchase Agreement, Wadi'ah Agreement, and Ijarah Agreement are used to ensure compliance with Islamic law (Niam and Hidayatulloh 2022). The use of electronic money is seen as a catalyst for a cashless society. in Indonesia, offering benefits such as increased financial inclusiveness

and improving financial performance for SMEs. However, challenges such as data security and digital literacy remains (Jagaddhita and Kusuma 2024).

3.2. Analysis of Potential Gharar Elements

The concept of gharar is the uncertainty in transactions that is of concern. in Islamic finance because it can lead to injustice. The analysis includes administrative costs, system uncertainty, and information transparency, which are important for assess the validity and ethics of transactions according to sharia. In the context of gharar, the cost administration can contribute to uncertainty if not clearly defined or if it fluctuates unexpectedly. This can lead to a lack of transparency and fairness in transactions, as the parties may not be fully aware of understand the costs involved until after the transaction is completed (Adelia et al. 2024).

Gharar relates to uncertainty in the system, such as unexpected outcomes. certain or unclear rules, for example in the All You Can Eat concept creates uncertainty about the amount of consumption within a certain time limit and price (Adelia et al. 2024). Similarly, financial products such as binary options and mystery boxes criticized for its inherent uncertainty and speculative nature, which is in line with gharar concept (Syarifati et al. 2025).

Transparency is important to reduce gharar because clear information help all parties understand the transaction and avoid uncertainty (Karimullah 2025). For example, the Tapera program in Indonesia faces challenges related to gharar due to uncertainty in the management of funds and disbursement of benefits, highlighting the need for greater transparency (Amelia et al. 2025).

Risks in financial transactions cannot be avoided, but must be managed appropriately. Sharia principles to remain fair and not harm any party. Gharar in transactions raise ethical issues because they can lead to injustice, so In Islamic finance, transactions containing excessive gharar are considered invalid. and unethical (Waeibrorheem 2016).

3.3. Analysis of Potential Elements of Usury

DSN-MUI fatwa on Gold Rahn allows the merging of qardh contracts (loans) and ijarah (rent), which can lead to usury if the service fee for maintaining collateral beyond reasonable costs. This excess is considered usury because is a profit obtained from loans, which is prohibited in finance Islam (Hamid 2023). Islamic Financial Institutions (IFIs) may charge service fees to maintain collateral (marhun) that exceeds reasonable costs. If these costs accepted by customers solely to obtain a loan, they are deemed usury (Hamid 2023).

In practice, the implementation of gold pawn financing in several Islamic banks not fully aligned with Sharia principles. Ujrah (fee) is often calculated based on the loan amount rather than the estimated value of the collateral, which leads to potential for usury (Khairunnisa

2021). DSN-MUI permits fines for late payments Sharia credit card payments, as long as they are used for social purposes. However, there are debate among scholars about whether this fine constitutes usury, because involves additional charges on delayed payments.

3.4. Implications for Transaction Validity

Transactions must not involve maysir, gharar, or riba. These elements considered dangerous and unfair, and their presence in transactions will making it invalid according to Islamic law (Imam Kamaluddin, bin Lahuri, and Cahya 2022). Transactions must not involve maysir, gharar, or riba. These elements considered dangerous and unfair, and their presence in transactions will making it invalid under Islamic law (Pangestu 2023). The transaction must be transparent, with clear terms and conditions, to avoid all forms of fraud or misunderstanding between the parties (Nst and Imsar 2025).

E-money is generally considered permissible under Islamic law because facilitate transactions and provide significant benefits, such as convenience and efficiency, which is in line with the principles of maqasid al-syariah (Q. Muttaqin and Treasury 2023). E-Money services in Indonesia, for example, are considered to be in accordance with Sharia principles when they comply with the guidelines set by the fatwa DSN-MUI, which provides a framework to ensure that e-transactions money does not involve prohibited elements (Q. Muttaqin and Khasanah 2023). The use of electronic money involves various contracts, such as wadiah (storage) and qardh (loans), which are permitted under Islamic law, provided they are implemented in a manner that complies with Sharia principles (Niam and Hidayatulloh 2022).

For electronic money to be valid, it must be registered and secure, ensuring that user funds are protected and that the system is not vulnerable to fraud or misuse (Hafidh 2022). Transactions must involve legitimate goods and services. Using e-money for transactions involving haram objects will make invalid transactions (Imam Kamaluddin, bin Lahuri, and Cahya 2022). Although e While money offers many benefits, there is potential for abuse if not regulated. properly. Issues such as unauthorized transactions or lack of transparency can causing problems that are contrary to Sharia principles (Pangestu 2023).

3.5. Analysis of Compliance with the DSN-MUI Fatwa

DSN-MUI fatwa on Sharia electronic money in Indonesia is a process multifaceted approach involving the alignment of modern financial technology with the principles of Islamic principles. Fatwas provide a framework that ensures that money electronics complies with Sharia law, which prohibits elements such as riba (usury), uncertainty (gharar), and gambling (maysir). This alignment is very important for gain the trust of the Muslim community and promote financial inclusion. However, the practical implementation of these guidelines faces challenges, including interpretation. which is different from Sharia principles and the

integration of conventional banking systems. The following sections examine the specifics of this implementation.

One of the significant challenges is the placement of electronic money in banks. conventional, which may conflict with Sharia principles. For example, if If the card is lost, the nominal amount is also lost, and the electronic money cannot be cashed. back, which raised concerns about compliance with Sharia law (Nengsih 2019). There are also problems related to the interpretation of the principles Sharia and the limited availability of trained human resources in banking sharia, which may hinder effective implementation (Rozi 2024).

4. CONCLUSION

Electronic money (e-money) is a digital financial system innovation that makes things easier, speed up and streamline transactions. In Indonesia, its use continues to grow along with the progress of fintech and the shift of society to non-cash payment systems. The e-money mechanism includes the process of topping up, storing balances, and using them. in transactions through publishers and merchants. However, from a sharia economic perspective, E-money can contain elements of gharar and usury. Gharar can arise due to uncertainty. agreements, lack of cost transparency, and system risks that users do not understand.

Meanwhile, usury can arise from additional costs that have no basis in an agreement. which is clear or from fund management that does not comply with sharia principles. The existence of these elements affect the validity of transactions. Transactions are declared valid if they meet the requirements and terms of the agreement and free from prohibited elements. Therefore, if e-money carried out transparently, with clear agreements, and free from usury, then its use permitted (mubah). Thus, the role of regulators, service providers, and sharia supervisors to ensure conformity with Islamic principles, as well as education to society so that the use of e-money remains safe and in accordance with sharia.

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THE INFLUENCE OF DIGITAL MARKETING, SHARIA E-COMMERCE, AND SHARIA FINANCIAL LITERACY ON NATIONAL INCOME FROM AN ISLAMIC ECONOMIC PERSPECTIVE 2015–2024

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Abstract

This study aims to analyze the influence of digital marketing, Islamic e-commerce, and Islam financial literacy on Indonesia's national income from an Islamic economic perspective during the 2015-2024 period. The study uses a quantitative approach with an associative approach and utilizes secondary time series data obtained from the Central Statistics Agency (BPS), Bank Indonesia (BI), the Financial Services Authority (OJK), and various publications related to the digital economy and Islamic economics. The independent variables in this study consist of digital marketing, Islamic e-commerce, and Islamic financial literacy, while the dependent variable is national income, proxied by Gross Domestic Product (GDP) at constant prices. The analytical techniques used include descriptive analysis and multiple linear regression. The results indicate that the development of digital marketing, Islamic e-commerce, and Islamic financial literacy in Indonesia has tended to increase during the study period and plays a strategic role in supporting the strengthening of the national economy. From an Islamic economic perspective, these three variables are not only related to economic growth but also to the values of honesty, justice, transparency, benefits, and benefits. This research confirms that the integration of digital marketing, Islamic e-commerce, and Islamic financial literacy have the potential to become crucial foundation for building an inclusive, productive, and sustainable Islamic digital economy ecosystem in Indonesia. The implications of this research point to the importance of strengthening policies, increasing literacy, and optimizing the use of Islamic digital platforms to support equitable national economic growth.

Keywords: Digital Marketing, Islamic E-Commerce, Islamic Financial Literacy, National İncome, Islamic Economics

INTRODUCTION

The development of the digital economy in Indonesia has become one of the main drivers economic growth in recent years (Purba et al., 2021). Digital transformation which took place massively not only changed the market structure, but also shifted the pattern interaction between producers and consumers. Interactive digital marketing has become a phenomenon global that influences people's consumption patterns and shopping behavior. The Internet runs important role in modern marketing. The internet functions as a medium for creating requests, guiding customers in the purchasing decision making process, fulfilling orders, provide customer service, and be a flexible and measurable advertising tool. (Yudilestari et al., 2025a). The use of digital marketing has been widely used by companies. As a means of promoting goods and services to meet consumer needs more effectively effective, efficient, and on target.

In the context of Indonesia as a country with the largest Muslim population in the world, The increase in internet users among the Muslim community presents opportunities significant for the development of sharia-based businesses through digital marketing (Hartini et al., 2022a). Digital marketing is not only a promotional instrument, but also a means of education and transparency of product information in accordance with Islamic economic principles such as honesty (shiddiq), justice ('adl), and openness (transparency). In addition, the growth of e-commerce in Indonesia is one of the main drivers of the digital economy which is able to increase online trading activities and contribute to economic growth national (Jannah et al., 2019a). The presence of sharia e-commerce expands transaction alternatives which is in accordance with the principles of halal, free from usury, gharar and maysir, so that it has the potential to strengthen national economic system based on Islamic values.

Based on the growth chart of Indonesia's Gross Domestic Product (GDP) from 2015 Until 2023, it can be seen that the general condition of the Indonesian economy shows a trend which was stable with positive growth in the period 2015 to 2019. Although in the year 2020 saw a contraction due to the COVID-19 pandemic, the national economy was gradually able to recover. recovered and showed positive growth again in the following years. Overall, the graph reflects the resilience of the Indonesian economy in facing crisis and its ability to recover and continue growth (Luthfiana et al., 2021). This condition shows that digital-based sectors have a strategic role. in maintaining stability and accelerating national economic growth.

On the other hand, the level of Islamic financial literacy is also an important indicator in measuring the extent to which people understand and are ready to use financial services and products Sharia-based. The results of the 2024 National Survey on Financial Literacy and Inclusion (SNLIK) were released. by the Financial Services Authority in collaboration with the Central Statistics Agency shows that The Islamic financial literacy index of the Indonesian

people is still recorded at 39.11%. In 2023, the conventional financial literacy index reached 65.43%. This shows that there is a gap in people's understanding of the Islamic financial system. compared to conventional systems. The low level of literacy can have an impact on less than optimal utilization of sharia financial products and services in supporting activities community economy.

National economic developments in recent years have shown a positive trend. positive along with the increasing contribution of the digital sector to economic activity. In From an Islamic economic perspective, economic activity is not only aimed at achieving economic growth. (growth), but also blessings (barakah), distributive justice, and social welfare (falah). Therefore, the integration between digital marketing, sharia e-commerce, and financial literacy Sharia is a strategic factor in strengthening the national economic structure based on Islamic values. The development of the digital economy has encouraged the birth of various innovations Sharia-based financial services are becoming increasingly accessible to the public. However, the relatively low level of Islamic financial literacy and inclusion shows that The utilization of these services is not yet optimal and still has room for development. big.

In addition, empirical studies on the relationship between digital marketing variables, e sharia commerce, and sharia financial literacy towards national income is still relatively limited, especially from an Islamic economic perspective (Ridwanullah et al., 2025). In fact, National income is the main indicator in measuring the level of welfare and prosperity of a country. Within the framework of Islamic economics, increasing national income must be in line with the principles of justice, sustainability, and equitable distribution. With Thus, it is important to analyze how the development of the sharia-based digital economy is going. can make a real contribution to increasing Indonesia's national income.

Thus, this study was designed to analyze and explain the influence of digital marketing, sharia e-commerce, and sharia financial literacy on income Indonesian national economy from an Islamic economic perspective with a quantitative approach using secondary data for 2015–2025. This research is expected to not only contribute theoretical in the development of Islamic economic literature and digital economy, but also provides relevant policy implications for the government, business actors, and Islamic financial institutions in formulating strategies to strengthen the sharia-based digital economy in Indonesia.

1. LITERATURE REVIEW

The development of the digital economy in Indonesia in recent years shows increasingly important role as a driver of national economic growth. Transformation Digital technology is not only changing market structures, but also shifting patterns of interaction between producers and consumers are becoming faster, broader, and technology-based. In the context of marketing In modern times, the internet functions as a medium for creating demand,

guiding the process making purchasing decisions, fulfilling orders, providing customer service, and become a flexible and measurable promotional tool, so that digital marketing is seen as effective and efficient instruments in meeting consumer needs (Yudilestari et al., 2025b). In the context of Indonesia, which has the largest Muslim population in the world, the increase Internet use among Muslim communities also opens up huge opportunities for Sharia-based business development through digital marketing (Hartini et al., 2022b). In addition, The growth of e-commerce in Indonesia is also one of the main drivers of the digital economy. because it is able to increase online trading activities and contribute to national economic growth (Jannah et al., 2019b). This condition is in line with the picture Indonesia's GDP growth, which was relatively stable in the 2015–2019 period, experienced a contraction in 2020 due to the pandemic, then recovered in the following years, which demonstrates the resilience of the national economy as well as the strategic role of the digital sector in maintaining stability and acceleration of economic growth.

From an Islamic economic perspective, digital marketing is not only understood as a tool promotion, but also as a means of education, information transparency, and fulfillment of needs consumers through halal products and services that are run based on the principles of honesty, justice, trustworthiness, and welfare (Junusi, 2020; MayaPutra & Yusrizal, 2025a). Transparency Product information that is conveyed clearly, accurately and not misleadingly has been proven to play a role important in building consumer trust in sellers in the marketplace, because Information transparency influences perceptions of credibility and transaction security. In the era of digital, consumer trust is a fundamental element in creating loyalty, strengthen the company's relationship with customers, and support the sustainability of interactions business, especially in the uncertain e-commerce environment (Sahabuddin et al., 2024a; Younis & Zeebaree, 2025). Thus, the contribution of digital marketing to the economy can be understood as the result of the creation of market efficiency which is strengthened by the application of the principle fairness and transparency in every communication process and business transaction (Putra & Doho, 2022a).

Furthermore, sharia e-commerce also shows significant development. as part of the digital economic transformation based on Islamic values. Literature in the file You explained that the increasing number of sharia e-commerce platforms and the involvement of young Muslim consumers show that there is quite strong ecosystem growth (Ridzki & Firmansah, 2025). Increasing public awareness of the importance of halal products and transactions that comply with sharia principles are the main factor driving development sharia e-commerce platform, because consumers are not only looking for ease of transactions, but also the certainty of conformity with Islamic values (Fauziah & Ardiansyah, 2025). The presence of Sharia e-commerce provides easier access for Muslim consumers to obtaining halal products and ensuring that transactions are carried out in accordance with usury-free principles, gharar, and

maysir (Sirjes et al., 2025). Several studies also show that the implementation of e-commerce from an Islamic economic perspective has a positive influence on increasing business actors' income, expanding market access for MSMEs, and ultimately being able to contribute to national economic growth and social welfare (Nur Latifah, Yuliatul Wahidah, & Amany, 2024; Rifa'i et al., 2025b).

On the other hand, Islamic financial literacy is an important indicator in assessing readiness. society to understand and use sharia-based financial products and services. In your manuscript it is stated that the results of SNLIK 2024 show the financial literacy index Indonesian society's sharia is still below conventional financial literacy, which indicates that there is still a gap in understanding of the Islamic financial system. Although Thus, various studies show that Islamic financial literacy has a relationship positive with sharia financial inclusion, both in the Islamic boarding school environment and among actors MSMEs, because the higher the understanding of sharia principles, contracts and products, the more there is a large tendency for individuals to use Islamic financial services (Arfiansyah, 2024; Rijal & Indrarini, 2022; Solikin et al., 2024). The literature also confirms that financial literacy Sharia supports participation in the halal ecosystem, including in financing and investment sharia-based, and contribute to more rational economic decision-making and productive, which in the long term can have an impact on welfare and growth national economy (Antara et al., 2016; Lusardi & Mitchell, 2014).

Overall, the literature you have compiled shows that digital marketing, e Sharia commerce and Sharia financial literacy are three variables that are interrelated in creating an inclusive and productive digital economic ecosystem. Digital marketing has proven to be increasing market reach and business performance, e-commerce strengthens productivity and MSME income, while Islamic financial literacy expands community participation in financial services and the halal ecosystem (Judijanto & Mu'min, 2024; Nuseir & Al Ain University of Science and Technology, 2018; Solikin et al., 2024). From an economic perspective Islam, the contribution of these three variables is not only assessed from the increase in transaction volume or GDP growth, but also from the extent to which economic activity embodies falah, distribution justice, transparency, and sustainability in accordance with maqasid al-shariah (Chapra, 2008; Dusuki & Bouheraoua, 2018; Hassan & Aliyu, 2018). Therefore, digital marketing integration, Sharia e-commerce and Sharia financial literacy are seen as having the potential to become important pillars in strengthening equitable and sustainable national economic growth.

2. RESEARCH METHODOLOGY

This research uses a quantitative approach with an associative research type. A quantitative approach is used to analyze the relationship and influence between variables. digital

marketing, sharia e-commerce, and sharia financial literacy on income Indonesian national development objectively and measurably. Associative research aims to explain the relationship between variables in a certain time period.

The type of data used is secondary data in the form of time series data (time series). series) during the period 2015–2024. Data was obtained from various official sources and trusted, such as the Central Statistics Agency (BPS) for Gross Domestic Product (GDP) data as national income indicators, Financial Services Authority (OJK) for sharia financial literacy data, Bank Indonesia (BI) for e-commerce transaction data, as well as ministry reports and publications related to the development of digital marketing and the Islamic digital economy in Indonesia.

The variables in this study consist of independent variables and dependent variables. The independent variables include: (1) Digital Marketing (Xÿ), (2) Sharia E-Commerce (Xÿ), and (3) Sharia Financial Literacy (Xÿ). The dependent variable is National Income (Y) which measured using Gross Domestic Product (GDP) at constant prices.

Operationally, digital marketing is measured through activity development indicators. digital economy or digital transaction value that reflects the intensity of digital-based marketing Internet. Sharia e-commerce is measured by transaction value or trade growth Sharia-based electronic financial literacy. Sharia financial literacy is measured based on the Sharia Financial Literacy Index. Islamic financial literacy published by the OJK. Meanwhile, national income is measured through GDP value as the main indicator of a country's economic growth.

Data analysis techniques are carried out through descriptive analysis to describe development of each variable during the research period. Next, an analysis was carried out quantitative using multiple linear regression models to determine the magnitude of the influence digital marketing variables, sharia e-commerce, and sharia financial literacy on income Indonesian national.

3. RESULTS AND DISCUSSION

Based on the results of the analysis of time series data for the period 2015–2024, the development of digital marketing, sharia e-commerce, and sharia financial literacy in Indonesia show a growing trend. increased. This increase is in line with the acceleration of digital transformation which is driving strengthening e-commerce activities and contributions to the national digital economy (BI, 2025; BPS, 2025). In the context of Islamic economics, digitalization also expands the development of halal ecosystem, especially in the aspects of marketing, financing, and strengthening halal-based businesses sharia (KNEKS, 2025; Pujianto & Muzdalifah, 2022). On the other hand, increasing financial literacy society shows

increasing readiness in understanding and utilizing financial services, including Islamic finance (Kaharuddin et al., 2024). Thus, the three These variables can be understood as part of Indonesia's digital economic transformation. increasingly inclusive and strategic. Descriptively, the development of information technology has driven change. marketing from conventional patterns to digital marketing, and the use of social media and Marketplaces are an important strategy for MSMEs to adapt to changes. consumer behavior and expanding the market (BI, 2025; Napu et al., 2025; Yusniar et al., 2024a). The increase in e-commerce activities and internet usage also shows a contribution positive impact on strengthening digital business activities and Indonesia's economic growth (BPS, 2025; Lubis et al., 2024; Situmorang & Prima, 2025). In addition, the digital economic transformation proven to have a positive impact on economic growth and national income, which reflected in the increasing digital consumption and its contribution to GDP (Alfikri & Riofita, 2025a; BPS, 2025).

Descriptively, the development of information technology has brought changes. significant in the world of marketing, which was previously conventional, has now transformed towards digital marketing. Utilizing social media and marketplaces is one strategy It is important for MSMEs to adapt to changes in consumer behavior and expanding market reach (Yusniar et al., 2024b). Increased e-commerce activity and The number of internet users shows a positive contribution to economic growth Indonesia, which is reflected in the increase in Gross Regional Domestic Product (GRDP) (Situmorang & Suci Rahmawati Prima, 2025). The results of the study show that the transformation The digital economy has a positive impact on economic growth and income national level, which is reflected in the increase in digital consumption and its contribution to the Product Gross Domestic Product (GDP) (Alfikri & Riofita, 2025b).

From an Islamic marketing perspective, digital marketing is understood as a strategy fulfilling consumer needs through halal products and services that are run on the basis of mutual agreement, honesty, and welfare, so that the orientation is not solely on profit, but also on achieving prosperity (falah) according to sharia values (Junusi, 2020) and can also be used as a medium for da'wah based on monotheistic values and principles honesty (sidq), trustworthiness, and justice (al-'adl), so that the business activities carried out do not not only profit-oriented, but also moral responsibility and welfare social, and economic sustainability. (MayaPutra & Yusrizal, 2025b). Transparency of information in digital marketing, which is realized through the delivery of product information clearly, accurately, and not misleading, plays a significant role in increasing consumer confidence in sellers in the marketplace, because this openness influences the perception of credibility and transaction security (JA et al., 2024). In the digital era, consumer trust is a crucial element fundamental to long-term business success because it plays a role in building loyalty, strengthen the relationship between customers and the company, and support sustainability sustainable business

transactions and interactions (Younis & Zeebaree, 2025). With This trust is the basis for creating a sustainable relationship between companies. and consumers in an e-commerce environment full of uncertainty (Sahabuddin et al., 2024b). Thus, the contribution of digital marketing to improving economic performance can be understood as the impact of creating market efficiency through the use of technology digital, which is also strengthened by the application of the principles of fairness and transparency in every communication processes and business transactions. (Putra & Doho, 2022b).

During the study period, digital transformation has driven significant growth. significant in the sharia e-commerce ecosystem, especially through the increasing number of platforms and the involvement of young Muslim consumers who are increasingly interested in internet-based services. sharia principles (Ridzki & Firmansah, 2025). Increasing consumer awareness of The importance of halal products and transactions that comply with sharia principles has become a driving force key in the rapid development of sharia-based e-commerce platforms, because consumers increasingly looking for e-commerce services that are not only convenient but also suitable Islamic values (Fauziah & Ardiansyah, 2025). The existence of sharia e-commerce provides easier access for Muslim consumers to obtain guaranteed products its halalness and ensuring that all transactions are carried out in accordance with Islamic economic principles, namely free from usury, gharar, and maysir, through the application of clear contracts and information and transparent (Sirjes et al., 2025).

The results of the study show that the application of e-commerce from an economic perspective Islam has a positive influence on increasing the income of business actors, which indirectly can directly contribute to national economic growth (Rifa'i et al., 2025a). E Sharia commerce plays a role in expanding market access for MSME products, which has an impact on increasing business income and community economic activities (Rifa'i et al., 2025a). The development of e-commerce within a sharia framework can support economic stability and community welfare through the application of sustainable Islamic business principles (Nur Latifah, Yuliatul Wahidah, & Al-Musaddadiyah Garut, 2024).

Meanwhile, Islamic financial literacy shows a positive influence on the level of financial inclusion and people's economic behavior, although the level is still lower compared to conventional financial literacy as mapped in the National Survey Financial Literacy and Inclusion (SNLIK) 2024 by the Financial Services Authority which recorded the index Islamic financial literacy is still below the national average, according to financial development report data. OJK also emphasized that increasing understanding of sharia products and services Islamic finance encourages more and more people to utilize financial products sharia and expanding the inclusion of this sector in the national economy (Progress Report Indonesian Islamic Finance). Research by (Arfiansyah, 2024) shows that Islamic financial literacy Islamic finance has a positive relationship with Islamic financial inclusion

in the environment Islamic boarding schools, increasing participation in sharia-based financial services and the ability personal and community financial management. In addition, studies in the context of MSMEs in Indonesia found the role of Islamic financial literacy and Islamic financial inclusion in support the financial performance of micro, small, and medium enterprises (Solikin et al., 2024). These findings together with the OJK report strengthen the argument that financial literacy Sharia literacy, although not as high as conventional literacy, has made a real contribution towards the use of Islamic financial services and has an impact on greater economic activities wide. (Rijal & Indrarini, 2022) proves that Islamic financial literacy has an influence significant impact on Islamic financial inclusion, which means the higher the level of understanding individuals towards sharia principles, contracts and products, the greater their tendency utilizing Islamic financial services.

This finding is supported by (Solikin et al., 2024) who shows that Islamic financial literacy and inclusion increase access to financing MSMEs, thereby encouraging productive business activities. (Antara et al., 2016) also emphasized that Islamic financial literacy supports participation in the halal ecosystem, including investment and sharia-based financing. More broadly, (Lusardi & Mitchell, 2014) explains that financial literacy contributes to more rational economic decision-making and productive, which in the long term will have an impact on increasing welfare and national economic growth.

Digital marketing has been proven to increase market reach and business performance so that driving revenue growth (Nuseir & Al Ain University of Science and Technology, 2018). The adoption of e-commerce also contributes significantly to increased productivity and MSME income in Indonesia (Judijanto & Mu'min, 2024). In the context of Islamic economics, Islamic financial literacy strengthens community participation in the halal ecosystem (Solikin et al., 2024) and encourage the use of sharia-based financial services (Antara et al., 2016; Rijal & Indrarini, 2022). At the macro level, strengthening the Islamic financial sector and increasing literacy Financial stability contributes to stability (Hassan & Aliyu, 2018) as well as economic growth national (Hassan & Aliyu, 2018; Lusardi & Mitchell, 2014). Thus, digital integration marketing, sharia e-commerce, and sharia financial literacy form an economic ecosystem digital that supports each other and contributes to increasing national income.

In the perspective of Islamic economics, economic growth is not only measured by increase in GDP, but from achieving prosperity (falah) and benefits according to maqasid al-shariah (Chapra, 2008). Quality growth must reflect justice, equitable distribution, and transparency (Dusuki & Bouheraoua, 2018) Islamic finance has been proven encourage inclusive and stable growth (Hassan & Aliyu, 2018), supported by instruments such as zakat which plays a role in income distribution at the micro and macro levels (Azam et al., 2014), as well as Islamic social finance that supports sustainable development (Rahmat et al., 2021). Therefore, the contribution of digital marketing and sharia e-commerce is not only assessed from transaction

volume, but also from its compliance with the principles of justice, blessings, and sustainability (Antara et al., 2016).

Sharia-based digital transformation contributes to growth and resilience Indonesian economy (Abdillah, 2024; Sakinah et al., 2022). Strengthening digital marketing improve business performance and competitiveness (Sudirjo et al., 2023), while digitalization of zakat, waqf and fintech expand access to financing and support economic development national (Alfian et al., 2025).

Its optimization requires increased literacy and sharia fintech (Rofik & Huda, 2025) as well as support for sharia industrial policies and infrastructure (Awaliah & Kasri, 2012; Irwandi & Arifin, 2026), so that it has the potential to become a pillar of equitable and sustainable growth. sustainable.

4. CONCLUSION & MANAGERIAL IMPLICATIONS

Based on the results of the discussion, it can be concluded that the development of digital marketing, e Sharia commerce and Sharia financial literacy in Indonesia during the 2015-2024 period shows a continuously increasing trend and plays an important role in supporting strengthening the national economy. Digital transformation has driven changes in marketing patterns from conventional to technology-based, expanding market reach, improving promotional efficiency, as well as strengthening e-commerce activities. In the context of economics Islam, these developments are not only relevant from the economic growth side, but also from the the aspect of implementing sharia values such as honesty, transparency, justice and welfare in digital business activities.

In addition, the growth of sharia e-commerce shows that digitalization can be strategic means to expand public access to appropriate products and transactions with the principles of halal, free from usury, gharar, and maysir. This development also opens up opportunities greater opportunities for MSMEs to increase revenue, expand markets, and strengthening its contribution to the national economy. On the other hand, Islamic financial literacy proven to be an important element in encouraging the use of Islamic financial services broader. Although the level of Islamic financial literacy is still lower than Islamic financial literacy conventional finance, increasing public understanding of products and principles Islamic finance makes a positive contribution to financial inclusion, business activities, and strengthening the national halal ecosystem.

Thus, the integration between digital marketing, sharia e-commerce, and financial literacy Sharia can be understood as an important foundation in building a digital economic ecosystem Sharia-based, inclusive, productive, and sustainable. From an Islamic economic perspective, The contribution of these three variables to national income is not only measured by

increasing economic output, but also from its ability to encourage the achievement of falah, equitable distribution, as well as fairer and more sustainable economic development.

The managerial implications of this study suggest that the government needs to strengthen Sharia-based digital economic development policy through infrastructure improvement digital, expanding internet access, regulatory support for sharia e-commerce, and strengthening integration between the digital sector and the Islamic financial sector. The government also needs encourage synergy between institutions, such as Bank Indonesia, the Financial Services Authority, the Central Agency Statistics, and the National Committee for Islamic Economics and Finance, so that economic development digital sharia is running more focused and has a broader impact on growth national economy.

For MSMEs and companies, the results of this study emphasize the importance of utilizing digital marketing more optimally, especially through social media, marketplaces, and strategies transparent communication in accordance with sharia principles. Business actors need to focus not only on on increasing sales, but also building consumer trust through delivering honest, accurate, and non-misleading information. In the context of sharia e-commerce, the perpetrators businesses also need to ensure that the business model, transaction mechanisms, and products offered in accordance with Islamic economic principles in order to increase loyalty Muslim consumers and strengthen business competitiveness in the digital market.

For Islamic financial institutions, this study shows the need for a more comprehensive education strategy. intensive efforts to improve public Islamic financial literacy. Islamic financial institutions need to develop socialization programs, digital education, and easier service innovations accessed, understood, and used by the wider community, including MSMEs. Increased This literacy is important so that people not only know about Islamic financial products in general conceptually, but also encouraged to utilize it in real terms in economic activities. daily life. With increasing literacy and inclusion of Islamic finance, financial institutions Sharia will have greater opportunities to expand market share while contributing on strengthening the national economy.

Overall, the managerial implications of this study emphasize that strengthening the economy digital sharia requires an integrated approach between public policy, business strategy, and financial education. Optimizing digital marketing, developing sharia e-commerce, and Increasing Islamic financial literacy must be carried out simultaneously in order to be able to create economic growth that is not only high quantitatively, but also high quality, inclusive, and in accordance with Islamic economic values. If you want, I can continue to make a shorter version ready to paste on paper, with a more formal journal style.

5. LIMITATIONS & FUTURE SCOPE

This research has limitations in the use of secondary data in the form of sequential data. time series over a ten-year period, namely from 2015 to 2024. Analysis focused specifically on the influence of three main independent variables, namely digital marketing, sharia e-commerce, and sharia financial literacy on proxied national income through Gross Domestic Product (GDP) at constant prices. The data source used limited to official publications from the Central Statistics Agency, Financial Services Authority, and Bank Indonesia, so the accuracy of the findings is highly dependent on the validity of the data released by these institutions. In addition, digital marketing measurements in this study were carried out through digital transaction value indicators or internet marketing intensity on a macro scale and not yet touching on campaign effectiveness at the micro level of the company.

Given these limitations, future research is expected to be able to broaden the scope of analysis by integrating other variables such as Islamic social finance which includes zakat, waqf, and the role of sharia fintech in supporting development sustainable. It is also important for future researchers to develop measurement models which is not only oriented towards GDP growth figures alone, but also includes achieving prosperity, blessings, and distribution justice in accordance with the principle of maqasid al-shariah. Use of more varied research methods, such as approaches qualitative or primary data through direct surveys of consumers and MSME actors, as well It is highly recommended to explore the ethical aspects of marketing and consumer trust thoroughly. more in-depth in the field. Thus, the integration between strengthening financial literacy sharia and optimization of the digital ecosystem can provide a more real contribution to national economic resilience based on Islamic values.

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ANALYSIS OF ISLAMIC DIGITAL SERVICE QUALITY, CUSTOMER TRUST AND SHARIA COMPLIANCE PERCEPTIONS ON THE LOYALTY OF SHARIA MOBILE BANKING SERVICE USERS

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Abstract

Significant changes in the digital world have transformed the way people use banking services. Now, Islamic banks are being urged to make mobile banking a front line service. This study aimed to examine how digital service quality, customer trust, and adherence to Sharia principles work together to build customer loyalty. The primary focus was to explore how advanced technology can align with religion values to create advantages not available at traditional banks. This study employed a descriptive qualitative method, exploring various literature and directly observing digital banking practices in Indonesia. This approach was chosen to understand the "spiritual" side of banking that is typically not reflected in statistics, such as the sense of peace (tumaninah) experienced during riba-free transactions. The data collected highlighted how customers perceive the professionalism (itqan) and convenience (taisir) offered by current Islamic banking applications. By examining real trends and expert opinions, this study presents a comprehensive picture of why customers remain loyal to conventional banks. The research results show that while sophisticated applications and robust security systems (hifdz al-maal) are mandatory, they alone are not enough to create truly loyal customers. True loyalty in Islamic banks stems from the bank's adherence to religious principles. Customers highly value a bank's honesty (siddiq and amanah) and its social commitment. When technology is appropriately combined with religious values, the customer-bank relationship transforms into a spirit of mutuality assistance (ta'awun). In conclusion, the future of Islamic banking lies in a balance between technological innovation and consistent Islamic ethics.

Keywords: Digital Service Quality, Customer Trust, Sharia Compliance, Customer Loyalty, Islamic Mobile Banking

INTRODUCTION

Digital transformation has changed the face of banking globally, not except for Islamic banks in Indonesia which are now starting to actively switch to Islamic services application-based to meet customer needs. This change is not just following the flow of technology, but rather a real form of implementing the principles convenience (Taisir) in Islamic economics. Services such as mobile banking and QRIS is here as a solution to make financial access more practical and inclusive. for everyone, especially young people or generation Z (Alvira, Iqbal, and Satriawan 2025). Currently, the quality of digital services (e-service quality) is becoming a reflection of the professionalism (itqan) of a sharia bank. Stable application, informative, and has many features like BSI Mobile or Muamalat DIN proven is the main reason why customers feel satisfied (Fahira and Mustamin 2025) (SARI) 2023). However, Islamic banks face a major challenge in continuing to maintain This service standard is so that customers do not turn to conventional banks or other financial platforms (Widyawaty and Widyaningsih 2024)(Dewa and Safitri 2020).

Islamic banks require that every technological innovation remains within corridor of religious rules or sharia compliance . For the community Muslims, data security and balance protection are not just technical matters. to prevent hacking, but rather a form of institutional trust in safeguarding assets customer's property according to the principles of Maqasid Syariah (Amzah, Fitri, and Lubis) 2024)(Mahmud 2022).

Customer trust grows when banks act honestly. (Siddiq) and trustworthy (Amanah), which can be seen from the openness regarding costs transactions and personal data protection (FA Nasution and Indra 2022)(Muis et al. 2021). Customer confidence that the bank truly stays away from usury practices or Flowers have a strong emotional appeal. They feel calmer when ensure that every digital feature used has been monitored and approved by the Board Sharia Supervisor (Ibrahim and Rachmawati 2020)(Sani and Firdaus 2024)(Sarah and Firman 2024). Building customer loyalty in this digital era involves many aspects, ranging from technical matters, psychological matters, to religious values. Loyalty This can be seen when customers are reluctant to change banks and instead invite other people. to participate in using the service voluntarily (word of mouth) as form of mutual assistance or Ta'awun (Azizah, Adha, and Wahyudi 2024)(Safitri and Widyastuti 2023).

Although the sophistication of the system is very influential, the inner satisfaction that based on spiritual values remains the main differentiating factor (Astuti, Agriyanto, and Turmudzi 2020)(Ismulyaty and Roni 2022). On that basis, This research aims to explore more deeply how digital services influence Islam, trust, and sharia compliance on mobile user loyalty Islamic banking . This is crucial for developing a digital banking strategy. which is not only

technologically advanced, but also solid in principle religion (Sholekhah, Abshor, and Guntoro 2025) (Purnama 2024).

1. LITERATURE REVIEW

The presence of digital services in Islamic banking today is no longer limited to... technological changes, but more about how Islamic values such as Customers can directly feel the security and ease of transactions through Mobile Banking or QRIS. Reliable, transparent, and high-quality digital services maintaining halal principles is the main reason why customers feel satisfied and increasingly confident in the identity of the Islamic bank (Alvira, Iqbal, and Satriawan 2025). In addition, a digital system that is capable of preventing cybercrime and protecting personal data will automatically build trust the strong one. This sense of trust is what binds the bank's image to its intentions customers to continue subscribing in the long term, especially if supported by competent staff and good customer understanding of finance digital (Ahmad, Siswadhi, and Sarmigi 2022)(Muis et al. 2021).

On the other hand, customer loyalty or loyalty in using Mobile Sharia banking is very dependent on their views on implementation Sharia compliance . Customers will usually remain loyal if feel that the bank truly adheres to the principles of justice, avoids usury practices, and managed honestly and openly (Ibrahim and Rachmawati 2020) (Sani and Firdaus 2024). The experience of using the application is smooth, coupled with satisfaction inner because they feel the transaction is in accordance with Islamic law, creating an emotional bond which makes it difficult for customers to move to another bank even though there are many attractive offers from conventional banks (Safitri and Widyastuti 2023)(Sudirman, Imran, and Prayoga 2024). In short, the combination of advanced technology, high sense of trust and consistency in religious rules are the main keys to maintain customer loyalty in this digital era.

2. RESEARCH METHODOLOGY

This research uses a qualitative descriptive approach. qualitative research was chosen to gain in-depth understanding understanding) regarding the role of digital service quality, trust, and other aspects Sharia compliance in building customer loyalty. The main focus is describe holistically (comprehensively) how real experiences are customers in using Islamic mobile banking , obstacles faced in digital transactions, as well as the bank's efforts to maintain Islamic principles so that they remain relevant in the eyes of the user.

3. RESULTS AND DISCUSSION

The results we present and the official banking literature we collected, it is clear that Islamic banks play a crucial role in managing the digital economic ecosystem. The annual report shows that The use of mobile banking features continues to increase rapidly every year.

Service management in Islamic banks is not only about providing technology that sophisticated, but also ensures that strict sharia supervision remains in place. This it is very important that bank operations remain aligned with the larger objectives the welfare of the people. Therefore, a strong strategy is needed to improve the quality of digital services so that customer loyalty reaches a point maximum, for example through transparency of contracts, Islamic financial education campaigns in various media, to direct interaction with potential communities become loyal customers (Fahira and Mustamin 2025).

If we refer to the principles of muamalah in Islamic economic literature, the aim Islamic banking digital services can be divided into two large parts: a) Providing efficiency and ease of transactions (Taisir); and b) Guaranteeing security and protection of customer assets (Hifdz al-Maal) (Satyadarma & Syamsudin 2023). In Islamic economics, service quality is seen as a form of itqan or professionalism. This means that banks are not just application providers, but also a party that carries out the mandate to serve the financial needs of the community honestly. In an effort to build loyalty, the main focus is fulfill technical satisfaction while providing spiritual peace for customers (Widyawaty and Widyaningsih 2024).

3.1. Effectiveness of Digital Services and the Principle of Convenience (Taisir)

In the modern banking world, technology has become the main face services that must reflect high professionalism (itqan). Findings shows that the quality of digital services on platforms such as BSI Mobile or Muamalat DIN is very important in determining whether customers will be satisfied and loyal (Fahira and Mustamin 2025)(Satyadarma and Syamsudin 2023). Customers want an application that is not only practical, but also provides spiritual peace through features that support worship (Widyawaty and Widyaningsih 2024)(SARI 2023). This is in line with the Taisir principle in Islam (QS. Al-Baqarah: 185) which emphasizes convenience for the people. Fast, accurate, and infrequent service experiencing technical problems creates a sense of inner satisfaction for customers (Dewa and Safitri 2020)(Setiagraha, Sakti, and Batin 2023)(Batin 2020). The use of QRIS and m-banking among the younger generation is also proven expanding the reach of Islamic finance while accelerating daily transactions day (Alvira, Iqbal, and Satriawan 2025)(Maryamah, Widowati, and Fajria 2023)(Rusliani and Notaria 2025).

3.2. Transaction Security as a Form of Asset Protection (Hifdz al-Maal)

Security is the main foundation in banking, especially in services digital technology that is prone to cybercrime . From an economic perspective Sharia, protecting customer funds is a real form of Maqasid Syariah, namely safeguarding assets (Hifdz al-Maal). The results of the analysis show that customers feel very satisfied when the bank provides data protection guarantees and a double security system transparent (Amzah, Fitri, and Lubis 2024)(Mahmud 2022). Security is not just a technical matter, but a matter of maintaining the trust of the

institution. regarding the customer's property rights, in accordance with the hadith of the Prophet SAW regarding the obligation to safeguard trust (HR. Abu Dawud). Customers who feel their money is safe tend to have a stronger emotional bond with the bank (Wiguna and Aerospace 2023) (Nafisa and Sukresna 2018). Bank efforts to prevent risks This digital technology further strengthens customer perception that Islamic banks are indeed superior in maintaining security integrity (Setiagraha, Sakti, and Batin 2023)(Amzah, Fitri, and Lubis 2024).

3.3. Institutional Integrity Through the Characteristics of Siddiq and Amanah

Customer trust does not arise instantly, but rather from consistency. a bank that reflects the prophetic qualities, namely Siddiq (honest) and Amanah (trusted). Qualitatively, it was found that customers really appreciate transparency regarding admin fees and clarity of profit sharing in the application (FA Nasution) and Indra 2022) (Muis et al. 2021). Dishonest information in digital services considered to damage Islamic business ethics and could destroy the bank's image in in an instant (Andespa et al. 2023)(Arfianti 2014). The bank's honesty in presenting Correct data becomes an emotional bridge that binds customer loyalty (Mandiri and Metekohy 2021) (Utami, Handayani, and Pusporini 2019) (Sari and Aprianti 2020). In addition, competent staff in serving also participate strengthening customer confidence in bank stability (Rahmawati et al. 2022)(Setiawan, Minarsih, and Fathoni 2016) (Wijaya and Wismantoro 2017) (Tumbuan, Kawet, and Pontoh 2014).

3.4. Spiritual Differences Through Sharia Compliance

The main thing that differentiates Islamic banks from conventional banks is guarantee that all digital operations are free from usury, gambling (maysir), and ambiguity (gharar). Sharia compliance becomes a very spiritual attraction strong for Muslim customers (Ibrahim and Rachmawati 2020)(Sani and Firdaus 2024).

This analysis reveals that customers feel inner peace when using Islamic m-banking because we are sure that every feature is supervised by the Supervisory Board Sharia (DPS) (Sarah and Firman 2024)(Yusra and Nurnarsrina 2024)(Sholekhah, Abshor, and Guntoro 2025).

Loyalty based on religious obedience (QS. Al-Baqarah: 275) has proven to be far more effective. more solid than loyalty due to material bonuses alone (Oktaviani and Rachmawati 2019)(Prastiwi 2018). Gratitude and blessings in transactions It is a personal satisfaction that makes customers proud to use bank products. Sharia (Alfionita, Ramadhan, and Fahrudin 2025)(Rizal 2025)(Sanjaya 2025). The principle of fairness also ensures that customers do not feel disadvantaged by fees. hidden(Rahayu and Suaidah 2022)(Effendi, Nabila, and Izza 2022)(Hutapea, Manurung, and Sihotang 2023).

3.5. Loyalty as a Form of Mutual Assistance (Ta'awun)

At the highest level, the loyalty of Islamic bank customers changes into Ta'awun relationship or helping each other in goodness (QS. Al-Ma'idah: 2). Customers no longer see themselves as ordinary consumers, but as supporters of the rise of Islamic economics (Azizah, Adha, and Wahyudi 2024)(Safitri and Widyastuti 2023). They voluntarily recommend banking services sharia to other people through positive testimonials or word of mouth (Triyanti, Kaban, and Iqbal 2021)(Sudirman, Imran, and Prayoga 2024). This finding emphasized that when banks provide great digital services but still compliant with sharia, customers will repay with long-term loyalty (Ismulyaty and Roni 2022)(Rahmansyah, Marliyah, and Atika 2024)(Purnama 2024). A comfortable user experience in the app strengthens the bond this emotional (Syahira, Indra, and Anggraini 2024)(Hafizh, Rahma, and Jannah 2023)(Wahyuningsih 2023). Finally, the synergy between technology, trust, and religiosity creates a fortress of loyalty that is difficult to penetrate by the temptations of banks others (RAV Nasution 2024)(Martasari and Mardian 2015)(Santalia, Adha, and Adi 2024).

4. CONCLUSION

Based on the analysis that has been carried out, it can be concluded that Customer loyalty to sharia mobile banking services is influenced by synergy between the quality of technology and the application of religious values. The quality of digital services Islam that reflects professionalism (itqan) and convenience (taisir) is a basic requirement for customer satisfaction. In addition, customer trust which is built through institutional integrity (siddiq and amanah) and guarantees security of assets (hifdz al-maal) is a crucial foundation in mitigating risks in digital era.

The key differentiator that strengthens customer loyalty is perception. Sharia compliance . Customers are not only looking for profit material or technical convenience, but also spiritual peace through blessed and usury-free transactions. When Islamic banks are able integrating advanced technology with adherence to sharia principles transparent, then customer loyalty will be transformed into a relationship ta'awun (mutual assistance). Thus, Islamic banks must continue to innovate in optimizing digital services without abandoning Islamic ethical values in order to maintain the economic sustainability of the people in the future.

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ARTIFICIAL INTELLIGENCE GOVERNANCE IN SHARIAH AUDIT: A SYSTEMATIC LITERATURE REVIEW ON RISKS, CONTROLS, AND ETHICAL BOUNDARIES

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Abstract

This study examines the governance of Artificial Intelligence (AI) in Sharia auditing through a Systematic Literature Review (SLR) approach, focusing on three key dimensions: risks, control mechanisms, and ethical boundaries. The rapid advancement of AI has significantly transformed audit practices from traditional rule-based systems into dynamic, data-driven environments. While AI improves audit efficiency, accuracy, and real-time risk detection, it also introduces new challenges such as algorithmic bias, lack of transparency (black-box problems), and data security vulnerabilities. The findings reveal that existing Sharia audit frameworks remain insufficient to address the complexity of AI-based systems due to limited technological adaptation, lack of standardized governance models, and gaps in auditor competencies. Furthermore, AI governance in Islamic financial institutions is still fragmented and lacks global standardization. The study highlights the critical role of internal control systems, Sharia Supervisory Boards (SSB), and ethical frameworks in ensuring accountability and Sharia compliance. Importantly, this research emphasizes the need to integrate maqÿÿid al-sharÿ'ah into AI governance, shifting from a technology-driven approach toward a value-driven framework that prioritizes justice, transparency, and public interest. The study contributes by proposing an integrative conceptual framework that combines AI governance principles with Islamic ethical values, providing both theoretical and practical insights for regulators, auditors, and Islamic financial institutions.

Keywords: Artificial Intelligence, Sharia Audit, AI Governance, Risk, Internal Control, Ethics, Maqÿÿid al-Sharÿ'ah

INTRODUCTION

The rapid development of Artificial Intelligence (AI) over the past decade has driven fundamental transformations in the global financial sector, including in audit functions and institutional governance. AI-based technologies, such as machine learning and data analytics, enable automation of audit processes, increased analytical accuracy, and predictive capabilities in detecting risks and anomalies in real time. In this context, AI plays a role not only as a technical tool but also as a strategic enabler in improving the quality of decision-making and the effectiveness of oversight (M. Ali et al., 2024; Kismawadi, 2025). This transformation becomes increasingly relevant in a complex and digitalized financial environment, where the volume and velocity of data exceeds traditional audit capabilities.

In the Islamic finance sector, the application of AI has a more complex dimension because audits focus not only on the fairness of financial reports but also on compliance with Islamic principles. Islamic audits require verification of the conformity of financial activities with the values of the maqÿÿid al-sharÿ'ah, applicable fatwas, and supervision by the Islamic Supervisory Board (Zahra & Khoirunnisa, 2025). Therefore, the integration of AI in Islamic audits is not only related to operational efficiency but also concerns religious and ethical legitimacy. In practice, this complexity is increasing with the development of digital financial products, such as Islamic fintech and technology-based instruments, which demand a more adaptive, responsive, and technology-based audit approach.

Nevertheless, various studies show that current sharia audit practices still face significant structural challenges. Limited auditor competency in understanding digital technology, the ever evolving complexity of regulations, and the low level of technology integration in the audit process are key obstacles to improving the quality of sharia audits. (Andriani et al., 2025; Faza' et al., 2024). On the other hand, the development of fintech and digitalization has increased risk exposure, including operational, compliance, and technological risks, which can no longer be effectively addressed through conventional audit approaches. This situation highlights the urgent need to adopt technologies such as AI to improve the effectiveness and efficiency of sharia audits.

In line with this, the literature has begun to highlight the potential of AI in improving the quality of sharia audits, particularly in terms of risk management, fraud detection, and strengthening compliance with sharia principles (Isnani & Rifai, 2024; Maman & Susila, 2025). Furthermore, research also emphasizes the importance of an adequate governance framework for integrating AI into the sharia financial system, particularly in addressing challenges regulation, transparency, and accountability (BS Nugroho & Al-Giffari, 2026; TP Nugroho, 2024). In this context, the concept of AI governance becomes crucial, as it serves

as a mechanism to regulate the use of AI to align with organizational goals, ethical principles, and applicable regulatory frameworks.

However, despite the growing attention paid to the use of AI, studies on AI governance in Sharia auditing remain relatively limited and underdeveloped. Most research focuses on the application of AI in Islamic finance in general, without specifically linking it to the audit function and its underlying governance mechanisms. Furthermore, existing studies tend to address the implications of AI in a fragmented manner, focusing solely on technical or compliance aspects, without integrating the dimensions of risk, internal control, and ethical constraints within a comprehensive analytical framework.

Furthermore, studies on sharia governance have developed through bibliometric and conceptual approaches (Quttainah & BenSaid, 2025; Tumewang, 2025), but have not explicitly examined the integration of AI into such governance frameworks. Yet, the implementation of AI brings significant new implications, such as the risk of algorithmic bias, a lack of transparency in the decision-making process (black-box problem), and potential violations of sharia ethical principles (Umam, 2026). Furthermore, issues related to internal control in an AI-based environment remain poorly defined in the context of sharia audits, even though control frameworks such as COSO have been widely implemented in conventional audits (Harb et al., 2025). This indicates a gap between technological developments and the readiness of governance frameworks in sharia audits.

From an academic perspective, relevant literature remains scattered across various disciplines, such as auditing, Islamic finance, fintech, and organizational governance, resulting in significant fragmentation of knowledge. To date, there are limited studies using a systematic literature review (SLR) approach to systematically integrate these various perspectives. Consequently, a comprehensive synthesis capable of providing a comprehensive understanding of how AI governance can be effectively applied in Islamic auditing is lacking.

Furthermore, although several studies have linked technological developments to the principles of maqÿÿid al sharÿ'ah, the integration of these values into the design of AI governance in sharia auditing remains underdeveloped. Yet, principles such as justice ('adl), transparency (ÿidq), and benefit (maÿlaÿah) are crucial in ensuring that the use of AI is not only technically efficient but also compliant with fundamental sharia values.

The absence of a conceptual framework that integrates AI governance with maqÿÿid al-sharÿ'ah indicates a significant research opportunity to develop a more holistic and contextual governance model.

Based on these gaps, this study aims to conduct a systematic literature review (SLR) to comprehensively examine the role of AI governance in sharia audits, focusing on three main

dimensions: risks, controls, and ethical boundaries. This study is expected to provide theoretical contributions in developing an integrative conceptual framework that combines modern AI governance principles with the values of maqÿÿid al-sharÿ'ah, as well as provide practical contributions for regulators, auditors, and Islamic financial institutions in designing AI-based audit systems that are accountable, transparent, and compliant with sharia principles.

1. RESEARCH METHODOLOGY

This study uses a Systematic Literature Review (SLR) approach to comprehensively identify, evaluate, and synthesize existing scholarly work related to Artificial Intelligence (AI) governance in sharia auditing, with a particular focus on risks, controls, and ethical boundaries. The SLR method was chosen for its ability to provide a comprehensive synthesis transparent, systematic, and replicable to the fragmented body of knowledge across various interdisciplinary domains, particularly in emerging research areas such as AI and Islamic finance. This research follows established SLR guidelines, including the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), which are widely recognized for enhancing methodological transparency and reliability of literature-based research (Amosh et al., 2022; Batool et al., 2025; Ismail & Ahmad, 2025).

The review process is conducted through three main stages: planning, implementation, and reporting. In the planning stage, the research scope and objectives are clearly defined, with a focus on the relationship between AI governance and sharia auditing. In the implementation stage, a systematic search, screening, and selection of relevant studies are conducted. The reporting stage involves synthesizing the findings and presenting them in a structured and analytical manner. This structured approach ensures consistency and repeatability of the review process (Darmawati et al., 2025). To guide the review process, several research questions were formulated. These questions include: (1) how is AI governance conceptualized and applied in sharia auditing; (2) what types of risks are associated with the implementation of AI in sharia auditing practices; (3) what control mechanisms are proposed or implemented to mitigate these risks; (4) what ethical challenges arise from the use of AI in sharia auditing; and (5) how are Islamic principles, particularly the maqÿÿid al sharÿ'ah, integrated into the AI governance framework. These questions serve as the basis for the analysis in identifying key themes and patterns in the literature.

A literature search was conducted through various reputable academic databases, including Scopus, Web of Science, Google Scholar, SpringerLink, and Emerald Insight, to ensure comprehensive coverage of high-quality publications. A structured search string was developed using Boolean operators to capture relevant studies, namely: ("artificial intelligence" OR AI OR “machine learning”) AND (“sharia audit” OR “islamic audit” OR

"shariah auditing") AND (governance OR regulation OR framework) AND (risk OR control OR ethics OR compliance). This search strategy was designed to balance sensitivity and specificity, so that the articles obtained were relevant and broad enough in scope (Darmawati et al., 2025).

To ensure the quality and relevance of the selected studies, clear inclusion and exclusion criteria were applied. The inclusion criteria required that the articles be peer-reviewed journal publications. or conference proceedings indexed in reputable databases (e.g., Scopus), published between 2015 and 2026, written in English, and directly related to AI, auditing, governance, or Islamic finance. Studies were excluded if they were non-academic publications, duplicates, lacked methodological rigor, or were irrelevant to the research focus. This selection process enhances the validity and reliability of the findings (Batool et al., 2025).

The study selection process followed the PRISMA framework, which consists of four stages: identification, screening, eligibility, and inclusion. In the identification stage, articles were collected from selected databases using predetermined keywords. In the screening stage, titles and abstracts were reviewed to eliminate irrelevant studies. The eligibility stage involved assessing the full text of the remaining articles to ensure their suitability for the research objectives. The inclusion stage resulted in a final set of studies that served as the basis for the analysis. The use of PRISMA enhances transparency and reduces selection bias in systematic reviews (Ismail & Ahmad, 2025).

Data extraction was conducted using a structured data extraction form to systematically capture essential information from each selected study. The extracted data included author(s), year of publication, research objectives, methodology, key findings, and contributions related to AI governance in Sharia auditing. Following data extraction, a thematic analysis approach was used to identify recurring patterns, themes, and relationships within the literature. The analysis focused on grouping findings into three main dimensions: risk, control mechanisms, and ethical considerations. This approach allows for a deeper understanding of the complexities of AI governance in sharia auditing (Batool et al., 2025).

Finally, a qualitative synthesis approach was used to synthesize the findings, integrating insights from various studies to generate a comprehensive and coherent understanding of this research area. The findings were systematically organized into thematic categories, enabling the development of an integrative conceptual framework linking AI governance principles to Sharia audit practices. To ensure the robustness of the findings, several validity measures were implemented, including the use of multiple databases, transparent selection criteria, and cross-verification of sources. These measures are essential to minimize bias and enhance the research's credibility and reliability (Darmawati et al., 2025).

2. RESULTS FINDINGS

2.1. Theme 1: Risk Transformation in Sharia Audit Driven by Artificial Intelligence (AI)

Literature findings indicate that the implementation of Artificial Intelligence (AI) in sharia auditing has fundamentally transformed the risk landscape, from one that was previously static and rules-based to one that is more complex, dynamic, and data-driven. In traditional audit environments, risks are generally related to human error, sampling limitations, and weaknesses in internal control systems. However, with the adoption of AI, new risk categories have emerged, such as algorithmic bias, model inaccuracy (model risk), lack of algorithm transparency (black-box problem), and vulnerability to data security breaches (Kismawadi, 2025; Maman & Susila, 2025). Furthermore, AI enables auditors to perform real-time data analysis and detect anomalies more accurately, significantly improving audit effectiveness. However, this capability also creates a high reliance on algorithmic systems, increasing the risk of systemic errors that are difficult to detect manually. In the context of sharia audits, this risk becomes even more complex because it must consider the dimension of compliance with sharia principles, which cannot always be directly translated into algorithmic logic (Isnani & Rifai, 2024).

Table 1. Summary of Key Studies on Artificial Intelligence (AI)-Based Risks in Audit Sharia

Author	Title and Year	Country	Objective	Methodology	Findings	Journal
Kismawa in (2025)	Artificial Intelligence in Finance Islam (2025)	Indonesia	To examine the role AI in finance Islam includes audit	Conceptual study	AI improve risk detection but also introduce new risks such as model uncertainty and dependence on data	IGI Global
Mom & Susila (2025)	AI and Machine Learning in Transformation the Industry Finance (2025)	Indonesia	To compare AI adoption in conventional and sharia fintech	Analysis comparative	AI increases efficiency but also creates cybersecurity risks and algorithmic risks	Journal of Finance and Islamic Banking
Isnani & Rifai (2024)	Evaluation Compliance Sharia on Product AI-Based (2024)	Indonesia	Indonesia | To assess sharia compliance of AI-based financial products	Normative legal analysis	AI output may not be fully aligned with Sharia principles due to lack of ethical interpretability.	Pen Justisia

Author	Title and Year	Country	Objective	Methodology	Findings	Journal
Ali et al. (2024)	AI in Finance: Application for Finance Islam (2024)	Global	For explore application of AI in global finance and finance Islam	Literature review	AI introducing systemic and operational risks that require a governance framework	Springer
Faza' et al. (2024)	Factor Determinant Effectiveness Audit Compliance Sharia (2024)	Palestine	To identify the factors which influences the effectiveness of sharia audits	Conceptual analysis	Weak audit systems struggle to adapt to evolving technology risks.	Journal of Money Launderi ng Control

Based on the literature synthesis in the Table above, there are several main patterns that show the risk transformation due to the implementation of AI in sharia audits. First, there is a shift from traditional risk-based auditing to data-driven risk environments. Studies (M. Ali et al., 2024; Kismawadi, 2025) show that AI enables more comprehensive risk analysis, but at the same time introduces new technical and systemic risks. This suggests that risks in sharia auditing are no longer solely related to reporting errors, but also encompass the validity of algorithmic models. Second, the emergence of algorithmic risk and ethical risk has become a central issue in AI-based sharia audits. (Isnani & Rifai, 2024) emphasized that AI-based decision-making results do not necessarily reflect sharia values in their entirety, primarily because algorithms lack the capability to to understand normative contexts such as maqÿÿid al-sharÿ'ah. This creates a gap between technological efficiency and sharia compliance. Third, the literature also indicates increasing cybersecurity risks and data governance challenges, as identified by (Maman & Susila, 2025). In AI-based systems, audit quality is highly dependent on data integrity, making the risk of data leakage and manipulation crucial. This requires a more robust control system than in conventional audits. Fourth, a study (Faza' et al., 2024) showed that the current sharia audit system is still not ready to manage the complexity of AI-based risks. This indicates a gap between technological developments and the readiness of sharia audit institutions, both in terms of regulations, auditor competency, and infrastructure.

Based on these findings, this study offers several significant novel contributions:

1. Reconceptualization of risk in AI-based sharia audits, from previously operational in nature become multidimensional (technical, ethical, and sharia).
2. Integration of the AI risk perspective with the principles of maqÿÿid al-sharÿ'ah, which has not been widely studied in previous literature.

3. Development of a comprehensive risk analysis framework, which combines aspects of algorithmic risk, Sharia compliance risk, and governance risk in one integrated model.
4. Provide a conceptual basis for the development of an AI governance framework in audits. Sharia that is more adaptive to technological developments.

Thus, this research not only enriches the literature related to AI and sharia auditing, but also provides strategic direction for the development of more relevant sharia auditing practices in the digital era.

2.2. Theme 2: Limitations of the Existing Sharia Audit Framework in Facing Artificial Intelligence Intelligence (AI)

Literature findings indicate that the current sharia audit framework is not yet fully capable of accommodating the complexity and dynamics of Artificial Intelligence (AI) technology. Traditionally, sharia audits are designed to ensure compliance with sharia principles through a rules -based approach, fatwas, and oversight by the Sharia Supervisory Board. However, this approach faces significant limitations when confronted with AI-based systems that are adaptive, dynamic, and driven by big data. Several studies have revealed that the main limitations lie in the lack of specific audit standards for AI technology, low auditor competency in understanding algorithm-based systems, and slow institutional adaptation to digital innovation (Andriani et al., 2025; Faza' et al., 2024). Furthermore, (Ahyani, 2021) emphasized that digital transformation in the Islamic finance sector has not been accompanied by comprehensive reforms in the Islamic audit system, creating a gap between existing audit practices and current technological needs. This situation indicates that the Islamic audit framework remains reactive, rather than proactive, in responding to AI developments.

Table 2. Limitations of the Sharia Audit Framework in Facing Artificial Intelligence (AI)

Author	Title and Year	Country	Objective	Methodology	Findings	Journal
Faza' et al. (2024)	Factor Determinant Effectiveness Audit Compliance Sharia (2024)	Palestine	To analyze factors which influences the effectiveness of sharia audits	Conceptual and theoretical analysis	Lack of framework standardized and technology integration limit audit effectiveness	Journal of Money Laundering Control
Andriani et al. (2025)	Challenge Audit Compliance Sharia in Banking Islam (2025)	Indonesia	Indonesia To examine the challenges of sharia auditing in the fintech era	Qualitative analysis	Limited auditor competency and weak technology adaptation hamper audit quality	Best Journal of Administration and Management

Author	Title and Year	Country	Objective	Methodology	Findings	Journal
Ahyani (2021)	Sharia Audit vs. Sharia Accounting in the Industry 4.0 Era (2021)	Indonesia	To compare n audit and accounting practices in the digital era	Conceptual study	Digital transformation is not balanced with audit system reform	Economics Journal
Tumewang et al. (2025)	Extended Review on Sharia Governance (2025)	Global	To review development of Sharia governance literature	Bibliometric review	Governance frameworks remain fragmented and lack technology integration	Journal of Islamic Accounting and Business Research
Quttainah & BenSaid (2025)	Tata Manage Sharia and Performance Finance (2025)	Global	To analyze the relationship between the rules management and performance	Bibliometric analysis	The lack of unified governance standards limits the effectiveness of institutions.	Journal of Islamic Accounting and Business Research

Based on the literature synthesis in the table above, there are several critical issues that reflect the limitations of the sharia audit framework in responding to AI developments. First, there is a lack of structured and integrated AI-based audit standards. (Faza' et al., 2024) show that sharia audits still rely on conventional approaches not designed to evaluate algorithmic systems. This makes it difficult for auditors to assess the validity and reliability of AI systems, especially black-box systems. Without specific standards, the audit process becomes inconsistent and potentially poses a risk of misinterpretation. Second, auditors' limited competence in understanding AI technology is a major obstacle. (Andriani et al., 2025) emphasized that many sharia auditors lack sufficient technical expertise to evaluate AI-based systems. This creates dependence on third parties or the systems themselves, which can ultimately compromise audit independence and quality. Third, there is a gap between digital transformation and audit system reform. (Ahyani, 2021) shows that although the Islamic financial sector has adopted digital technology, the audit systems that support it have not undergone significant changes. As a result, Islamic auditing has become less relevant in addressing the complexities of AI-based digital transactions. Fourth, the literature also shows the existence of fragmentation in the sharia governance framework. Studies (Tumewang, 2025) and (Quttainah & BenSaid, 2025) reveal that governance in Islamic finance is still developing separately from technological innovation. This results in the lack of global standards that can serve as a reference for integrating AI into Islamic audits.

Based on these findings, this study provides several significant novel contributions:

1. Systematically identify the structural limitations of sharia audit in dealing with AI technology, which were previously only discussed partially.
2. Offers an integrative perspective between audit, technology, and governance, which connects competency limitations, standards, and regulations in one analytical framework.
3. Propose the need for the development of an AI-based Sharia audit framework, which is adaptive, risk-based, and in line with sharia principles.
4. Provide a conceptual basis for reforming sharia auditing towards a more transparent approach. proactive and technology-driven.

Thus, this research contributes to bridging the gap between traditional sharia audit practices and modern technological demands, as well as providing strategic direction for the development of AI-based sharia audit systems in the future.

2.3. Theme 3: Emerging Artificial Intelligence Governance Mechanisms in Institutions Islamic Finance

The literature shows that the development of Artificial Intelligence (AI) in the Islamic financial sector has driven the emergence of various emerging AI governance mechanisms, although they are still in their early stages of development. Unlike conventional systems, AI governance in the Islamic context is not only oriented towards efficiency and regulatory compliance but must also ensure compliance with Islamic principles such as justice ('adl), transparency (ÿidq), and the benefit (maÿlaÿah). A number of studies confirm that the institutionalization of AI in Islamic finance requires a strong governance framework, including formal regulations, supervisory mechanisms, and integration of sharia values into technology design. (BS Nugroho & Al-Giffari, 2026) show that without clear regulatory support, AI implementation has the potential to create legal uncertainty and compliance risks. Furthermore, (Purnama et al., 2025) emphasize the importance of harmonizing fatwas, state regulations, and supervisory systems to ensure that technological innovation remains within sharia. However, in general, the literature indicates that the AI governance framework in sharia auditing remains fragmented, unstandardized, and lacks a comprehensive implementation model.

Table 3. Emerging Artificial Intelligence Governance Mechanisms in Institutions Islamic Finance

Writer	Title and Year	Country	Objective	Methodology	Findings	Journal
Nugroho & Al Giffari (2026)	Institutional analysis the Intelligence Made in Architecture Zakat in Indonesia (2026)	Indonesia	To analyze institutional analysis the intelligence made in Islamic economic system	Normative and regulatory analysis	Implementation the artificial intelligence need strong regulatory framework and governance structure	Journal Law Economy Islam Indonesia
Purnama et al. (2025)	From Fatwa to Compliance in Fintech Sharia (2025)	Indonesia	For designing a sharia fintech governance framework	Conceptual framework	Integration of fatwas, regulations, and supervision is very important for governance	Journal Mu'amalah
Tumewang et al. (2025)	Review Continued Study Governance Sharia (2025)	Global	For reviewing the development of sharia governance	Bibliometric analysis	Governance framework continues to grow However still not well integrated with developing technologies	Journal of Islamic Accounting and Business Research
Quttainah & BenSaid (2025)	Governance Sharia and Performance Finance (2025)	Global	To analyze the relationship between the rules management and performance	Bibliometric study	Lack of framework standards governance between institution	Journal of Islamic Accounting and Business Research
Umam (2026)	Al-Hisbah in Economics Modern Islam (2026)	Indonesia	To explore i supervision Islam in the digital era	Conceptual analysis	The concept of traditional Islamic governance can be a guideline in the mechanism artificial intelligence surveillance	Journal Economy and Economy Sharia (JESYA)

Based on the literature synthesis in the table above, several important developments in AI governance mechanisms in Islamic finance can be identified.

First, there is a shift toward regulatory-driven AI governance, where regulation plays a dominant role in guiding technology implementation. (BS Nugroho & Al-Giffari, 2026) emphasize that without a clear regulatory framework, AI adoption has the potential to create legal risks and uncertainty regarding Sharia compliance. This demonstrates that AI governance cannot be separated from the role of regulatory authorities in building an accountable and transparent system.

Second, there is a need for integrated multi-layered governance, encompassing fatwas, formal regulations, and internal oversight mechanisms. (Purnama et al., 2025) emphasize that AI governance in Islamic finance must be holistic, combining religious authorities and state

institutions within a single, coordinated system. This approach is a key distinction from governance in conventional systems, which focus solely on regulatory aspects.

Third, the literature shows that existing governance frameworks remain fragmented and not yet globally standardized. Studies (Tumewang, 2025) and (Quttainah & BenSaid, 2025) reveal that although the concept of sharia governance has evolved, its integration with AI technology remains limited. This leads to variations in practices across countries and institutions, potentially leading to inconsistencies in implementation.

Fourth, there are efforts to integrate classical Islamic governance concepts such as Hisbah into a modern context. (Umam, 2026) shows that the principle of supervision based on moral and ethical values in Islam can form the basis for developing AI governance that is more oriented towards justice and welfare. This opens up opportunities to develop governance models that are based not only on regulations but also on normative Islamic values.

Based on these findings, this research provides the following novelty contributions:

1. Identifying the evolution of AI governance mechanisms in the context of Islamic finance, which has not previously been systematically synthesized in the literature.
2. Integrating a multi-layer governance approach (regulation, fatwa, and supervision) as AI governance model in sharia audit.
3. Offering a new perspective by combining modern governance concepts and classical Islamic principles (hisbah) in AI governance design.
4. Provide a conceptual basis for the development of a more standardized and sharia-compliant global AI governance framework.

Thus, this research contributes to broadening the understanding of how AI governance can be developed holistically in sharia audits, as well as providing strategic direction for the formation of a more mature governance framework in the future.

2.4. Theme 4: The Role of Internal Control Systems in Artificial Intelligence-Based Sharia Audits

Literature shows that internal control systems AI plays a crucial role in ensuring the reliability, transparency, and accountability of the use of Artificial Intelligence (AI) in Sharia audits. In an AI-based audit environment, internal controls are no longer limited to manual procedures and documentation, but also encompass oversight of algorithms, model validation, data integrity, and digital system security. Therefore, a robust control framework is a key prerequisite for maintaining audit quality and compliance with Sharia principles.

A number of studies emphasize the importance of implementing a structured internal control framework, such as COSO (Committee of Sponsoring Organizations of the Treadway Commission), in improving the quality of financial reporting and the effectiveness of risk control. (Harb et al., 2025) showed that COSO implementation significantly contributed to improving the quality of financial reporting by strengthening internal control systems. However, in the context of AI-based audits, this framework faces limitations because it has not been designed to accommodate the complexities of technologies such as machine learning and automated decision-making.

Furthermore, the literature shows that the integration of internal control systems and AI technology in sharia audits is still limited and not standardized. This creates a gap between traditional control practices and the needs of modern, technology-based audit systems. In this context, the development of a more adaptive internal control model is needed, capable of integrating sharia audit principles with AI-based technological oversight mechanisms.

Table 4. Internal Control System in Artificial Intelligence-Based Sharia Audit

Author	Title and Year	Country	Objective	Methodology	Findings	Journal
Harb et al. (2025)	System COSO and Quality Reporting Finance (2025)	Jordan	To assess the impact of the COSO internal control system	Analysis quantitative	COSO increases n quality of financial reporting and effectiveness of risk control	Springer
Alsaffar et al. (2025)	Role Officer Compliance in Audit Compliance (2025)	Iraq	To assess the role of compliance in audits	Descriptive study	Internal control it is very important to ensure compliance to regulation and audit	Journal of Madenat Alelem
Alqarale h et al. (2026)	Audit Internal and Reporting Finance (2026)	Global	To analyze audit quality and reporting clarity	Study Empirical	Auditor experience and internal controls strengthen the reliability of reporting.	Journal of Islamic Marketing
Harb et al. (2025)	Controller n Internal and Reporting Finance (2025)	Global	To analyze the internal control framework	Study Conceptual	Traditional control frameworks need to be adapted to digital systems	Springer
Sari et al. (2026)	Technology Digital and Islamic system (2026)	Global	For integrate n digital technology with principles Islam	Framework Conceptual	Digital systems require mechanism adaptive governance and control	Journal Accounting and Research Business Islam

Based on the literature synthesis in the table above, there are several important findings related to the role of internal control systems in AI-based sharia audits.

First, there is a shift from traditional control systems to technology-enabled control systems. A study (Harb et al., 2025) showed that the COSO framework is effective in improving the quality of financial reporting, but it is not yet fully capable of addressing the complexity of dynamic, algorithm-based AI systems. This suggests that internal control systems need to be expanded to include AI model validation, algorithm audits, and data oversight.

Second, the role of internal control in maintaining Sharia compliance is becoming increasingly complex. In Sharia audits, controls aim not only to ensure the accuracy of financial reports but also to ensure that all AI-based processes and decisions comply with Sharia principles. A study (Hussein et al., 2025) confirms that oversight and compliance functions are becoming increasingly important in a complex digital environment.

Third, there is a need for integration between internal control and AI governance. A study (Alqaraleh et al., 2026) shows that audit quality is significantly influenced by the combination of auditor experience and the effectiveness of internal control systems. In the context of AI, this means that internal controls must be designed to support algorithmic transparency and system accountability.

Fourth, the literature shows that the current internal control system is still reactive and not yet adaptive to AI technology. Sari et al. (2026) emphasize that integration digital technology in the Islamic financial system requires a more flexible and innovative approach to governance and control. This demonstrates the urgent need to develop a technology-based internal control model that aligns with Sharia principles.

Based on these findings, this research provides the following novelty contributions:

1. Developing a new perspective on internal control in AI-based sharia audits, which beyond the traditional COSO-based approach.
2. Integrate the concept of internal control with AI governance, resulting in a more comprehensive and relevant approach to technological developments.
3. Highlight the importance of algorithm audits and data governance as part of the control system. modern internal.
4. Provide a conceptual basis for the development of an adaptive internal control framework. able to answer the challenges of sharia audits in the digital era.

Thus, this research contributes to expanding the literature related to internal control in sharia audits, as well as providing strategic direction for the development of a more effective, transparent, and sharia-compliant control system.

2.5. Theme 5: Ethical Challenges and Sharia Compliance in Artificial Intelligence Implementation

The literature consistently shows that ethical challenges are one of the most dominant issues in the implementation of Artificial Intelligence (AI) in Islamic auditing and finance. Unlike conventional systems, the use of AI in the Islamic context is assessed not only in terms of efficiency and accuracy, but also in terms of its compliance with Islamic normative values based on the maqÿÿid al-sharÿ'ah (the principles of Islamic law), such as justice ('adl), transparency (ÿidq), and the benefit (maÿlaÿah).

In this context, (Umam, 2026) highlights the importance of the concept of hisbah as a moral oversight mechanism in Islamic economics that can be adapted to AI governance. This concept emphasizes social and ethical responsibility in ensuring that technology does not harm society. Furthermore, (Munandar, n.d.) emphasizes that AI implementation must align with sharia objectives holistically, not simply fulfill technical or regulatory requirements.

However, the literature also identifies several key ethical challenges, including the lack of algorithmic transparency (black-box problem), the potential for algorithmic bias , and the risk of unexplainable decision-making . These challenges have the potential to create injustice and violate Sharia principles, particularly those related to fairness and accountability (M. Ali et al., 2024; Isnani & Rifai, 2024).

Table 5. Ethical Challenges and Sharia Compliance in Artificial Intelligence Implementation

Author	Title and Year	Country	Objective	Methodology	Findings	Journal
Umam (2026)	Al-Hisbah in Economy Islam Modern (2026)	Indonesia	To explore the supervisor Islam in the digital era	Conceptual analysis	Hisbah can be an ethical basis for artificial intelligence governance	Journal Economy and Economy Sharia (JESYA)
Munandar (2025)	Intelligence Made in Finance Islam: Perspective Maqasid (2025)	Indonesia	To analyze artificial intelligence from the perspective of maqasid al-shariah	Conceptual study	Artificial intelligence must be aligned with justice, transparency and the public interest.	Proceedings Conference
Isnani & Rifai (2024)	Evaluation Compliance Sharia on Product Based Intelligence Artificial (2024)	Indonesia	To assess sharia compliance in artificial intelligence based finance	Normative legal analysis	Artificial intelligence lacks interpretability so there is a risk of not being in accordance with sharia principles	Justisia's Pen

Author	Title and Year	Country	Objective	Methodology	Findings	Journal
Ali et al. (2024)	Intelligence Made in Finance: Application for Finance Islam (2024)	Global	To examine the application of artificial intelligence in finance Islam	Review Literature	Artificial intelligence poses ethical risks such as bias and lack of transparency	Springer
Fuad & Rohman (2025)	Technology Biometrics in Banking Sharia (2025)	Indonesia	To assess technology from a maqasid perspective	Analysis conceptual	Ethical compliance with maqasid is very important in the system digital	Journal of Integrative Sustainability and Ethics

Based on the literature synthesis in the table above, several key issues related to ethical challenges and sharia compliance in AI implementation can be identified.

First, there is a tension between technological efficiency and Sharia ethical values. Studies (M. Ali et al., 2024) and (Isnani & Rifai, 2024) show that although AI can improve operational efficiency, this technology is often opaque and difficult to explain. This contradicts the Islamic principle of ÿidq (transparency), which demands clarity in every decision making process.

Second, algorithmic bias poses a serious threat to the principle of justice ('adl). AI trained on unrepresentative data can produce discriminatory or unfair decisions. In the context of sharia auditing, this could lead to a violation of the principle justice and harm certain parties, which is normatively unacceptable in the Islamic economic system.

Third, there is a need for ethical governance based on maqÿÿid al-sharÿ'ah. (Munandar, n.d.) and (Fuad, 2025) emphasize that technology must be directed towards achieving the overall objectives of sharia, including the protection of religion, life, intellect, property, and descendants. This demonstrates that AI governance in sharia audits cannot rely solely on a technical approach but must also be values-based.

Fourth, the concept of hisbah as a moral oversight mechanism offers an alternative perspective in addressing the ethical challenges of AI. (Umam, 2026) suggests that hisbah can function as an oversight system that emphasizes moral and social responsibility, thus complementing modern governance frameworks that tend to be based on formal regulations.

Based on these findings, this research provides the following novelty contributions:

1. Integrate the ethical challenges of AI with the principles of maqÿÿid al-sharÿ'ah, which are still rarely discussed systematically in the literature.
2. Developing an ethical AI governance perspective based on Islamic values, which goes beyond the approach technical and regulatory.

3. Introducing the concept of hisbah as a normative foundation in AI supervision, which is new conceptual contributions in sharia audit studies.
4. Provide an analytical framework for identifying and managing ethical risks in audits. AI-based sharia.

Thus, this research not only enriches the literature related to AI ethics, but also makes an important contribution in developing an AI governance model that is aligned with Sharia principles.

2.6. Theme 6: The Strategic Role of the Sharia Supervisory Board (SSB) in AI Governance

Literature shows that the Sharia Supervisory Board (SSB) plays a very strategic role in ensuring that the implementation of Artificial Intelligence (AI) in Islamic financial institutions remains aligned with Sharia principles. In the context of AI-based Sharia audits, the SSB serves not only as compliance oversight but also as a normative authority bridging technological innovation and Islamic values.

As the complexity of AI-based systems increases, the role of the SSB has expanded from its traditional fatwa based function to a more dynamic one, encompassing technology evaluation, algorithmic risk interpretation, and oversight of automated decision -making. (Zahra & Khoirunnisa, 2025) emphasize that the SSB is responsible for ensuring that all technology-based activities, including the use of AI, do not deviate from Sharia principles. However, the literature also indicates that the effectiveness of this role still faces various challenges, particularly related to limited technological competency among SSB members.

Furthermore, the development of digital technology demands a transformation in the structure and capacity of SSBs, including increased technological literacy, cross-disciplinary collaboration, and integration with modern governance mechanisms. Without such capacity building, SSBs could potentially struggle to oversee complex and opaque AI systems.

Table 6. Strategic Role of SSB in AI Governance

Writer	Title and Year	Country	Objective	Methodology	Findings	Journal
Zahra & Khoirunnisa (2025)	Role Body Supervisor Sharia (2025)	Indonesia	Analyzing the role of SSB in ensuring compliance Sharia	Qualitative analysis	SSB ensures compliance but faces internal challenges technology surveillance	Journal Accounting and Business Islam Contemporary
Khalid et al. (2024)	Performance Auditor Sharia Internal (2024)	Global	For Sharia evaluate auditor performance	Conceptual study	Role Auditors and SSB is very important in ensuring governance Effective Sharia	Springer

Writer	Title and Year	Country	Objective	Methodology	Findings	Journal
Umam (2026)	Al-Hisbah in Economy Islam Modern (2026)	Indonesia	To explore the supervisor Islam in the digital era	Analysis Conceptual	The concept of supervision Islam can guide modern governance including the role of SSB	Journal Economy and Economy Sharia (JESYA)
Berlianty et al. (2025)	Supervisor Banking Sharia in Indonesia (2025)	Indonesia	To assess back to the supervisory framework	Analysis socio-legal	Institution supervision needs to be modernized in era digital	MILRev
Hussein et al. (2025)	Role Officer Compliance in Audit (2025)	Iraq	To analyze the role of compliance in auditing	Descriptive study	Governance actors must adapt to regulatory and technological changes.	Journal of Madenat Alelem

Based on the literature synthesis in the table above, there are several main findings related to the role of SSB's strategic approach to AI governance.

First, the role of the SSB has expanded from compliance-based oversight to technology-aware governance. (Zahra & Khoirunnisa, 2025) indicates that the SSB is no longer solely focused on verifying compliance with fatwas but must also be able to understand the implications of technology for business processes and audits. This requires a paradigm shift in the sharia oversight function.

Second, there is a technological competency gap within the SSB. A study (Khalid et al., 2024) and (Berlianty et al., 2025) showed that most SSB members have a background in sharia science but lack the technical capacity to evaluate AI systems. This gap can reduce the effectiveness of supervision and increase the risk of sharia non-compliance.

Third, there is an emerging need for multidisciplinary collaboration in AI governance. To address the complexities of AI, SSBs need to collaborate with technologists, data scientists, and regulators. This aligns with findings (Hussein et al., 2025) that emphasize the importance of synergy between various actors in the governance system.

Fourth, the literature also shows that classical Islamic supervisory concepts such as hisbah can strengthen the role of SSBs in a modern context. (Umam, 2026) emphasized that moral-based supervisory principles and social responsibility can serve as a foundation for developing a more technology-adaptive role for SSBs.

Based on these findings, this research provides the following novelty contributions:

1. Developing the concept of the role of SSB in the context of AI governance, which was previously limited on traditional compliance functions.

2. Identifying technological competency gaps in SSB, and their implications for effectiveness of AI-based sharia audit.
3. Offering a collaborative model between SSB and technology experts, as a new approach in governance. manage AI.
4. Integrating the concept of hisbah with the role of modern SSB, thus producing a framework more holistic and values-based oversight.

Thus, this research makes an important contribution in expanding the role of SSB in the digital era, as well as providing strategic direction for strengthening institutional capacity in facing technological transformation.

2.7. Theme 7: Integration of Maqÿÿid al-Sharÿ'ah into the AI Governance Framework

Literature shows that the integration of the maqÿÿid al-sharÿ'ah principles into the framework of Artificial Intelligence (AI) governance is an increasingly urgent need in the context of sharia auditing. Unlike conventional approaches that focus on efficiency, accuracy, and regulatory compliance, AI governance in the sharia system must prioritize the fundamental objectives of sharia, namely the protection of religion (ÿifÿ al-dÿn), life (ÿifÿ al-nafs), reason (ÿifÿ al-'aql), property (ÿifÿ al-mÿl), and descendants (ÿifÿ al-nasl).

Several studies emphasize that technology, including AI, should not be value -neutral, but rather should be directed toward achieving comprehensive social welfare. (Ibrahim, 2025) emphasizes that innovation in Islamic finance must remain within the framework of maqÿÿid al-sharÿ'ah, thus pursuing not only economic efficiency but also social justice and welfare. Similarly, (Umam, 2026) points out that Islamic supervisory concepts such as hisbah can be a normative basis for integrating maqÿÿid values into modern governance systems, including AI. However, the literature also shows that to date, there is no explicit and integrated conceptual framework linking maqÿÿid al-sharÿ'ah with AI governance, particularly in the context of sharia auditing. Most studies remain conceptual or normative in nature, without offering operational models that can be implemented practically.

Table 7. Integration of Maqÿÿid al-Sharÿ'ah into AI Governance

Author	Title and Year	Country	Objective	Methodology	Findings	Journal
Abraham (2025)	Innovation Products in Banking Sharia (2025)	Global	To evaluate innovation within the maqasid framework	Conceptual analysis	Innovation must be in line with the principles of maqasid beyond efficiency.	IQTISHADI
Umam (2026)	Al-Hisbah in Economy Islam Modern (2026)	Indonesia	To explore the supervisoion Islam in the digital era	Analysis Conceptual	Hisbah provides n the basis of ethical which governance in line with maqasid	Journal Economy and Economy Sharia (JESYA)

Author	Title and Year	Country	Objective	Methodology	Findings	Journal
Fuad & Rohman (2025)	Technology Biometrics and Analytics Maqasid (2025)	Indonesia	To assess digital technology using the maqasid approach	Analysis Conceptual	Technology must support the protection of basic human values	Journal of Integrative Sustainability and Ethics
Sari et al. (2026)	Principle Principle Islam in System Digital (2026)	Global	For integrate n values Islam with digital technology	Analysis Conceptual	Digital governance requires n alignment with ethical principles Islam	Journal of Islamic Accounting and Business Research
Mom & Susila (2025)	AI and ML in Transformation Finance (2025)	Indonesia	For compare fintech system	Studies comparison	AI lacks a values-based framework in implementation at this moment	Journal of Finance and Islamic Banking

Based on the literature synthesis in the table above, there are several main findings related to integration. maqÿÿid al-sharÿ'ah in AI governance.

First, there is a need to shift the paradigm from a technology-driven approach to value-driven governance. A study (Ibrahim, 2025) shows that technological innovation in Islamic finance should not only be oriented towards efficiency but also reflect the values of fairness, transparency, and welfare. This suggests that AI governance in Islamic audits must be designed with a holistic view of Islamic objectives.

Second, the literature emphasizes the importance of maqÿÿid as a normative framework for AI-based decision-making. (Fuad, 2025) suggests that digital technology, including AI, must contribute to the protection of fundamental human values. In the context of sharia auditing, this means that AI systems must be able to support decisions that are not only accurate but also ethical and fair.

Third, there is an opportunity to integrate the concept of hisbah as an operational mechanism in AI governance. (Umam, 2026) asserts that hisbah can function as a value-based oversight system that complements modern regulatory approaches. This integration can help bridge the gap between the normative principles of maqÿÿid and the technical implementation of technology.

Fourth, the literature demonstrates a lack of an operational and integrated conceptual framework. Studies (Maman & Susila, 2025; Sari et al., 2026) show that despite efforts to link technology to Islamic values, no model explicitly links maqÿÿid al-sharÿ'ah (obligatory objectives) with AI governance in sharia auditing. This creates a significant research opportunity to develop a more comprehensive framework.

This provides the following novelty contributions:

1. Integrating maqÿÿid al-sharÿ'ah into the AI governance framework, which has not been widely developed in previous literature.
2. Propose a paradigm shift from technology-driven to value-driven AI governance, particularly in sharia audits.
3. Develop an integrative concept between maqÿÿid and hisbah as a normative basis operational in AI governance.
4. Provide a conceptual basis for the development of a maqÿÿid-based AI governance model can be implemented in sharia audit practices.

Thus, this research makes an important contribution in filling the literature gap regarding the integration of sharia values in technology governance, as well as offering a new direction in the development of more ethical and sustainable AI-based sharia audits.

2.8. Theme 8: Fragmentation and Lack of Standardization in the AI Governance Literature

The literature broadly demonstrates significant fragmentation in research related to Artificial Intelligence (AI), auditing, and Islamic finance. This fragmentation is reflected in the separation of research developments across three primary domains: AI technology, governance, and auditing. As a result, an integrated conceptual framework has not yet been established that can explain how AI should be systematically managed in the context of sharia audits. The study (Tumewang, 2025) shows that research on sharia governance is still dominated by traditional approaches that focus on institutional structures and supervisory mechanisms, without adequately considering developments in digital technology such as AI. Meanwhile, (Quttainah & BenSaid, 2025) emphasized that although there is an increasing number of studies related to governance in Islamic finance, these studies are still scattered and have not yet produced uniform global standards. Furthermore, AI-related literature tends to develop within the disciplines of technology and management without explicitly integrating Sharia principles. This creates an epistemological gap between technical and normative Islamic approaches, ultimately reinforcing fragmentation in the literature.

Table 8. Fragmentation and Lack of Standardization in the AI Governance Literature

Writer	Title and Year	Country	Objective	Methodology	Findings	Journal
Tumewang et al. (2025)	Review Deep about Study of Layout Manage Sharia (2025)	Global	To review the evolution of Sharia governance research	Analysis bibliometrics	Study fragmented and less integrated with new technologies.	Journal of Islamic Accounting and Business Research
Quttainah & BenSaid (2025)	Governance Sharia and Performance Finance (2025)	Global	To analyze trend literature governance	Bibliometric analysis	Lack of unified standards across institutions and country	Journal of Islamic Accounting and Business Research
Ali et al. (2024)	AI in Finance (2024)	Global	For explore the AI application in finance	Literature review	AI research is driven by technology with limited ethical integration.	Springer
Sari et al. (2026)	Principle-Principle Islam and Technology Digital (2026)	Global	For integrate and values Islam into digital systems	Conceptual framework	Lack of an integrated framework that combines technology and Islamic principles	Journal of Islamic Accounting and Business Research
Mom & Susila (2025)	AI and ML in Transformation Finance (2025)	Indonesia	To compare fintech system	Comparative study	AI adoption is lacking model order standardized management in finance Islam	Journal of Finance and Islamic Banking

Based on the literature synthesis in the table above, there are several main patterns that illustrates the fragmentation and lack of standardization in AI governance in sharia auditing.

First, there is disciplinary fragmentation between the fields of technology, auditing, and Islamic finance. A study (H. Ali et al., 2024) shows that AI research primarily focuses on technical aspects without considering ethical and sharia aspects. Conversely, studies on sharia governance focus more on normative aspects without integrating technological developments. This creates a significant conceptual gap.

Second, there is a lack of global standards for Sharia-compliant AI governance. (Quttainah & BenSaid, 2025) show that Sharia governance practices vary widely across countries and institutions. Without global standards, the implementation of AI in Sharia audits will be inconsistent and potentially lead to differing interpretations of Sharia principles.

Third, the literature shows methodological fragmentation, with most studies using conceptual or bibliometric approaches without producing implementable operational models. (Tumewang, 2025) emphasized that despite the increasing number of studies, contributions to the development of applicable frameworks remain limited.

Fourth, there is an urgent need for integration between Islamic values and modern technology. Studies (Maman & Susila, 2025; Sari et al., 2026) show that although there are efforts to combine sharia principles with digital technology, the approach is still partial and has not yet produced a comprehensive framework.

Based on these findings, this research provides the following novelty contributions:

1. Synthesizing fragmented literature from three main domains (AI, audit, and Islamic finance) into one integrated analytical framework.
2. Systematically identify gaps in global standards in AI governance based on sharia, which has not been discussed comprehensively.
3. Propose multidisciplinary integration as a new approach, which combines technology, governance, and sharia principles perspectives.
4. Provide a conceptual basis for the development of a standardized AI governance framework in sharia audit.

Thus, this research contributes to reducing the fragmentation of the literature and provides a new direction in the development of AI governance that is more integrated, consistent, and in accordance with Sharia principles.

3. METHODOLOGY

This study employed a Systematic Literature Review (SLR) approach guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 framework to ensure methodological rigor, transparency, and reproducibility. The PRISMA 2020 protocol is widely recognized as a robust standard for conducting systematic reviews across a wide range of multidisciplinary fields, including artificial intelligence, auditing, and governance (Page et al., 2021). The use of SLR in this study aims to systematically identify, evaluate, and synthesize relevant literature on AI governance in Shariah auditing, specifically focusing on the risk dimensions, internal control, and ethical boundaries. This approach enables the integration of fragmented knowledge into a coherent analytical structure while minimizing selection bias and enhancing the reliability of the findings.

A literature search was conducted across several major academic databases indexed in Scopus and other leading platforms, including Scopus, Web of Science, ScienceDirect, and Google Scholar, to ensure comprehensive coverage of high-quality publications. The search process was limited to studies published between January 2021 and December 2026 to capture the latest developments in AI and Islamic finance. A structured search string was developed using Boolean operators to maximize retrieval accuracy and relevance, incorporating keywords such as "Artificial Intelligence," "Shariah Audit," "Islamic Audit," "Governance," "Risk," "Control," and "Ethics." Inclusion criteria were defined to include peer-reviewed journal articles, conference proceedings, and book chapters written in English and directly related to

AI, audit, governance, and Islamic finance. Studies were excluded if they were non-academic publications, lacked full text availability, or were not directly relevant to AI governance in the context of Shariah audit.

The PRISMA 2020 process began with an identification phase, during which a total of 1,285 records were retrieved from various databases and supplementary sources. This initial dataset reflects a broad and inclusive search strategy designed to capture all potentially relevant studies within the defined scope. The distribution of records across the various databases is presented in Table 9, which demonstrates the dominance of Scopus-indexed publications as the primary source of high-quality literature in this field.

Table 9. Identification of Records

Source Database	**Records Identified**
Scopus	512
Web of Science	286
ScienceDirect	221
Google Scholar	229
Other sources	37
Total	**1,285**

Following identification, the screening phase involved removing duplicate records and evaluating titles and abstracts for relevance. A total of 312 duplicate records were removed, resulting in 973 unique articles. Furthermore, 681 articles were excluded based on title and abstract screening due to lack of relevance to AI governance, auditing, or Sharia-related topics. This process significantly impacted the overall quality of the articles narrowing the data set to studies that conceptually align with the research objectives, as shown in Table 10.

Table 10. Screening Results

Screening Process	**Number of Records**
Records after duplicates removed	973
Excluded (title/abstract)	681
Remaining records	**292**

The eligibility stage involved a full-text review of the remaining 292 articles to evaluate their methodological quality and relevance to the research focus. During this stage, 198 articles were excluded for specific reasons, including a lack of focus on Sharia auditing, an absence of discussion of AI governance, a lack of methodological rigor, or unavailability of full-text access. This rigorous screening process ensured that only high-quality, directly relevant studies were retained for the synthesis. Details of the exclusion criteria are presented in Table 11.

Table 11. Eligibility Assessment

Exclusion Criteria	Number of Articles
Not related to Sharia auditing	74
Not related to AI governance	63
Low methodological rigor	41
No full-text access	20
Total excluded	**198**
Eligible articles	**94**

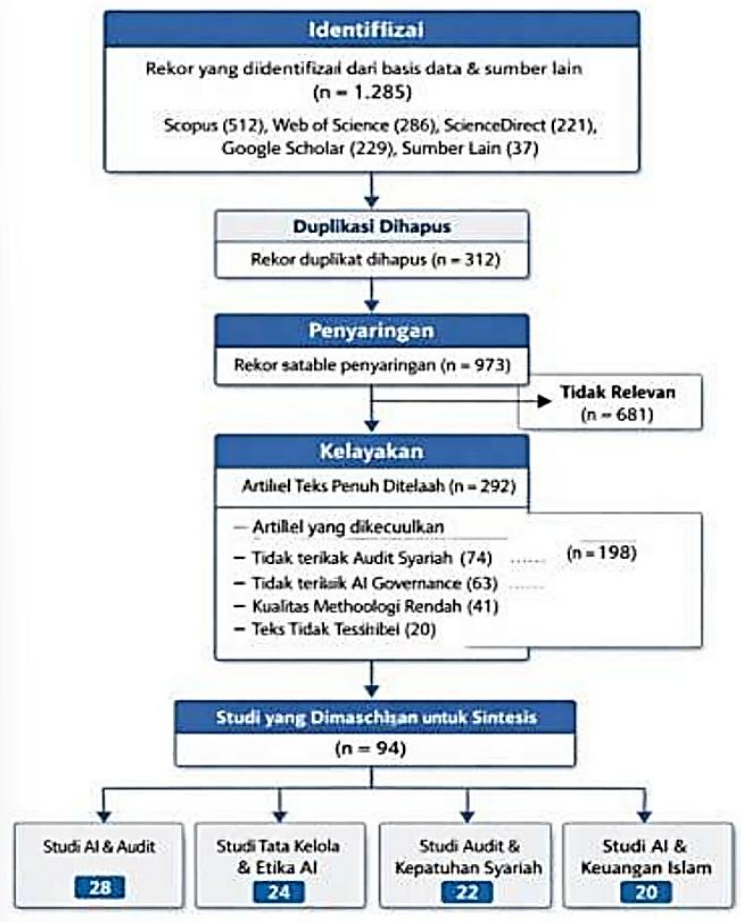
The final stage of the PRISMA process resulted in the inclusion of 94 studies that met all predetermined criteria and were deemed suitable for in-depth analysis. These studies represent a balanced and interdisciplinary body of literature covering AI in auditing, governance frameworks, ethical considerations, and Sharia compliance. A classification of the included studies is presented in Table 12, which highlights the distribution of research themes within the selected literature.

Table 12. Final Included Studies

Category	Number of Studies
AI and auditing	28
AI governance and ethics	24
Sharia auditing and compliance	22
Integrated AI and Islamic finance	20
Total Included Studies	**94**

The analysis of the selected studies was conducted using a thematic synthesis approach, which involves systematic coding, categorization, and interpretation of patterns across the literature. This method enabled the identification of recurring themes related to AI-driven risks, governance mechanisms, internal control systems, and ethical challenges in Shariah auditing. The thematic synthesis was further strengthened through iterative cross-validation and comparison of findings to ensure consistency and analytical depth. By integrating insights from governance theory, audit frameworks, and Islamic ethical principles, this study provides a multidimensional understanding of AI governance in Shariah auditing.

Figure 1. PRISMA 2020 Flowchart for Selection of Studies on Artificial Intelligence Governance in Shariah Audit: A Systematic Literature Review of Risks, Controls, and Ethical Boundaries



4. DISCUSSION

The findings of this study demonstrate that the integration of Artificial Intelligence (AI) into Sharia auditing is not only a technological advancement but also a fundamental transformation in the paradigms of risk, governance, and ethics. The SLR results indicate that AI is significantly reshaping the audit risk landscape from a static, rules-based structure to a dynamic, data-driven system. These findings align with recent studies in financial AI, which emphasize that AI improves efficiency, accuracy, and predictability, while introducing new

risks such as algorithmic bias, data security vulnerabilities, and a lack of transparency (Alareeni & Elgedawy, 2023; H. Ali & Aysan, 2026).

However, this study extends previous research by demonstrating that, in the context of Shariah auditing, these risks are not only technical but also normative, as they may conflict with core Islamic principles such as justice ('adl) and transparency (ÿidq). Furthermore, the findings suggest that existing Shariah audit frameworks remain inadequate in addressing the complexity of AI-based systems. This is consistent with contemporary literature showing that audit systems, particularly in Islamic financial institutions, remain constrained by limited technological adaptation and a lack of standardized frameworks. Recent research highlights that digital transformation in auditing has outpaced regulatory and methodological developments, creating a structural gap between technological innovation and audit practice (Abdullah & Almaqtari, 2024).

This study makes a further contribution by identifying that these limitations are not only operational but systemic, particularly in the inability of traditional audit frameworks to evaluate algorithm-driven decision-making processes.

In terms of governance, the findings confirm that emerging AI governance mechanisms in Islamic financial institutions are still in their early stages of development. This observation is supported by a recent study that emphasized the need for a robust regulatory framework to ensure the responsible adoption of AI in finance (H. Ali & Aysan, 2026).

Nonetheless, this study advances the literature by highlighting the absence of a globally standardized AI governance model specifically designed for Shariah auditing. This lack of standardization contributes to inconsistencies in implementation across jurisdictions and institutions.

Furthermore, this study found that internal control systems, such as the COSO framework, remain relevant but require substantial adaptation to effectively manage an AI-based audit environment. Previous literature confirms that AI can improve fraud detection and financial reporting quality through automation and data analytics (Alareeni & Elgedawy, 2023).

However, this study adds a new perspective by emphasizing the need to integrate algorithmic auditing, model validation, and data governance into the internal control system, thus shifting from traditional control-based auditing towards a technology-enabled audit framework.

From an ethical perspective, the findings underscore that the implementation of AI in Sharia auditing raises critical concerns regarding transparency, fairness, and accountability. Recent studies in AI governance highlight that ethical risks, particularly algorithmic bias and lack of explainability, are remains a major challenge in financial applications (H. Ali & Aysan, 2026).

This study makes a unique contribution by embedding these ethical concerns within the maqÿÿid al-sharÿ'ah framework, thereby providing a values-based lens for evaluating AI systems also introduces the concept of hisbah as a complementary ethical governance mechanism, strengthening accountability beyond formal regulatory compliance.

Furthermore, the role of the Sharia Supervisory Board (SSB) has emerged as a crucial governance actor in AI implementation. Existing literature asserts that SSBs are responsible for ensuring Sharia compliance in financial operations; however, their effectiveness is increasingly challenged by technological complexity. This study extends previous research by demonstrating that SSBs must evolve into technology-aware governance bodies, capable of understanding AI systems and collaborating with technical experts to ensure effective oversight.

Another important contribution of this study lies in the integration of maqÿÿid al-sharÿ'ah into an AI governance framework. While recent literature recognizes the importance of aligning technology with Islamic ethical principles, there is still a lack of operational models that translate these principles into governance mechanisms (Hidayanti et al., 2024).

This study addresses this gap by proposing a shift from efficiency-driven AI adoption to value driven AI governance, where technological systems are evaluated based on their contribution to social welfare and ethical compliance.

Finally, these findings confirm the significant fragmentation of the literature on AI, auditing, and Islamic finance. Bibliometric studies indicate that research in these areas has developed in parallel rather than integrated, resulting in conceptual and methodological gaps (Riani, 2024).

This study contributes by synthesizing these fragmented streams into a unified analytical framework, thereby providing a more comprehensive understanding of AI governance in Shariah auditing.

5. CONCLUSION

This study systematically examines the governance of artificial intelligence (AI) in sharia auditing, focusing on risks, controls, and ethical boundaries. The systematic literature review (SLR) findings indicate that AI integration significantly transforms the sharia audit landscape from a static system to a dynamic and complex one. AI not only improves efficiency and analytical capabilities, but also introduces new risks such as algorithmic bias, a lack of transparency (black-box problems), and data security vulnerabilities. These findings confirm that the impact of AI is far broader than anticipated, challenging the traditional assumption that technology serves only as a supporting tool and opening new discussion regarding the need for more adaptive and values-based governance in sharia auditing.

Scientifically, this study contributes by strengthening and expanding the literature on AI in Islamic finance, particularly by integrating the dimensions of technology, governance, and ethics within a comprehensive analytical framework. It also critiques the limitations of existing Islamic audit frameworks and introduces a novel approach, an integrated AI governance framework based on the maqÿÿid al sharÿ'ah (the principles of Islamic law). Thus, this study not only unifies the previously fragmented literature but also provides a conceptual contribution that enriches academic discourse. However, this study has limitations, including reliance on literature that is largely conceptual in nature and the lack of extensive empirical testing, which limits the generalizability of the findings.

Based on this, further research is recommended to develop and empirically test a maqÿÿid al sharÿ'ah-based AI governance model, as well as expand the scope of the study to various country and institutional contexts. From a practical perspective, the development of related global standards is needed.

AI governance in sharia auditing, enhancing the capacity of auditors and the Sharia Supervisory Board through a multidisciplinary approach, and strengthening internal control systems that can accommodate AI-based technologies, including algorithmic audits and data risk management. Ultimately, this study confirms that the success of digital transformation in sharia auditing is determined not only by technology adoption but also by the ability to integrate it with ethical values and sharia objectives in a sustainable manner.

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BLOCKCHAIN AND SMART CONTRACTS FOR TRANSPARENCY AND ACCOUNTABILITY IN ZAKAT MANAGEMENT: A SYSTEMATIC LITERATURE REVIEW

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Abstract

This study analyzes scientific literature regarding the application of blockchain technology and smart contracts in zakat management, with an emphasis on transparency and accountability. The methodology used is a Systematic Literature Review (Systematic Literature Review/SLR) that follows the PRISMA principles. Data obtained from the Google Scholar and Scopus databases through the Publish or Perish tool for period 2020–2025. Of the initial 195 articles, 85 articles met the requirements for analyzed. The study findings show a significant increase in publication trends, especially since 2023. VOSviewer analysis revealed that the main keywords that dominant are transparency, accountability, blockchain, and smart contracts. This shows that the research focus covers both technological and governance dimensions zakat. Research findings show that blockchain can improve openness and accountability through open and accessible recording mechanisms verified. Simultaneously, smart contracts facilitate the automation of activities zakat management, increasing efficiency. However, its implementation continues facing obstacles such as regulations, infrastructure, and human resource readiness.

Keywords: Blockchain, Smart Contract, Zakat, Transparency, Accountability

INTRODUCTION

Advances in digital technology in recent decades has bring about a massive transformation in various sectors, including banking and Islamic social finance. Transformation digital, which is marked by the emergence of Financial Technology drive increased efficiency, speed, and accessibility in (FinTech), financial system for the wider community (Milian et al., 2019; Saadan & Hassan, 2022). Within the framework of Islamic economics, digital technology integration has emerged as a strategic necessity for financial institutions and social entities Islam to improve quality service, competitiveness, and transparency and accountability in management public funds (Putra & Alfian, 2025; Rashid et al., 2025).

Zakat is an instrument fundamentals in the financial system Islamic social, which includes aspects religious and socio-economic as means of income redistribution and alleviation poverty. Zakat doubles as a liability religion for Muslims as well as a tool economic policies that can maintain stability social, reduce inequality riches, and improve community welfare if managed efficiently and reduce and professional (Musana, 2023). From the perspective view maqÿÿid al-sharÿÿah, zakat management aims to protect wealth, increase welfare public, provides an economic framework fair and sustainable (Dusuki & And Bouheraoua, 2011; Ismail & Kareem, 2025).

Indonesia, a country with the largest Muslim population in the world, has significant zakat potential; However, the realization of the collection is still not optimal. Various studies shows that the potential for zakat nationally estimated to exceed Rp. 300 trillion to Rp. 327 trillion per year; however, fundraising the real zakat remains in below 10% of the total potential (Mu'adzah & Rachmad, 2024; Syahputra et al., 2022; Gunawan Baharuddin, 2024). The inequality between the potential and realization of zakat indicates there are fundamental problems in governance manage zakat, especially regarding the lack of public trust, limitations transparency, and weak accountability in reporting and allocation of zakat funds (Adiwijaya et al., 2022; Andriani & Wahyudi, 2024; Yusra & Riyaldi, 2020).

Zakat management in Indonesia organized by the Zakat Collection Agency National (BAZNAS) and Amil Institutions Zakat (LAZ), in accordance with the Law Law Number 23 of 2011 concerning Zakat Management. Apart from the initiative carried out by institutions this is to improve professionalism in zakat management, various research reveals that financial reporting system, supervision internal, and audit mechanisms are still not optimal, so it is damaging public trust in institutions zakat (Rizal & Abidin, 2024; Romdoni & Nurpalah, 2025). Lack of transparency in fund administration Zakat can pose risks abuse, inaccuracy distribution, and targeting of recipients inappropriate benefits (Alivian et al., 2023; Hendri & Yusnita, 2024). Transparency and accountability are the basic principles in the governance of public institutions, especially zakat institutions, which realized through

openness information, financial reporting accurate, and control mechanisms solid internal. In finance In Islam, accountability includes dimensions administrative and spiritual, which serves as a trust to Allah SWT in managing the wealth of the people (Salamon & Elliott, 2002; Sharia Enterprise Theory). Therefore, increase openness And accountability in zakat management very important to grow public trust and increase involvement public zakat donations (Anheier, 2024; Yusof & Basri, 2025).

As technology advances in digital, various technological innovations have applied in zakat management in order to increase efficiency and system effectiveness. Digital technology, including electronic payment systems, online zakat application, and system zakat management information has been prove his ability in improve operational efficiency and speed up the collection process and distribution of zakat funds (Fauzi et al., 2023; Hudaefi et al., 2020). However Thus, traditional digital systems still shows limitations in ensure data security, transparency transactions, and system reliability real-time reporting (Narayanan et al., 2016; Sugeng et al., 2024).

In this context, technology blockchain emerges as a breakthrough significant increase Which potential transparency And accountability in zakat management. Blockchain decentralized is For system take notes transparent, secure transactions, and cannot be changed, so allows tracking real-time transactions by all stakeholders (Casino et al., every 2019; Swan, 2015). Blockchain features which cannot be changed and can verified making it a solution that effective in preventing Narayanan forgery data, increase public trust, and strengthen zakat organization governance (Chadjib) Halik et al., 2025; Tapscott et al., 1995).

Besides blockchain technology, use of smart contracts in blockchain framework offers significant prospects for improve management efficiency zakat. Smart contracts are programs computer that automatically execute the contract when the conditions certain predetermined conditions are met, thus reducing dependency on intermediaries, lowering costs transactions, and minimize risks human error in distribution zakat funds (Matondang et al., 2024; Susanto et al., 2025). Application of smart contract in zakat management enable the distribution process done automatically, transparently, and accurate according to the criteria designated beneficiaries (Pratiwi et al., 2025; Shahimi & Zahari, 2025).

Various previous studies shows that the implementation blockchain technology in management zakat can increase transparency, efficiency, and public trust towards zakat institutions. Implementation blockchain technology in various countries, including the United Arab Emirates, Qatar, and Malaysia, has shown good results positive in improving quality services, accelerate the distribution of funds, and strengthen the governance framework evidence-based (Al-Kuwari et al., 2023; Karim & Hussain, 2024). In addition, blockchain technology has demonstrated its effectiveness in improving tracking zakat funds, reducing

risk abuse, as well as strengthening audit and reporting framework zakat organization finance (Omar & Harun, 2024; Rachmawati & Iskandar, 2025).

However, the implementation of blockchain technology and smart contracts in zakat administration facing several constraints, including limitations technological infrastructure, lack of understanding among resources humans, as well as the need for regulation explicit and in accordance with standards sharia. show Various that digital institutions and literacy is an important element for study readiness application of blockchain technology effective in the zakat management system (Awan, 2021; Wan Mohamed Salleh et al., 2019). Technological compatibility with Sharia principles are important attention in development blockchain-based system for ensure alignment with values Islamic values, including justice, transparency, and reliability (Ahmad et al., 2024; Kamali, 2008).

In contrast, research on utilization of blockchain technology in zakat administration still dominated by theoretical approaches, with a lack of empirical case studies, so there is no in-depth review yet regarding research progress, trends thematic, and research deficiencies that exist in this field. Some literature shows that research on digitalization of zakat for the most part emphasizes the technical system aspects, while studies that combine transparency, accountability, governance, and the principles of maqÿÿid al-sharÿÿah is still relatively rare (Antonio, 2021; Safitri et al., 2024). This condition require he did more systematic investigation and thorough to describe progress study identify potential and obstacles in the application of blockchain technology and smart contracts in management zakat (Mubina & Hasan, 2025; Narayanan et al., 2016). This research aims to conducting a Systematic Literature Review (SLR) on various studies that discuss implementation technology blockchain and smart contracts in zakat management, with a special focus on increasing transparency and accountability of zakat institutions. Research as well as this aims to identify trends study, classify methodology, and identify research gaps through reviews systematic library, so that it can become foundation for system more transparent zakat management, accountable, and sustainable in the era digital.

1. LITERATURE REVIEW

1.1. The Concept of Zakat and Its Management

Zakat is the third pillar in Islam which includes social components economy and worship. Zakat is not only spiritual obligations that must be fulfilled by every Muslim who fulfills the requirements conditions, but also a tool for distribute wealth aim welfare For increase public and upholding social justice, seen from sharia perspective (Alshater et al., 2021; Bin-Nashwan et al., 2023; Muneeza et al., 2023). Conceptually, zakat understood as a particular part of wealth required by Allah SWT. For taken from the well-off group distributed to interested parties entitled. (Al-Qaradawi, confirms that zakat is part of the assets designated for

mustahik, but (Zaim, (1999) (1989) consider zakat as a mandatory tax on the excess wealth of the Muslim community for helping those in need. Zakat, in the literal sense, means growth, increase, and sanctification, which shows that zakat is not only purify wealth but also foster moral and spiritual awareness from muzakki (Al-Fanjari, 1982; Al Qaradawi, 1973). Zakat obligation applies to Muslims whose wealth has reached the nisab and has been owned during a certain period (haul). Some assets, including savings, gold, silver, and trading assets, subject to tariffs general is 2.5% (Al-Qaradawi, 1999; Hoque et al., 2015; King, 2021). In practice, zakat is divided into two main forms: zakat fitrah and zakat Zakat mal. Zakat mal is studied more in the context of wealth management and economic distribution of society (Fitriani & Suprayogi, 2023; Sulaiman & Jamil, 2014).

Zakat functioning as strategic mechanisms in the landscape socio-economic as a tool for redistribution of wealth aimed at reduce poverty, reduce gap income, increase social cohesion within Muslim community (Kasri, 2016; Musana, 2023; Shirazi, 2014). Various studies show that zakat is significantly improve welfare public with basic needs of mustahik and fulfil facilitating economic empowerment Long term (Alshater et al., 2021; Kholid, 2019; Wahyi & Razkia, 2020). The main long-term goal of zakat is to change mustahik into muzakki, thus making zakat not only alms but also productive and transformative (Lubis, 2021; Zahra, 2004). Zakat is considered as important mechanisms within the framework Islamic economics that can encourage national socio-economic growth in a more inclusive and fair manner (Alim, 2023).

As a financial instrument Islamic social, zakat is not enough only understood from a normative perspective, but also must be managed through good governance well so that the sharia objectives can be achieved achieved optimally. Management Good zakat must be based on principles sharia, especially trust, transparency, and accountability, because these three principles are the foundation And key to building trust public towards zakat institutions (Khatiman et al., 2021; Yusra & Riyaldi, 2020). The principle of trust confirms that zakat funds are deposits people whose management must be done honestly, carefully, and in accordance with sharia provisions. In the context In this case, the zakat collector is not only responsible for administratively responsible to society, but also morally and spiritually before Allah SWT. on every decision in the collection, management and distribution of funds zakat (Khatiman et al., 2021; Othman et al., 2020). Therefore, the mandate in zakat management demands integrity high so that zakat really reaches to asnaf who has the right and use according to the objectives of sharia.

Besides can trusted, transparency is an important principle in zakat governance because in general directly related to accessibility information regarding collection, management and distribution of funds to the community and muzakki. Transparency allows the public to understand the collection, utilization and distribution of zakat funds, thus reducing distrust

and increase the legitimacy of the institution zakat managers (Hanefah et al., 2020; Yusra & Riyaldi, 2020). In context In this case, openness is a necessity contemporary administrative as well the embodiment of Islamic principles in management of public finances.

Principle next is accountability, which refers to the ability of zakat institutions to provide clear, measurable accounts, and can be audited from the entire process management zakat. Accountability includes presentation of financial reports, distribution documentation, compliance to sharia rules, and transparency achievement of the zakat program in improving the welfare of mustahik (Aulia et al., 2025; Khatiman et al., 2021). Accountability is a concept which is multifaceted in the context of governance manage zakat, because not only includes administrative obligations to stakeholders but as well as ethical and religious obligations. By therefore, to prevent any deviation, duplication in distribution, or exploitation of zakat funds, zakat institutions must build a system management Which well documented, and professional, consistent (Androulaki et al., 2018; Saad & Sawandi, 2016). With the existence of strong accountability, trust muzakki towards zakat institutions can strengthened, and distribution effectiveness zakat can be more guaranteed.

The significance of trust, transparency and accountability in institutional practices are becoming increasingly clearly because of the current zakat management carried out through formal institutions, such as BAZNAS in Indonesia. The success of zakat management as social development instruments are very influenced by the quality of governance BAZNAS, which is authorized to gather, manage, distribute zakat nationally based on Law Number 23 2011 (Alim, 2023; BAZNAS, 2021). (Malik, 2016; Tahliani, 2018) And shows that the application of the principles the principle of zakat in institutions such as BAZNAS is an indication of efforts to achieve justice in distribution, efficiency in administration, and transparent reporting to the public. However, various studies continue identify obstacles in forms of infrastructure limitations, regional distribution imbalance, internal control system that is not effective, and resistance to integration technology in zakat management (Musa et al., 2022; Nawai & Ruzaiman, 2022; Setyawigasta et al., 2024).

In addition, the capacity of the institution zakat to ensure distribution fair, efficient and significantly appropriate affect the effectiveness of management zakat. Wrong target, distribution double, delay in assistance, and decline in donor confidence and beneficiary satisfaction can occur due to improper zakat administration adequate (Hamzah & Hasri, 2021; Mehilda et al., 2021). Therefore, effective zakat governance requires integration of Sharia values with approach managerial contemporary, which includes the application of reliable accounting system, reporting transparent, and internal controls adequate (Hadijah et al., 2024; Hanefah et al., 2020). Within the framework In this case, trust serves as the basis ethics, transparency as a means openness and accountability as accountability mechanisms. All three

interrelated and function as the main framework for zakat governance professional, fair and trustworthy socially.

1.2. Transparency and Accountability in Zakat

Accountability in management zakat is an obligation of institutions to be accountable for every activities and use of funds to muzakki, society, and in general spiritual to Allah SWT. (Gray et al., 1991; Halim & Kusufi, 2017). Meanwhile, transparency refers to on the openness of institutions in provide relevant information, honest, and easily accessible to the public (Nurhayati et al., 2016; Ramadona, 2020). In the context of zakat institutions, transparency and accountability are not only related to reports finance, but also includes program transparency, distribution process, as well as performance institution overall (Rapindo et al., 2021). in a way Success of zakat management seen from the extent to which zakat institutions able to consistently apply accountability and transparency in governance management. The main indicators consist of availability of financial reports in accordance with established standards determined, information disclosure to the public, the existence of an audit or external supervision, program distribution, collection clarity And and utilization accounting systems and information technology which facilitates the taking effective decisions (Hermawan & Astriana, 2010; Irpan et al., 2021; Kuncaraningsih & Ridla, 2015).

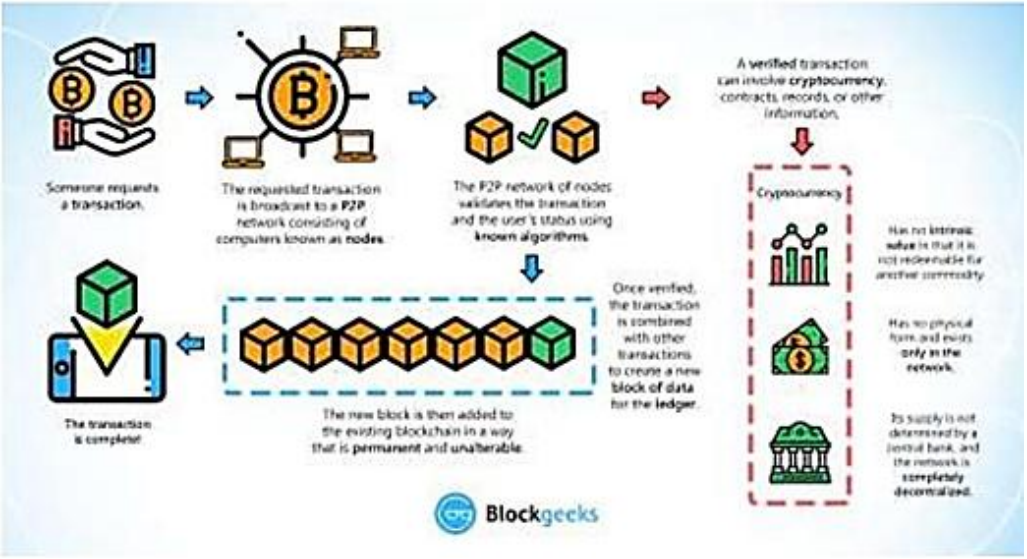
1.3. Blockchain Technology

The development of digital technology has brought innovation in transaction recording system, wrong one of them is through blockchain technology. Blockchain is a ledger system distributed ledger who records transactions in a way transparent, secure, and immutable that, success is shown by increasing the trust of muzakki, interest in paying zakat through institutions official, as well as efficiency and accuracy distribution of funds to mustahik (Kabib et al., 2021; Litriani et al., 2021; Pangestu & Jayanto, 2017). According to various study, optimization zakat collection can be hampered by low transparency accountability, which can reduce trust public, encourage muzakki to distribute zakat directly, and ultimately damage it (Kamal et al., 2024; And Sawmar & Mohammed, 2021; Wahyudi et al., 2022). Therefore, the quality professional institutional governance, transparent, sharia compliant, and capable maintaining public trust continuously become a factor determinants of the success of zakat management, besides the amount of funds collected. (immutable) (Crosby et al., 2015; IBM, 2022). This technology works automatically decentralized without so that it allows each intermediary, transactions are verified by the network and stored permanently.

Main characteristics of blockchain includes decentralization, transparency, security, and traceability (traceability). This property allows subtraction asymmetry information, increased efficiency, and strengthening surveillance system (Fanning & Centers, 2016). In the context of zakat, blockchain potential create more transparent management and can be traced in real-

time by all stakeholders (Ghofur & Ichwan, 2020; Wang, 2024). In sector finance, blockchain has been applied to various instruments such as digital sukuk, crypto-based payments, and systems digital donations. This technology is considered able to improve operational, system efficiency lower cost transactions, as well as strengthening security and trust in the financial system (H. Mohamed & Ali, 2019). This is make blockchain as potential technologies for adoption in zakat management.

Figure 1. Basic Flow of Blockchain Technology



1.4. Smart Contract

Smart contracts are blockchain-based program that automatically execute agreements when certain conditions are met. Unlike traditional contracts, smart contract programmed, and runs without intermediary, thereby increasing efficiency and reduce risk human error (Feng et al., 2019; Musana, 2023). Draft this allows the transaction process to be nature faster, more transparent, and can digital, reliable. How smart contracts work based on if–then logic, where the system will execute the instructions automatically after the condition fulfilled. In zakat management, smart contracts can be used for automate process nisab verification, fundraising, to the distribution of zakat to mustahik directly (Millatina et al., 2022). In fact, this technology makes it possible zakat distribution through digital wallets blockchain-based (Ardhiyansyah et et al., 2025). Excess covering smart efficiency, contract transparency, security, and cost reduction transaction. However, there are also limitations such as uncertainty regulations, infrastructure needs sharia technology, and the absence of standards related Which clear its

implementation (G. Mohamed & Lahsasna, 2020). Therefore, smart contract implementation requires technological and institutional readiness adequate.

1.5. Blockchain in Islamic Finance

In the context of Islamic finance, blockchain offers a solution to increase transparency, efficiency, and compliance with sharia principles. This technology enables transactions done without intermediaries, so reduce costs and increase trust (Muneeza et al., 2018). In addition, blockchain can help overcome classic problems such as like information asymmetry and delay transaction. Implementation of blockchain in Islamic finance has covered various instruments, such as sukuk blockchain-based donation system digital, as well as zakat management and waqf. This technology can also integrated with smart contracts to ensure that the transaction carried out in accordance with the provisions sharia automatically (Dahdal et al., 2022). However, the challenges such as regulations, infrastructure readiness, and conformity with muamalah fiqh still needs to be studied further.

1.6. Previous Research

Research on blockchain in zakat management shows that this technology has potential great in increasing transparency, accountability, and efficiency of the zakat system. Blockchain enables record keeping open and accessible transactions traced, thus reducing asymmetry information between zakat institutions and stakeholders (Ghofur & Ichwan, 2020; Wang, 2024). In addition, integration with smart contracts enables process automation zakat management, such as fund distribution directly to the mustahik (Musana, 2023). Several studies have proposed conceptual model of zakat-based system blockchain that enables muzakki tracks the use of funds in real-time, thus increasing public trust (Zulfikri et al., 2021). However, most of the research still conceptual and not yet widely supported by empirical studies. In addition, the integration aspect with the principles sharia, institutional readiness, and regulatory factors are still not discussed in depth. Based on matter the, there is a research gap in the form of a lack empirical research related to implementation blockchain in zakat management and the lack of studies that integrating technological aspects, institutional and sharia comprehensive. Therefore, gap This research aims to fill the through systematic literature review approach in order to provide an understanding more comprehensive regarding the role blockchain and smart contracts in increase transparency accountability of zakat management.

2. RESEARCH METHODS

This research uses a strategy Systematic Literature Review (SLR) along with qualitative methods), SLR technique is the gold standard in among other types of reviews because is a synthesis of research findings systematic, clear, and repeatable (Aprianto & Nuarini, 2022;

Snyder, 2019). Systematic literature review in this study is based on According to Aprianto and Nuarini (2022) and Snyder (2019 publications from the last decade and comes from an accredited journal nationally and internationally, including Scopus and Google Scholar. This research uses a framework time 2020–2025 consider For acceleration advancement of blockchain technology and smart contracts in the financial sector, with special emphasis on zakat management. The article that use is limited to publication English and Indonesian.

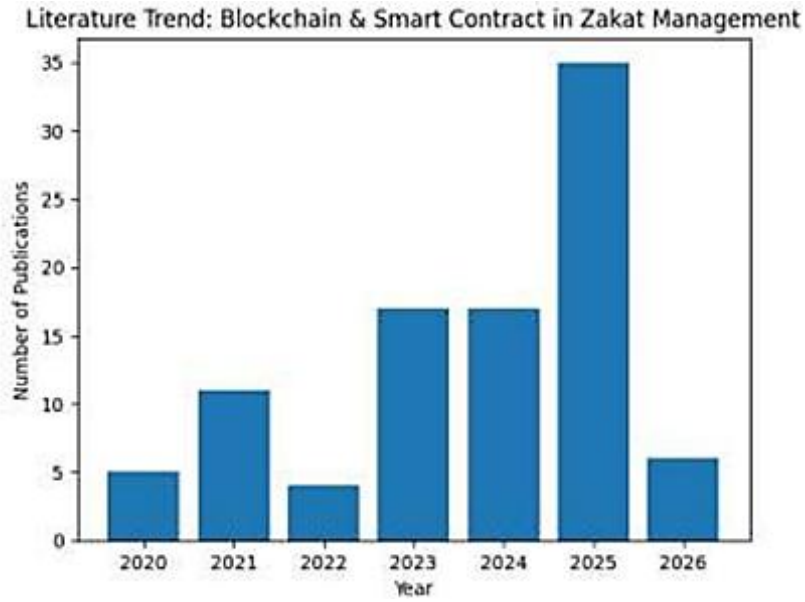
Publish or Perish (PoP) Application used to perform searches literature, with main keywords “blockchain,” “smart contracts,” “zakat management," "transparency," "accountability." In addition, the literature that contains relevant keywords in title, abstract, and keywords are selected for further examination. (Nomran & Haron, develop systematic methods (2020) Literature Review (SLR), which became basic collection procedures and data analysis in this study. First, as many as 195 references relevant literature successfully identified based on search keywords that are performed in a range 2020 to 2025. Second, for ensure there is no data duplication, selection process is carried out on literature that has been found. In addition Therefore, the literature was selected based on criteria that have been set previously, namely related to the type of literature. Only articles originating from journals scientific methods used in research this. In this second stage, there were 192 literature references were successfully collected. A total of 192 literature references those that have been selected are then analyzed its contents. This research specifically analyze the literature that discusses application of blockchain technology and smart contracts in zakat management, with a focus on transparency, And accountability, management, And distribution of zakat funds. After the process this filtering, literature references that relevant selected for further research. Step fourth involving documentation of the results of each stage research, which culminates in the stage the end where conclusions are drawn from existing data. During the second and third phases In this research, the author carried out a process literature selection using Covidence software. Metadata obtained through the Publish or program Perish (PoP), which results in a total 195 well-recognized literature references domestically and globally. Data is processed using Covidence, which leads to detection and elimination of three duplicate entries, so that yielded 192 references for the phase screening. As a result, 84 studies eliminated during the screening phase, so that there are 108 studies remaining that have advanced to feasibility evaluation phase. At this stage, 23 studies were excluded due to several reasons, including duplicate data, articles non-research, unavailability of text incomplete, or not relevant to the topic zakat management, so that in finally 85 studies were included in systematic review, which is illustrated in the PRISMA diagram (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). At stage closing, all selected literature analyzed through thematic analysis, equipped with bibliometric analysis use device VOSviewer to illustrate soft relationships between topics, research trends, and to identify focus areas major in the study of blockchain and zakat management. This research aims to compiling a literature mapping

comprehensive and provide conceptual and practical contributions to digitalization of zakat governance in Indonesia through a systematic review approach and structured meta-analysis (SLR).

3. RESULTS AND DISCUSSION

3.1. Results

Figure 2. Development of Studies on The Issue of Zakat Distribution Management



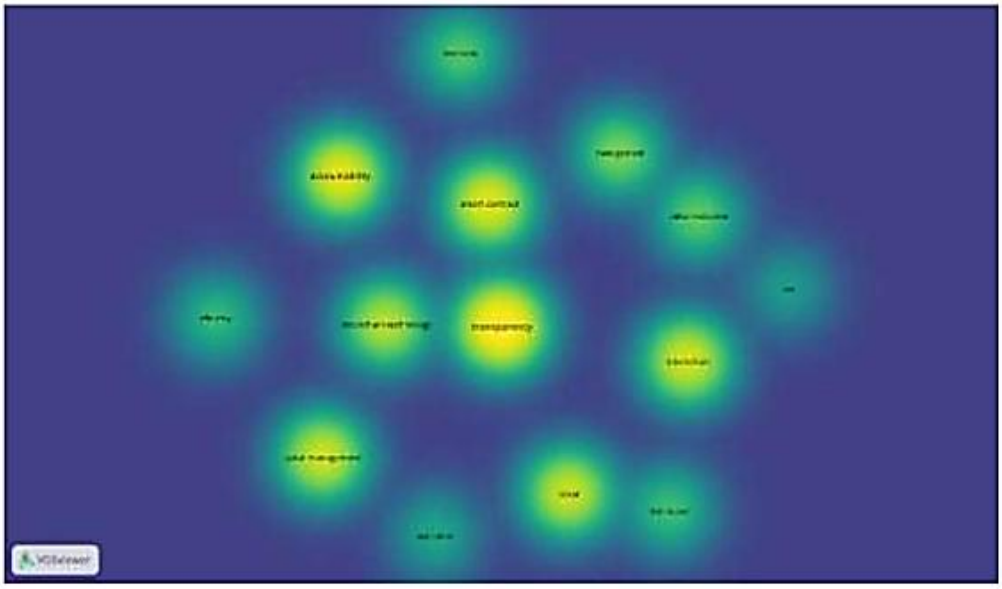
Based on the results analysis literature that has been carried out, obtained overview of research trends and mapping of topics related to implementation blockchain technology and smart contracts in zakat management. Analysis results This is presented in the form of publication trends. And visualization bibliometrics using VOSviewer.

First, the development of the number publication is shown in Figure 2. The data shows that the research related to blockchain and smart contracts in the management of zakat experienced general increase in the period 2020–2026. In 2020, the number of publication is still relatively low, namely as many as 5 publications, then increased to 11 publications in 2021. However, there was a decline in 2022 to 4 publications. After that, the number of publications returned increase significantly in 2023 and 2024 with 17 each publication. The peak of publication occurred in 2025 with a total of 35 publications, before experiencing a decline again in 2026 to 6 publications.

Overall, the trend is shows that research in This field is experiencing growth quite rapidly in recent years most recently, especially since 2023, which indicates an increase academic attention to integration digital technology in management zakat. This finding is in line with the pattern development of literature in studies systematic, where the number of publications may experience fluctuations but tends to increase when a topic start to grow and get widespread attention. Thus, it can it is concluded that the topic of blockchain and smart contracts in zakat are a relatively new field of research but growing rapidly.

Next, based on the results keyword density mapping utilise device soft VOSviewer is displayed in the form density visualization in Figure 3. This image depicts the density the emergence of keywords in studies related to blockchain and zakat management, which is shown through changes in color intensity.

Figure 3. *Visualization of Keyword Density for Blockchain Research in Zakat Management.*

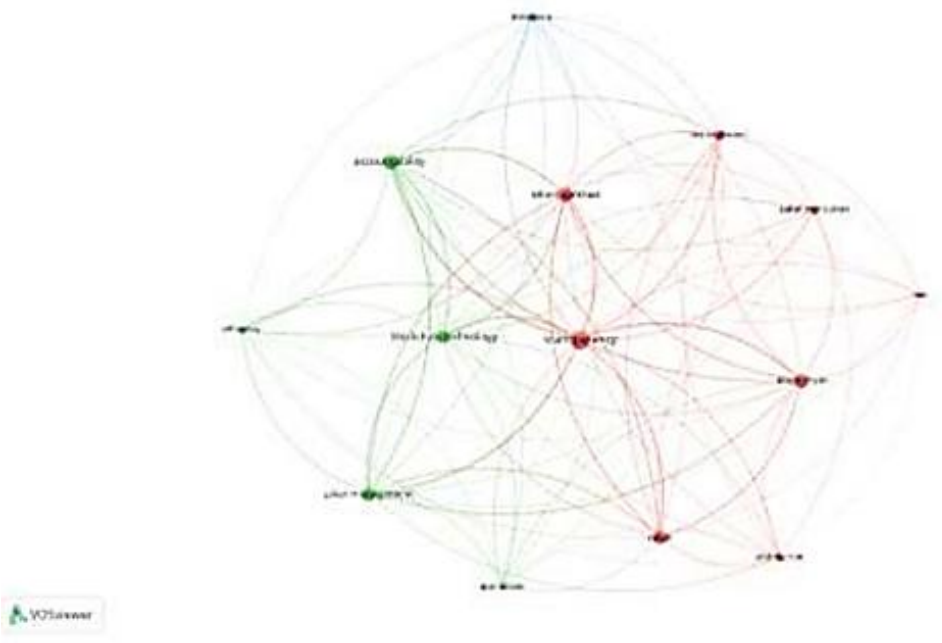


Source: VOSviewer, data processed by the author.

Bright colors indicate high degree of density, which shows that the keyword appears frequently in the literature studied. The visualization results show that terms such as transparency, blockchain, smart contracts, and accountability has color intensity which is higher than the word key other, so that it can identified as a key focus in studies on the application of technology blockchain in zakat administration. In research on zakat administration technology-based.

In addition, additional keywords such as zakat management, distribution, efficiency, and zakat institutions shows sufficient density high, which indicates that This research does not only discuss transparency, but also efficiency management, fund distribution process zakat, as well as the role of institutions in management show zakat. Chart This that the implementation between all the keywords that found, transparency shows the highest density level, which indicates that the term has been emerged as a major focus in blockchain technology in administration Zakat aims to increase transparency, accountability, and efficiency in managing zakat funds, as well as strengthening public trust towards management institutions zakat. Next, network visualization Figure 4 illustrates relationships between terms in research related to utilization blockchain technology in administration zakat.

Figure 4. Network Visualization of the Relationship between Blockchain Research Keywords in Zakat Management



Source: VOSviewer, data processed by the author

Visualization Figure 4 shows that network on research on blockchain in zakat management is developing multidisciplinary, by combining elements of technology, management, and governance of zakat organizations. Relationship close relationship between keywords This indicates that the implementation of blockchain technology aims to increase system efficiency

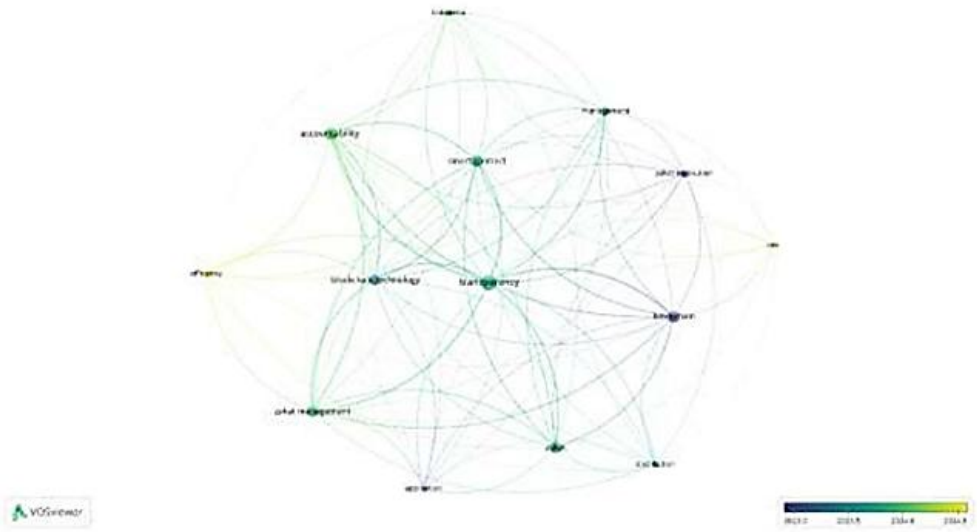
at the same time strengthen transparency accountability in fund management zakat, so that strengthen public trust in zakat management institutions in the era digital.

Cluster analysis identifies three main groups: technology clusters (blockchain, smart contracts, applications), governance cluster (transparency, accountability), and operational clusters (zakat, distribution, efficiency). This is indicates that this research developing in a multidisciplinary manner with And incorporate technological elements, management, and zakat administration.

Correlation between terms This shows that the implementation blockchain aim For increase efficiency, transparency, and accountability in management zakat, which will eventually strengthening public trust towards management institutions zakat.

Lastly, Overlay Visualization Figure 5 illustrates development of related research topics application of blockchain technology in zakat management from time to time.

Figure 5. Overlay Visualization of the Development of Blockchain Research Keywords in Zakat Management by Year



Source: VOSviewer, data processed by the author.

This image uses color the lighter (yellow) for shows the research themes that relatively new and darker in color (blue) to indicate topics longer research. With Thus, this overlay visualization provide a comprehensive overview regarding research development patterns and the direction of research focus in the last few years. The graph shows that themes such as

blockchain and the application is displayed in the color that darker, which indicates that these topics have been researched previously and became the foundation for further research developments. Meanwhile, topics such as smart contracts, efficiency, and zakat management displayed in more colors bright, which indicates that the topic the topic is a field relatively new research and has been developed in recent years last. This shows that there is shifting research focus from merely implementing blockchain technology to make use of it for increase efficiency and effectiveness zakat management.

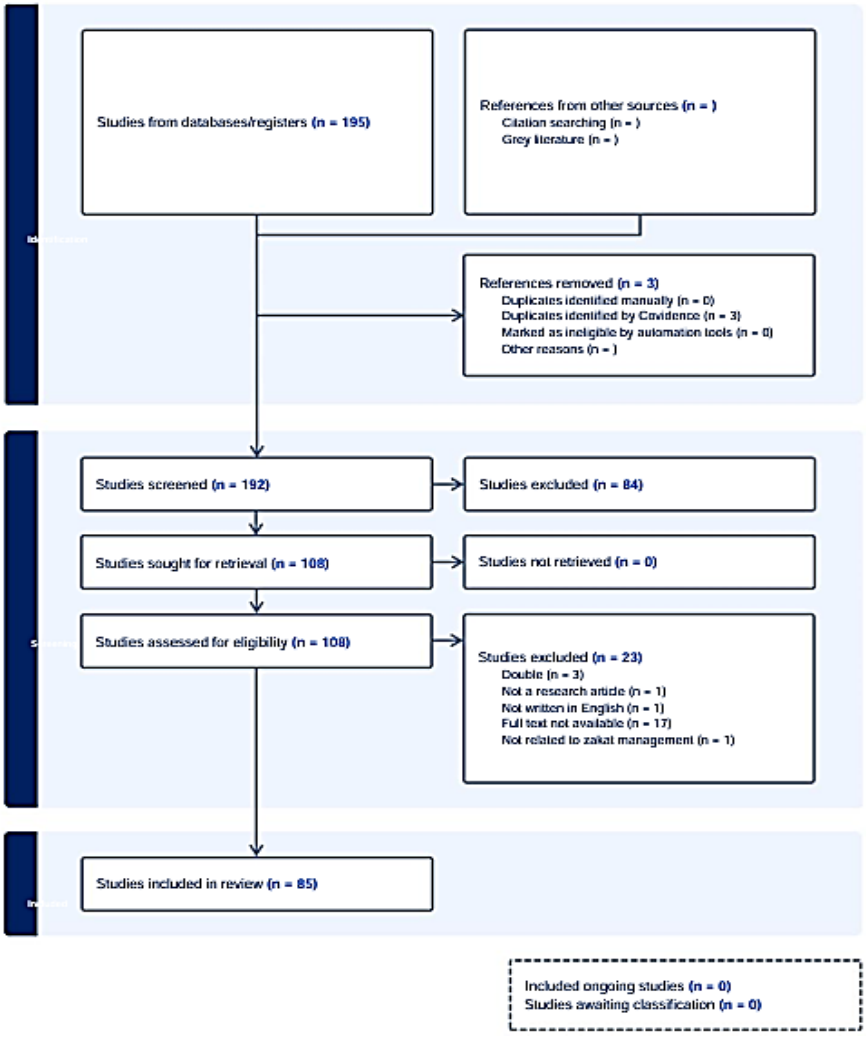
In addition, terms such as transparency And displayed in medium color accountability (green), which indicates that the topic the topic has consistently been main focus during the research period. This consistency shows that transparency And are important concepts accountability in zakat management, especially in the context of digital transformation and integration of information technology in zakat organization.

Overlay visualization on Image 5 shows that the research regarding blockchain in administration Zakat has experienced development significant over time. This development is marked by the emergence of new topics that focused on the application of technology, management efficiency, as well as increasing governance of zakat institutions. This finding indicates that the implementation of blockchain technology in administration zakat is starting to emerge as a trend research and strategic needs to improve the quality of service, transparency and public trust towards zakat management organizations in digital era.

Identification and selection process literature in this research was conducted systematically with reference to PRISMA method (Preferred Reporting Items for Systematic Reviews and Meta filtering, a total of 3 articles were removed due to duplication using the application Covidence. Furthermore, on stage screening, a total of 192 articles were selected Analyses). Based on search results through the Scopus and Google databases Scholar, obtained as many as 195 articles beginning. After the process is carried out filtering, a total of 3 articles were removed due to duplication using the application Covidence.

Furthermore, on stage screening, a total of 192 articles were selected based on the title and abstract. From this process, as many as 23 articles eliminated for not meeting the requirements inclusion criteria, such as not being an article research, not relevant to the topic zakat, not available in languages English, as well as limited full access text. The next stage is assessment eligibility , where 108 articles are analyzed in more depth. Of this number, 84 articles eliminated because it does not comply with research focus. In the final stage, A total of 85 articles were obtained meets the criteria and is used in analysis of this research. This process shows that research has through a strict selection process to ensuring quality and relevance literature used.

Figure 6. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)



Source: Flowchart , data processed by the author using Convidence software.

Based on data analysis from Covidence, research analyzed shows that most of studies focused on improving transparency, efficiency, and accountability in managing zakat through blockchain technology. From the side methodology, majority study using a qualitative approach and conceptual, while research empirical research is still limited. In addition, many studies recommend the need for development implementation and strengthening of regulations to support technology adoption blockchain in zakat management.

3.2. Discussion

The results of the study show that blockchain technology has significant potential in increasing transparency in zakat management. The dominance of the keyword transparency in VOSviewer analysis indicates that the issue of information transparency become the main focus in the literature. This is in line with the findings that stated that blockchain as distributed ledger technology allows recording of transactions which is transparent and can be audited real-time, thus increasing public trust (Crosby et al., 2015).

In addition, the use of smart contract as part of the ecosystem blockchain enables automation in the process of collecting and distribution of zakat. Smart contracts can execute transactions automatically based on the conditions that have been determined, without the need for intermediaries (G. Mohamed & Lahsasna, 2020). Implementation of smart contracts on platforms like Ethereum too model allows for increased efficiency operational and cost reduction transactions significantly (Buterin, 2014). The findings of this study also shows that blockchain is capable of increase efficiency and accountability in zakat management. Technology blockchain is known to reduce information asymmetry and increase quality of organizational governance (Yermack, 2017). In the context of zakat, the system blockchain-based enables muzaki to track the distribution of funds directly to the mustahik, thereby increasing accountability zakat institutions (Zulfikri et al., 2021). However, the results of the analysis also revealed that some most of the research is still preliminary conceptual, so that implementation practical blockchain technology in zakat management is still limited. Despite its great potential, adoption blockchain still faces various technical and non-technical challenges (Casino et al., 2019). The main challenge is identified include regulatory aspects, infrastructure readiness, and literacy digital users. Ambiguity regulation is one of the obstacles key in blockchain implementation in public sector (Ølnes et al., 2017). In addition that, technological and resource readiness humans are also an important factor in determining the success of adoption this technology (Alaeddin et al., 2021).

Furthermore, the results of the analysis network shows that research blockchain in zakat is in nature multidisciplinary, combining aspects technology, management, and social. This confirms that the implementation blockchain does not only depend on technology alone, but also on institutional readiness and acceptance society. Blockchain is not only is a technological innovation, but also transformation in social systems and economy (Swan, 2015). With Thus, this study confirms that the application of blockchain in management zakat need a comprehensive approach that covers aspects of technology, regulation, governance management, as well as user literacy. Without comprehensive integration, potential technology blockchain in increase transparency and efficiency zakat management will not be able to utilized optimally.

4. CONCLUSION

This study examines the literature in the form of a scientific article that discusses issues related to zakat management with method systematically. From this study, found a number of literature references relevant to the topic of application technology in zakat management, especially blockchain and smart contracts. The study results show that this topic continues to experience quite significant development from year to year, along with increasing need for systems more transparent zakat management, efficient, and accountable.

Based on a review of selected literature, it was found that blockchain technology give increase contribution transparency capable in And accountability through a recording system decentralized, cannot changed, and can be traced in real-time. Meanwhile, the smart contract play a role in automating processes transaction increase zakat, so that it can efficiency as well as minimize potential error and abuse in management of zakat funds. In its implementation, technology-based zakat management can be done more systematically both in terms of collection and distribution, which includes approaches both consumptive and productive. However great potential in transforming zakat management system becomes more modern and reliable, even though.

Thus, the application of this technology does not despite the various challenges that need to be considered, including readiness technological infrastructure, regulations that not fully supported, and digital literacy levels are still low varies among zakat institutions.

Therefore, in its development to front, blockchain-based zakat management And smart contract considering several factors main, namely: need

1. Strengthening cooperation between zakat institutions, government, and other stakeholders in supporting transformation digital.
2. Increasing resource capacity humans, especially in aspects technology and managerial.
3. Development of distribution model zakat Which sustainable, innovative And including utilization of productive schemes.
4. Optimizing the use of technology information as increased transparency and efficiency of zakat management.

Thus, this research means concluded that technology blockchain and smart contracts have its implementation still requires readiness from various supporting aspects.

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E-TİCARETTE YEŞİL LOJİSTİK VE BT YETKİNLİĞİ: ÇEVRESEL BELİRSİZLİKTEN STRATEJİK ÇEVİKLİĞE GEÇİŞTE KAVRAMSAL BİR MODEL

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Özet

Küresel dijitalleşme ile ivme kazanan e-ticaret sektörü, ambalaj atıkları ve artan karbon emisyonları gibi çevresel belirsizlikler yaratmaktadır. Bu durum, işletmeleri pazarın gerektirdiği yüksek teslimat performansı ile sürdürülebilirlik hedefleri arasında sıkıştırmaktadır. Bu çalışmanın amacı, işletmelerin Bilgi Teknolojileri (BT) yetkinliği ve dijital tedarik zinciri entegrasyonu aracılığıyla bu çevresel zorlukları nasıl stratejik çevikliğe dönüştürülebileceğini ortaya koyan kavramsal bir model önermektir. Çalışmada nitel araştırma tasarımı benimsenerek e-ticaret ve yeşil lojistik alanındaki güncel ampirik ve teorik çalışmalar BT yetkinliği, dijitalleşme ve stratejik çeviklik odaklı olarak sistematik bir süzgeçten geçirilmiş ve sentezlenmiştir. Araştırma bulguları, yeşil lojistiğin işletmeler için yalnızca bir uyum maliyeti veya Çevresel, Sosyal ve Kurumsal Yönetişim (ÇSKY) raporlama zorunluluğu olmadığını ortaya koymaktadır. Büyük veri, blokzinciri ve Nesnelerin İnterneti (IoT) gibi dijital teknolojilerle desteklenen yeşil lojistik stratejileri, tedarik zincirindeki "yeşil aklama" (greenwashing) risklerini azaltmakta ve operasyonel görünürlüğü artırmaktadır. Sonuç olarak, güçlü bir BT yetkinliği ile entegre edilen yeşil lojistik uygulamalarının, e-ticaret ağlarına makroekonomik ve çevresel şoklara karşı sosyo-ekolojik dayanıklılık (resilience) sağladığı ve işletmelere stratejik çeviklik kazandırdığı tespit edilmiştir.

Anahtar Kelimeler: Dijital Tedarik Zinciri Yönetimi, E-Ticaret Performansı, Yeşil Lojistik, BT Yetkinliği, Stratejik Çeviklik

GREEN LOGISTICS AND IT CAPABILITY IN E-COMMERCE: A CONCEPTUAL MODEL FOR TRANSITIONING FROM ENVIRONMENTAL UNCERTAINTY TO STRATEGIC AGILITY

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Abstract

Accelerated by global digitalization, the e-commerce sector generates profound environmental uncertainties, such as packaging waste, high return rates, and increasing carbon emissions. This situation catches enterprises in a dilemma between the high delivery performance demanded by the market and their sustainability goals. The objective of this study is to propose a conceptual model demonstrating how enterprises can transform these environmental challenges into strategic agility through Information Technology (IT) capability and digital supply chain integration. By adopting a qualitative research design, current empirical and theoretical studies in the fields of e-commerce and green logistics are systematically filtered and synthesized with a focus on IT capability, digitalization, and strategic agility. Research findings reveal that green logistics is not merely a compliance cost or an Environmental, Social, and Corporate Governance (ESG) reporting obligation for enterprises. On the contrary, green logistics strategies supported by digital technologies such as big data, blockchain, artificial intelligence, and IoT eliminate greenwashing risks in the supply chain and maximize operational visibility. Consequently, it is established that green logistics practices, when integrated with a robust IT capability, provide e-commerce networks with socio-ecological resilience against macroeconomic and environmental shocks, directly granting enterprises strategic agility.

Keywords: Digital Supply Chain Management, E-Commerce Performance, Green Logistics, IT Capability, Strategic Agility

GİRİŞ

Dünya genelinde e-ticaret, dijitalleşmenin ivme kazanmasıyla birlikte gözle görülür bir büyüme sürecine girmiştir. Özellikle COVID-19 pandemisinin tüketici alışkanlıklarını kalıcı olarak değiştirmesiyle bu büyüme daha da hızlanmıştır (Koch vd., 2020; Nanda vd., 2021). Bu önemli genişleme, küresel perakende satışlarını yeni zirvelere taşırken (Mondal ve Giri, 2022), e-ticaretin doğası gereği ortaya çıkan yüksek teslimat hacimleri çevresel sorunları da beraberinde getirmiştir. Özellikle tek kullanımlık ambalaj atıkları ve son kilometre teslimatlarının neden olduğu yoğun karbon emisyonları, tedarik zincirindeki ekolojik tahribatı artıran temel aktörleri haline gelmiştir (Escursell vd., 2021; Ram vd., 2024).

Günümüzde işletmeler; bir yanda pazarın dayattığı hızlı teslimat beklentileri, diğer yanda yeni çevre regülasyonları ile karbon ayak izini düşürme zorunluluğu arasında stratejik bir ikileme düşmektedir (Georgescu vd., 2025). Karbon vergilendirme politikaları, artan iade oranları ve öngörülemeyen talep dalgalanmaları, özellikle kısıtlı kaynaklara sahip işletmeler için e-ticaret lojistiğindeki yapısal ve çevresel belirsizlikleri arttırmaktadır. Mevcut yazın bu çevresel belirsizlikleri genellikle büyük e-ticaret platformlarının maliyet optimizasyonu ekseninde ele alırken, kısıtlı kaynaklara sahip işletmelerin bu baskıları teknolojik entegrasyon ile nasıl stratejik bir avantaja dönüştüreceği sorusu büyük ölçüde yanıtsız kalmaktadır.

Bu çalışmanın amacı, işletmelerin BT yetkinliği ve dijital tedarik zinciri entegrasyonu aracılığıyla çevresel zorlukları nasıl stratejik çevikliğe dönüştürebileceğine ortaya koyan kapsamlı bir model önermektir. Bu bağlamda, bu araştırma şu temel soruları yanıtlamayı hedeflemektedir:

- E-ticaret işletmeleri artan çevresel belirsizlikleri yönetmek ve tersine lojistik zorluklarını aşmak için BT yetkinliğini nasıl bir stratejik araca dönüştürebilir?
- Yeşil lojistik uygulamaları ile BT yetkinliğinin entegrasyonu, değişken pazar koşulları altında işletmelere nasıl bir stratejik çeviklik kazandırır?

Bildiri şu sırayla ilerlemektedir: Bölüm 2'de çalışmanın kuramsal altyapısı ve temel değişkenler arası teorik bağlantılar sunulmaktadır. Bölüm 3'te araştırmanın yöntemi detaylandırılmakta, Bölüm 4'te TCCM literatür sentezi bulguları verilmektedir. Bölüm 5'te TCCM tablosu sunulmakta, Bölüm 6'da önerilen kavramsal model önermelerle birlikte açıklanmaktadır. Çalışma, Bölüm 7'deki tartışma, özgün katkı, sınırlılıklar ve gelecek araştırma önerileri ile son bulmaktadır.

1. LİTERATÜR TARAMASI VE TEORİK ALTYAPI

Bu bölümde, e-ticaret ve yeşil lojistik konularında mevcut literatürdeki temel kavramlar ve teorik altyapı incelenecek; önerilen kavramsal modelin temelleri üzerinde durulacaktır. E-

ticaret hacminin küresel ölçekte genişlemesi, işletmelere pazar payı ve hız kazandırırken, emisyon yoğunluğu ve ambalaj atıkları gibi çevresel belirsizlikleri yüksek seviyelere çıkarmıştır. Geleneksel e-ticaret yapılarında yüksek müşteri beklentileri ile ekolojik hedefler arasındaki dengeyi salt süreçleri "yeşillendirerek" kurmak yeterli olmamakta; bu durum güçlü bir dijital tedarik zinciri entegrasyonunu gerektirmektedir.

1.1. Çevresel Belirsizlik

Çevresel belirsizlik, özellikle pazar dinamiklerinin öngörülemezliği ve değişkenliğinden kaynaklanmaktadır. İşletmelerin çevresel belirsizliklere yanıtları ekonomik, politik ve çevresel koşullar tarafından şekillendirilmektedir. Örneğin e-ticaret alanında karbon fiyatlandırma mekanizmalarındaki değişiklikler, yeni emisyon regülasyonları, öngörülemeyen pazar talepleri, yüksek iade oranları, tersine lojistik ağlarında zaman kısıtlarına ve operasyonel belirsizliklere yol açmaktadır (Frei vd., 2020). Gelişmekte olan pazarlardaki KOBİ'ler, sermaye ve altyapı kısıtları nedeniyle bu makroekonomik ve çevresel şoklara karşı daha hassas bir konumdadır. Çevresel belirsizliklerin yarattığı bu tehditler, işletmelerin bilgi akışlarını optimize edecek teknolojik çözümlere yönelmesini zorunlu kılmaktadır. Bu doğrultuda BT yetkinliği kritik bir değişken olarak öne çıkmaktadır.

1.2. BT Yetkinliği ve Dijital Tedarik Zinciri

Bilgi Teknolojileri (BT) yetkinliği, işletmelerin veri görünürlüğünü artırarak karar alma süreçlerini optimize etmelerini sağlayan teknolojik kapasitedir. Nesnelerin İnterneti (IoT), büyük veri ve blokzinciri teknolojileri, tedarik zincirinde gerçek zamanlı veri akışı ve şeffaflık sağlamaktadır (Prajapati vd., 2022). Özellikle ürün yaşam döngüsü verilerinin değiştirilemez şekilde kaydedilmesi, bilgi asimetrisini azaltmakta ve yeşil aklama (greenwashing) risklerini önlemektedir (Dong vd., 2023). KOBİ'lerin bu dijital araçları operasyonlarına entegre etmesi, pazar adaptasyonlarını desteklemektedir. BT yetkinliğinin sağladığı bu şeffaflık ve dijital izlenebilirlik, doğrudan operasyonel süreçlerin ekolojik optimizasyonuna, yani yeşil lojistik faaliyetlerine zemin hazırlamaktadır.

1.3. Yeşil Lojistik

Yeşil lojistik, taşıma, depolama ve iade süreçlerinin çevresel etkilerini ölçen ve azaltmayı hedefleyen operasyonel uygulamalar bütünüdür (Olkiewicz ve Dyczkowska, 2025). E-ticaret bağlamında tek kullanımlık ambalajlar yerine geri dönüştürülebilir taşıma ürünlerinin (RTI) kullanılması, ambalaj atıklarını ve ilgili maliyetleri düşürmektedir (Clement ve Spinler, 2025). Yapay zekâ destekli akıllı rota optimizasyonu ve alternatif yakıtlı araç kullanımı, son kilometre teslimatlarında yakıt sarfiyatını ve birim operasyonel maliyetleri asgari seviyeye indirmektedir (Ermağan vd., 2024; Qi vd., 2023). Yeşil lojistik uygulamalarının başarıyla yürütülmesi sadece çevresel hedeflere ulaşmayı değil, aynı zamanda değişken dış koşullara

karşı işletmenin stratejik manevra kabiliyeti kazanmasını, bir diğer ifadeyle stratejik çevikliğini de desteklemektedir.

1.4. Stratejik Çeviklik

Stratejik çeviklik, işletmelerin dışsal regülasyonlara ve pazar dalgalanmalarına dinamik uyum sağlama yeteneğidir. Çevresel belirsizliklerin yüksek olduğu durumlarda, dijital entegrasyona sahip işletmeler yenilikçi hizmet paylaşımları geliştirerek kapasite esnekliği elde etmektedir. KOBİ'ler için stratejik çeviklik, kısıtlı kaynaklara rağmen ekolojik krizlere ve ani talep değişimlerine yanıt verebilme kapasitesini ifade etmektedir. Kaynaklara Dayalı Kuram ve Dinamik Yetenekler ekseninde oluşturulan bu kavramsal zemin, araştırma modelinin temel mekanizmalarını oluşturmaktadır.

2. YÖNTEM

Bu çalışmada, e-ticaret ve yeşil lojistik operasyonları arasındaki dinamikleri incelemek ve gelecekteki ampirik çalışmalara zemin hazırlayacak kavramsal bir model önermek amacıyla nitel araştırma tasarımı benimsenerek "Sistematik Literatür Sentezi" yöntemi kullanılmıştır. Veri toplama sürecinde Web of Science (WoS) veri tabanı üzerinden; e-ticaret, yeşil lojistik, çevresel belirsizlik, BT yetkinliği ve stratejik çeviklik kavramlarının kombinasyonları 2021-2026 yılları aralığı baz alınarak taranmıştır. Ön tarama sonucunda ulaşılan 82 makaleden 17'si; e-ticaret odağından uzak olmaları, tam metinlerine ulaşılamaması ve hakemli akademik dergilerde İngilizce dilinde yayımlanmamış olmaları gibi dışlama kriterleri doğrultusunda elenmiş ve nihai olarak araştırma hedefleriyle örtüşen 65 temel makale analize dahil edilmiştir.

Elde edilen 65 makaleden oluşan literatür havuzunu sistematik bir şekilde yapılandırmak ve mevcut araştırma boşluklarını (research gaps) nesnel bir biçimde ortaya çıkarmak için, literatürde yaygın olarak kabul gören TCCM çerçevesi (Paul ve Criado, 2020) kullanılmıştır. TCCM, dağınık haldeki literatürü dört temel boyutta inceleyen analitik bir çerçevedir:

- Teori (Theory): İncelenen çalışmaların hangi kuramsal temeller üzerine inşa edildiğini analiz eder.
- Bağlam (Context): Araştırmaların uygulandığı coğrafi bölgeleri, pazarları ve işletme ölçeklerini haritalandırır.
- Özellikler (Characteristics): Literatürdeki araştırma modellerinde yer alan temel değişkenleri, odaklanılan kavramları ve ilişkileri tespit eder.
- Metodoloji (Methodology): Mevcut çalışmalarda tercih edilen araştırma desenlerini ve veri analiz tekniklerini inceler.

Bu matris yardımıyla, özellikle kısıtlı kaynaklara sahip KOBİ'ler odağındaki bağlamsal eksiklikler ile stratejik değişkenlerin bir arada kullanılmamasından doğan teorik boşluklar tespit edilerek önerilen kavramsal modelin temelleri atılmıştır.

3. BULGULAR: TCCM LİTERATÜR SENTEZİ VE ARAŞTIRMA BOŞLUKLARI

Bu bölümde, e-ticaret ve yeşil lojistik kesişiminde yer alan 65 makalenin TCCM (Teori, Bağlam, Özellikler, Metodoloji) analizi üzerinden elde edilen bulgular sentezlenmiş ve çalışmanın dayandığı araştırma boşlukları (research gaps) nesnel bir çerçevede sunulmuştur. Tablo 1, ilgili literatürdeki genel eğilimleri açıkça ortaya koymakta ve bu çalışmanın literatüre yapacağı özgün katkının temelini detaylandırmaktadır.

Tablo 1. TCCM Literatür Sentezi ve Araştırma Boşlukları

TCCM Boyutu	Literatürdeki Eğilim	Tespit Edilen Araştırma Boşluğu (Research Gap)
(T) Teori	Çoğu çalışmada kuramsal çerçevenin "Belirtilmemiş" olması; operasyonel optimizasyon odaklı ilerleme (Oyun Teorisi, TAM, TPB gibi kuramların dar kullanımı).	Süreçleri açıklarken Kaynaklara Dayalı Kuram (RBV) veya Dinamik Yetenekler gibi işletmelerin stratejik adaptasyonunu açıklayan üst düzey kuramların eksikliğinden doğan **teorik sığlık**.
(C) Bağlam Coğrafya	Yoğunlukkla Çin ve AB ülkeleri ve kısmen gelişmiş Asya ülkeleri. Türkiye bağlamında ise araştırmaların genellikle büyük ticaret ve lojistik merkezleriyle (örn. İstanbul) sınırlı kalması.	Operasyonel zorluklarla mücadele eden ve krizlere açık olan **gelişmekte olan pazarların** derinlemesine analiz edilmemesi.
(C) Bağlam Örneklem	Analizlerin büyük oranda küresel lojistik firmaları, B2C/B2B dev e-ticaret platformları (Amazon, Alibaba, Trendyol vb.) veya makro sistemler üzerinden yapılması.	Sermaye ve teknoloji erişimi düşük olan, ancak pazarın belkemiğini oluşturan **kısıtlı kaynaklara sahip KOBİ'lerin** e-ticaret ve yeşil dönüşüm yapılarının ihmal edilmesi.
(C) Özellikler Değişkenler	Araç rotalama verimliliği, karbon/ambalaj maliyeti optimizasyonu, yeşil aklama, fiyatlandırma, bilgi asimetrisi gibi izole edilmiş operasyonel karar değişkenleri.	**'Çevresel Belirsizlik', 'BT Yetkinliği', 'Dijital Tedarik Zinciri Yönetimi' ve 'Stratejik Çeviklik'** değişkenlerinin bir arada ve bütüncül bir kurgu ile (eşzamanlı paralel yapıda) incelenmemesi.
(M) Metodoloji	Aşırı nicel ağırlıklı yöneylem araştırmaları: MILP/MINLP matematiksel modellemeleri, algoritmik simülasyonlar, Stackelberg / Nash denge analizleri.	Bilişim ve stratejik yönetim perspektifi barındıran stratejik ve kavramsal modellerin, KOBİ'lerden toplanacak birincil veriler eşliğinde **Yapısal Eşitlik Modellemesi (PLS-SEM)** ile ampirik test ihtiyacı.

Tablo 1'de detaylandırılan bulgular ışığında, TCCM boyutlarına yönelik temel çıkarımlar şu şekilde yapılandırılmıştır:

3.1. Teorik Eğilimler (Theory)

E-ticaret ve yeşil lojistik alanındaki mevcut çalışmaların teorik altyapısı incelendiğinde, makalelerin birçoğunda kuramsal çerçevenin zayıf kaldığı görülmektedir. Mevcut literatür; araç rotalama, maliyet minimizasyonu ve kapasite ataması gibi doğrudan operasyonel çözümlere odaklanmaktadır. Dijital teknolojilerin işletmelere rekabet avantajı ve esneklik kazandırma potansiyelini açıklayan Kaynaklara Dayalı Kuram (RBV) veya Dinamik Yetenekler Kuramı gibi temel stratejik yönetim teorilerinin eksikliği alanda teorik bir sığlık yaratmaktadır.

3.2. Bağlam Analizi (Context)

Literatürdeki çalışmaların bağlamsal yığılması analiz edildiğinde, araştırmaların coğrafi olarak büyük ölçüde gelişmiş pazarlar üzerinde kümelendiği; örneklem olara ise küresel lojistik devlerinin, kompleks çok tesisli ağaların ve büyük e-ticaret platformlarının tercih edildiği tespit edilmiştir.. Literatürdeki asıl araştırma boşluğu; gelişmekte olan pazarlardaki kısıtlı kaynaklara sahip KOBİ'lerin eksenindedir. Büyük platformların stratejilerini optimize eden mevcut modeller, kısıtlı kaynaklara sahip ancak pazarın esnekliğini sağlayan KOBİ'lerin dijital ve yeşil dönüşüm ihtiyacını yansıtmaktan uzaktır.

3.3. Kavramsal Özellikler (Characteristics)

Literatürde karbon emisyon cezaları, teslimat optimizasyonu ve yeşil aklama (greenwashing) gibi faktörler çoğunlukla izole operasyonel bağımsız değişkenler olarak ele alınmıştır. Ancak e-ticaret performansını doğrudan etkileyen 'BT Yetkinliği' ve 'Stratejik Çeviklik' gibi yetenek bazlı gizil (latent) yapılar ile 'Çevresel Belirsizlik' gibi dışsal düzenleyici (moderatör) faktörlerin, eşzamanlı ve sistemik bir nedensellik bağıyla bütüncül bir kurgu içinde incelenmediği saptanmıştır.

3.4. Metodolojik Yönelimler (Methodology)

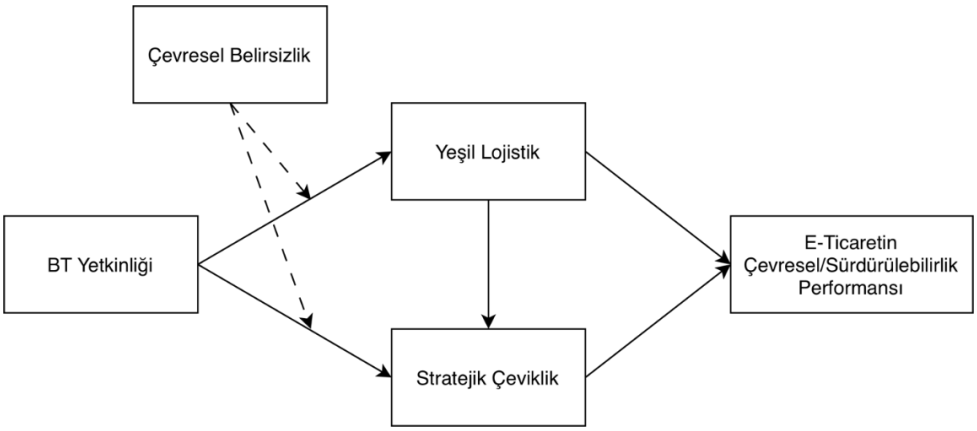
İncelenen çalışmaların metodolojik yönelimleri, e-ticaret lojistiği alanının büyük oranda Karma Tam Sayılı Doğrusal Programlama (MILP/MINLP) ve sayısal simülasyonlara dayandığını göstermektedir. Yöneylem araştırmaları doğrudan maliyet ve rota optimizasyonuna odaklansa da; bilişim ve stratejik yönetim perspektifi gerektiren ölçülmesi zor yapıların KOBİ yöneticilerinin algıları üzerinden değerlendirilmesi, ampirik doğrulama için PLS-SEM gibi varyans temelli yaklaşımları zorunlu kılmaktadır.

4. ÖNERİLEN KAVRAMSAL MODEL VE ÖNERMELER

TCCM analizi sonucunda tespit edilen literatür boşluklarını doldurmak amacıyla geliştirilen kavramsal araştırma modeli Şekil 1'de sunulmaktadır. Önerilen model, işletmelerin teknolojik ve operasyonel varlıklarını rekabet avantajına çevirmesini açıklayan Kaynaklara Dayalı

Kuram (RBV) ve değişen dış çevre koşullarına uyum sağlama yeteneğini vurgulayan Dinamik Yetenekler (Dynamic Capabilities) kuramına dayanmaktadır.

Şekil 1: Araştırma Kapsamında Önerilen Kavramsal Model



BT yetkinliği, yeşil lojistik operasyonlarını pasif bir maliyet olmaktan çıkarıp dinamik bir rekabet unsuruna dönüştürür. Sistemin temel belirleyicisi olan BT yetkinliği, eşzamanlı olarak hem yeşil lojistik operasyonlarını optimize eder hem de işletmeye stratejik çevik kazandırır. Bu süreçte "Çevresel Belirsizlik", pazar dinamiklerini ve regülasyon baskılarını yansıtan dışsal bir koşul olarak, teknolojik yetkinliklerin eyleme dönüşüm hızını belirleyen bir düzenleyici (moderatör) faktör olarak modelde konumlandırılmıştır. Bu yapısal çerçeve bağlamında, kavramsal modelin önermeleri aşağıdaki gibi kurgulanmıştır:

- P1: İşletmelerin sahip olduğu BT yetkinliği, yeşil lojistik uygulamalarını pozitif yönde etkiler.
- P2 İşletmelerin sahip olduğu BT yetkinliği, stratejik çeviklik kapasitesini pozitif yönde etkiler.
- P3: Başarıyla yürütülen yeşil lojistik uygulamaları, stratejik çeviklik kapasitesini artırır
- P4: Yeşil lojistik uygulamaları, e-ticaretin sürdürülebilirlik performansını pozitif yönde etkiler.
- P5: Kazanılan stratejik çeviklik yeteneği, e-ticaretin sürdürülebilirlik performansı üzerinde pozitif yönlü bir etkiye sahiptir.
- P6: Çevresel belirsizlik; BT yetkinliğinin, yeşil lojistik ve stratejik çeviklik üzerindeki pozitif etkilerinde düzenleyici (moderatör) bir role sahiptir. Dışsal belirsizlik arttıkça, BT yetkinliğinin bu stratejik eylemlere dönüşüm gücü artar.

5. TARTIŞMA VE SONUÇ

Çalışma bulguları, yeşil lojistiğin işletmeler için sadece bir ÇSKY (ESG) raporlama zorunluluğu veya yasal uyum maliyeti olmadığını göstermektedir. Geliştirilen kavramsal model, yeşil lojistik süreçlerinin güçlü bir BT altyapısıyla birleştiğinde e-ticaret firmaları için pasif bir operasyonel adım olmaktan çıkıp proaktif bir rekabet kalkanına dönüştüğünü ortaya koymaktadır.

Bu çalışmanın literatüre özgün katkısı, e-ticaret lojistiği literatüründe genellikle izole olarak incelenen kavramları bütüncül bir modele entegre etmesi ve kısıtlı kaynaklara sahip KOBİ'ler bağlamında çevresel belirsizlikleri yönetmeye yönelik PLS-SEM ile test edilebilir net bir teorik mimari sunmasıdır. Özellikle kısıtlı kaynaklara sahip KOBİ'ler açısından değerlendirildiğinde; değişken karbon vergileri, ani talep dalgalanmaları ve regülasyonlar gibi çevresel belirsizlik faktörleri, işletmelerin elindeki BT yetkinliklerini yeşil lojistik ve stratejik çeviklik eylemlerine dönüştürme gücünü artıran kritik birer katalizör rolü oynamaktadır. Dinamik Yetenekler Kuramı ekseninde kurgulanan bu mekanizma, makroekonomik şoklar karşısında e-ticaret ağlarına yapısal bir sosyo-ekolojik dayanıklılık (resilience) kazandırmaktadır.

5.1. Sınırlılıklar

Bu araştırmanın temel sınırlılığı, TCCM literatür sentezine ve stratejik yönetim teorilerine dayanılarak oluşturulan kavramsal modelin henüz ampirik verilerle test edilmemiş olmasıdır. Salt kavramsal çıkarımlara dayanan modelin dinamik Pazar koşullarındaki geçerliliği pratik kanıtlara ihtiyaç duymaktadır.

5.2. Gelecek Araştırma Önerileri

Modelin ampirik geçerliliğinin sınanması için çok fazlı bir araştırma ajandası öngörülmektedir. Faz I kapsamında sistematik literatür sentezi ile teorik çerçeve inşa edilmiştir. Faz II ve Faz III kapsamında ise, modelin gelişmekte olan pazar odaklı eksikliğe yanıt verebilmesi amacıyla Türkiye'de e-ticaret sektöründe faaliyet ve büyük ticaret/lojistik merkezlerinde (örn. Marmara Bölgesi) komunlanan KOBİ yöneticilerinden anket yöntemi ile birincil verilerin toplanması planlanmaktadır. Elde edilecek bu veriler ışığında, kavramsal modelin Yapısal Eşitlik Modellemesi (PLS-SEM) kullanılarak ampirik olarak test edilmesi ve literatürden uyarlanacak ölçeklerin geçerlilik ve güvenirlik analizlerinin yapılması hedeflenmektedir.

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DÖNGÜSEL EKONOMİ POLİTİKALARI EKSENİNDE AB VE ÇİN ARASINDAKİ KÜRESEL GÜÇ REKABETİ

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Özet

Küresel iklim krizine verilen yanıtların biçimlenmesiyle birlikte sürdürülebilirlik politikaları, yalnızca çevresel bir politika olmaktan çıkarak uluslararası sistemdeki güç ilişkilerini doğrudan etkileyen stratejik bir alana dönüşmüştür. Bu araştırma, söz konusu dönüşümü döngüsel ekonomi politikaları ekseninde ele alarak Avrupa Birliği ve Çin Halk Cumhuriyeti'nin sürdürülebilirlik stratejilerini karşılaştırmalı biçimde incelemeyi amaçlamaktadır. Çalışmanın temel araştırma sorusu şudur: Avrupa Birliği'nin normatif düzenleyici yaklaşımı ile Çin'in devlet güdümlü endüstriyel modeli, döngüsel ekonomi politikaları kapsamında küresel güç ilişkilerini nasıl yeniden şekillendirmektedir? Araştırma, Avrupa Birliği'nin konumunu Ian Manners'ın Normatif Güç Avrupa kavramı ile açıklarken; Çin'in stratejisini Chalmers Johnson'ın Kalkınmacı Devlet kuramı çerçevesinde değerlendirmektedir. Çalışmada karşılaştırmalı nitel analiz yöntemi kullanılmış; AB Yeşil Mutabakatı, Döngüsel Ekonomi Eylem Planı ve Kritik Hammaddeler Yasası ile Çin'in 14. Beş Yıllık Planı birincil kaynak olarak incelenmiş; akademik literatür ve uluslararası kuruluş raporlarıyla desteklenmiştir. Araştırmanın temel iddiası şudur: AB, bağlayıcı çevresel standartlar ve sınırda karbon düzenlemeleri aracılığıyla küresel ticareti biçimlendirmeye çalışan normatif bir aktör olarak hareket ederken; Çin, devlet sübvansiyonları ve ölçek ekonomisi üzerinden yeşil teknoloji üretiminde yapısal bir üstünlük kurmaktadır. Çin'in kritik hammaddeler üzerindeki egemenliği AB'nin stratejik özerklik arayışını zora sokmakta; bu durum iki aktörü eş zamanlı olarak hem rakip hem de karşılıklı bağımlı bir konuma taşımaktadır. Bu durum, döngüsel ekonominin yalnızca çevresel değil, aynı zamanda jeopolitik bir rekabet alanına dönüştüğünü göstermektedir.

Anahtar Kelimeler: Döngüsel Ekonomi, Avrupa Birliği, Çin, Normatif Güç, Kalkınmacı Devlet

GLOBAL POWER COMPETITION BETWEEN THE EUROPEAN UNION AND CHINA WITHIN THE FRAMEWORK OF CIRCULAR ECONOMY POLICIES

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Abstract

As responses to the global climate crisis have taken shape, sustainability policies have evolved from being merely environmental policies into a strategic domain that directly influences power relations within the international system. This study aims to examine the sustainability strategies of the European Union and the People's Republic of China in a comparative manner, focusing on the transformation of sustainability policies through the lens of circular economy policies. The central research question of the study is: How do the European Union's normative regulatory approach and China's state-driven industrial model reshape global power relations within the framework of circular economy policies? The study explains the European Union's position using Ian Manners' concept of "Normative Power Europe," while evaluating China's strategy within the framework of Chalmers Johnson's "Developmental State" theory. The study employs a comparative qualitative analysis method; the EU Green Deal, the Circular Economy Action Plan, and the Critical Raw Materials Act, along with China's 14th Five-Year Plan, are examined as primary sources and supported by academic literature and reports from international organizations. The central argument of the research is as follows: While the EU acts as a normative actor seeking to shape global trade through binding environmental standards and border carbon adjustments, China is establishing a structural advantage in green technology production through state subsidies and economies of scale. China's dominance over critical raw materials is complicating the EU's quest for strategic autonomy; this situation places the two actors simultaneously in a position where they are both rivals and mutually dependent. This demonstrates that the circular economy has become not only an environmental but also a geopolitical arena of competition.

Keywords: Circular Economy, European Union, China, Normative Power, Developmental State

GİRİŞ

Küresel iklim krizi karşısında geliştirilen sürdürülebilirlik politikaları artık yalnızca çevresel bir gündem olmaktan çıkmıştır. Yeşil dönüşüm; ülkelerin enerji güvenliği, endüstriyel rekabet gücü ve teknolojik egemenlik arayışlarıyla iç içe geçmiş, doğrudan güç ilişkilerini etkileyen stratejik bir alana dönüşmüştür. Döngüsel ekonomi, bu dönüşümün belki de en somut araçlarından birini sunmaktadır: doğrusal üretim modelini ikame eden, kaynakların yeniden kullanım, onarım ve geri dönüşüm yoluyla değer ürettiği bir ekonomik düzen oluşumudur (Ghisellini, Cialani ve Ulgiati, 2016; Geissdoerfer, Savaget, Bocken ve Hultink, 2017). Avrupa Birliği ile Çin Halk Cumhuriyeti, bu oluşumu en sistematik biçimde mevzuata ve endüstriyel politikaya tercüme eden iki aktördür; ancak bunu birbirinden farklı siyasi mantıklarla yapmaktadırlar.

Çalışmanın temel araştırma sorusu şudur: Avrupa Birliği'nin normatif düzenleyici yaklaşımı ile Çin'in devlet güdümlü endüstriyel modeli, döngüsel ekonomi politikaları kapsamında küresel güç ilişkilerini nasıl yeniden şekillendirmektedir? Bu soruyu yanıtlamak için çalışma; AB'nin Yeşil Mutabakat, Döngüsel Ekonomi Eylem Planı ve Kritik Hammaddeler Yasası gibi temel düzenleyici araçları ile Çin'in 14. Beş Yıllık Planı kapsamında geliştirdiği endüstriyel-çevresel stratejileri karşılaştırmaktadır. Çalışmanın temel iddiası, döngüsel ekonominin AB ile Çin arasında bir iş birliği alanı olmaktan çıkıp yapısal bir rekabet sahnesine dönüştüğü; ancak bu rekabetin saf bir çatışma değil, karşılıklı bağımlılık tarafından sınırlandırılmış bir mücadele biçimi ürettiği üzerinedir.

1. LİTERATÜR ARAŞTIRMASI

Döngüsel ekonomi üzerine akademik literatür son on yılda önemli bir derinlik kazanmıştır. Ghisellini ve diğerleri (2016) döngüsel ekonomiyi çevresel ve ekonomik sistemler arasında dengeli bir etkileşime yönelik bir geçiş olarak ele almış; Geissdoerfer ve diğerleri (2017) döngüsel ekonomiyi yeni bir sürdürülebilirlik paradigması olma potansiyeli olarak ele almıştır. Kirchherr, Reike ve Hekkert (2017), literatürde yer alan 114 farklı döngüsel ekonomi tanımını analiz ederek kavramın çok boyutlu ve ortak bir tanım üzerinde uzlaşılamayan yapısını ortaya koymuştur. Korhonen, Honkasalo ve Seppälä (2018) ise döngüsel ekonomi yaklaşımının ekolojik, termodinamik ve ölçek temelli sınırlarına dikkat çekerek kavramın teorik uygulanabilirliğine yönelik eleştiriler geliştirmiştir. Rahla, Mateus ve Bragança (2021) ise döngüsel ekonomi stratejilerinin özellikle inşaat sektörü bağlamında teoriden uygulamaya aktarım sürecinde karşılaşılan yapısal ve operasyonel zorlukları incelemiştir.

Avrupa Birliği ve Çin'in döngüsel ekonomi deneyimleri literatürde farklı boyutlarıyla incelenmiştir. Mathews ve Tan (2011) Çin'in eko-endüstriyel girişimlerinin sürücülerini ve engellerini analiz etmiş; Geng, Fu, Sarkis ve Xue (2012) Çin'in ulusal döngüsel ekonomi gösterge sistemini eleştirel olarak değerlendirmiştir. McDowall ve diğerleri (2017), AB ve

Çin'deki döngüsel ekonomi politikalarını sistematik biçimde karşılaştırarak iki aktörün benzer söylem etrafında değerlendirse de farklı kurumsal mantıklar üzerinden farklı yörüngeler izlediğini ortaya koymuştur. Ranta, Aarikka-Stenroos, Ritala ve Mäkinen (2018) ise AB, ABD ve Çin arasındaki kurumsal sürücü ve engelleri karşılaştırarak Çin'de düzenleyici baskı ve devlet desteğinin, AB'de ise pazar talebi ile düzenleyici çerçevenin etkileşiminin baskın olduğu kanısına varmıştır.

Yapılan çalışmada AB ve Çin arasındaki etkileşimin söylemsel boyutu da incelenmiştir. Luo ve diğerleri (2021), AB-Çin döngüsel ekonomi iş birliği söyleminde ortak çıkarların ve kolektif eylemin çevresel iş birliği için tek başına yeterli olmadığını göstermiş; Luo, Rodríguez ve Leipold (2023), 2017 Çin Atık Yasağı üzerinden bu siyasi gerilimi örneklendirerek, tarafların aynı olayı farklı şekillerde çerçevelediğini ortaya koymaktadır. AB içindeki politika tutarlılığı meselesinde Friant, Vermeulen ve Salomone (2021), söylem ile eylem arasındaki uçurumu analiz ederek, AB döngüsel ekonomi politikalarının iddialı söylemine rağmen yapısal dönüşümü gerçekleştirmekte yetersiz kaldığını ileri sürmüştür.

Türkçe literatür ise döngüsel ekonomiyi büyük ölçüde Türkiye bağlamında ele almıştır. Önder (2018) döngüsel ekonomiyi sürdürülebilir kalkınma anlayışındaki yeni bir kavram olarak tanıtmış; Ay Türkmen ve Kılıç (2020) ise aynı bakış açısını model çerçevesinde tartışmıştır. Yalçın ve Negiz (2020) Türkiye'deki kentsel döngüsel ekonomi uygulamaları üzerine bir yazın taraması sunmuş; Ecer, Güner ve Çetin (2021) Avrupa Yeşil Mutabakatı karşısında Türkiye ekonomisinin uyum politikalarını analiz etmiştir. Samsun (2021) AB'nin iklim diplomasisini, Çanakçıoğlu (2023) ise yeşil büyüme ve yeşil finans ekseninde sürdürülebilir ekonomik kalkınmayı incelemiştir.

Teorik düzlemde çalışma iki kurucu yaklaşımı esas almaktadır. AB'nin döngüsel ekonomi politikasını anlamak için Manners'ın (2002) Normatif Güç Avrupa kavramı kullanılmaktadır. Manners'a göre AB'nin uluslararası etkisi zorlayıcı kapasitelerden çok değerler, hukuk ve standartlar aracılığıyla işlemekte; AB diğer aktörler için "normal olarak geçerli olanı" şekillendirmektedir. Çin'in döngüsel ekonomi modeli ise Johnson'ın (1999) ve Woo-Cumings'in (1999) kalkınmacı devlet kuramı üzerinden okunmaktadır. Bu çerçeve, siyasi olarak yalıtılmış bir bürokrasinin endüstriyel politika ve seçici teşvikler aracılığıyla stratejik sektörleri yönlendirdiği kurumsal yapılanmayı tanımlar. Vogel (2011), Deng Xiaoping reform döneminde Çin'in bu modeli Leninist siyasi kurumları piyasa mekanizmalarıyla birleştirerek nasıl uyarladığını izlemiştir. Bu çalışmada Çin'in döngüsel ekonomi stratejisi, kalkınmacı devletin endüstriyel araçlarının yeşil sektörlere uyarlanmış hâli olarak ele alınmaktadır. Mevcut literatür döngüsel ekonomiyi ayrı ayrı AB ve Çin için kapsamlı biçimde belgelemiş olsa da iki modelin etkileşimini güç ilişkileri perspektifinden bütüncül biçimde ele alan çalışmalar Türkçe literatürde sınırlıdır; bu çalışma söz konusu boşluğu doldurmaya katkı sunmayı amaçlamaktadır.

2. YÖNTEM

Çalışma karşılaştırmalı nitel analiz yöntemiyle yürütülmüştür. Çalışmada kullanılan karşılaştırmalı nitel analiz yaklaşımı, Ragin'in (2014) karşılaştırmalı yöntem anlayışına dayanmaktadır. Ragin'e göre karşılaştırmalı analiz, nitel ve nicel araştırma stratejileri arasında keskin bir ayrım yerine, vakalar arasındaki benzerlik ve farklılıkların sistematik biçimde analiz edilmesini mümkün kılan bütüncül bir araştırma mantığı sunmaktadır. Bu çerçevede araştırma, Avrupa Birliği ve Çin Halk Cumhuriyeti'nin döngüsel ekonomi politikalarını ayrı ayrı betimlemekten ziyade, bu politikaların kurumsal yapı, politika araçları ve stratejik yönelimler üzerinden karşılaştırmalı olarak çözümlenmesine odaklanmaktadır. Böylece her iki aktörün döngüsel ekonomi yaklaşımı, güç ilişkileri ve devlet kapasitesi bağlamında anlamlandırılmaktadır. Bu çalışmada karşılaştırmalı nitel analiz yönteminin tercih edilmesinin temel nedeni, Avrupa Birliği ve Çin'in döngüsel ekonomi politikalarının sayısal verilerden ziyade kurumsal belgeler, politika metinleri ve stratejik söylemler üzerinden incelenmesidir. Bu yöntem, farklı kurumsal bağlamlara sahip iki aktörün politika tasarımlarını sistematik biçimde karşılaştırmaya ve anlamlandırmaya imkân sağlamaktadır.

Veri kaynağı olarak iki tür belge kullanılmıştır. Birinci grup birincil kaynaklardır: AB tarafında Avrupa Komisyonu (2019, 2020, 2024) tarafından yayımlanan Yeşil Mutabakat, Döngüsel Ekonomi Eylem Planı ve Kritik Hammaddeler Yasası incelenmiş; Çin tarafında 14. Beş Yıllık Plan (2021-2025) ve eki niteliğindeki Döngüsel Ekonomi Geliştirme Planı resmî belgeleri esas alınmıştır. İkinci grup ikincil kaynaklardır: yukarıda anılan akademik literatür ve Uluslararası Enerji Ajansı (IEA, 2024) ile Avrupa Komisyonu raporlarından sayısal veriler elde edilmiştir. Çözümleme üç aşamadan oluşmuştur: her iki vakanın döngüsel ekonomi mimarisi ayrı ayrı betimlenmiş; dört analitik boyut üzerinden karşılaştırmalı bir matris oluşturulmuş; ortaya çıkan etkileşim örüntüleri Normatif Güç Avrupa ve kalkınmacı devlet çerçevelerinden okunmuştur. Yöntemin sınırlılıkları arasında ABD'nin doğrudan analize dahil edilmemesi ve nitel sentezin doğasındaki yorumsal değerlendirme payı yer almaktadır.

3. BULGULAR

3.1. AB'nin Normatif Düzenleyici Döngüsel Ekonomi Mimarisi

Avrupa Birliği'nin döngüsel ekonomi mimarisi, Aralık 2019'da açıklanan Avrupa Yeşil Mutabakatı ile somut bir çerçeveye kavuşmuştur. Avrupa Komisyonu (2019), Yeşil Mutabakatı AB'yi 2050'ye kadar iklim açısından nötr ilk kıta hâline getirme hedefine bağlamıştır. Bu hedefin uygulama kollarından biri olarak Mart 2020'de açıklanan Döngüsel Ekonomi Eylem Planı (Avrupa Komisyonu, 2020); Sürdürülebilir Ürünler Tüzüğü, Eko-tasarım çerçevesi, atık çerçeve direktifi ve ürün-grup bazlı sektörel düzenlemelerle ürünün tasarım aşamasından ömür sonuna kadar tüm değer zincirini kapsayan bütünleşik bir yaklaşım benimsemiştir. Sayısal hedefler bakımından plan, 2030'a kadar AB'nin malzeme ayak izinde

belirgin bir azalma ve geri dönüşüm oranlarında artış öngörmektedir; ancak Eurostat verilerine göre 2022 yılı itibarıyla AB'nin döngüsel malzeme kullanım oranı yalnızca %11,5 düzeyindedir.

Friant ve diğerleri (2021) bu yasal mimarinin iddialı bir söylem ürettiğini, ancak söylem-eylem uçurumunun belirgin kaldığını belgelemiştir. Yazarlara göre AB döngüsel ekonomi politikaları geleneksel doğrusal üretim mantığını dönüştürmek yerine onun çeperinde işlemekte; yeniden kullanım ve onarım gibi yüksek değerli döngüsellik stratejileri yerine geri dönüşüme aşırı vurgu yapmaktadır. Bu eleştiri, Korhonen ve diğerlerinin (2018) Döngüsel ekonominin mutlak kaynak azaltımıyla sınırlı angajmanına yönelik erken uyarısıyla örtüşmektedir.

AB mimarisinin belirleyici özelliği kasıtlı ülke dışı erişimidir. Sınırda Karbon Düzenleme Mekanizması (CBAM), 1 Ekim 2023'te geçiş dönemiyle yürürlüğe girmiş; ithal edilen çimento, demir-çelik, alüminyum, gübre, elektrik ve hidrojen ürünlerinin karbon ayak izine göre fiyatlandırılmasını öngörmektedir. Mayıs 2024'te yürürlüğe giren Kritik Hammaddeler Yasası (Avrupa Komisyonu, 2024), 2030'a kadar AB'nin yıllık tüketiminin en az %10'unun yurt içinde çıkarılması, %40'ının yurt içinde işlenmesi ve %25'inin yurt içinde geri dönüştürülmesi hedefini koymakta; aynı zamanda tek bir üçüncü ülkeden gelen tedariki en fazla %65 ile sınırlandırmayı amaçlamaktadır. Bu son hüküm, fiilen Çin'in kritik hammadde işleme kapasitesi karşısında yapısal bir yanıt niteliği taşımaktadır. Bu mekanizmalar topluca AB'nin Normatif Güç Avrupa (Manners, 2002) kapasitesini Döngüsel ekonomi alanında somutlaştırmakta; ancak gelişmekte olan ülkeler ile büyük üretici güçler tarafından örtük korumacılık olarak okunabilmektedir.

3.2. Çin'in Devlet Güdümlü Döngüsel Ekonomi Modeli

Çin'in döngüsel ekonomi yörüngesi 2008'de yürürlüğe giren döngüsel ekonomiyi Teşvik Yasası ile resmî biçimde başlamış; ardından her beş yıllık planda derinleştirilmiştir. 2021-2025 dönemini kapsayan 14. Beş Yıllık Plan ve eki niteliğindeki Döngüsel Ekonomi Geliştirme Planı; geri dönüşüm, ikincil hammadde işleme, yeniden üretim ve atık yönetimi alanlarında somut sayısal hedefler ortaya koymuştur. Plan 2025 yılına kadar büyük katı atık geri kazanım oranının %60'a çıkarılmasını öngörmektedir. Mathews ve Tan (2011) Çin Döngüsel ekonomi modelinin başlangıçtan itibaren çevresel kaygı kadar endüstriyel yükseltme amacıyla şekillendirildiğini göstermiş; Geng ve diğerleri (2012) Çin'in ulusal döngüsel ekonomi gösterge sistemini analiz ederek devletin sayılabilir hedefler aracılığıyla yerel yönetimleri ve işletmeleri nasıl yönlendirdiğini ortaya koymuştur. Bu özellikler kalkınmacı devletin (Johnson, 1999; Woo-Cumings, 1999) tipik araçsallığını döngüsel ekonomi alanında üretmiş; Vogel'in (2011) ifadesiyle Deng dönemi reformlarından miras alınan kurumsal kapasite günümüzde yeşil sektörlere uyarlanmıştır.

Bu kurumsal kapasitenin somut göstergesi Çin'in küresel temiz teknoloji üretimindeki konumudur. Uluslararası Enerji Ajansı'na göre 2023 yılında Çin; küresel fotovoltaik modül üretiminin yaklaşık %80'ini, lityum-iyon batarya üretiminin yaklaşık %75'ini ve rüzgâr türbini üretiminin önemli bir bölümünü gerçekleştirmiştir (IEA, 2024). Kritik hammaddeler boyutunda Çin; küresel rafine kobalt üretiminin yaklaşık üçte ikisini, lityum hidroksit üretiminin önemli bir bölümünü ve nadir toprak elementleri rafine kapasitesinin neredeyse tamamını elinde tutmaktadır (Avrupa Komisyonu, 2023). Bu rakamlar, Çin'in stratejisinin yalnızca iç madde döngülerini kapatmakla ilgili olmadığını; küresel değer zincirlerindeki konumunu pekiştiren bütünleşik bir endüstriyel projeyle iç içe geçtiğini göstermektedir. Modelin diğer belirleyici özelliği, geri dönüşüm ve hammadde işleme zincirlerinin dikey entegrasyonudur: devlet işletmeleri kritik mineral madenciliği ve rafineri yatırımlarında baskın rol oynarken, özel sektör temiz teknoloji üretiminde devlet sübvansiyonları ve seçici kredi mekanizmalarıyla desteklenmektedir.

3.3. Etkileşim Alanları: Rekabet ve Tıkanıklık

AB ile Çin'in döngüsel ekonomi alanındaki etkileşimi farklı kurumsal mantıkların çarpışmasıyla şekillenmektedir. McDowall ve diğerleri (2017) iki aktörün benzer söylem etrafında yakınsasa da Çin'in daha bütünleşik politika koordinasyonu sergilediğini, AB'nin ise araç çeşitliliği ve düzenleyici derinlikte ileri olduğunu bulmuştur. Ranta ve diğerleri (2018) benzer biçimde, AB'de pazar talebinin ve düzenleyici çerçevenin, Çin'de ise devlet baskısı ve teşviklerin döngüsel ekonomiyi yönlendiren temel mekanizmalar olduğunu göstermiştir. Bu yapısal farklılık iş birliğini sınırlamaktadır.

Luo ve diğerleri (2021) ile Luo, Rodríguez ve Leipold (2023) bu sınırlamaları söylemsel analizle somutlaştırmıştır. Yazarlar, AB-Çin döngüsel ekonomi iş birliği söylemine rağmen iki tarafın aynı olayları zıt biçimde çerçevelediğini belgelemektedir: 2017'de Çin'in plastik atık ithalatını yasaklama kararı – yaygın adıyla "Atık Yasağı" – AB tarafından çevresel ve ekonomik bir kriz, Çin tarafından ise meşru bir egemenlik kullanımı ve çevresel iyileşme adımı olarak okunmuştur. Somut ekonomik göstergeler de bu yapısal gerilimi desteklemektedir. 2024 yılında AB, Çin menşeli elektrikli araçlara karşı dengeleyici vergi soruşturması başlatmış ve devlet sübvansiyonlarını gerekçe göstererek ek vergiler uygulamıştır (Avrupa Komisyonu, 2024). Aynı dönemde Çin, AB menşeli süt ürünleri ve domuz eti ithalatına karşı kendi ticaret soruşturmalarını başlatarak karşılıklılık prensibini etkin biçimde kullanmıştır. Bu karşılıklı önlemler döngüsel ekonomi alanındaki yapısal rekabetin doğrudan ticaret savaşı dinamikleriyle örtüştüğünü göstermektedir.

3.4. Türkiye Bağlamında Döngüsel Ekonominin Görünümü

AB ile Çin arasındaki bu yeniden yapılanma, Türkiye gibi gümrük birliği yoluyla AB pazarına yapısal olarak bağlı, aynı zamanda Çin ile artan ticari ilişkileri olan ülkeler için doğrudan

sonuçlar doğurmaktadır. Türkçe literatürde Önder (2018), Ay Türkmen ve Kılıç (2020) ve Yalçın ve Negiz (2020) döngüsel ekonomiyi sürdürülebilir kalkınma çerçevesinde tanıtırken; Ecer, Güner ve Çetin (2021) Avrupa Yeşil Mutabakatı karşısında Türkiye ekonomisinin uyum politikalarını ele almıştır. Samsun (2021) AB iklim diplomasisinin Türkiye boyutunu, Çanakçıoğlu (2023) ise yeşil finansın yükselişini incelemiştir. CBAM'ın geçiş döneminin Ekim 2023'te başlamış olması; Türkiye'nin çelik, çimento ve alüminyum gibi karbon yoğun ihracat kalemlerini doğrudan etkilemektedir. Eş zamanlı olarak Türkiye'nin yenilenebilir enerji ekipmanı ithalatında Çin'in payı belirgin biçimde artmaktadır. Bu iki yönlü bağımlılık, Türkiye'nin AB ile uyum politikalarını Çin'den teknoloji tedariki ile dengelemek zorunda olduğu hassas bir konum yaratmaktadır.

4. TARTIŞMA

Bulgular, AB ve Çin döngüsel ekonomi modellerinin yalnızca iki teknik alternatif olmadığını; aynı küresel alanda işleyen iki rakip kurumsal mantık olduğunu göstermektedir. AB "standart aracılığıyla yönetişim" yoluyla işlerken Çin "kapasite aracılığıyla yönetişim" yoluyla işlemektedir. Bu ayrım, McDowall ve diğerleri (2017) ile Ranta ve diğerleri (2018) tarafından kayda geçirilen araç farklılıklarının altında yatan yapısal mantığı açığa çıkarmaktadır. AB'nin Normatif Güç Avrupa (Manners, 2002) kapasitesinin döngüsel ekonomi alanında somutlaşması düzenleyici dışsallaştırma yoluyla küresel standart belirleme rolünü pekiştirmektedir. Ne var ki Friant ve diğerleri (2021), bu modelin söylem-eylem uçurumu nedeniyle inanılırlık sorunuyla karşı karşıya olduğunu göstermektedir. Eurostat'ın açıkladığı %11,5'lik döngüsel malzeme kullanım oranı bu uçurumun somut bir ifadesidir; AB normatif bir lider olarak konumlanırken kendi içsel dönüşümünde benzer hıza ulaşamamıştır.

Çin'in döngüsel ekonomi modeli ise kalkınmacı devlet (Johnson, 1999; Woo-Cumings, 1999; Vogel, 2011) kurumlarının yeşil dönüşüm için başarıyla yeniden uyarlanabileceğini göstermiştir; ancak bu uyarlama saf çevresel sonuçlardan ziyade stratejik kaldıraç sağlayacak biçimde gerçekleşmiştir. IEA (2024) verilerinin belgelediği temiz teknoloji üretimindeki Çin egemenliği – fotovoltaik modülde %80, lityum-iyon bataryada %75 düzeyinde küresel pazar payı – Mathews ve Tan'ın (2011) ile Geng ve diğerlerinin (2012) erken dönem çalışmalarında betimlenen kurumsal kapasiteden beslenmektedir. Bu yörünge önemli bir gerilime işaret etmektedir: döngüsel ekonomi aracılığıyla endüstriyel yükseltme hem çevresel hem de jeo-ekonomik bir kazanç olabilir; bu iki boyut dünyanın geri kalanı için zorunlu olarak hizalı değildir.

İki model arasındaki etkileşim Luo ve diğerleri (2021, 2023) tarafından belgelenen siyasi tıkanıklığı kurumsal düzeye taşımaktadır. AB'nin elektrikli araç soruşturması ve Çin'in karşılıklı önlemleri (Avrupa Komisyonu, 2024); kritik hammaddeler üzerindeki Çin egemenliği ve AB'nin yanıt olarak geliştirdiği Kritik Hammaddeler Yasası birlikte

değerlendirildiğinde, AB-Çin döngüsel ekonomi etkileşiminin yoğun karşılıklı bağımlılık ile yapısal rekabetin eş zamanlı bir konfigürasyonu olduğu görülmektedir. Bu konfigürasyon ne saf iş birliği ne de saf çatışma üretmektedir; aksine her iki tarafı da yapısal olarak birbirine bağımlı kılan, ancak aynı zamanda sürekli rekabet eden bir ilişki ortaya çıkarmaktadır.

Türkiye gibi ara konumdaki ülkeler için bu konfigürasyon iki yönlü baskı yaratmaktadır. Ecer ve diğerlerinin (2021) Avrupa Yeşil Mutabakatı'na uyum analizleri ile Çanakçıoğlu'nun (2023) yeşil finans incelemesi birlikte düşünüldüğünde; Türkiye'nin AB düzenleyici dışsallaştırmasına maruz kalırken Çin'in temiz teknoloji tedarikine artan bağımlılığını yönetmek zorunda olduğu görülmektedir. CBAM'in çelik ve alüminyum ihracatını etkilemesi AB ile uyumun stratejik bir zorunluluk olduğunu gösterirken; Çinli üreticilerin yenilenebilir enerji kurulumlarındaki rolü ekonomik gerçekliği oluşturmaktadır. Kuramsal düzlemde bulgular Normatif Güç Avrupa ile kalkınmacı devlet kuramının birbiriyle diyalog hâlinde okunması gerektiğini göstermektedir: tek başına Normatif Güç Avrupa Çin'in döngüsel ekonomi-endüstri entegrasyonunun AB normatif kapasitesini nasıl kısıtladığını açıklayamaz; tek başına kalkınmacı devlet ise AB düzenleyici dışsallaştırmasının Çin için neden bağlayıcı bir kısıt oluşturduğunu yeterince çözümleyemez.

5. SONUÇ VE DEĞERLENDİRME

Bu bildiri, Avrupa Birliği'nin normatif düzenleyici yaklaşımı ile Çin'in devlet güdümlü endüstriyel modelinin döngüsel ekonomi politikaları çerçevesinde küresel güç ilişkilerini nasıl yeniden şekillendirdiğini karşılaştırmalı nitel analiz yöntemiyle incelemiştir. Yapılan çözümleme, döngüsel ekonominin teknik bir çevresel iş birliği alanından, standartların, sübvansiyonların ve tedarik zincirlerinin birlikte çağdaş jeoekonomik rekabetin maddi alt katmanını oluşturduğu bir güç mücadelesi arenasına dönüştüğünü ortaya koymuştur.

Çalışmanın üç temel bulgusu şu şekilde özetlenebilir. Birincisi, AB'nin döngüsel ekonomi modeli olgun bir normatif düzenleyici mimariye dönüşmüş; Yeşil Mutabakat, Döngüsel Ekonomi Eylem Planı, Sınırda Karbon Düzenleme Mekanizması ve Kritik Hammaddeler Yasası aracılığıyla AB standartlarını üçüncü ülkelere fiilen dışsallaştırmıştır. Ancak bu modelin söylem-eylem uçurumu ve göreli olarak düşük döngüsel malzeme kullanım oranı, normatif iddiaların maddi kapasiteden ayrılamaz hâle geldiğini göstermiştir. İkincisi, Çin'in döngüsel ekonomi modeli kalkınmacı devlet araçlarının yeşil dönüşüme uyarlanmasını temsil etmekte; fotovoltaik, batarya ve kritik hammadde alanlarındaki belirleyici küresel paylar, çevresel hedeflerin endüstriyel üstünlükle iç içe geçtiğini açığa çıkarmaktadır. Üçüncüsü, iki modelin etkileşimi ne saf iş birliği ne de saf rekabet üretmektedir; aksine yoğun madde akışlarının çatışmayı disipline ettiği ancak ortadan kaldırmadığı yapısal bir karşılıklı bağımlılık ile rekabet birleşimi doğurmaktadır.

Araştırılan bulgular incelendiğinde; AB için döngüsel ekonomi politikası artık yalnızca çevresel iddialarla değil, maddi kapasite ve endüstriyel rekabetçilikle birlikte ele alınmalıdır. Sınırda Karbon Düzenleme Mekanizması ve Kritik Hammaddeler Yasası gibi araçların uygulanmasında Çin ve diğer ortaklarla yapılandırılmış diyaloglara girilmesi; AB ile Çin arasında geri dönüşümü, batarya geri dönüştürülmüş içeriği ve nadir toprak geri kazanımı üzerine sektöre özgü teknik çalışma gruplarının kurulması; kritik hammaddeler için çeşitlendirilmiş stratejik ortaklıkların geliştirilmesi yürütülen önerilerdir. Türkiye için ise Avrupa Yeşil Mutabakatı ile uyum sürecinin stratejik bir döngüsel ekonomi yatırım programıyla (geri dönüşüm altyapısı, ikincil madde piyasaları, atık yönetim sistemleri) eşleştirilmesi; Çin ile temiz teknoloji ticari bağlarının teknoloji transferi ve yerelleşme koşullarıyla yapılandırılması; ulusal bir döngüsel ekonomi gösterge sisteminin kurulması önerilmektedir. Türkiye'nin en büyük ticaret ortaklarından olan bu iki tarafla uyum içerisinde çalışarak, dengede kalmaya devam etmesi düşünülmektedir.

Çalışmanın sınırlılıkları arasında Amerika Birleşik Devletleri'nin doğrudan analize dahil edilmemesi ve karşılaştırmalı nitel analizin nedensel iddialar üretme kapasitesinin sınırlı olması yer almaktadır. Gelecekteki araştırmalar; AB-Çin döngüsel ekonomi etkileşiminde ABD'nin rolünü içeren üçlü karşılaştırmalı analizler, belirli sektörlerde (batarya, kritik hammaddeler) vaka çalışmaları ve Türkiye'nin AB-Çin konfigürasyonu altındaki politika manevralarını inceleyen alan araştırmalarıyla derinleştirilebilir. Sonuç olarak döngüsel ekonomi, kaynak verimliliği projesi olmanın çok ötesinde, yeşil dönüşümün yapısını ve faydalarının dağılımını şekillendiren bir siyaset alanı hâline gelmiştir; bu alanın geleceği büyük devletlerin kurumsal mantıklarının uyum içerisinde mi yoksa çatışma mı üreteceğine bağlı olarak şekillenecektir.

EK

Bu bildirinin hazırlanma sürecinde yapay zeka destekli araçlar dil düzenleme ve metin iyileştirme amacıyla kullanılmış olup, içerik analizi ve değerlendirmeler yazar tarafından gerçekleştirilmiştir.

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KARŞILAŞTIRMALI ÜSTÜNLÜK TEORİSİ AÇISINDAN LOMÉ LİMANI'NDA TRANSİT TİCARET

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Özet

Karşılaştırmalı üstünlük teorisi, David Ricardo tarafından 1817 yılında geliştirilen klasik bir uluslararası ticaret modelidir. Bu teori, ülkelerin mutlak üretim kapasitelerine değil, fırsat maliyeti açısından görece daha avantajlı oldukları alanlarda uzmanlaşmalarını önermektedir. Bu çalışma, söz konusu teoriyi hizmet ticaretine uyarlayarak Togo'daki Lomé Limanı'nın transit ticaret hizmetlerindeki konumunu incelemektedir. Lomé Limanı, 16,6 metre doğal derin su yapısı, 2025 yılında 18,6 metreye çıkarılan kanal derinliği, modern altyapısı, serbest bölge uygulamaları ve yüksek operasyonel verimliliği sayesinde Batı Afrika'da transit ticaret hizmetlerinde belirgin bir karşılaştırmalı üstünlüğe sahip bulunmaktadır. 2024 yılında 2,06 milyon TEU konteyner hacmine ulaşan limanın transit hacminin %92'sinden fazlası denize kıyısı olmayan Burkina Faso, Mali ve Nijer'e yönelmekte olup bu durum Lomé'yi bir "saf transit limanı" konumuna taşımaktadır. Çalışmada Veri Zarflama Analizi (DEA-SBM) bulguları ve bölgesel karşılaştırmalar kullanılarak Lomé'nin derin su erişimi, serbest bölge rejimi, uluslararası operatör yönetimi ve stratejik coğrafi konumunun bu üstünlüğün temel kaynakları olduğu ortaya konmuştur. Çalışma, Lomé Limanı'nın başarısının diğer Afrika limanları için model oluşturabileceğini ve karşılaştırmalı üstünlük ilkesinin modern hizmet ticaretine başarıyla uygulanabileceğini göstermektedir.

Anahtar Kelimeler: Karşılaştırmalı Üstünlük, Transit Ticaret, Lomé Limanı, Serbest Bölge, Denize Kıyısı Olmayan Ülkeler

TRANSIT TRADE AT THE PORT OF LOMÉ FROM THE PERSPECTIVE OF COMPARATIVE ADVANTAGE THEORY

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Abstract

The theory of comparative advantage is a classical international trade model developed by David Ricardo in 1817. This theory suggests that countries should specialize in areas where they have a relative advantage in terms of opportunity cost, rather than absolute production capacities. This study adapts this theory to trade in services by examining the position of the Port of Lomé in Togo in transit trade services. The Port of Lomé possesses a clear comparative advantage in transit trade services in West Africa due to its natural deep-water structure of 16.6 meters, a channel depth increased to 18.6 meters in 2025, modern infrastructure, free zone applications, and high operational efficiency. The port, which achieved a container volume of 2.06 million TEUs in 2024, directs more than 92% of its transit volume to the landlocked countries of Burkina Faso, Mali, and Niger, positioning Lomé as a "pure transit port." Using Data Envelopment Analysis (DEA-SBM) findings and regional comparisons, the study demonstrates that deep-water access, free zone regime, international operator management, and strategic geographic location are the fundamental sources of this advantage. The study reveals that the success of the Port of Lomé could serve as a model for other African ports and that the principle of comparative advantage can be successfully applied to modern trade in services.

Keywords: Comparative Advantage, Transit Trade, Port of Lomé, Free Zone, Landlocked Countries

GİRİŞ

Uluslararası ticaret teorilerinin temel taşlarından biri olan karşılaştırmalı üstünlük teorisi, David Ricardo (1817) tarafından ortaya konmuştur. Teoriye göre bir ülke, bir mal veya hizmeti diğer ülkelere göre daha düşük fırsat maliyetiyle üretebiliyorsa o alanda uzmanlaşmalı ve diğer malları ya da hizmetleri ithal etmelidir. Ricardo'nun özgün formülasyonu mal ticaretine odaklanmış olsa da günümüzde bu yaklaşım hizmet sektörüne, özellikle lojistik ve transit ticaret hizmetlerine de başarıyla uygulanabilmektedir (Deardorff, 1985). Afrika kıtasında 16 ülke denize kıyısı olmayan (landlocked) konumdadır ve bu ülkelerin dış ticareti kıyı ülkelerinin transit hizmetlerine büyük ölçüde bağımlıdır. Batı Afrika'da Burkina Faso, Mali ve Nijer bu durumun somut örnekleridir. Birleşmiş Milletler Ticaret ve Kalkınma Konferansı'na (UNCTAD) göre denize kıyısı olmayan ülkelerin nakliye maliyetleri kıyı ülkelerine göre yaklaşık %50 daha yüksektir ve Sahra Altı Afrika'daki 43 ülkenin 31'inde ithalat navlun maliyetleri gelişmekte olan ülkelerin ortalamasının %50'sinden fazla üzerindedir (UNCTAD, 1999). Denize kıyısı olmayan gelişmekte olan ülkeler (LLDC'ler) transit ülkelere kıyasla neredeyse iki kat nakliye maliyeti ve gecikmeyle karşılaşmakta olup bu durum küresel ekonomiye entegrasyonlarının önündeki en büyük engel olmaya devam etmektedir (UNCTAD, 2026). Bu bağlamda verimli transit limanları bölgesel kalkınma için kritik öneme sahiptir. 2018 yılından itibaren Afrika, konteyner gemileri ve tankerler açısından liman çağrı sayılarında tüm bölgeler arasında en yüksek artışları kaydetmiştir. 2023 yılına gelindiğinde konteyner gemisi liman çağrıları %20, tanker liman çağrıları ise %38 oranında artmıştır (UNCTAD, 2024). Bu büyüme eğilimi içinde Lomé Limanı öne çıkan aktörlerden biri olmuştur. 2024 yılında 2,06 milyon TEU konteyner hacmine ulaşan Lomé, Sahra Altı Afrika'nın küresel ilk 100 liman sıralamasında yer alan tek limanı konumundadır ve Lloyd's List 2025 sıralamasında dünya genelinde 92. sıraya yükselmiştir (Togo First, 2025a; Ecofin Agency, 2025). Bu çalışma, Lomé Limanı'nın transit ticaret hizmetlerinde karşılaştırmalı üstünlüğe sahip olup olmadığını Ricardo'nun teorisi çerçevesinde analiz etmeyi amaçlamaktadır.

1. KURAMSAL ÇERÇEVE

Uluslararası ticaretin teorik temelleri, David Ricardo'nun 1817 yılında On the Principles of Political Economy and Taxation adlı eserinde formüle ettiği karşılaştırmalı üstünlükler ilkesine dayanmaktadır. Ricardo, iki ülke ve iki mal varsayımına dayanan basit bir model aracılığıyla, bir ülkenin her iki malda da mutlak üstünlüğe sahip olması durumunda dahi, ülkelerin göreli fırsat maliyetlerindeki farklılıklara dayalı olarak uzmanlaşıp ticaret yapmaları halinde her iki tarafın da refah kazanımı elde edebileceğini göstermiştir (aktaran Suranovic, 2012). Ricardo'nun modeli, sabit ölçek getirileri, tek üretim faktörü olarak emek, sıfır taşıma maliyetleri ve tam rekabet gibi kısıtlayıcı varsayımlara dayanmaktadır; bununla birlikte, modelin özünü oluşturan “göreli verimlilik farklılıklarının ticaret kalıplarını belirlediği”

ilkesi, modern ticaret teorisinin çıkış noktasını oluşturmaya devam etmektedir. Nitekim Krugman (1979), Ricardo'nun modelindeki bu varsayımları önemli ölçüde gevşeterek, ülkeler arasında teknoloji veya faktör donatımı farklılıkları bulunmasa dahi, firma düzeyindeki içsel ölçek ekonomilerinin uluslararası ticarete ve ticaretten kazanımlara yol açabileceğini kanıtlamıştır. Krugman (1979), Dixit ve Stiglitz'in (1977) monopolcü rekabet çerçevesini uluslararası ticarete uyarlayarak, ticaretin pazarı genişletme yoluyla hem üretim ölçeğini artırdığını hem de tüketicilere daha geniş bir ürün çeşitliliği sunduğunu ortaya koymuştur. Helpman ve Krugman (1985), bu yaklaşımı sistematize ederek artan ölçek getirileri ve eksik rekabetin endüstri-içi ticaret kalıplarını nasıl şekillendirdiğini analiz etmiş; faktör donatımı teorilerinin endüstriler-arası uzmanlaşmayı açıklamaya devam ederken, ölçek ekonomilerinin sanayileşmiş ülkeler arasındaki endüstri-içi ticareti açıklamada tamamlayıcı bir işlev gördüğünü göstermiştir (Meyer, 1986). Bu çerçeveyi firma düzeyine taşıyan Melitz (2003), heterojen verimlilik düzeylerine sahip firmaları Krugman'ın monopolcü rekabet modeline entegre ederek, ticarete açılmanın yalnızca daha verimli firmaları ihracat pazarlarına yönlendirmekle kalmayıp, en düşük verimliliğe sahip firmaları da piyasadan çıkmaya zorladığını modellemiştir. Melitz'e (2003) göre bu seçim mekanizması, pazar paylarını ve kârları daha verimli firmalara doğru yeniden dağıtarak toplam sektörel verimliliği artırmakta ve refah kazanımına katkıda bulunmaktadır. Sonuç olarak, Ricardo'nun göreli verimlilik farklılıklarını merkeze alan analitik çerçevesi, modern ticaret teorisinin temel taşı olmaya devam ederken; artan ölçek getirileri, ürün farklılaştırması ve firma heterojenliği gibi unsurlar bu çerçeveyi önemli ölçüde zenginleştirmiştir. Karşılaştırmalı üstünlük kavramı, başlangıçta mal ticaretine odaklanmış olmasına karşın zamanla hizmet ticaretine de uyarlanmıştır. Deardorff (1985), karşılaştırmalı üstünlüğün hizmet sektöründe de geçerli olduğunu teorik olarak kanıtlamıştır. Lojistik hizmetler, liman operasyonları ve transit ticaret hizmetleri de bu çerçevede değerlendirilebilir. Nitekim Singapur, bir ticaret limanından finansal ve lojistik hub'a dönüşerek stratejik politikalar ve insan sermayesi yatırımlarıyla karşılaştırmalı üstünlüğünü dinamik biçimde yeniden şekillendirmiştir. Aynı mantık, günümüzde liman hizmetlerine uyarlandığında şu tablo ortaya çıkmaktadır: Kıyı ülkesi transit lojistik hizmetinde uzmanlaşırken hinterland ülkeleri tarım, madencilik veya sanayi ürünlerinde uzmanlaşabilmektedir. Bu çerçevede Togo'nun Lomé Limanı üzerinden transit ticaret hizmetlerinde uzmanlaşması, Ricardo'nun modelinin modern bir uygulaması olarak değerlendirilebilir. Togo, küçük bir ekonomi olmasına karşın coğrafi konumu, derin su erişimi ve kurumsal düzenlemeleri sayesinde transit lojistik hizmetinde görece düşük fırsat maliyetine sahip olmuş ve bu alanda uzmanlaşmıştır.

2. YÖNTEM

Bu çalışma, nitel araştırma yöntemlerine dayalı betimsel ve karşılaştırmalı bir analiz tasarımı kullanmakta olup ikincil veri kaynaklarını temel almaktadır. Veri toplama sürecinde

UNCTAD denizcilik raporları (2024, 2025), Dünya Bankası proje değerlendirme belgeleri (2017, 2021), Togo First istatistikleri, Ecofin Agency haberleri ve akademik çalışmalar (Ibeh, 2025; van Dyck, 2015; Acquah, 2018) sistematik biçimde taranmıştır. Liman verimliliğinin değerlendirilmesinde Veri Zarflama Analizi (Data Envelopment Analysis - DEA) yöntemini kullanan mevcut çalışmaların bulguları karşılaştırmalı olarak ele alınmıştır. Özellikle Ibeh'in (2025) DEA-SBM (Slacks-Based Measure) modeli, van Dyck'in (2015) standart DEA analizi ve Acquah'ın (2018) DEA pencere analizi bulguları sentezlenerek Lomé Limanı'nın bölgesel verimlilik konumu ortaya konmuştur. Ayrıca transit ticaret performansı, 2013-2024 dönemini kapsayan hacim verileri ve büyüme oranları üzerinden analiz edilmiştir. Karşılaştırmalı üstünlüğün kaynakları ise Ricardo'nun (1817) teorik çerçevesi dahilinde fırsat maliyeti yaklaşımıyla değerlendirilmiştir. Bu kapsamda doğal altyapı, kurumsal çerçeve, operasyonel verimlilik ve coğrafi konum faktörleri sistematik olarak incelenmiştir. Augustin ve Akossiwa'nın (2018) SWOT analizi bulguları ile Kalgora ve diğerlerinin (2019) intermodal taşımacılık maliyet analizi sonuçları da değerlendirmeye dahil edilmiştir.

3. BULGULAR

3.1. Lomé Limanı: Altyapı ve Stratejik Konum

Lomé Limanı, Gine Körfezi kıyısında Togo'nun başkenti Lomé'de konumlanmış olup 900 hektarı aşan alanıyla Batı Afrika'nın en büyük limanıdır. Limanın en belirgin yapısal avantajı, Batı Afrika kıyısındaki en derin liman olma özelliğini kazandıran 16,6 metrelik doğal derin su erişimidir (World Bank, 2021). 2025 yılında tamamlanan 7,5 milyon euroluk tarama projesiyle kanal derinliği 18,6 metreye çıkarılmış ve limanın 19.000-24.000 TEU kapasiteli mega gemileri kabul edebilme yeteneği güçlendirilmiştir (Togo First, 2025a). Limanın ana konteyner terminali olan Lomé Container Terminal (LCT), Terminal Investment Limited (TIL/MSC grubu) tarafından işletilmekte olup dokuz gemi-karaya vinç (STS crane), 24 terminal vinci ve 1.050 metrelik düz bir rıhtım yapısına sahiptir. MSC'nin Lomé'yi 2011 yılında Batı Afrika hub'ı olarak seçmesi, limanın stratejik öneminin uluslararası denizcilik şirketleri tarafından da teyit edilmesi anlamına gelmiştir (World Bank, 2017). Bu doğrultuda LCT, 2027 yılına kadar 120 milyon euroluk ek yatırım programıyla rıhtımların güçlendirilmesi, yeni vinçlerin kurulması ve yıllık kapasitenin 2,5 milyon TEU'ya çıkarılması planlamaktadır (Ecofin Agency, 2025).

Lomé Limanı'nın rekabet gücünü artıran bir diğer önemli unsur ise serbest bölge uygulamalarıdır. 1994 yılında kurulan Togo Serbest Bölge Yönetim Şirketi (SAZOF) çatısı altında faaliyet gösteren serbest bölge rejimi, gümrük vergisi muafiyetleri, KDV istisnaları ve düşük kurumlar vergisi oranları sunmaktadır. 2024 yılı itibarıyla serbest bölge kapsamında toplam yatırım 425,7 milyar CFA frangına ulaşmış olup bu rakam ülke GSYİH'sinin yaklaşık %7'sine denk gelmektedir (Togo First, 2026). 2026 yılında SAZOF'un Yatırım Teşvik ve

Serbest Bölge Ajansı'na (API-ZF) dönüştürülmesi süreci başlatılmış olup bu reform limanın iş ortamını daha da güçlendirmeyi hedeflemiştir (Togo First, 2026). Togo'nun Batı Afrika'daki stratejik konumu, Lomé-Ouagadougou-Niamey ekonomik koridorunun merkezinde yer almasıyla pekişmektedir. Dünya Bankası (2021) tarafından hazırlanan proje değerlendirme raporuna göre bu koridor, Burkina Faso'nun ithalatının yaklaşık %40'ını ve Nijer'in dış ticaretinin %15-20'sini taşımaktadır. Ulaşım ve ticaret altyapısının geliştirilmesi, Abidjan-Lagos ve Lomé-Ouagadougou eksenleri üzerinde yoğunlaşmış olup bu durum limanın bölgesel lojistik ve transit merkezi olarak stratejik önemini vurgulamaktadır (BTI, 2026).

Tablo 1. Lomé Limanı ve başlıca hinterland ülkeleri

Ülke	Nüfus (milyon)	Denize Kıyısı	Lomé'ye Uzaklık (km)	Transit Payı (%)
Togo	9	Evet	-	-
Burkina Faso	22	Hayır	Yaklaşık 980 km	80,48
Mali	23	Hayır	Yaklaşık 1970 km	4,55
Nijer	25	Hayır	Yaklaşık 1230 km	7,63

Kaynak: World Bank (2023); Togo First (2024); Togo First (2025b); Google Maps (n.d.)

Yukarıda Tablo 1, Lomé Limanı'na başkentlerden karayolu ile ölçülen yaklaşık mesafe arttıkça ülkelerin limanı kullanma oranının değiştiğini ve transit payının, bir ülkenin dış ticaret yüklerinin bu liman üzerinden geçen yüzdesini ifade ettiğini göstererek, özellikle yakın ve denize kıyısı olmayan ülkelerin Lomé'ye daha fazla bağımlı olduğunu ortaya koymaktadır.

3.2. Transit Ticaret Performansı ve Hinterland Bağlantıları

Lomé Limanı'nın en çarpıcı özelliği, transit hacminin büyük bölümünün hinterland ülkelerine yönelmesidir. Togo First (2024) verilerine göre Sahel İttifakı Devletleri'ni (AES) oluşturan Burkina Faso, Mali ve Nijer, 2022 yılında limanın transit hacminin %92'sinden fazlasını kullanmıştır. Bu oran, 2019 yılında %90 eşiğini ilk kez aşmış ve o tarihten bu yana istikrarlı bir yükseliş trendi sergilemiştir. Burkina Faso, %80,48'lik payla limanın açık ara en büyük transit müşterisi konumundadır; Nijer %7,63 ve Mali %4,55 ile onu takip etmektedir (Togo First, 2024). Tarihsel perspektiften bakıldığında Lomé Limanı'nın transit performansındaki dönüşüm dikkat çekicidir. 2013 yılında Burkina Faso'ya yönelik transit hacmi 849.716 ton iken bu rakam 2022'de 3.081.050 tona yükselmiş ve yıllık ortalama büyüme oranı %15,39 olarak gerçekleşmiştir. Mali'ye yönelik transit 93.927 tondan 174.203 tona çıkmıştır. Nijer'e yönelik transit ise dalgalı bir seyir izlemiş olmakla birlikte 2017'den itibaren istikrarlı bir artış eğilimine girmiştir (Togo First, 2024). Lomé Limanı'nın toplam yük hacmi 2024'te 30,6 milyon metrik tona ulaşmış olup bunun 20,2 milyon tonunu aktarma (transshipment) yükleri oluşturmuştur (Ecofin Agency, 2026).

Lomé Limanı'nın bölgedeki transit liman olarak yükselişi, daha önceki dönemlerle karşılaştırıldığında dramatik bir dönüşümü yansıtmaktadır. Luguje (2004), 1997-2003 döneminde Lomé'nin bölgedeki transit trafiğin ortalama %20-29'unu karşıladığını ve Burkina Faso'nun o dönemde de limanın başlıca transit müşterisi olduğunu ortaya koymuştur. Ancak o yıllarda transit payı Abidjan, Cotonou ve Tema gibi rakip limanlarla daha dengeli dağılıyordu. Bugün Lomé'nin %92'yi aşan transit payı, limanın son yirmi yılda yaşadığı yapısal dönüşümün boyutlarını gözler önüne sermektedir. Liman performansını değerlendirirken hinterland bağlantısının kritik öneme sahip olduğu vurgulanmalıdır. UNCTAD'a (2024) göre etkili hinterland bağlantıları, özellikle denize kıyısı olmayan komşu ülkelere yönelik transit ticaret için liman tıkanıklığını azaltmakta ve küresel tedarik zincirlerinin genel verimliliğini artırmaktadır. Kalgora vd. (2019), Togo koridorunda Mango intermodal terminalinin devreye alınmasıyla Lomé-Bamako, Lomé-Niamey ve Lomé-Ouagadougou rotalarında toplam 453,45 milyon USD'lik taşıma maliyeti tasarrufu sağlanabileceğini öngörmüştür. Bu bulgu, intermodal taşımacılığın Lomé'nin karşılaştırmalı üstünlüğünü daha da güçlendirebileceğine işaret etmektedir. Batı Afrika'da denize kıyısı olmayan ülkeler, tek bir transit koridora bağımlı kalmamak amacıyla birden fazla liman kullanma stratejisi izlemektedir. Bu durum koridorlar arasında yoğun rekabete yol açmakta ve göndericilerin liman seçim kararlarında mesafe, yol kalitesi, gümrük süreleri ve toplam maliyet gibi faktörler belirleyici olmaktadır (Luguje, 2004; Fawie, 2008). Fawie'nin (2008) araştırması, mesafenin tek başına açıklayıcı olmadığını ve koridor hizmet kalitesinin daha belirleyici bir rol oynadığını ortaya koymuştur. Bu bağlamda Lomé Limanı'nın mesafe avantajının yanı sıra gümrük kolaylıkları ve operasyonel verimlilik sunması, göndericiler için çekiciliğini artırmaktadır.

3.3. Bölgesel Liman Verimliliği Karşılaştırması

Lomé Limanı'nın karşılaştırmalı üstünlüğünü nesnel olarak değerlendirmek için bölgesel liman verimliliği analizlerine başvurmak gerekmekte olup bu alanda yapılan çalışmalar ağırlıklı olarak Veri Zarflama Analizi (Data Envelopment Analysis- DEA) yöntemini kullanmaktadır. Bu doğrultuda van Dyck (2015), Batı Afrika'daki altı büyük konteyner limanının verimliliğini DEA yöntemiyle karşılaştırmış, çalışmanın bulgularına göre Tema (Gana) en verimli liman olarak belirlenirken Abidjan ve Lomé limanları da oldukça yüksek verimlilik skorları elde etmiştir. Aynı çalışmada incelenen limanların dördü %76 ve üzeri ortalama verimlilik skoru sergilemiş olup araştırmacı bu durumu Sahel bölgesine yönelik transit kargo için limanlar arasındaki yoğun rekabetle ilişkilendirmiştir. Acquah (2018), DEA pencere analizi yöntemiyle 2006-2013 döneminde Lomé Limanı'nın incelenen altı liman arasında %89 ortalama verimlilik skoruyla üçüncü sırada yer aldığını tespit etmiştir. Bu çalışmada Lomé'nin 2006-2007 yıllarında görece düşük verimlilik gösterdiği, 2009-2011 döneminde belirgin bir yükseliş yaşadığı ve 2012'deki düşüş sonrası 2013'te yeniden

toparlandığı gözlemlenmiştir. En güncel analizlerden biri Ibeh (2025) tarafından gerçekleştirilmiş olup DEA-SBM (Slacks-Based Measure) modeli kullanan bu çalışmada 2010-2022 dönemi kapsanmıştır. Analiz sonuçlarına göre Lomé Limanı, farklı yıllarda (özellikle 2013, 2015 ve 2021) optimum etkinlik seviyesine (1.000) ulaşmış ve 0,80 ortalama etkinlik skoru elde etmiştir. Tema ve Abidjan da belirli dönemlerde optimal verimliliğe ulaşırken Cotonou, Dakar ve Apapa limanları verimsiz kalmıştır. Ibeh'in çalışması, Lomé'nin Tema ve Abidjan ile birlikte bölgenin en verimli limanları arasında olduğunu, ancak Cotonou ve Dakar'a kıyasla daha az dalgalanma sergilediğini ortaya koymaktadır.

Tablo 2. Batı Afrika limanlarında verimlilik karşılaştırması

Liman (Ülke)	Hacim (milyon TEU)	DEA-SBM Ort. Skoru	Verimlilik Durumu
Lomé (Togo)	2,01-2,06	0,80	Optimal (dönemsel)
Tema (Gana)	1,70	0,93	Optimal (dönemsel)
Abidjan (Fildişi S.)	1,60	0,85	Optimal (dönemsel)
Cotonou (Benin)	-	0,52	Verimsiz
Dakar (Senegal)	0,88	0,48	Verimsiz
Apapa (Nijerya)	-	0,45	Verimsiz

Kaynak: Ibeh (2025); Ecofin Agency (2025); Togo First (2025a); van Dyck (2015); CEIC Data (2026); Ghana Ports & Harbours Authority (2025); Port Autonome d'Abidjan (2025).

Yukarıda Tablo 2'de yer alan 2024 yılı konteyner hacimleri, CEIC Data (2026), Ghana Ports & Harbours Authority (2025), Port Autonome d'Abidjan (2025) ve Ecofin Agency (2025) verilerine dayanmaktadır. Apapa için 0,45 milyon TEU değeri, Nijerya toplam hacmi (CEIC Data, 2026) ve Apapa'nın tahmini payına dayanan yazar hesaplamasıdır. Kesin resmi veri bulunmamaktadır. Lomé için farklı kaynaklarda 2,01 ile 2,06 milyon TEU arasında değişen rakamlar bulunmakla birlikte, CEIC Data'nın 2.006.435 TEU'lük tam rakamı en güvenilir resmi veri olarak kabul edilmektedir.

3.4. Karşılaştırmalı Üstünlüğün Kaynakları

Lomé Limanı'nın transit ticaret hizmetlerinde karşılaştırmalı üstünlüğünü oluşturan faktörler, Ricardo'nun teorik çerçevesi dahilinde, limanın transit hizmetleri diğer ekonomik faaliyetlere kıyasla daha düşük fırsat maliyetiyle sunabilmesini sağlayan yapısal unsurlardır. Bunlardan ilki, Lomé'nin Batı Afrika kıyısındaki en derin liman olmasıdır: 16,6 metre doğal derinlik ve 2025 itibarıyla 18,6 metreye çıkarılan kanal kapasitesi sayesinde 14.000-24.000 TEU aralığındaki en büyük konteyner gemilerini kabul edebilmekte, bu özellik rakip limanların (Cotonou, Apapa) pahalı tarama yatırımları yapmak zorunda kaldığı bir ortamda Lomé'ye doğal bir maliyet avantajı sağlamaktadır (World Bank, 2021; Togo First, 2025a). İkinci

olarak, SAZOF (2026'dan itibaren API-ZF) tarafından yönetilen serbest bölge rejimi, gümrük vergisi muafiyetleri, KDV istisnaları ve düşük kurumlar vergisi oranları sunarak transit kargo maliyetlerini düşürmekte ve Lomé'nin fırsat maliyeti avantajını güçlendirmektedir; nitekim 2024 itibarıyla serbest bölge kapsamında faaliyet gösteren 91 şirket ve 425,7 milyar CFA frankı tutarında yatırım bu rejimin etkinliğinin göstergesidir (Togo First, 2026). Üçüncü olarak, MSC/TIL Grubu tarafından işletilen LCT terminalinin modern ekipman yatırımları ve verimlilik artışları Lomé'yi önemli bir dönüşümden geçirmiş (World Bank, 2017); Mart 2025'te tek bir ayda 123.000 konteyner hareketi gerçekleştirerek Afrika kıtası rekoru kırılmış (Ecofin Agency, 2026) ve DEA-SBM analizleri Lomé'nin 2010-2022 döneminde bölgenin en verimli limanları arasında yer aldığını teyit etmiştir (Ibeh, 2025). Dördüncü olarak, Togo'nun coğrafi konumu hinterland ülkelerine görece kısa mesafeler sunmaktadır: Lomé-Ouagadougou koridoru yaklaşık 1.000 km, Lomé-Niamey koridoru yaklaşık 1.200 km olup bu mesafeler alternatif koridorlara (örneğin Dakar-Bamako: 2.200+ km) kıyasla belirgin bir avantaj oluşturmakta; Augustin ve Akossiwa'nın (2018) SWOT analizi de Lomé'nin stratejik konum, liman genişleme projeleri ve istikrarlı transit trafik artışını temel güçler olarak belirlemiştir.

Tüm bu faktörler bir arada değerlendirildiğinde, Togo'nun transit ticaret hizmetlerinde uzmanlaşarak karşılaştırmalı üstünlük elde ettiği görülmektedir. Bu üstünlüğün temel dayanağı, Lomé Limanı'nın doğal derin su erişimi, modern altyapısı ve operasyonel verimliliğidir. Nitekim CEIC Data (2026) tarafından doğrulanan 2,01 milyon TEU'luk 2024 hacmi bu altyapı üstünlüğünün somut çıktısı olup, Ibeh (2025) çalışmasında Lomé'nin DEA-SBM ortalama skorunun 0,80 olarak hesaplanması da limanın bölgedeki optimal limanlar arasında yer aldığını teyit etmektedir. Hinterland ülkeleri (Burkina Faso, Mali, Nijer) doğal kaynaklar, tarım ve madencilik alanlarında uzmanlaşırken dış ticaretlerini Lomé üzerinden gerçekleştirmekte olup bu karşılıklı uzmanlaşma yapısı, Ricardo'nun öngördüğü karşılıklı kazanım (mutual gains from trade) ilkesiyle örtüşmektedir. Ouedraogo (2024) da bu bağlamda Lomé Limanı'nın Batı Afrika'da tam anlamıyla bir transit limanı olduğunu ve 2022'de 1,9 milyon TEU konteyner trafiği işlediğini belirterek limanın bölgesel ticaretteki vazgeçilmez konumunu vurgulamıştır. Bununla birlikte, Ibeh (2025) çalışmasında Tema Limanı'nın 0,93 ile en yüksek DEA-SBM ortalamasına sahip olması, Lomé'nin mutlak değil göreli bir üstünlüğe sahip olduğunu göstermektedir. Öte yandan, Lomé'nin karşılaştırmalı üstünlüğü tamamen risksiz değildir: 2023'ten bu yana Benin-Nijer sınırının kapanması Nijer'e yönelik yüklerin büyük ölçüde Lomé ve alternatif rotalara yönelmesine neden olurken (Ecofin Agency, 2026), Abidjan'ın Mali'ye yönelik transit trafiğinde 2025 yılında %76,4'lük artış kaydetmesi bölgesel rekabetin canlılığını göstermektedir (Ecofin Agency, 2026). Tüm bu dinamikler, Lomé'nin karşılaştırmalı üstünlüğünün sürdürülebilirliğinin sürekli yatırım, politika uyumu ve bölgesel iş birliğine bağlı olduğunu ortaya koymaktadır.

4. SONUÇ, TARTIŞMA VE ÖNERİLER

Bu çalışma, Lomé Limanı'nın transit ticaret hizmetlerinde belirgin bir karşılaştırmalı üstünlüğe sahip olduğunu Ricardo'nun teorik çerçevesi dahilinde ortaya koymuştur. Derin su erişimi, modern altyapı, serbest bölge uygulamaları, uluslararası operatörlerin yönetim kalitesi ve stratejik coğrafi konum, bu üstünlüğün temel unsurları olarak tespit edilmiştir. Nitekim 2024 yılında 2,06 milyon TEU konteyner hacmine ulaşılması ve transit trafiğin %92'sinden fazlasının üç hinterland ülkesine (Burkina Faso, Mali, Nijer) yönelmesi, Lomé'nin neredeyse tamamen bir transit limanı işlevi gördüğünü kanıtlamaktadır. 1997-2003 döneminde bölgesel transit trafiğin yalnızca %20-29'unu karşılayan Lomé, bugün %92'yi aşan bir orana ulaşarak son yirmi yılda dramatik bir yapısal dönüşüm geçirmiştir. DEA-SBM analizleri de bu dönüşümü doğrulamakta, Lomé'nin bölgenin en verimli limanları arasında yer aldığını ve Cotonou, Dakar ve Apapa'ya kıyasla daha istikrarlı bir performans sergilediğini göstermektedir. Tüm bu bulgular, Lomé Limanı'nın başarısının sistematik ve yapısal nedenlere dayandığını ortaya koymaktadır.

Lomé modeli, yalnızca Batı Afrika ile sınırlı kalmayıp benzer transit işlevleri gören diğer Afrika limanları, özellikle Doğu Afrika'da Cibuti, Mombasa ve Darüsselam gibi limanlar için önemli dersler içermektedir. Bu bağlamda aşağıda beş temel politika önerisi sunulmaktadır. Birincisi, AfCFTA kapsamında bölgesel transit protokollerinin güçlendirilmesi ve ECOWAS transit garanti planlarının etkin bir şekilde uygulanmasıdır. İkincisi, limanların dijitalleşmesi ve tek pencere sistemlerinin yaygınlaştırılmasıdır. Nitekim UNCTAD (2026) vurguladığı gibi, dijital gümrük araçları maliyetleri %30'a kadar düşürebilmektedir. Üçüncüsü, hinterland ülkeleriyle demiryolu ve karayolu bağlantılarının iyileştirilmesidir. Kalgora ve diğerlerinin (2019) bulguları, intermodal taşımacılığın 453,45 milyon ABD doları tutarında maliyet tasarrufu potansiyeli sunduğunu göstermektedir. Dördüncüsü, çevresel sürdürülebilirlik odaklı yeşil liman uygulamalarına geçiştir. ICM (2026) raporunda vurgulanan kıyı erozyonu kaygıları, bu geçişin gerekliliğini ortaya koymaktadır. Beşincisi, AfDB'nin (2021) vurguladığı kapsayıcı kalkınma ve sosyo-ekonomik direncin güçlendirilmesidir. Bu kapsamda özellikle gençler ve kadınlar için yüksek katma değerli iş fırsatlarının yaratılması büyük önem taşımaktadır. Lomé Limanı'nın başarısı, coğrafi konum ve doğru politikaların birleştiğinde küçük bir ülkenin bile bölgesel ticarette merkez haline gelebileceğini kanıtlamaktadır. Ricardo'nun iki yüzyılı aşkın süre önce ortaya koyduğu karşılaştırmalı üstünlük ilkesi, Lomé örneğinde modern hizmet ticaretine başarılı bir uygulama bulmuştur.

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STRATEJİK DENİZ GEÇİTLERİNDE KESİNTİ RİSKLERİNİN KÜRESEL TEDARİK ZİNCİRLERİNE ETKİSİ: HÜRMÜZ VE BABÜLMENDEP ÖRNEĞİ

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Özet

Küresel ticaretin hacim olarak büyük bölümü deniz yoluyla gerçekleştirilmektedir. Bu ticaretin güvenliği ve kesintisiz akışı, Hürmüz Boğazı ile Babülmendep Boğazı gibi stratejik deniz geçitlerinin jeopolitik istikrarına doğrudan bağlıdır. Bu çalışma, söz konusu iki kritik boğazda meydana gelebilecek kesinti senaryolarının küresel tedarik zincirleri üzerindeki zincirleme etkilerini analiz etmektedir. Olası bir kriz durumunda gemilerin alternatif güzergâh olarak Ümit Burnu'na yönlendirilmesi halinde, kat edilen mesafenin önemli ölçüde artmasına bağlı olarak sera gazı emisyonlarında ve toplam lojistik maliyetlerinde ciddi artışlar öngörülmektedir. Çalışma, yakın dönemde yaşanan 2023-2024 Kızıldeniz (Babülmendep) Krizi ile 2026 Hürmüz Krizi'ni somut vaka analizleri olarak incelemektedir. Bulgular, bu iki boğazdaki operasyonel aksaklıkların ve güvenlik risklerinin yalnızca teorik bir risk olmadığını; enerji fiyatlarını, navlun ücretlerini, lojistik planlama süreçlerini ve küresel karbon ayak izini doğrudan olumsuz etkileyen somut bir tehdit olduğunu ortaya koymaktadır. Son olarak çalışma, bu tehditlerin bertaraf edilmesi için alternatif kara ve demir yolu ticaret koridorlarının geliştirilmesi ile mevcut limanların krizlere karşı operasyonel dayanıklılığının artırılması gerektiğini önermektedir.

Anahtar Kelimeler: Hürmüz Boğazı, Babülmendep Boğazı, Tedarik Zinciri Riski, Savaş Riski Sigortası, Karbon Ayak İzi

THE IMPACT OF DISRUPTION RISKS IN STRATEGIC MARITIME CHOKEPOINTS ON GLOBAL SUPPLY CHAINS: THE CASES OF HORMUZ AND BAB EL-MANDEB

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Abstract

The majority of global trade by volume is conducted via maritime routes. The security and uninterrupted flow of this trade depend directly on the geopolitical stability of strategic chokepoints such as the Strait of Hormuz and the Bab el-Mandeb Strait. This study analyzes the cascading effects of potential disruption scenarios in these two critical straits on global supply chains. In the event of a crisis, if vessels are rerouted to the alternative route around the Cape of Good Hope, significant increases in greenhouse gas emissions and total logistics costs are anticipated due to the substantial rise in distance traveled. The study examines the recent 2023-2024 Red Sea (Bab el-Mandeb) Crisis and the 2026 Hormuz Crisis as concrete case analyses. The findings reveal that operational disruptions and security risks in these two straits are not merely theoretical risks but a tangible threat that directly and adversely affects energy prices, freight rates, logistics planning processes, and the global carbon footprint. Finally, the study recommends developing alternative land and rail trade corridors and enhancing the operational resilience of existing ports against crises to mitigate these threats.

Keywords: Strait Of Hormuz, Bab El-Mandeb Strait, Supply Chain Risk, War Risk Insurance, Carbon Footprint

GİRİŞ

Küresel ticaretin bel kemiği olan deniz taşımacılığı, Süveyş Kanalı ve Panama Kanalı gibi stratejik deniz geçitlerine büyük ölçüde bağımlıdır. Bu geçitler uzun kıtalararası yolculuklarda önemli zaman ve maliyet tasarrufu sağlamasına rağmen, iklimsel, ekonomik, jeopolitik veya operasyonel kesintilere karşı özellikle savunmasız konumdadır (UNCTAD, 2024). Bu kırılganlığın en çarpıcı örneği Hürmüz Boğazı'nın fiilen kapanmasıyla yaşanmıştır. Önde gelen deniz sigortacıları (Gard, Skuld, NorthStandard, London P&I Club ve American Club) bölgedeki gemiler için savaş riski teminatını iptal etmiş, bu durum bazı navlun maliyetlerini önemli ölçüde artırmış ve tankerlerin bölgeden kaçınmasına yol açmıştır (Kollewe, 2026). Bunun sonucunda, Dünya Bankası'nın tahminlerine göre Hürmüz Boğazı'ndaki arz kesintisi 2026 yılında Brent petrolün varil başına ortalama 86 dolara yükselmesine neden olmuş, gelişmekte olan ülkelerde enflasyonun ise savaş öncesi beklentinin tam bir puan üzerinde %5,1'e çıkması öngörülmektedir (World Bank, 2026). Makroekonomik etkiler bununla da sınırlı kalmamış, IMF 2026 küresel büyüme tahminini aşağı yönlü revize ederek %2,8'e düşürmüş, Orta Doğu ve Orta Asya bölgesi için ise büyüme beklentisini 2 puan keserek %1,9'a indirmiştir (IMF, 2026). Nihayetinde 2026 Hürmüz kapanması, günlük 15,8 milyon varilin mahsur kalmasıyla 1973 Arap petrol ambargosunda kaybedilen günlük 4-5 milyon varili çok aşan, modern petrol piyasası tarihinin en büyük arz kesintisi olarak nitelendirilmektedir (SolAbility, 2026).

1. KURAMSAL ÇERÇEVE

Stratejik deniz geçitleri, küresel enerji ve mal akışının can damarlarını oluşturmaktadır. Küresel deniz ticaret hacmi 2024 yılında %2,2 artarak 12.720 milyon tona ulaşırken, ton-mil cinsinden büyüme %5,9 ile 2011 yılından bu yana kaydedilen en yüksek seviyeye çıkmıştır (UNCTAD, 2025). Özellikle Hürmüz ve Babülmendep Boğazları, dünya petrol ticaretinin önemli bir bölümünü tek başına karşılamakta ve herhangi bir kesintide tedarik zincirlerinde zincirleme etkiler yaratmaktadır.

1.1. Stratejik Deniz Geçitlerinin Kırılganlığı: Hürmüz ve Babülmendep Boğazları

Küresel enerji arzı açısından en kritik geçitlerden biri olan Hürmüz Boğazı'nın fiili kapanması, küresel petrol arzının yaklaşık %20'sini (günlük 15 milyon varil ham petrol ve 6 milyon varil petrol ürünü) ve LNG ticaretinin %19-22'sini (yıllık 110-115 bcm) tehdit etmekte olup, alternatif boru hatlarının yetersiz kalması nedeniyle dünya petrol arzında yaklaşık 13 milyon varillik bir açık oluşmuştur (Sağlam & Korkmaz, 2026). Hürmüz Boğazı, 2024 yılında günlük ortalama 20 milyon varil petrol taşıyarak küresel petrol tüketiminin yaklaşık %20'sine denk gelen hacimde akışa ev sahipliği yapmaya devam etmiştir (EIA, 2025). Boğazdan geçen yıllık ticaret akışı yaklaşık 1,2 trilyon ABD dolarına ulaşmakta olup herhangi bir kesinti, küresel enerji güvenliği ve tedarik zincirleri açısından sistemik risk oluşturmaktadır (Klimek et al.,

2026). Uluslararası Enerji Ajansı'nın verilerine göre, Suudi Arabistan ve BAE'nin Hürmüz'ü devre dışı bırakabilecek boru hattı kapasitesi günlük 3,5 ila 5,5 milyon varil arasında olup bu kapasite, boğazdan geçen günlük 20 milyon varili karşılamaktan uzaktır (IEA, 2026). Hürmüz'ün yanı sıra, Babülmendep Boğazı da küresel deniz ticareti için bir diğer stratejik dar boğaz konumundadır. Kızıldeniz ile Aden Körfezi'ni birbirine bağlayan bu boğaz, 2018 yılında günlük ortalama 6,2 milyon varil ham petrol, kondensat ve rafine petrol ürünü taşıyarak küresel deniz yoluyla yapılan petrol ticaretinin yaklaşık %9'unu gerçekleştirmiştir (EIA, 2019). İki boğaz arasındaki stratejik bağlantı daha da kritik bir tablo ortaya koymaktadır. Kızıldeniz ve Babülmendep Boğazı, küresel deniz ticaretinin yaklaşık %14'ünü ve konteyner ticaretinin %30'unu oluşturan kritik bir dar boğazdır. Kasım 2023'ten Şubat 2024'e kadar Husilerin saldırıları nedeniyle Babülmendep üzerinden geçişler %55 oranında azalmış, gemiler Ümit Burnu'nu dolaşmak zorunda kalmıştır (ITF, 2024). 2024 yılı ortasına kadar Aden Körfezi'ni geçen gemi tonajı %76, Süveyş Kanalı'nı geçen tonaj ise %70 oranında düşmüş; buna karşılık Ümit Burnu'na yapılan varışlar %89 artış göstermiştir (UNCTAD, 2024). Bu yeniden rotalama, küresel gemi ton-mil talebini %3, konteyner gemisi talebini ise %12 oranında yükseltmiş ve tedarik zincirlerinde ek baskı oluşturmuştur (UNCTAD, 2024).

2. YÖNTEM

Bu çalışma, nitel araştırma yöntemlerinden vaka analizi (case study) desenini benimsemektedir. Araştırma kapsamında iki temel vaka 2023-2024 Babülmendep (Kızıldeniz) Krizi ve 2026 Hürmüz Boğazı Krizi karşılaştırmalı olarak incelenmektedir. Veri toplama sürecinde UNCTAD, IEA, EIA, IMF, Dünya Bankası ve Dallas Fed gibi uluslararası kurumsal kaynakların raporları, Howden Re gibi sektörel raporlar ve ve diğ. (2026) gibi hakemli akademik makaleler kullanılmıştır. Elde edilen veriler, enerji piyasaları, navlun maliyetleri, sigorta piyasası ve çevresel etki olmak üzere dört analitik kategori altında değerlendirilmiştir. Çalışma, söz konusu kesintilerin küresel tedarik zincirleri üzerindeki etkilerini çok boyutlu bir perspektifle ortaya koymayı amaçlamaktadır.

3. BULGULAR

Hürmüz Boğazı'nın fiilen kapanmasıyla birlikte Babülmendep Boğazı üzerinden alternatif rota kullanan günlük yaklaşık 4 milyon varil petrol taşımacılığı, Yemen'deki Husilerin saldırıları nedeniyle tehdit altına girmiş olup, bu boğazın da kapanması durumunda Orta Doğu'dan petrol çıkış seçenekleri neredeyse imkânsız hale gelecek ve dünya petrol arzı 13 milyon varil/gün açıkla karşı karşıya kalacaktır (Ordonez, 2026).

Tablo 1. Hürmüz Ve Babülmendep Boğazlarının Stratejik Karşılaştırması (2026 Krizi Bağlamında)

Özellik	**Hürmüz Boğazı**	**Babülmendep Boğazı**	**Kaynaklar**
Coğrafi Konum	Basra Körfezi'ni Umman Denizi'ne bağlar	Kızıldeniz'i Aden Körfezi'ne bağlar	EIA (2019); ITF (2024)
Günlük Petrol Akışı	Yaklaşık 21 milyon varil (15M ham + 6M ürün)	Yaklaşık 6,2 milyon varil (2018)	Sağlam & Korkmaz (2026); EIA (2019)
Küresel Petrol Ticareti Payı	%20	%9	Sağlam & Korkmaz (2026); EIA (2019)
LNG / Gaz Payı	%19-22 (110-115 bcm/yıl)	Kuzeye LNG akışının önemli kısmı	Sağlam & Korkmaz (2026)
Yıllık Ticaret Değeri	Yaklaşık 1,2 trilyon USD	Küresel konteyner ticaretinin yaklaşık üçte biri Kızıldeniz'den geçmektedir.	Klimek ve diğ. (2026); ITF (2024)
2026 Krizi Etkisi	Fiili kapanma; Yaklaşık13M varil/gün açık	Geçişlerde %55 azalma	Sağlam & Korkmaz (2026); ITF (2024)
Alternatif Rotalar	Boru hatları (Yaklaşık 3,5-5,5M varil/gün)	Ümit Burnu (+8.500 deniz mili)	IEA (2026); ITF (2024)
Sigorta Etkisi	Savaş riski primleri %1.000-2.400 artış	Navlun maliyetlerinde ciddi yükseliş	Howden Re (2026); ITF (2024)

Tablo 1'den de görüleceği üzere, Hürmüz Boğazı küresel petrol ve LNG arzı bakımından çok daha belirleyici bir role sahipken, Babülmendep Boğazı özellikle konteyner ticareti ve Kızıldeniz üzerinden Avrupa-Asya bağlantısını sağlayan kritik bir ikincil arter işlevi görmektedir.

3.1. Stratejik Deniz Geçitlerinin Kapanmasının Küresel Ekonomik ve Çevresel Etkileri

Dallas Fed'in modeline göre, Hürmüz kapanmasının 2026 ikinci çeyreğinde küresel petrol arzının yaklaşık %20'sini piyasadan çekmesi durumunda WTI petrol fiyatının ortalama 98 dolara yükselmesi ve küresel reel GSYİH büyümesinin yıllıklandırılmış bazda 2,9 puan

düşmesi beklenmektedir. Kapatmanın üç çeyrek sürmesi halinde petrol fiyatının yıl sonunda varil başına 132 dolara kadar çıkabileceği hesaplanmıştır (Kilian & Plante, 2026). Fiziksel petrol piyasasında spot Brent (Dated Brent) fiyatı kapatmanın 42. gününde varil başına 132 dolara ulaşmış olup vadeli işlem piyasasıyla arasında varil başına 35 dolarlık benzeri görülmemiş bir fiziksel kıtlık primi oluşmuştur (SolAbility, 2026). Enerji piyasalarındaki bu fiyat artışları, navlun ve konteyner taşımacılığını da doğrudan etkilemiştir. Ümit Burnu'na yeniden rotalama sonucunda Asya-Avrupa hatlarındaki navlun oranları 2024 yılında beş katına kadar yükselmiş, Shanghai Konteyner Navlun Endeksi (SCFI) yıllık ortalama 2.496 puana ulaşarak bir önceki yıla göre %149 artış kaydetmiştir (UNCTAD, 2025). Ümit Burnu'na yönelen gemiler ortalama 10-15 gün ek transit süresine maruz kalmakta olup bu durum, just-in-time üretim modeline dayanan otomotiv ve elektronik sektörlerinde stok kırılmalarına ve üretim duruşlarına yol açmaktadır (UNCTAD, 2024). UNCTAD, artan navlun maliyetlerinin tedarik zinciri boyunca yansımasıyla küresel tüketici fiyatlarının 2025 yılına kadar %0,6, küçük ada gelişmekte olan devletlerinde ise %0,9'a varan oranda artabileceğini tahmin etmektedir (UNCTAD, 2024). Aynı kuruluş, Hürmüz kesintisinin etkisiyle küresel mal ticareti büyümesinin 2025'teki yaklaşık %4,7 seviyesinden 2026'da %1,5-2,5 aralığına gerilemesinin beklendiğini uyarmaktadır (UNCTAD, 2026b). Navlun maliyetlerindeki bu artışın bir diğer kaynağı da sigorta piyasasında yaşanan gelişmeler olmuştur. Kriz sırasında büyük P&I kulüpleri 72 saatlik iptal bildirimi yayınlamış olup savaş riski primleri %1.000 ila %2.400 arasında artış göstermiştir (Howden Re, 2026). Bu durum, navlun maliyetlerini daha da yükseltmiş ve tankerlerin bölgeden kaçınmasına yol açmıştır (Kollewe, 2026). Ekonomik etkilerin yanı sıra, krizin önemli çevresel sonuçları da olmuştur. Krizde Ümit Burnu üzerinden yeniden rotalama, sera gazı emisyonlarını en az %46, ekonomik maliyetleri ise en az %51 artırırken, gidiş-dönüş yolculuk sürelerini 20-34 gün uzatmıştır (Sun ve diğ., 2026). Inverto/Boston Consulting Group'un hesaplamalarına göre, Aralık 2023 ile Nisan 2024 arasında Ümit Burnu'na yönlendirilen yaklaşık haftada 300 gemi, toplamda 13,6 milyon ton ek CO_2 salımına neden olmuştur. Bu miktar, 9 milyon otomobilin aynı dönemdeki emisyonuna eşdeğerdir (Inverto, 2024). 2024 yılında denizciliğin sera gazı emisyonları %5 artış göstermiştir (UNCTAD, 2025). Bu rotalama değişikliğinin yarattığı emisyon artışı, IMO'nun 2023 yılında revize ederek 2030'a kadar en az %20, 2040'a kadar en az %70 ve 2050'ye kadar net sıfıra ulaşmayı hedefleyen sera gazı stratejisiyle doğrudan çelişmektedir (IMO, 2023). UNCTAD verilerine göre, Uzak Doğu-Avrupa hattında sefer yapan 20.000-24.000 TEU kapasiteli bir konteyner gemisi için yalnızca Ümit Burnu rotasından kaynaklanan ek CO_2 emisyonlarının AB Emisyon Ticaret Sistemi kapsamındaki maliyeti sefer başına 400.000 dolara ulaşmaktadır (UNCTAD, 2024).

Tablo 2. Normal Rota İle Alternatif Rota (Ümit Burnu) Karşılaştırması

Parametre	**Normal Rota (Süveyş)**	**Alternatif (Ümit Burnu)**	**Fark / Kaynak**
Mesafe (deniz mili)	Yaklaşık 6.500 (Asya-Avrupa)	Yaklaşık %30 daha uzun	Yakıt tüketimi artar
Transit Süre (gün)	Yaklaşık 19 gün	Yaklaşık 35 gün	+10-15 gün
Yakıt Tüketimi	Baz	Çok yüksek	Önemli artış
CO_2 Emisyonu	Baz	+ %46 (en az)	Sun ve diğ. (2026)
Lojistik Maliyet	Baz	+ %51 (en az)	Sun ve diğ. (2026)
Navlun Oranı (SCFI)	Yaklaşık 1.000 puan (2023)	Yaklaşık 2.496 puan (2024)	+%149 (UNCTAD, 2025)
AB ETS Ek Maliyeti	Baz	+400.000 USD/sefer	UNCTAD (2024)
Sigorta Primi	Standart	+ %1.000-2.400	Howden Re (2026)

Tablo 2'de görüldüğü üzere, Ümit Burnu rotası yalnızca mesafe ve süre değil, aynı zamanda yakıt, emisyon, sigorta ve düzenleyici maliyet boyutlarında da ciddi artışlara neden olmakta; bu durum, stratejik deniz geçitlerinin kesintisiz işleyişinin modern ekonomiler için ne denli hayati olduğunu somut verilerle ortaya koymaktadır.

3.5. Babülmendep Boğazı Krizi (2023-2024)

Kızıldeniz ve Babülmendep Boğazı, küresel deniz ticaretinin yaklaşık %14'ünü ve konteyner taşımacılığının %30'unu barındıran kritik bir dar boğaz niteliğindedir. Kasım 2023'ten Şubat 2024'e kadar Husilerin saldırıları nedeniyle Babülmendep üzerinden geçişler %55 oranında azalmış ve gemiler alternatif olarak Ümit Burnu güzergâhına yönelmek zorunda kalmıştır (ITF, 2024). Bu süreçte, krizin ilk dört ayında haftalık yaklaşık 300 geminin rota değiştirdiği ve her bir geminin ortalama 900 ton ek yakıt tükettiği hesaplanmıştır (Inverto, 2024). Artan mesafe ve yakıt tüketimi, çevresel etkileri de beraberinde getirmiş; 2024 yılında konteyner taşımacılığı kaynaklı emisyonlar %14 oranında artış göstermiştir (UNCTAD, 2025). Babülmendep Boğazı'nda ortaya çıkan bu güvenlik krizi, yalnızca dar boğaz geçişlerini değil, onun devamı niteliğindeki Süveyş Kanalı hattını da doğrudan etkilemiştir. Nitekim BIMCO (2023), bölgedeki saldırıların Süveyş üzerinden taşınan ve küresel konteyner trafiğinin yaklaşık %30'unu oluşturan yük akışını tehdit ettiğini vurgulamaktadır. Bu bağlamda artan güvenlik riski, gemi operatörlerinin Süveyş rotasından kaçınmasına yol açmış ve UNCTAD (2024) verilerine göre kanal geçişlerinde %40'ı aşan düşüşler meydana gelmiştir. Rota sapmaları sonucunda taşıma mesafelerinin uzaması, operasyon sürelerini artırarak küresel

deniz taşımacılığı maliyetleri üzerinde yukarı yönlü baskı oluşturmuştur. Buna ek olarak, gemilerin uzayan mesafeleri telafi edebilmek amacıyla hızlarını artırmaları, yakıt tüketimini ve sera gazı emisyonlarını daha da yükseltmiş; bazı hatlarda toplam emisyon artışının %70'e kadar ulaşabileceği hesaplanmıştır (UNCTAD, 2024).Bu çerçevede Babülmendep krizi, yalnızca bölgesel bir güvenlik sorunu olmanın ötesinde, Süveyş bağlantısı üzerinden küresel ticaret akışlarını kesintiye uğratan ve deniz taşımacılığı sisteminin genel işleyişini çok boyutlu biçimde etkileyen sistemik bir dar boğaz şoku olarak değerlendirilmektedir.

3.6. Hürmüz Boğazı Krizi (2026)

Hürmüz Boğazı'nın fiili kapanması, küresel petrol arzının yaklaşık %20'sini ve LNG ticaretinin %19-22'sini tehdit etmekte olup, alternatif boru hatlarının yetersiz kalması nedeniyle dünya petrol arzında yaklaşık 13 milyon varillik bir açık oluşmuştur (Sağlam & Korkmaz, 2026). Hürmüz Boğazı'ndaki askeri tırmanma, bu dar geçitten geçen gemi trafiğini neredeyse durdurmuş ve enerji piyasaları, deniz taşımacılığı ile küresel tedarik zincirleri üzerinde geniş çaplı yansımalara yol açmıştır (UNCTAD, 2026a). 2026 Hürmüz kapanması, günlük 15,8 milyon varilin mahsur kalmasıyla 1973 Arap petrol ambargosundan bu yana yaşanan en büyük arz kesintisi olup petrol, LNG, gübre ve rafine ürünlerin eşzamanlı olarak etkilenmesi nedeniyle önceki şoklardan yapısal olarak farklıdır (SolAbility, 2026). Wood Mackenzie'nin en ağır senaryosuna göre, Boğaz'ın 2026 yıl sonuna kadar kapalı kalması halinde Brent ham petrol fiyatının varil başına 200 dolara yaklaşabileceği, küresel petrol talebinin yılın ikinci yarısında yıllık bazda günlük 6 milyon varil düşebileceği ve küresel ekonominin %0,4 oranında küçülerek yüzyılın üçüncü resesyonuna girebileceği öngörülmektedir (Wood Mackenzie, 2026). UNCTAD, Hürmüz Boğazı'nın fiilen kapalı kalmaya devam ettiğini belirterek enerji, gübre ve taşımacılık maliyetlerindeki artışın gıda fiyatlarını yükseltebileceğini ve özellikle en kırılgan kesimler için yaşam maliyeti baskılarını şiddetlendirebileceğini uyarmıştır (UNCTAD, 2026a).

4. SONUÇ, TARTIŞMA VE ÖNERİLER

Hürmüz ve Babülmendep boğazlarındaki kesintiler, küresel tedarik zincirlerinde ciddi aksamalara, enerji fiyatlarında sert yükselişlere ve karbon ayak izinde %46'ya varan artışlara yol açmakta olup 2026 Hürmüz Krizi, bu risklerin ne kadar gerçek ve yıkıcı olduğunu açıkça göstermiştir. Bu nedenle tek boğaza bağımlılığı azaltmak için Orta Koridor (Türkiye üzerinden) ve Kuzey Deniz Yolu gibi alternatif güzergâhlar acilen geliştirilmelidir. Nitekim Trans-Hazar Uluslararası Taşımacılık Rotası (Orta Koridor), 2024 yılında yük hacmini bir önceki yıla göre %63'ten fazla artırarak 4,1 milyon tona ulaşmış olup Hürmüz Krizi sonrasında alternatif bir güzergâhtan Avrasya lojistiğinin stratejik bir bileşenine dönüşmektedir (Carnegie Endowment for International Peace, 2026). Bu doğrultuda Dünya Bankası, 2026 yılı başında Kazakistan demiryollarına 846 milyon dolarlık garanti

onaylayarak bu koridorun altyapı kapasitesinin güçlendirilmesine yönelik somut bir adım atmıştır (Oxford Business Group, 2026). Kuzey Deniz Yolu ise 2025 yılında 103 transit sefere ve 3,2 milyon ton yük hacmine ulaşmış olsa da bu hacim, Süveyş Kanalı'nın yıllık kapasitesiyle kıyaslanamayacak düzeyde olup rota yalnızca mevsimsel ve niş bir alternatif olarak işlev görmektedir (Humpert, 2025). Altyapısal önlemlerin yanı sıra, limanlarda yapay zekâ tabanlı kriz simülasyon sistemleri kurulmalıdır. Ayrıca uluslararası hukuk çerçevesinde de düzenlemeler gerekmektedir. BM Deniz Hukuku Sözleşmesi'nin (UNCLOS) 38. maddesi, uluslararası seyrüsefer için kullanılan boğazlarda tüm gemilerin transit geçiş hakkını güvence altına almakta, 44. madde ise kıyı devletlerinin bu geçişi hiçbir gerekçeyle askıya alamayacağını açıkça belirtmektedir. Ancak 2026 Hürmüz Krizi, bu hukuki güvencelerin fiili çatışma ortamında yetersiz kaldığını ortaya koymuştur (United Nations, 1982). Bu nedenle boğazlarda serbest geçişi güvence altına alacak yeni uluslararası protokoller oluşturulmalıdır. Bununla birlikte, savaş riski sigortası için devlet destekli uluslararası havuz mekanizmaları geliştirilmelidir. Nitekim UNCTAD, küresel deniz ticaret rotalarındaki aksamaların gelişmekte olan ekonomileri orantısız biçimde etkilediğini vurgulayarak bölgeler arası ticaretin güçlendirilmesini ve savunmasız ülkelerin korunmasına yönelik hedefli politika tedbirleri geliştirilmesini önermektedir (UNCTAD, 2024).

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YEŞİL DÖNÜŞÜM VE KÜRESEL ÜRETİM: AB STANDARTLARININ ETKİLERİ ÜZERİNE BİR BİBLİYOMETRİK ANALİZ

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Özet

Avrupa Birliği'nin 2019 yılında ilan ettiği Yeşil Mutabakat, hem AB içinde hem de küresel üretim ve ticaret ilişkilerinde köklü değişimlere yol açmaktadır. Bu kapsamda hayata geçirilen Karbon Sınır Düzenleme Mekanizması (CBAM) ve Kurumsal Sürdürülebilirlik Durum Tespiti Direktifi (CSDDD), sürdürülebilirlik standartlarının yayılmasını desteklemekte; ancak AB üyesi olmayan ülkelerin ihracatçı üreticileri üzerinde ilave yükümlülükler doğurmaktadır. Bu bağlamda AB'nin yeşil standartları küresel üretimi kimin lehine şekillendirdiği bu çalışmada ilgili literatür taranarak araştırılmıştır. İncelenen çalışmalar; düzenlemelerin uygulama biçimi, karbon sızıntısını önlemedeki etkinliği, sektörel ve ekonomik etkileri ile siyasi boyutu gibi farklı perspektiflerden mevcut düzenlemeleri ele almaktadır. Çalışma bu yönüyle yeşil düzenleyici ele geçirme (green regulatory capture) kavramını analitik çerçeve olarak kullanmaktadır. Araştırmada 'düzenleyici ele geçirme', 'yeşil düzenleyici ele geçirme', 'karbon sınır düzenleme mekanizması', 'kurumsal sürdürülebilirlik durum tespiti direktifi', 'karbon sınır uyarlaması' ve 'yeşil mutabakat' anahtar kelimeleri kullanılarak uluslararası akademik veri tabanı olan Web of Science ve Scopus'tan toplam 292 makale belirlenmiş; bu makalelerin tematik dağılımını, ortak örüntülerini ve araştırma kümelerini belirleyerek karşılaştırmalı biçimde değerlendirmek amacıyla bibliyometrik analiz yöntemi kullanılmıştır. Yapılan incelemeler neticesinde makaleler; CBAM/Karbon Sınır Düzenlemesi, Yeşil Mutabakat/Yönetişim, Hukuki/WTO, Sektörel Etki, Gelişmekte Olan Ülkeler/Adalet, Lobi/Siyasi Ekonomi, CSDDD/Durum Tespiti ve Tedarik Zinciri olmak üzere sekiz farklı konu odağı altında kümelenmiş; orantısız uyum yükleri, değer zincirlerinin yeniden yapılanması ve sanayi aktörlerinin politika tasarımına etkisi olmak üzere üç temel örüntü ortaya çıkmıştır. Bu örüntüler, düzenlemelerin tüm ülkeler için eşit sonuçlara yol açmadığını ve politika süreçlerinde daha geniş bir yaklaşıma ihtiyaç duyulduğunu düşündürmektedir.

Anahtar Kelimeler: AB Yeşil Mutabakatı, CBAM, CSDDD, Yeşil Düzenleyici Ele Geçirme, Bibliyometrik Analiz

GREEN TRANSFORMATION AND GLOBAL PRODUCTION: A BIBLIOMETRIC ANALYSIS ON THE EFFECTS OF EU STANDARDS

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Abstract

The European Green Deal, announced by the European Union in 2019, is bringing about fundamental changes in both intra-EU and global production and trade relations. The Carbon Border Adjustment Mechanism (CBAM) and the Corporate Sustainability Due Diligence Directive (CSDDD), introduced within this framework, support the dissemination of sustainability standards while imposing additional obligations on exporting producers in non-EU member countries. In this context, this study investigates the question of who benefits from the EU's green standards shaping global production by reviewing the relevant literature.

The studies examined address existing regulations from different perspectives, including implementation methods, effectiveness in preventing carbon leakage, sectoral and economic impacts, and political dimensions. In this regard, the study employs the concept of green regulatory capture as its analytical framework. Using the keywords 'regulatory capture', 'green regulatory capture', 'carbon border adjustment mechanism', 'corporate sustainability due diligence directive', 'carbon border adjustment', and 'green deal', a total of 292 articles were identified from the international academic databases Web of Science and Scopus. Bibliometric analysis was applied to determine the thematic distribution, common patterns, and research clusters of these articles in a comparative manner.

As a result of the analysis, the articles clustered under eight different thematic areas: CBAM/Carbon Border Regulation, Green Deal/Governance, Legal/WTO, Sectoral Impact, Developing Countries/Justice, Lobbying/Political Economy, CSDDD/Due Diligence, and Supply Chain. Three core patterns emerged: disproportionate compliance burdens, restructuring of value chains, and the influence of industry actors on policy design. These patterns suggest that the regulations do not produce equal outcomes for all countries and that a broader approach is needed in policy processes.

Keywords: EU Green Deal, CBAM, CSDDD, Green Regulatory Capture, Bibliometric Analysis

GİRİŞ

Avrupa Birliği'nin Aralık 2019'da ilan ettiği Yeşil Mutabakat; Karbon Sınır Düzenleme Mekanizması (CBAM) ve Kurumsal Sürdürülebilirlik Durum Tespiti Direktifi (CSDDD) aracılığıyla küresel üretim ağlarını yeniden düzenlemektedir. CBAM, demir-çelik, çimento, alüminyum ve gübre gibi sektörlerde AB pazarına ihracat yapan üreticilerin üretim sürecinde ortaya çıkan karbon emisyonları belgelemelerini ve bu emisyonlara karşılık gelen karbon maliyetini karşılamalarını zorunlu kılmaktadır. CSDDD ise çok uluslu şirketleri tedarik zincirlerindeki çevre ve insan hakları yükümlülüklerini yerine getirmekle sorumlu tutmaktadır. Bu iki düzenleme birlikte ele alındığında, AB'nin kendi sınırlarının ötesinde de belirleyici bir rol üstlendiği görülmektedir (Szulecki, Overland ve Smith, 2022).

Çalışmada analiz edilen makaleler Web of Science (251 makale) ve Scopus (41 makale) indeksli dergilerden derlenmiştir. Bu makaleler AB'nin CBAM ve CSDDD aracılığıyla küresel üretim ve ticaret ilişkileri üzerinde giderek daha belirleyici bir rol üstlendiğine işaret eden bulguları desteklemektedir. Bununla birlikte, literatürde bu düzenlemelerin gelişmekte olan ülkelerdeki ihracat yapan üreticiler üzerindeki etkilerine odaklanan çalışmaların, düzenlemelerin teknik ve yönetişim boyutlarını inceleyen çalışmalara kıyasla göreceli olarak daha sınırlı kaldığı görülmektedir. Bu durum, düzenlemelerin gelişmekte olan ülkelerdeki ihracat yapan üreticiler üzerindeki etkilerinin daha ayrıntılı incelenmesine ihtiyaç olduğunu göstermektedir. Magacho ve diğerleri (2024), CBAM'ın gelişmekte olan ülkeler üzerindeki etkilerinin coğrafi ve sektörel açıdan önemli ölçüde farklılaştığını göstermektedir. Das ve Bandyopadhyay (2025), Hindistan çelik sektörünün karbonsuzlaştırma baskıları ile kapasite kısıtları arasında önemli bir gerilim içinde olduğunu ortaya koymakta; Kamal, Mohieldin ve Ramzy (2025) ise pek çok gelişmekte olan ülke ihracatçısının CBAM uyum altyapısından henüz yoksun olduğunu belgelemektedir. Çalışmanın literatüre en önemli katkısı CBAM ve CSDDD düzenlemelerini yeşil düzenleyici ele geçirme yaklaşımıyla değerlendiren sistematik bir çerçeve önermesidir. Ayrıca 292 çalışmanın bibliyometrik analizi yapılarak ilgili alanda çalışacak araştırmacılara fayda sağlanması amaçlanmıştır. Çalışmanın planı sırasıyla şu şekilde tasarlanmıştır: Kavramsal Çerçeve, Yöntem, Bulgular ve Sonuç

1. KAVRAMSAL ÇERÇEVE

AB Yeşil Mutabakatı, Aralık 2019 yılında açıklanan ve AB'nin 2050 yılına kadar iklim nötr bir kıta olmasını hedefleyen üretim, ticaret ve yatırım süreçlerini yeniden şekillendirmeyi amaçlayan kapsamlı bir politika paketidir. Literatürde AB Yeşil Mutabakatı yalnızca bir çevre politikası olarak değil; AB'nin büyük pazar gücünü kullanarak ticaret ortakları üzerinde dolaylı bir standart belirleme etkisi yaratan bir araç olarak da değerlendirilmektedir. İncelenen 292 makale içinde AB Yeşil Mutabakatını ele alan 104 çalışmanın büyük bölümü,

mutabakatın jeopolitik boyutuna ve AB'nin küresel tedarik zincirleri üzerindeki etkilerine odaklanmaktadır.

CBAM: CBAM, Ekim 2023'te geçiş dönemiyle yürürlüğe girmiş; 2026'dan itibaren tam kapsamda uygulanması öngörülmektedir. Demir-çelik, çimento, alüminyum, gübre ve elektrik sektörlerini kapsamakta; ithalatçıların ürünlerin üretim sürecinde ortaya çıkan karbon emisyonlarını raporlamalarını ve bu emisyonlara karşılık gelen CBAM sertifikalarını edinmelerini zorunlu kılmaktadır. Shum (2024), CBAM'ın tasarım sürecinde serbest tahsislerin kaldırılma takviminin sanayi baskısına yanıt verdiğini belgelemektedir. Mehling, Dolphin ve Ritz (2025), karbon sızıntısını önlemedeki ampirik kanıtların hâlâ sınırlı olduğuna dikkat çekmektedir. Szulecki, Overland ve Smith (2022) ise CBAM'ı fiilen bir iklim kulübü işlevi gören bir araç olarak nitelendirmektedir.

CSDDD: Haziran 2024'te kabul edilen CSDDD, büyük ölçekli çok uluslu şirketleri kendi operasyonlarında ve tedarik zincirlerinde çevre ile insan hakları durum tespiti yükümlülüklerini yerine getirmekle sorumlu tutmaktadır. Direktif yalnızca AB'deki şirketleri değil, AB pazarına erişmek isteyen yabancı üreticileri de kapsamaktadır. Kirsch (2026), zorunlu raporlama rejimlerinin büyük ölçekli çok uluslu şirketler için hem yükümlülük hem de olası bir rekabet avantajı unsuruna dönüşebildiğini savunmaktadır.

Yeşil Düzenleyici Ele Geçirme: Düzenleyici ele geçirme teorisi, düzenleyici kurumların zamanla düzenledikleri sektörlerin etkisi altına girebileceğini ve bu sektörlerin çıkarları doğrultusunda hareket edebileceğini ileri sürmektedir. Stigler (1971), düzenleyici süreçlerin zaman içinde denetlenen sektörlerin çıkarlarına hizmet eder hâle gelebileceğini öne sürmektedir. Yeşil düzenleyici ele geçirme ise düzenleyici ele geçirme teorisinin çevre politikası alanındaki bir yansıması olarak değerlendirilebilir. Kavram kısaca, çevresel amaçlarla tasarlanan düzenlemelerin uygulamada yerleşik sanayi aktörlerinin rekabet avantajlarını güçlendirebildiği durumları ifade etmektedir. Bu çalışma, 292 makalenin bibliyometrik analizi aracılığıyla literatürdeki yansımalarını değerlendirmeyi amaçlamaktadır.

Yeşil düzenleyici ele geçirme yaklaşımının bu çalışmada tercih edilmesinin nedeni, araştırmanın kurumsal sürdürülebilirlik performansını değil, AB'nin çevresel düzenlemelerinin farklı aktörler üzerindeki etkilerini incelemesidir. İncelenen literatürde uyum maliyetleri, tedarik zincirlerinin yeniden yapılandırılması ve düzenleme süreçlerinde etkili aktörlerin rolü ön plana çıktığından, yeşil düzenleyici ele geçirme yaklaşımı bu örüntüleri açıklamada daha uygun bir analitik çerçeve sunmaktadır.

2. YÖNTEM

AB Yeşil Mutabakatı'nın 2019 yılında açıklanmasının ardından konuya yönelik akademik ilginin belirgin biçimde arttığı ve literatürde kapsamlı bir yayın birikiminin oluştuğu görülmektedir. Bu yayın birikimin bütününe sistematik biçimde bakmak amacıyla bibliyometrik analiz yöntemi tercih edilmiştir. Tematik sınıflandırma, konu uyumluluğu değerlendirmesi ve analiz süreçlerinde Claude AI (Anthropic) yapay zeka aracından yararlanılmıştır. Sınıflandırma kararları ve yorumlar araştırmacılar tarafından kontrol edilmiştir.

Veri seti, Web of Science (WoS) ve Scopus veri tabanlarında indekslenmiş hakemli dergilerden derlenmiştir. Bu iki veri tabanının tercih edilmesinin nedeni, uluslararası akademik çevrelerde atıf kalitesi ve yayın güvenilirliği sunmalarıdır. WoS, sosyal bilimler ve çevre alanında çok sayıda etki faktörü yüksek dergiyi kapsamakta; Scopus ise daha geniş coğrafi ve disiplinlerarası kapsama sahiptir. Bu iki endeksin birlikte kullanılması kapsam açısından daha geniş bir veri seti elde edilmesini sağlamıştır.

Bu çalışmada kullanılan tematik sınıflandırma, makalelerin başlık, özet ve anahtar kelimeleri esas alınarak gerçekleştirilmiş, gerekli görülen durumlarda tam metin incelemesine başvurulmuştur. Sınıflandırma sürecinde Claude AI (Anthropic) yapay zeka aracından yararlanılmış, nihai değerlendirmeler ise araştırmacı tarafından yapılmıştır. Bununla birlikte bazı çalışmaların birden fazla tema ile ilişkili olması nedeniyle aynı makale birden fazla tematik küme altında sınıflandırılmıştır.

3. BULGULAR

2019-2026 yılları arasında yayımlanmış ve konu uyumluluğu kriterlerine göre seçilmiş 292 makale analize dahil edilmiştir. AB yeşil politikasıyla doğrudan bağlantısı bulunmayan çalışmalar kapsam dışı bırakılmıştır. Veri setinin %86'sı (251 makale) WoS, %14'ü (41 makale) Scopus kaynaklıdır. Makalelerin %40'ı (117 makale) tek yazarlı, %60'ı (175 makale) çok yazarlı olup ortalama yazar sayısı 2,4'tür. Makaleler içeriklerinde öne çıkan araştırma temaları dikkate alınarak sınıfladırılmıştır. Bununla birlikte bazı çalışmaların birden fazla temayla ilişkili olması nedeniyle gerekli durumlarda aynı makale birden fazla küme kapsamında da değerlendirilmiştir. Tematik sınıflandırma öncelikle makalelerin başlık, özet ve anahtar kelimeleri üzerinden gerçekleştirilmiş, sınıflandırmada tereddüt edilen durumlarda tam metinler incelenmiştir. Bu nedenle tematik kümelerde yer alan makale sayılarının toplamı, veri setindeki toplam makale sayısından daha yüksek olabilmektedir. Analiz sonucunda belirlenen sekiz tematik küme ve bu kümelerde yer alan makale sayıları Tablo 1'de gösterilmektedir.

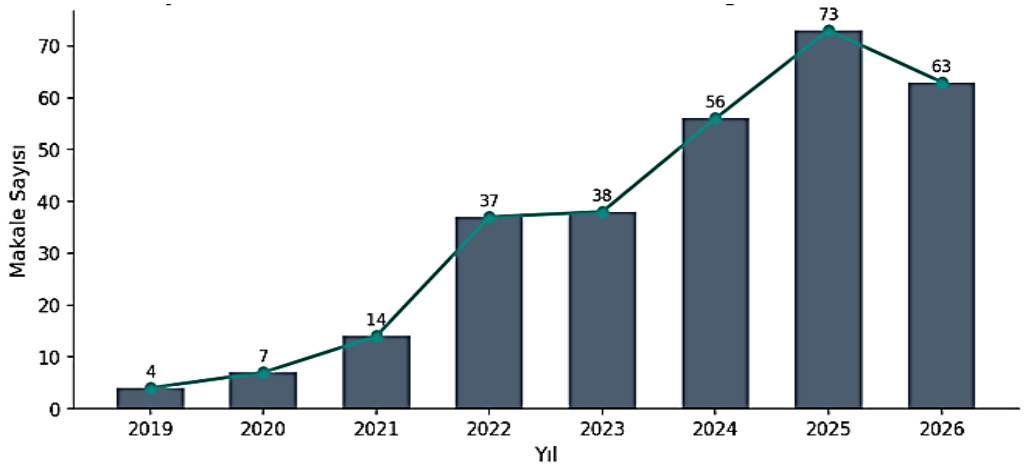
Tablo 1. Tematik Kümeler, Temel Anahtar Kelimeler ve Makale Sayıları

Tematik Küme	Temel Anahtar Kelimeler	Makale
CBAM/Karbon Sınır Düzenlemesi	CBAM, carbon border adjustment, carbon leak	143
Yeşil Mutabakat/Yönetişim	European Green Deal, Fit for 55, climate club	104
Sektörel Etki	Steel, cement, aluminium, decarbonization	108
Tedarik Zinciri	Supply chain, GVC, ESG, compliance	70
Hukuki/WTO	WTO, GATT, trade law, legal compatibility	36
Gelişmekte Olan Ülkeler/Adalet	Developing countries, Global South, CBDR	41
CSDDD/Durum Tespiti	CSDDD, due diligence, corporate sustainability	19
Lobi/Siyasi Ekonomi	Lobbying, political economy, regulatory capture	17

İkinci aşamada makaleler AB standartlarının etkilerini AB sanayisi, gelişmekte olan ülkeler ve her iki boyutu birlikte alan yaklaşımlar çerçevesinde değerlendirmiştir.

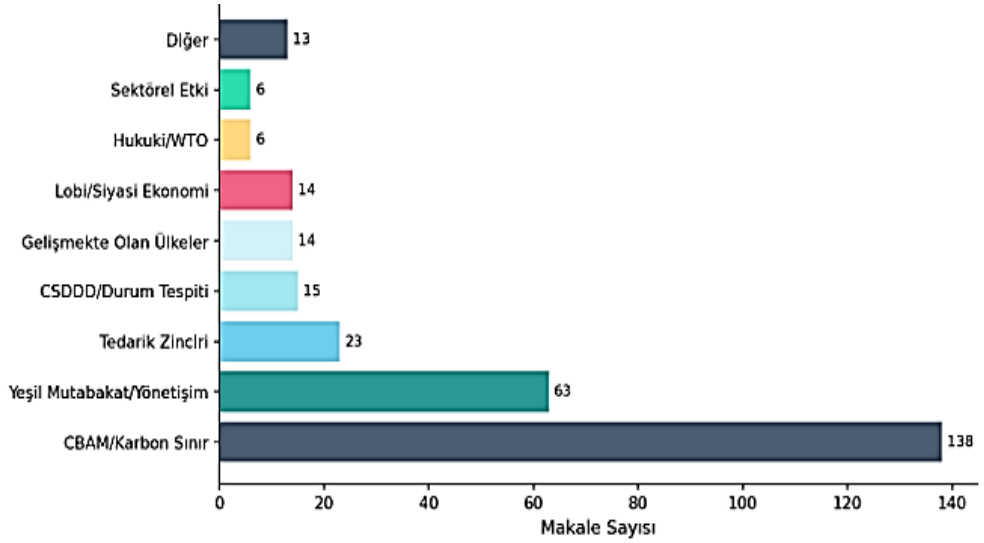
Şekil 1'de analize dahil edilen makalelerin yıllara göre dağılımı gösterilmektedir. Veri setinde yer alan makale sayısının yıllar itibari ile genel olarak artış eğiliminde olduğu görülmektedir. Araştırma kapsamında en çok yayın yapan dergiler Journal of World Trade (14 makale), Climate Policy (11), Sustainability (11) ve Energy Policy (11) olmuştur. Veri setindeki makalelerin %40'ı tek yazarlı, %60'ı çok yazarlı olup bu dağılım konunun disiplinlerarası işbirliği gerektiren yapısını yansıtmaktadır.

Şekil 1. Veri Setindeki Makalelerin Yıllara Göre Dağılımı (2019-2026)



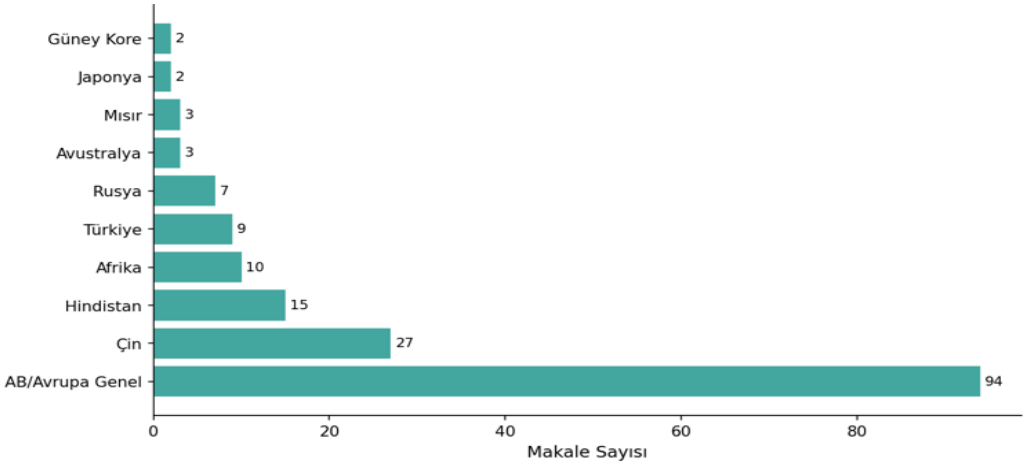
Makalelerin tematik kümelere göre dağılımı incelendiğinde, en yoğun araştırma alanlarının CBAM, Karbon Sınır Düzenlemesi ve Yeşil Mutabakat / Yönetişim başlıklarında toplandığı görülmektedir. Tematik kümelerin dağılımı Şekil 2'de gösterilmektedir.

Şekil 2. Tematik Küme Dağılımı



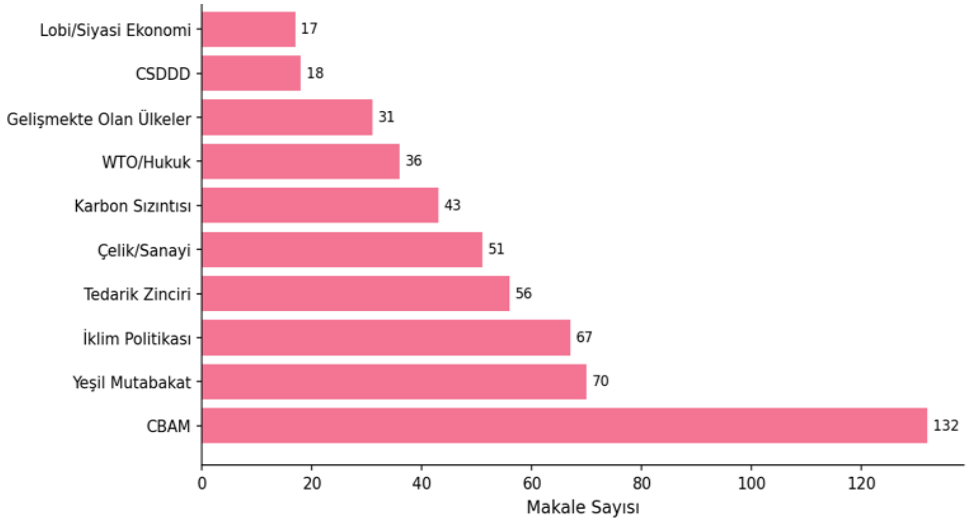
Makalelerin coğrafi odaklarına bakıldığında, akademik ilginin ağırlıklı olarak AB dışı ihracatçı ülkelere yöneldiği görülmektedir. AB/Avrupa genel çerçevesi (94 makale) en fazla ele alınan coğrafya olurken; Çin (27), Hindistan (15) ve Afrika (10) da önemli yer tutmaktadır. Coğrafi odakların dağılımı Şekil 3'te gösterilmektedir.

Şekil 3. Makalelerin Coğrafi Odak Dağılımı



İncelenen 292 makaleden üç örüntü öne çıkmaktadır. İlk olarak CBAM ve Gelişmekte Olan Ülkeler/Adalet başlıklarında yoğunlaşan çalışmalar, düzenlemelerin AB dışındaki üretici ve ihracatçı ülkeler üzerindeki etkilerine odaklanmaktadır. İkinci olarak, CBAM, Sektörel Etki ve Hukuki/WTO başlıklarında yer alan çalışmalar uyum maliyetlerini ve ticari yükümlülükleri ön plana çıkarmaktadır. Üçüncü olarak Lobi/Siyasi Ekonomi başlığındaki çalışmalar düzenlemelerin oluşum sürecinde farklı çıkar gruplarının etkisini incelemektedir. Lobi/Siyasi Ekonomi kümesinde yer alan çalışmalar, düzenlemelerin yalnızca teknik veya çevresel boyutlarıyla değil, aynı zamanda politika oluşturma süreçlerine katılan aktörler arasındaki güç ilişkileri bağlamında da ele alındığını göstermektedir. Anahtar kelime gruplarına göre makale dağılımı Şekil 4'te gösterilmektedir.

Şekil 4. Anahtar Kelime Gruplarına Göre Makale Dağılımı



Özellikle CBAM'ın gelişmekte olan ülkeler, ihracatçı üreticiler ve küresel tedarik zincirleri üzerindeki etkileri araştırmalarda sıklıkla vurgulanmaktadır. Magacho ve diğerleri (2024), CBAM'ın gelişmekte olan ülkeler üzerindeki coğrafi açıdan farklılaştığını ortaya koyarken; Corvino (2025), düzenlemenin CBDR-RC ilkesiyle ilişkili tartışmalar yarattığını belirtmektedir. Benzer şekilde Zhang ve Sovacool (2025), CBAM'ın Küresel Güney ülkeleri üzerindeki etkilerine dikkat çekmektedir. Shum (2024), serbest tahsislerin kaldırılma sürecinin sanayi üzerindeki etkilerini değerlendirirken, Bisetti ve diğerleri (2026) tedarik zincirlerinde çevresel risklerin ekonomik sonuçlarını ortaya koymaktadır.

WTO/hukuki kümesindeki çalışmalar CBAM'ın GATT uyumluluğu konusunda farklı değerlendirmeler sunmaktadır. Quirico (2024), CBAM'ı uluslararası hukukta bir karşı önlem

olarak yorumlarken; Leal-Arcas (2022) ve Magnaghi (2025) kapsamlı tasarım revizyonları gerektiğini savunmaktadır. Bu çalışma, Szulecki ve diğerleri (2022)'nin iklim kulübü çerçevesini yeşil düzenleyici ele geçirme yaklaşımıyla yeniden değerlendirmekte ve Kirsch (2026)'ın uyum kavramını CBAM-CSDDD bağlamında genişletmektedir.

Literatürdeki çalışmalar CBAM gelirlerinin bir bölümünün gelişmekte olan ülkelerin uyum kapasitesini arttırmaya yönelik teknik destek programlarına yönlendirlmesi önerilmektedir. Ayrıca düzenlemelerin revizyon süreçlerinde etkilenen ülke ve sektör temsilcilerinin daha aktif biçimde dahil edilmesi, gelişmekte olan ülkelerin farklı ekonomik koşullarının dikkate alınması ve CSDDD yükümlülüklerinin küçük işletmeler açısından aşamalı şekilde uygulanması faydalı olacaktır.

4. SONUÇ

292 makale üzerinde yürütülen bu çalışma, literatürde üç temel eğilimin öne çıktığını göstermektedir. Bunlar uyum yüklerinin AB üyesi olmayan ülkelerin ihracatçı üreticileri üzerindeki etkileri, küresel değer zincirlerinin AB düzenlemeleri çerçevesinde yeniden şekillenmesi ve düzenlemelerin oluşum sürecinde farklı aktörlerin rolüdür. Elde edilen bulgular, yeşil düzenleyici ele geçirme kavramının CBAM ve CSDDD tartışmalarını değerlendirmede yararlı bir analitik çerçeve sunabileceğini göstermektedir.

İlgili alanda yapılan akademik çalışmalar AB'nin CBAM ve CSDDD gibi düzenlemeler aracılığıyla küresel üretim ve ticaret standartlarının belirlenmesinde giderek daha etkili bir rol üstlendiğini göstermektedir. İncelenen çalışmaların önemli bir bölümünün uyum maliyetleri, ihracatçı üreticiler üzerindeki etkiler ve küresel değer zincirlerinin yeniden yapılanması üzerinde yoğunlaşması, düzenlemelerin etkilerinin tüm aktörler açısından eşit dağılmadığına işaret etmektedir. Özellikle karbon raporlama, izlenebilirlik, tedarik zinciri denetimi ve kurumsal uyum süreçlerine ilişkin yükümlülükler, finansal ve kurumsal kapasitesi yüksek işletmeler tarafından daha kolay karşılanabilmektedir. Bu durum, söz konusu aktörlerin yeni düzenleyici çerçeveye uyum sağlamada görece daha avantajlı bir konuma gelmesine yol açarken, gelişmekte olan ülkelerdeki üreticiler ve uyum kapasitesi sınırlı işletmeler açısından ilave maliyetler ve uyum baskılarıyla karşı karşıya kalmasına yol açmaktadır.

Literatürdeki çalışmalar, CBAM ve CSDDD'ye ilişkin uyum yüklerinin farklı ülke ve sektörler üzerinde eşit olmayan etkiler yaratabileceğine işaret etmekte, özellikle gelişmekte olan ülkeler ve AB dışındaki ihracatçı üreticiler üzerindeki etkilerin yoğun biçimde ele alındığı görülmektedir. Ayrıca, yayınların önemli bir bölümünün son yıllarda üretilmiş olması, konunun akademik literatürde giderek daha fazla ilgi gördüğünü göstermektedir. CSDDD'ye ilişkin çalışmaların sayısının görece sınırlı olması ise bu alanda daha fazla araştırmaya ihtiyaç duyulduğuna işaret etmektedir.

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DÖNGÜSEL EKONOMİNİN SÜRDÜRÜLEBİLİR KALKINMADAKİ ROLÜ

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Özet

Sürdürülebilir kalkınma, günümüzde çevresel bozulma, kaynak kıtlığı, iklim değişikliği ve artan atık miktarı gibi küresel sorunların çözümünde temel bir yaklaşım olarak kabul edilmektedir. Bu bağlamda döngüsel ekonomi (DE), kaynakların verimli kullanımını teşvik eden, atık oluşumunu en aza indiren ve ekonomik büyümeyi çevresel sürdürülebilirlikle uyumlu hale getirmeyi amaçlayan yenilikçi bir model olarak öne çıkmaktadır. Geleneksel doğrusal ekonomi modelinin aksine döngüsel ekonomi; yeniden kullanım, geri dönüşüm, onarım ve kaynak verimliliği ilkelerine dayanmaktadır. Bu çalışmanın amacı, döngüsel ekonominin sürdürülebilir kalkınmadaki rolünü incelemek ve Birleşmiş Milletler Sürdürülebilir Kalkınma Amaçları (SKA) ile olan ilişkisini değerlendirmektir. Özellikle SKA 12 (Sorumlu Üretim ve Tüketim), SKA 13 (İklim Eylemi), SKA 7 (Erişilebilir ve Temiz Enerji) ve SKA 9 (Sanayi, Yenilikçilik ve Altyapı) hedefleri çerçevesinde döngüsel ekonomi uygulamalarının katkıları ele alınmaktadır. Araştırma bulguları, döngüsel ekonomi yaklaşımının doğal kaynak tüketimini azaltarak çevresel etkileri sınırlandırdığını, enerji verimliliğini artırdığını ve sürdürülebilir üretim süreçlerini desteklediğini göstermektedir. Ayrıca bu model, yeni iş alanlarının oluşmasına katkı sağlayarak ekonomik kalkınmayı desteklemekte ve toplumun sürdürülebilirlik bilincinin gelişmesine yardımcı olmaktadır. Bununla birlikte, yetersiz yasal düzenlemeler, finansman eksiklikleri, teknolojik altyapı sorunları ve farkındalık düzeyinin düşük olması gibi çeşitli engeller, döngüsel ekonomi uygulamalarının yaygınlaşmasını sınırlandırmaktadır. Sonuç olarak, döngüsel ekonomi sürdürülebilir kalkınmanın gerçekleştirilmesinde önemli bir araç olarak değerlendirilmektedir. Bu modelin etkin bir şekilde uygulanabilmesi için kamu kurumları, özel sektör ve akademik çevreler arasında iş birliğinin güçlendirilmesi, yenilikçi teknolojilere yatırım yapılması ve uygun politika mekanizmalarının geliştirilmesi gerekmektedir.

Anahtar Kelimeler: Döngüsel Ekonomi, Sürdürülebilir Kalkınma, Sürdürülebilir Kalkınma Amaçları, Kaynak Verimliliği, Geri Dönüşüm

THE ROLE OF THE CIRCULAR ECONOMY IN SUSTAINABLE DEVELOPMENT

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Abstract

Sustainable development is widely recognized as a fundamental approach to addressing global challenges such as environmental degradation, resource scarcity, climate change, and the increasing generation of waste. In this context, the Circular Economy (CE) has emerged as an innovative model that promotes efficient resource utilization, minimizes waste generation, and aligns economic growth with environmental sustainability. Unlike the traditional linear economic model, the circular economy is based on the principles of reuse, recycling, repair, and resource efficiency. The aim of this study is to examine the role of the circular economy in sustainable development and to evaluate its relationship with the United Nations Sustainable Development Goals (SDGs). In particular, the study focuses on the contribution of circular economy practices to SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), SDG 7 (Affordable and Clean Energy), and SDG 9 (Industry, Innovation and Infrastructure). The findings indicate that the circular economy approach reduces environmental impacts by decreasing the consumption of natural resources, improving energy efficiency, and supporting sustainable production processes. Furthermore, this model contributes to economic development by creating new employment opportunities and enhancing public awareness of sustainability issues. However, several barriers, including inadequate regulatory frameworks, limited financial resources, technological infrastructure challenges, and low levels of awareness, continue to hinder the widespread implementation of circular economy practices. In conclusion, the circular economy is considered an important instrument for achieving sustainable development. The effective implementation of this model requires stronger collaboration among public institutions, private sector organizations, and academic communities, as well as increased investment in innovative technologies and the development of supportive policy mechanisms.

Keywords: Circular Economy, Sustainable Development, Sustainable Development Goals, Resource Efficiency, Recycling

İKİZ DÖNÜŞÜM MÜ, İKİZ KRİZ Mİ? AVRUPA BİRLİĞİ'NDE DİJİTALLEŞME VE YEŞİL POLİTİKANIN ÇATIŞAN DİNAMİKLERİ

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Özet

İkiz dönüşüm yaklaşımı, Avrupa Birliği'nin dijitalleşme ve yeşil dönüşüm gündemlerini tek bir çerçevede ele alır ve bu iki sürecin rekabet gücünü artırırken iklim nötrlüğüne ve toplumsal uyuma da hizmet edebileceği varsayımına yaslanır. Bu çalışma, söz konusu birlikteliğin uygulamadaki geçerliliğini eleştirel bir gözle sorgulamakta; AB'nin gerçekten bütünleşik bir ikiz dönüşüm mü yürüttüğünü, yoksa enerji kullanımı, sermaye ihtiyacı, düzenleyici çerçeve ve emek piyasası üzerinde birbiriyle yarışan taleplerin doğduğu bir ikiz krizle mi karşı karşıya olduğunu tartışmaktadır. 2026'da yayımlanan otuz güncel ampirik ve kuramsal çalışmanın tematik incelemesine dayanan araştırmada dört temel yapısal gerilim öne çıkıyor: dijital altyapının enerji tüketimi ve maddi kaynak kullanımı yoluyla iklim hedefleri üzerinde yarattığı baskı; Avrupa Yeşil Mutabakatı ile Dijital Piyasalar Yasası, Yapay Zekâ Yasası ve Kurumsal Sürdürülebilirlik Raporlama Direktifi arasındaki düzenleyici uyumsuzluklar; küçük ve orta ölçekli işletmelerin bu iki gündeme uyum kapasitelerindeki eşitsizlikler; ve dönüşümün çevre bölgeler ile kırılgan iş gücü grupları üzerindeki farklılaşan etkileri. Çalışma, politika belgelerinde sık sık öne çıkarılan sinerji söyleminin ampirik temelinin zayıf olduğunu; karmaşık bir sorunu basit ve umut verici göstererek esasen siyasete kolaylık sağladığını ileri sürer. Bu söylem, uygulamada beliren geri tepme etkilerini, denetimin yetişemediği açıkları ve dönüşümün eşitsiz biçimde benimsenmesini çoğu kez görünmez kılmaktadır. Mevcut bulgular, dijital ve yeşil yönelimi birlikte yürütebilen firmaların yalnızca tek bir alana odaklananlara kıyasla daha iyi sonuç aldığını gösteriyor; ne var ki bu firmaların hâlâ azınlıkta olması, ikiz dönüşümün yaygın ve dengeli biçimde gerçekleşmediğine işaret eder. Tartışma bölümünde bu gerilimler sınırlı rasyonalite, dinamik yetenekler ve sürdürülebilirlik dönüşümleri yazınıyla ilişkilendirilerek ele alınmakta; dijitalleşmenin karbonsuzlaşmaya katkı sağlaması için gereken koşulların AB belgelerinde varsayılandan çok daha karmaşık olduğu ortaya konmaktadır. Sonuç bölümünde ise olası bir ikiz krizi daha tutarlı ve uygulanabilir bir ikiz dönüşüme çevirmeye dönük somut politika önerileri sunulmakta; bunların başında dijital altyapılar için zorunlu çevresel muhasebe mekanizmalarının kurulması gelmektedir.

Anahtar Kelimeler: İkiz Dönüşüm, Avrupa Birliği, Dijitalleşme, Yeşil Dönüşüm, Sürdürülebilirlik Ödünleşimleri, Avrupa Yeşil Mutabakatı, Endüstri 4.0, Geri Tepme Etkileri

TWIN TRANSFORMATION OR TWIN CRISIS? THE CONFLICTING DYNAMICS OF DIGITALISATION AND GREEN POLICY IN THE EUROPEAN UNION

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Abstract

Across EU policy, digitalization and the green transition are no longer framed as separate reforms but as a single, mutually reinforcing project — the "twin transition." This paper critically examines whether that promise holds in practice. Reading thirty empirical and theoretical studies published in 2026, it argues that the two agendas are at least as likely to compete as to reinforce one another, and that the Union may be drifting toward a "twin crisis" rather than a coherent transition. Four structural tensions carry the argument. First, digital infrastructure is hungry for energy and raw materials, pulling against the absolute emission cuts that climate targets demand. Second, the green and digital rulebooks — the European Green Deal, the Digital Markets Act, the AI Act, the Corporate Sustainability Reporting Directive — grew up in parallel and now heap uncoordinated compliance costs on smaller firms. Third, the firms that manage both transitions at once turn out to be a capable minority, not the norm. Fourth, the costs of change land unevenly across regions, sectors, and workers. The much-repeated synergy rhetoric, the paper contends, is empirically thin and politically convenient: by making a hard problem look simple and hopeful, it conceals the rebound effects, governance gaps, and uneven uptake that surface in practice. Taken together, the studies imply that the conditions under which digitalization genuinely aids decarbonization are far more exacting than EU documents presume. The paper ends with workable proposals — starting with mandatory environmental accounting for digital infrastructure — for turning a looming twin crisis into a transition worthy of the name.

Keywords: Twin Transition, European Union, Digitalization, Green Transition, Sustainability Trade-Offs, European Green Deal, Industry 4.0, Unintended Consequences

GİRİŞ

Avrupa Birliği'nin "ikiz dönüşüm" kavramı bir süredir politika gündeminin tam ortasında; bu çalışma da söz konusu tartışmaya eleştirel bir perspektiften katkı sunmayı amaçlar. Avrupa Birliği, bu "ikiz geçiş" denen şeyin âdeta küresel laboratuvarı; en azından Brüksel kendini böyle görüyor. Bu stratejik tasavvurda dijital dönüşüm ile yeşil gündem ayrı reform başlıkları olarak değil, birbirini besleyen tek bir proje olarak kurgulanır. Avrupa Yeşil Anlaşması, NextGenerationEU, Fit for 55 paketi, Dijital On Yıl 2030 hedefleri ve Kurtarma ve Dayanıklılık Tesisi aynı öncülden hareket eder: yapay zekâ, ileri veri analitiği, Nesnelerin İnterneti ve platform temelli iş modelleri karbonsuzlaşmayı hızlandıracak; iklim yatırımları ise Avrupa'nın dijital kapasitesini genişletecek talebi doğuracaktır. Bu çerçevenin kökleri, yeşil ve dijital geçişi tek bir stratejik ufukta birleştiren Avrupa Yeşil Anlaşması'na (European Commission, 2019) ve bu ikiliği erken dönemde kavramsallaştıran politika araştırmalarına (Muench ve ark., 2022) uzanır. Bu tasavvurun önemi Brüksel'le sınırlı değildir. AB dünyanın üçüncü büyük ekonomisi, en iddialı iklim otoritesi ve en kararlı dijital düzenleyicisidir; dolayısıyla tercihleri kendi sınırlarının çok ötesinde ticaret kurallarını, teknoloji standartlarını ve sermaye akışlarını biçimlendirir. Güncel veriler, dijital dönüşümün AB ülkelerinde hem ekonomik performansın hem de Sürdürülebilir Kalkınma Hedefleri'ne doğru ilerlemenin yapısal bir itici gücü hâline geldiğini; rekabet gücü, inovasyon ve çevresel göstergeler üzerinde ölçülebilir izler bıraktığını ortaya koyuyor (Fülöp & Cifuentes-Faura, 2026). Bu yüzden ikiz geçişin başarısı ya da başarısızlığı yalnızca Avrupa sanayi politikasının inandırıcılığını değil, gelişmiş ekonomiler için düşük karbonlu ve teknolojik açıdan egemen bir kalkınma modelinin uygulanabilirliğini de tayin edecektir.

Anlatının siyasi ağırlığına karşın akademik yazın kavramsal olarak parçalı ve dengesiz kalmaktadır. Ağırlıkla yönetim odaklı bir damar, dijitalleşme ile sürdürülebilirliği doğal birer tamamlayıcı gibi sunar ve firma düzeyindeki sinerjik mekanizmalara — dinamik yetkinlikler, çevresel-sosyal-yönetişim (ESG) performansı, stratejik dijital yönelim — odaklanır (Hussain ve ark., 2026; Sabau-Popa ve ark., 2026). Tedarik zinciri, inovasyon ve operasyon araştırmalarından beslenen ikinci bir damar, dijital araçların döngüsel ekonomi uygulamalarına ve yalın üretim paradigmalarına eklemlenmesini vurgular (Bernhard ve ark., 2026; Bandi ve ark., 2026). Daha yeni olan üçüncü bir grup ise mevcut karar çerçevelerinin yakalayamadığı geri tepme etkilerini, yönetişim başarısızlıklarını ve ödünleşimleri belgeleyerek bu sinerji varsayımını sorgulamaya başlamıştır (Van de Walle & Aerts, 2026). Yine de AB'nin ikiz geçişinin bir politika kurgusu olarak kavramsal tutarlılığını, temel varsayımlarının ampirik geçerliliğini ve iki dönüşümün gerçekte zıt yönlere çekip çekmediğini doğrudan inceleyen çalışma sayısı son derece azdır. Bu boşluğu görmezden gelmenin bedeli ağırdır: sınanmamış bir sinerji anlatısına sürekli yaslanmak, kamu yatırımlarının yanlış tahsisine, dijitalleşmenin iklim faydalarının abartılmasına ve eşzamanlı

yapısal değişimin toplumsal ve bölgesel maliyetlerinin küçümsenmesine kapı aralar. Bu boşluk yalnızca kuramsal bir eksiklik olarak değerlendirilmemelidir. Çünkü ikiz dönüşüm yaklaşımı, önemli ölçüde kamu kaynağının yönlendirildiği bir politika çerçevesi niteliği taşımaktadır.

Bu çalışmanın hareket noktası olan sorun şudur: sinerji varsayımı yalnızca sınanmadan kalmamış, AB politika mimarisi onu bir muhasebe yanılgısının üzerine kurmuştur. Dijitalleşme ile karbonsuzlaşma pek çok belgede sanki aynı hesabın iki kalemiymiş gibi toplanır. Oysa ikisinin işleyiş mantığı farklıdır. Karbonsuzlaşma mutlak ve geri dönüşü olmayan bir azaltım ister; dijitalleşme ise büyümek, hızlanmak ve ölçeklenmek üzerine kuruludur. Üstelik ikisi aynı kıt kaynaklara göz diker: elektriğe, kritik hammaddeye, yatırım sermayesine, nitelikli iş gücüne ve en kıt olanına, yani düzenleyicinin dikkatine ve yöneticinin zamanına. Politika dili bu kaynakları sessizce "eklenebilir" sayar; dijital yatırımın iklim hedefine kendiliğinden bir değer kattığını varsayar. İşte bu makalenin asıl işaret ettiği nokta burada: aynı kaynak iki yerde birden sayıldığında, kâğıt üzerinde sinerji görünen ilişki sahada bir ödünleşmeye, kimi zaman da düpedüz bir mahsuplaşmaya dönüşür. Dolayısıyla temel soru, dijitalleşmenin yeşil dönüşüme katkı sağlayıp sağlamadığı değil; bu katkının hangi koşullar altında ve hangi maliyetlerle ortaya çıktığıdır.

Bu makalenin temel savı, AB'nin ikiz geçiş yaklaşımının kendi iki bileşeni arasındaki yapısal gerilimleri hafife aldığıdır. Dijitalleşme doğası gereği çevreci olmaktan uzak; enerji, hammadde ve sermaye yoğun bir süreçtir. Enerji geçişi ve dijitalleşme malzeme ayak izini azaltma potansiyeli taşısa da bu etki, yeşil ve yeşil olmayan malların üretimiyle gelen kaynak baskısını dengeleyememekte; dolayısıyla dijitalleşmenin net çevresel etkisi yönetişim koşullarına sıkı sıkıya bağlı kalmaktadır (Islam ve ark., 2026). Veri merkezlerinin, uç bilişim sistemlerinin, üretken yapay zekânın ve yüksek frekanslı bağlantının yayılması, tam da AB iklim hedeflerinin mutlak azaltım talep ettiği bir dönemde elektriğe ve kritik hammaddelere yönelik yeni bir talep yaratır. Bu sırada yeşil ve dijital gündemlerin düzenleyici mimarisi birbirinden bağımsız gelişmiştir: Avrupa Yeşil Anlaşması, Kurumsal Sürdürülebilirlik Raporlama Direktifi, Dijital Piyasalar Yasası ve Yapay Zekâ Yasası, özellikle özümseme kapasitesi sınırlı KOBİ'lere ağır ama eşgüdümsüz uyum yükümlülükleri getirir (Sivaiah & Vinodan, 2026; Miśkiewicz, 2026). Bu gerilimleri AB politika bileşiminin yapısal özellikleri olarak değil de geçici sürtünmeler olarak görmek, hem gevşek bir düşünmeye hem de hedefleri uygulanabilirlikle karıştıran politika tasarımlarına yol açar.

Makalenin amacı üç koldan ilerler. Önce AB'nin ikiz dönüşüm gündeminin kavramsal çerçevesini yeniden kuruyor ve bu çerçevenin kendi içinde tutarlı olup olmadığını güncel ampirik yazına soruyoruz. Ardından dijitalleşme ile yeşil politikanın Avrupa'da tam olarak nerelerde birbirine sürttüğünü ayırt etmeye çalışıyoruz; bu sürtünmeler enerji ve malzeme akışlarından düzenleyici yapıya, firmaların uyum kapasitesinden dağılımsal sonuçlara kadar

uzanıyor. Son aşamada ise saptanan ödünleşimleri halının altına süpürmek yerine yönetmeyi amaçlayan, uygulanabilir bir politika seti öneriyoruz. Bu üç adımdan çıkan başlıca bulgular şöyle: Sinerji anlatısı yalnızca yönetişim kalitesi, sektörel uygunluk ve yönetim kapasitesi gibi kısıtlayıcı koşullar altında geçerlidir. Dengeli bir ikiz yönelim benimseyen firmalar, iki yörüngeden yalnızca birini seçenlere göre daha iyi performans gösterir; ama yapısal olarak azınlıkta kalırlar (Hein ve ark., 2026). AB politikasının düzenleyici parçalanması, firma büyüklüğüne ve coğrafyaya göre regresif işleyen uyum yükleri üretir. Dijital finans, yapay zekâ ve ESG odaklı dijital araçlar ise kurumsal tasarıma bağlı olarak sürdürülebilirlik sonuçlarını hızlandırabilir de zayıflatabilir de (Wang ve ark., 2026; Mumcu & Brieger, 2026). Bir arada okunduğunda bu bulgular, politika çerçevesi köklü biçimde yeniden ayarlanmadıkça AB'nin ikiz geçişten çok bir ikiz kriz üretme riski taşıdığı yönündeki ana savı destekler.

Yöntem açısından bu çalışma, sistematik bir meta-analiz değil, tematik ve eleştirel bir sentezdir; amaç istatistiksel temsil değil, kavramsal bir örüntüyü görünür kılmaktır. Çalışmaların seçiminde üç ölçüt gözetilmiştir. İlki güncelliktir: ikiz dönüşüm tartışmasının en güncel hâlini yansıtması için yalnızca 2026'da yayımlanmış hakemli çalışmalar dâhil edilmiştir. İkincisi tematik yakınlıktır: bir çalışmanın kümeye girebilmesi için dijitalleşme, sürdürülebilirlik ve politika/yönetişim eksenlerinden en az ikisini aynı anda ele alması koşulu aranmış, yalnızca dijitalleşmeye ya da yalnızca sürdürülebilirliğe odaklanan çalışmalar kapsam dışı bırakılmıştır. Üçüncüsü yöntemsel çeşitliliktir: tek bir yaklaşımın sınırlarına bağlı kalmamak için panel veri ekonometrisi, yapılandırılmış literatür taramaları, nitel vaka çalışmaları ve kavramsal çerçeveler bilinçli olarak bir arada tutulmuştur. Tarama; dijitalleşme, yeşil dönüşüm, ikiz/çifte dönüşüm, sürdürülebilirlik ve Avrupa Birliği anahtar sözcüklerinin bileşimleriyle yürütülmüştür. Nihai otuz çalışmalık küme de bu ölçütleri karşılayanlar arasından, konuya doğrudan değme derecesine göre belirlenmiştir.

İncelenen çalışmaların önemli bir kısmı dijitalleşme ile sürdürülebilirlik arasındaki ilişkiyi başlangıçta olumlu varsaymaktadır. Ancak bu çalışmalar birlikte değerlendirildiğinde, söz konusu ilişkinin çoğu zaman koşullu olduğu görülmektedir: belirli yönetişim, kapasite ya da sektör koşulları sağlanmadığında olumlu etki ortaya çıkmamakta, hatta ters etki gözlemlenmektedir. Birbirinden bağımsız yürütülmüş çalışmaların bu noktada yakınsaması tesadüf değil; yapısal bir örüntünün işaretidir ve araştırmanın çıkış noktasını oluşturur. Bununla birlikte çalışma, alanın yansız bir haritasını çıkarma iddiasında değildir; hâlihazırda işleyen uyum söylemine yönelik bilinçli bir eleştiri niteliği taşır. Kıyaslama amacıyla yer yer AB dışı örneklere başvurulsa da coğrafi ve kurumsal odak ısrarla Avrupa'da tutulmuştur.

Bundan sonrası şöyle kurgulandı. İkinci bölüm dört yapısal gerilimi tek tek ele alıp savın kavramsal ve ampirik zeminini döşer. Üçüncü bölüm aynı gerilimleri sınırlı rasyonalite, dinamik yetkinlikler, sosyo-teknik geçiş kuramı ve Avrupa bütünleşmesinin politik ekonomisi mercekleriyle yeniden okur; böylece AB deneyimi salt bir Brüksel meselesi olmaktan çıkıp

daha genel bir kurama oturur. Dördüncü bölüm, olası bir ikiz krizi tutarlı bir ikiz dönüşüme çevirecek somut ve gerçekçi önerileri sıralar. Sonuç bölümü ise savı toparlar, çalışmanın sınırlarını teslim eder ve açtığı araştırma kapılarını gösterir.

1. KAVRAMSAL ÇERÇEVE VE LİTERATÜR TARAMASI: AB İKİZ GEÇİŞİNİN DÖRT YAPISAL GERİLİMİ

Aşağıda incelenen dört gerilim, çalışmanın temel savının dayanaklarını oluşturur. Bunlar bir arada ele alındığında ortaya çıkan tablo, politika belgelerinin çizdiği uyumlu resimden belirgin biçimde uzaktır: ikiz geçiş, sunulduğu kadar sinerjik değildir. Sıralama bilinçli olarak kurulmuştur; çelişkilerin gelip geçici aksaklıklar değil, sistemin yapısından doğan özellikler olduğunu göstermek için çözümleme, dönüşümün önce fiziksel ve teknik katmanından başlayıp kurumsal, örgütsel ve toplumsal katmanlara doğru ilerler. Aşağıdaki tablo, bu dört gerilimi özet biçimde bir araya getirmektedir.

Tablo 1. AB ikiz geçişinin dört yapısal gerilimi: özet karşılaştırma

Gerilim	Katman	Temel çelişki	Anahtar çalışmalar	AB için sonuç
Enerji ve malzeme ayak izi	Fiziksel / teknik	Dijital altyapı, mutlak azaltım hedefiyle çatışan yeni bir enerji ve hammadde talebi doğurur	Islam ve ark. (2026); Imran ve ark. (2026)	İklim faydası kendiliğinden gelmez, yönetişime bağlıdır
Düzenleyici parçalanma	Kurumsal	Yeşil ve dijital mevzuat eşgüdümsüz gelişir; uyum yükleri üst üste biner	Van de Walle & Aerts (2026); Sivaiah & Vinodan (2026)	Küçük firmalara orantısız maliyet yükler
İşletme düzeyinde heterojenlik	Örgütsel	Dengeli ikiz yönelim azınlıktadır; özel kaynak ve yetkinlik ister	Hein ve ark. (2026); Miśkiewicz (2026)	Tek tip strateji başarısız olma eğilimindedir
Dağılım ve sektörel dengesizlik	Toplumsal	Maliyetler bölgeler, sektörler ve gruplar arasında eşitsiz dağılır	Kandel ve ark. (2026); Zöllner ve ark. (2026)	Açık bir dağılım tasarımı olmadan eşitsizlik derinleşir

Kaynak: Yazar tarafından, taranan literatürden derlenmiştir.

1.1. Dijitalleşmenin Enerji ve Malzeme Ayak İzi İle Karbon Salımını Azaltma Zorunluluğu Arasındaki Çelişki

İlk ve en somut çelişki, dijital altyapı ile enerji sistemi arasındaki ilişkide yatar. AB iklim hedefleri sera gazı emisyonlarında mutlak ve hızlı bir düşüş ister; oysa dijitalleşme, enerji ve malzeme talebinin giderek büyüyen bir kaynağıdır. Bazıları AB üyesi olan G7

ekonomilerinden gelen son veriler, hem yeşil hem yeşil olmayan malların üretiminin malzeme ayak izini büyütmeyi sürdürdüğünü gösteriyor. Enerji geçişi ve dijitalleşme bu baskıyı hafifletebilse de yetersiz kalmakta; kaynak yoğunluğu üzerindeki yapısal baskı sürmektedir (Islam ve ark., 2026). Bu bulgu, dijital ekonominin doğası gereği maddesizleştiği yönündeki örtük varsayımı sarstığı için AB'yi doğrudan ilgilendirir. Esasen bu maddesizleşme tezi yeni bir kuşkuyla karşılaşmıyor; ulusların malzeme ayak izini izleyen daha eski çalışmalar, ekonomik büyümeden kaynak kullanımının kolayca ayrışmadığını çoktan göstermişti (Wiedmann ve ark., 2015).

Gelişmekte olan ve öncü ekonomileri konu alan tamamlayıcı araştırmalar ise yeşil teknolojilerin, yeşil enerji tüketiminin ve dijitalleşmenin çevresel sürdürülebilirliği ancak belirli kurumsal koşullarda ve çevresel performans dağılımının belli noktalarında birlikte iyileştirebildiğini ortaya koyuyor (Olanrewaju & Kirikkaleli, 2026). Yenilenebilir enerji ve dijitalleşme güzergâhları üzerine yapılan başka çalışmalar da yönetişim etkinliğinin belirleyici bir düzenleyici (moderatör) olduğunu doğruluyor; güçlü düzenleyici ve kurumsal kapasite yoksa dijital araçların çevresel faydaları geri tepme etkileriyle aşınıyor (Imran ve ark., 2026). Verimlilik kazanımlarının ek tüketimle yutulması anlamına gelen bu geri tepme olgusu, enerji iktisadında yeni değildir; Jevons paradoksuna kadar uzanan köklü bir tartışmanın konusudur (Sorrell, 2009). AB açısından bunun anlamı açıktır: dijital geçişin iklim faydaları kendiliğinden gerçekleşmez, kuşatan yönetişim çerçevesinin gücüne ve tutarlılığına büyük ölçüde bağlıdır. Aslında literatür bu noktada belirgin biçimde ikiye ayrılır. Islam ve arkadaşları (2026), enerji geçişinin ve dijitalleşmenin malzeme ayak izini azaltabildiğini gösterse de bu kazanımların yeşil ve yeşil olmayan malların üretiminden kaynaklanan kaynak baskısı tarafından dengelendiğini ortaya koyar. Olanrewaju ve Kirikkaleli (2026) ile Imran ve arkadaşları (2026) ise dijitalleşmeyi, doğru kurumsal koşullarda, çevresel iyileşmenin aracı sayar. Oysa iki kamp aynı veriye değil, farklı koşul setlerine bakıyor. Yani anlaşmazlık dijitalleşmenin doğası hakkında değil, onu çevreleyen yönetişim hakkındadır; ilk kamp yönetişimi zayıf ortamlardaki sonuçları, ikincisi ise güçlü ortamlardakileri öne çıkarır. Bu ayrımı görmek, sinerji tartışmasının neden bir türlü kapanmadığını da açıklıyor.

Sektörel veriler burada sinerji savını güçlendirmek için değil, onu sınırlandırmak için önemlidir. Tedarik zinciri yönetiminde öngörücü dijital modeller sürdürülebilirlik performansını iyileştirebiliyor; ancak Rahman ve arkadaşları (2026) bu kazanımın çoktan yeşil yetkinliklere yatırım yapmış firmalarda yoğunlaştığını, yatırım yapmamış olanları ise daha da geriye ittiğini gösteriyor. Önceden yeşil altyapısı olmayan firmalarda dijital yatırımın çevresel eşitsizlikleri derinleştirmesi, AB'nin uyum politikası açısından görmezden gelinemeyecek bir örüntüdür. İlaç endüstrisinden gelen kanıtlar da benzer bir koşulluluk işaret ediyor: yapay zekâ ve dijital ikizler çevresel etkiyi azaltabilir, ama yalnızca araçlar daha geniş

bir sürdürülebilirlik stratejisine eklemlendiğinde ve gerekli altyapıyla desteklendiğinde (Eugster & Luciani, 2026). Araç başka; onu anlamlı kılan bağlam başka.

1.2. Düzenleyici Parçalanma: Ortak Bir Mantıktan Yoksun Paralel Mimariler

İkinci gerilim kurumsaldır ve AB'nin kural koyma mimarisiyle ilgilidir. Yeşil ve dijital düzenleme paketleri, her biri kendi hukuki dayanağı, araçları ve uygulama mantığıyla yan yana ama ayrı gelişmiştir. Yeşil tarafta Kurumsal Sürdürülebilirlik Raporlama Direktifi, AB Taksonomisi ve Karbon Sınır Ayarlama Mekanizması; dijital tarafta Dijital Piyasalar Yasası, Dijital Hizmetler Yasası ve Yapay Zekâ Yasası şirketlere kayda değer raporlama, uyum ve izleme yükümlülükleri yükler. Gelgelelim bunlar sistematik biçimde eşgüdümlenmez. Güncel araştırmalar, kurumsal dijitalleşmeye ilişkin mevcut karar çerçevelerinin daha geniş, ekosistem düzeyindeki olguları gözden kaçırma ve dar anlamda ekonomik performansa odaklanma eğiliminde olduğunu; sürdürülebilirlik boyutları arasındaki dengeleri yönetme konusunda ise pek az yol gösterdiğini belirtiyor (Van de Walle & Aerts, 2026).

Frankfurt Borsası'nda işlem gören şirketlerin siber güvenlik ve sürdürülebilirlik performansını inceleyen ampirik çalışmalar, dijitalleşme yoğunluğu ile yönetim kurulu düzeyindeki BT uzmanlığının sürdürülebilirlik sonuçlarını birlikte etkilediğini gösteriyor; yani mevzuata uyum, şirket içi yönetişim yapılarınca aracılanıyor (Kurair & Adedokun, 2026). Kamu düzenlemeleri parçalı olduğunda, iç uzmanlığı yüksek şirketler uyum taleplerini daha verimli karşılarken küçük ve dijital olgunluğu düşük şirketler orantısız maliyete katlanır. Düzenleyici karmaşıklığın bu firmalar üzerindeki olumsuz etkisi KOBİ yazınında belgelenmiştir; kaynak kısıtlı şirketlerin sürdürülebilirlik raporlamasına dâhil olabilmesi için giderek daha çok olgunluk temelli benimseme modelleri önerilmektedir (Sivaiah & Vinodan, 2026).

Kavramsal düzeyde bile, kurumsal dijitalleşme çerçeveleri üzerine çalışan akademisyenler baskın yaklaşımların üretici ya da firma düzeyindeki bakışı öne çıkardığını, ekosistem düzeyindeki geri tepme ve indüksiyon etkilerini ise küçümsediğini savunur (Van de Walle & Aerts, 2026). Bu, firma düzeyindeki raporlama ve uyumun sistem düzeyindeki sonuçlara düzgün biçimde toplandığını varsayan AB düzenleme tasarımına dolaysız bir meydan okumadır. Buna karşılık AB, iki geçişin birbirini güçlendirmek yerine yönetsel ilgi, uyum kaynakları ve siyasi sermaye için yarıştığı yoğun ama zayıf bütünleşmiş bir düzenleyici ortam üretmektedir. Kanımca buradaki asıl sorun kuralların çokluğu değil, aralarında ortak bir mantığın bulunmayışıdır: AB her iki gündemi de ayrı ayrı "düzenlemiş," ama ikisini birbirine bağlayacak üst bir çerçeve kurmayı ihmal etmiştir.

1.3. İşletme Düzeyinde Heterojenlik: İkiz Dönüşüm Azınlıkta Görülen Bir Örüntüdür

Üçüncü gerilim örgütseldir. Politika kurgusu kusursuzca tutarlı olsa bile, işletmelerin iki dönüşümü birden içselleştirme kapasiteleri büyük farklılık gösterir. Almanya'daki yenilikçi

KOBİ'leri konu alan yakın tarihli geniş çaplı bir çalışma yeşil, dijital ve ikiz stratejik yönelimleri açıkça karşılaştırır ve dengeli bir ikiz yönelime sahip işletmelerin yalnızca tek yolu seçenlere göre daha iyi performans gösterdiğini ortaya koyar. Ne var ki bu firmalar azınlıktadır ve özel kaynak ile yetkinlik gerektirir (Hein ve ark., 2026). KOBİ'lerin Avrupa istihdamı ve katma değerindeki merkezî yeri düşünüldüğünde, bulgu AB için fazlasıyla önemlidir. Hein ve arkadaşlarının (2026) çalışması bu literatürün en sağlam ampirik dayanağını sunarken aynı zamanda en belirgin sınırını da taşımaktadır; bu sınırların yöntemsel ayrıntısını üçüncü bölüme bırakıp burada daha temel bir eksiğe işaret etmek istiyorum. Mevcut çalışmalar, ikiz yönelimi başaran firmaların azınlık olduğu konusunda hemfikirken, bu azınlığın nasıl çoğunluğa dönüşeceği konusunda suskundur. Araştırma tasarımlarının çoğu başarılı firmaların hangi yetkinliklere sahip olduğunu ölçer, bu yetkinliklerin nasıl edinileceğini ise ölçmez. Yani literatür sonucu betimliyor, ama onu üreten nedensel mekanizmayı açık bırakıyor; oysa politika açısından asıl kıymetli olan tam da o mekanizmadır.

Miśkiewicz'in (2026) bütünleştirici çerçevesi de yetenek yönetiminin geleneksel imalat KOBİ'lerinde dijital dönüşüm ile sürdürülebilirliği hizalayan dinamik bir yetkinlik olarak işlediğini savunur. Burada insan sermayesi, ikiz dönüşümün bağlayıcı kısıtı hâline gelir: becerilere, liderliğe ve örgüt kültürüne dönük hedefli yatırımlar olmadan dijital araçlar sürdürülebilirlik sonucu üretemez. Aile şirketlerinden gelen benzer kanıtlar, sahiplik ve yönetişim yapılarının — kuşaklar arası yönelime ve risk tercihlerine bağlı olarak — sürdürülebilirlik için iş stratejisinin dijitalleşmesini ya katalize ettiğini ya da köstek olduğunu gösterir (Forés ve ark., 2026).

Girişimler üzerine yapılan araştırmalar aynı çizgiyi sürdürür: sürdürülebilirliğe dönük inovasyon yetenekleri, yönetim vizyonu, ağ erişimi ve ekosistem desteği gibi öncüllerin aracılık ettiği dijital yönelimin bir çıktısıdır (Lu ve ark., 2026). Dijital çağa ilişkin daha geniş ampirik çalışmalar da dijitalleşmenin sürdürülebilir performansı ancak belirli stratejik hizalama ve örgütsel hazırlık koşullarında desteklediğini doğrular (Z. Ali ve ark., 2026). Benzer biçimde, yönetsel algılara dayanan Endüstri 4.0 çalışmaları, sürdürülebilirlik sonuçlarına ulaşmak için teknolojik modernizasyonun örgüt kültürüne entegre edilmesi gerektiğini vurgular (Sabau-Popa ve ark., 2026). AB için çıkarım nettir: tek tip bir ikiz geçiş stratejisinin, Avrupa'nın heterojen kurumsal ortamında başarılı olma ihtimali düşüktür.

1.4. Dağılım ve Sektörel Dengesizlikler: İkiz Geçişin Maliyetini Kim Üstleniyor?

Tarım sektörü bu eşitsizliğin açık bir örneğini sunar. Dijital tarım araçları daha verimli ve daha sürdürülebilir bir üretim vaat etse de, bu vaadin karşılığı altyapıya, beceriye ve veriye erişime bağlıdır; bu olanaklardan yoksun en kırılgan çiftlikler, dijital tarım-gıda geçişinden yapısal olarak dışlanmaktadır (Kandel ve ark., 2026). Dördüncü gerilim de tam bu noktada

belirir: ikiz geçiş, uyum maliyetlerini sektörler, bölgeler ve toplumsal gruplar arasında eşitsiz dağıtır. Döngüsel ekonomi uygulamalarında, kısa gıda tedarik zincirlerinde ve dijitalleşmenin daha donanımlı üreticileri kayırdığı daha geniş tarım-gıda alanında benzer örüntüler beliriyor (Bandi ve ark., 2026). Avrupa dışı kanıtlar da bunu doğruluyor: Asya tarımına dair bulgular, dijitalleşme ile sürdürülebilirlik arasındaki sinerjinin tarımsal verimliliğe ancak belirli koşullarda dönüştüğünü gösteriyor (Muzammal ve ark., 2026).

Almanya'daki bakım sektöründen gelen kanıtlar dağılım sorununun başka bir yüzünü açığa çıkarıyor. Bakım hizmetlerinde ESG faktörlerini ve dijitalleşmeyi ele alan MORE modeli, dijital araçlar benimsense bile çevresel sürdürülebilirliğin yeterince ele alınmadığını gösteriyor; bu da sektörün emek yoğun yapısını ve hizmet sağlayıcıların sınırlı özümseme kapasitesini yansıtıyor (Zöllner ve ark., 2026). Öte yandan sanayileşmiş Avrupa'daki gizli şampiyonlar üzerine çalışmalar, inovasyonu, dijitalleşmeyi ve sürdürülebilirliği birleştiren yeni "gözle görülür şampiyonların" ikiz geçişin kazananları olarak doğabileceğini öne sürüyor; gelgelelim bu şirketlerin başarısı, benzer pazarlardaki daha az görünür firmaların yaşadığı zorluklarla keskin bir karşıtlık oluşturuyor (Podevin ve ark., 2026).

İkiz dönüşümün kültürel ve coğrafi boyutları tabloyu daha da karmaşıklaştırır. Turizm destinasyonlarındaki gastronomi kültürlerine bakan araştırmalar, dijitalleşmenin kültürel mirası korurken aynı anda standardizasyonu körükleyebileceğini, dolayısıyla sürdürülebilirlik açısından hem olumlu hem olumsuz sonuçlar doğurabileceğini gösteriyor (Seyitoglu, 2026). Tüketici pazarlarında ise sürdürülebilirlik ile dijitalleşmenin kesişimi yeni tüketici tipolojileri yaratıyor; üstelik sürdürülebilirliğe en çok önem veren kesim ile dijital olarak en aktif kesim çoğu zaman örtüşmüyor, bu da hedefli politika tasarımını zorlaştırıyor (Turek ve ark., 2026). Tarımdan bakıma, gastronomi kültüründen tüketici tipolojilerine uzanan bu tablo tutarlı bir örüntü ortaya koyuyor: ikiz geçiş, riski ve fırsatı eşitsiz dağıtıyor. Kazananlar yetkinlik, coğrafya ve sermaye açısından zaten güçlü olanlar; kaybedenler ise en az hazırlıklı olanlar. AB bu örüntünün farkında görünüyor, ama ölçeğine denk düşen sistematik bir dağılım stratejisi henüz yok.

Bunlara ek olarak, gelişmekte olan ekonomilerden gelen kanıtlar ile 2020–2022 pandemisi sırasında BT ve BT dışı firmaları karşılaştıran nedensel analizler, dijitalleşmenin belirli koşullarda çevresel suistimalleri azaltıp sürdürülebilir performansı yükseltebileceğini; ama bu etkilerin büyük ölçüde bağlama bağlı olduğunu gösteriyor (A. Ali ve ark., 2026; Sobolevschi-David ve ark., 2026). Gelişmekte olan ekonomilerden ve pandemi döneminden gelen bu veriler, ayrıca dijital ve yeşil sonuçlar arasında varsayılan yakınsamanın ampirik olarak kırılgan olduğunu gösteriyor. Politika dilinin bunu görmezden gelmesi anlaşılır; çünkü kabul etmek, pek çok taahhüdü yeniden müzakereye açmak anlamına gelir. Ama görmezden gelmenin de bir bedeli var.

2. TARTIŞMA: SİNERJİ ANLATISINDAN İKİZ KRİZ HİPOTEZİNE

Önceki bölümde belirlenen dört gerilim, daha genel tek bir iddiada buluşur: AB'nin ikiz geçişi, bugünkü hâliyle sinerjik olmaktan çok çatışmalı bir girişimdir. Bu bölüm önce, alanı temsil eden birkaç anahtar çalışmayı yakından eleştirerek bu iddianın ampirik zeminini sınar; ardından bulguları birbirini tamamlayan dört kuramsal mercekten geçirir: kurumsal kararın sınırlı rasyonalitesi, eşzamanlı dönüşümleri özümsemede dinamik yetenekler, sosyo-teknik geçiş kuramı ve Avrupa bütünleşmesinin politik ekonomisi. Amaç yazını özetlemek değil, ondan kendi sonucunu çıkarmaktır.

2.1. Birkaç Anahtar Çalışmanın Eleştirel Okuması

Sinerji anlatısının ampirik dayanaklarını tartmak için, geniş bir literatür özetindense alanı temsil eden birkaç çalışmaya yakından bakmak daha aydınlatıcıdır. Aşağıda dört çalışma seçildi; çünkü bunlar hem sıkça atıf alıyor hem de ikiz geçiş tartışmasının farklı kanatlarını temsil ediyor.

Fülöp ve Cifuentes-Faura'nın (2026) AB için dijitalleşme, rekabet gücü ve sürdürülebilirlik arasında bütünleştirici bir sinerji öneren çalışması, sinerji tezinin en güçlü temsilcilerindendir. Gelgelelim bu çerçeve AB'yi büyük ölçüde tek bir birim gibi ele alır ve üye devletler ile sektörler arası heterojenliği toplulaştırmanın içinde eritir. Bu çalışma açısından buradaki asıl sorun yöntemseldir: olumlu bir ortalama ilişki, kazananların kayıpları dengelediği bir dağılımı pekâlâ gizleyebilir. Başka bir deyişle çalışmanın "sinerji" diye gösterdiği şey, bir avuç yüksek kapasiteli ekonominin sürüklediği bileşik bir etkiden ibaret olabilir. Bu da tam olarak, bu makalenin dağılımsal gerilim başlığı altında işaret ettiği körlüktür.

Hein ve arkadaşlarının (2026) Alman yenilikçi KOBİ'leri üzerine çalışması, bu literatürün en sağlam ampirik dayanaklarından biridir; dengeli ikiz yönelimin üstün performansını ikna edici biçimde ortaya koyar. Bulgu değerli olmakla birlikte, nedenselliğin yönü açık değildir. "İkiz yönelim daha iyi performans getirir" yorumu kadar, "zaten daha yetkin ve kaynaklı firmalar ikiz yönelimi sürdürebilmektedir" yorumu da verilerle tutarlıdır; kesitsel tasarım bu içsellik (endojenite) sorununu çözememektedir. Ayrıca bulgu, tek bir ülkenin — üstelik Avrupa'nın en güçlü sanayi tabanına sahip ülkesinin — yenilikçi firmalarından elde edilmiştir; çevre ekonomilerin KOBİ'lerine genellenirken bu nedenle temkinli olunması gerekir. Bu sınır, ikiz yönelimin neden "azınlıkta" kaldığını da açıklar: söz konusu olan bir tercih değil, bir kapasite ayrıcalığıdır.

Van de Walle ve Aerts (2026) ise karşı kanatta durur ve mevcut çerçevelerin geri tepme ile indüksiyon etkilerini görmezden geldiğini ikna edici biçimde gösterir. Bu makalenin kuramsal omurgası büyük ölçüde onların prosedürel rasyonalite eleştirisinden beslenir; nitekim sinerjiyi savunan çalışmalarla onu eleştirenleri ortak bir zeminde buluşturmak, bu araştırmanın en

zorlu yöntemsel uğraşlarından biri olmuştur. Yine de bu çerçevenin kendi sınırı var: tanı koyucu ve kavramsal, ölçücü değil. Ters tepmelerin ne ölçüde, hangi koşullarda baskın çıktığını sayıya dökmüyor. Yani uyum söyleminin zayıflığını ortaya sermekte güçlü; gelgelelim yerine ne konacağına dair işe yarar bir ölçüt vermiyor. O boşluğu doldurmaksa bu makalenin politika önerileri bölümüne kalıyor.

Islam ve arkadaşlarının (2026) G7 malzeme ayak izi çalışması, enerji geçişi ve dijitalleşmenin malzeme ayak izini azaltabildiğini gösterse de bu etkinin yeşil ve yeşil olmayan malların üretiminden kaynaklanan kaynak baskısı tarafından karşılandığını ortaya koyar; böylece dijital büyümenin kendiliğinden bir "maddesizleşme" getireceği beklentisini bir kez daha boşa çıkarır. Bu makale söz konusu bulguyu merkezine alır; ama onun bir sınırını da teslim eder: toplulaştırılmış makro veriler, dijitalleşmenin malzeme ayak izine katkısını diğer büyüme etkenlerinden temiz biçimde ayrıştıramaz. Asıl mesele, bu çalışmanın da ima ettiği gibi, etkinin yönünü belirleyenin teknolojinin kendisi değil, onu kuşatan yönetişim çerçevesi olmasıdır.

Bu dört çalışma yan yana konunca makalenin temel konumu da netleşir. İyimser sinerji yazını ortalamalara bakar ve dağılımı, nedenselliği fazla rahat okur. Geri tepme yazını ise haklı bir teşhis koyar, gelgelelim ne yapılması gerektiği sorusunu havada bırakır. Bu çalışma kendini ikisinin tam ortasına değil, ikisine de mesafeli bir yere koyar; her iki kampın gördüğünü almaya, körlüklerini ise düzeltmeye çalışır.

2.2. Sınırlı Rasyonalite ve Sinerjinin Sınırları

Dijital ve yeşil hedeflerin firma düzeyinde birlikte optimize edilebileceği düşüncesi, ampirik araştırmaların tutarlı biçimde doğrulamadığı ölçüde yüksek bir yönetsel bilgi, beceri ve öngörü gerektirir. Van de Walle ve Aerts (2026), sınırlı rasyonalite kuramını açıkça kullanarak sürdürülebilir dijitalleşmeye dönük mevcut çerçevelerin karar ortamını aşırı yalınlaştırdığını; geri tepme ve indüksiyon etkilerini göz ardı ettiğini ve ödünleşim yönetimine pek az kılavuzluk ettiğini ileri sürer. Sınırlı rasyonalite kavramının kendisi yeni değildir; Simon'ın (1955) karar vericinin bilişsel ve enformasyonel sınırlar içinde "eniyi" yerine "yeterince iyi" çözümlere razı olduğunu öne süren klasik formülasyonuna dayanır. Bu açıdan AB'nin ikiz geçiş anlatısı, kurumsal sınırlı rasyonalitenin bir örneği olarak okunabilir: iki eşzamanlı dönüşümü yönetmenin bilişsel karmaşıklığıyla yüz yüze gelen politika yapıcılar, ödünleşimleri perdeleyen bir çerçeveye sığınmaktadır.

Bu yorum, dijitalleşme ve yapay zekânın karışık ya da olumsuz sürdürülebilirlik sonuçlarına rağmen sıklıkla doğası gereği olumlu güçler sayıldığı Endüstri 4.0 bağlamlarındaki yönetsel algı kanıtlarıyla örtüşür (Sabau-Popa ve ark., 2026). Aynı zamanda gelişmekte olan teknoloji işletmelerindeki dijital sürdürülebilirlik yönelimine ilişkin bulgularla da uyumludur: ticari ödünleşimlerin farkında olup sorumlu inovasyona yönelen firmalar, dijital büyümeyi eleştirel

bir süzgeçten geçirmeden kovalayanlardan daha iyi sonuç alır (Li ve ark., 2026). Sınırlı rasyonaliteyi inkâr etmek değil kabul etmek, ikiz geçişi gerçekten destekleyen politikalar tasarlamanın ön koşuludur. Başka bir deyişle: karar vericilerin kapasite sınırları dışarıda bırakılarak kurulan her politika çerçevesi, uygulamada o kapasite sınırlarına takılacaktır.

2.3. Dinamik Yetenekler ve İkiz Geçişin Heterojenliği

Dinamik yetenekler yazını ikinci bir kuramsal bakış sunar. Bu yazın, Teece, Pisano ve Shuen'in (1997) ortaya attığı ve Teece'in (2007) sonradan derinleştirdiği temel bir fikre yaslanır: bir firmanın değeri, sahip olduğu kaynaklardan çok, değişen çevreye uyum için iç ve dış yetkinliklerini bütünleştirme, inşa etme ve yeniden yapılandırma kapasitesinde yatar. Miśkiewicz'in (2026) bütünleştirici çerçevesi, yetenek yönetimini imalat KOBİ'lerinde dijital dönüşüm ile sürdürülebilirliği hizalayan bir dinamik yetenek olarak ele alır. Bu bakışa göre ikiz geçişin başarısı dijital araçların ya da sürdürülebilirlik standartlarının varlığına değil, bunları nitelikli iş gücü, örgütsel öğrenme ve stratejik vizyon yoluyla birleştirme kapasitesine bağlıdır.

Karşılaştırmalı kanıtlar bu görüşü destekler. Aile şirketleri, yönetişim yapılarının kuşaklar arası hedeflerin nasıl hayata geçirildiğine bağlı olarak sürdürülebilir dijitalleşmeyi hızlandırabildiğini ya da engelleyebildiğini gösterir (Forés ve ark., 2026). Dengeli bir ikiz yönelim benimseyen Alman yenilikçi KOBİ'ler tek yönlü yol izleyenlerden daha iyi performans gösterir; ama bu firmalar sistematik olarak belirli yetkinlik paketleriyle ilişkilenir (Hein ve ark., 2026). Girişimler üzerine çalışmalar, sürdürülebilirlik odaklı inovasyon yetkinliklerini dijitalleşme ile sürdürülebilirlik arasındaki ilişkiye aracılık eden ayrı bir yapı olarak tanımlar (Lu ve ark., 2026). ESG performansı ile dijital yönelime dair kanıtlar da sürdürülebilirlik sonuçlarını yönlendirenin teknolojinin benimsenmesi değil stratejik duruş olduğunu doğrular (Hussain ve ark., 2026; Z. Ali ve ark., 2026). Bu çalışmaların ortak noktası nettir: sürdürülebilirlik sonuçlarını belirleyen, teknolojinin kendisi değil, firmanın stratejik duruşu ve yetkinlikleridir. Buradan da AB'nin ikiz geçişinin aslında bir yetkinlik geliştirme projesi olduğu çıkar; politika araçları teknoloji sübvansiyonları ile raporlama yükümlülüklerinden yetkinlik yatırımına doğru kaymalıdır. Bu çalışma bu noktada bir adım daha ileri gitmektedir: dinamik yetenekleri yalnızca firma içi bir özellik değil, kamu politikasının üretebileceği veya köreltebileceği bir kamusal varlık olarak görmek gerekir. Aksi hâlde "yetkinlik" vurgusu, sorumluluğu tümüyle firmaya yıkan ve devletin rolünü gizleyen bir söyleme dönüşür.

2.4. Politik Ekonomi: Tutarlılık, Dağılım ve Meşruiyet

Firma ve kurum düzeyindeki çözümlemelere üçüncü bir boyutun, siyasetin eklenmesi gerekir. Politik ekonomi ve sürdürülebilirlik geçişleri yazınından beslenen bu bakış, ikiz geçişi Avrupa bütünleşmesinin daha geniş örüntüleri içine yerleştirir. Bu yazın (Geels, 2002, 2011;

Markard, Raven & Truffer, 2012) dönüşümleri tek tek teknolojilerin benimsenmesi olarak değil, sosyo-teknik sistemlerin çok düzeyli ve çatışmalı bir yeniden yapılanması olarak ele alır. AB düzenleme yetkisine, koşullu finansmana ve standart belirlemeye dayandığından, ikiz geçiş hem piyasalar hem de bürokratik yönetişim eliyle hayata geçirilir. Sürdürülebilirlik geçişlerinde aracılık üzerine çalışmalar, dijital araçlara duyulan meşruiyet ve güvenin sistemik değişimin ön koşulu olduğunu; aracıların teknolojik potansiyeli benimsenen uygulamalara çevirmede hayati rol oynadığını gösterir (Cornish ve ark., 2026).

AB bağlamında aracılık bölgeler arasında eşitsiz dağılmıştır. Çekirdek üye devletler; ticaret birlikleri, bölgesel kalkınma ajansları ve teknoloji transfer kurumlarından oluşan yoğun ağlardan yararlanırken çevre bölgeler çok daha zayıf ekosistemlerle baş başadır. Dijital finans ve sürdürülebilirliğe dair kanıtlar, sermaye mevcut olsa bile kalkınma üzerindeki etkisinin finansal erişilebilirliğe, kurumsal kaliteye ve dijital finansal altyapıların tasarımına bağlı olduğunu gösterir (Wang ve ark., 2026). KOBİ'lerde sürdürülebilirlik uygulamalarının katalizörü olarak yapay zekâya ilişkin bulgular ise sürdürülebilirlik, dijitalleşme ve inovasyona ilişkin uygulama engellerinin bu ilişkiyi belirgin biçimde zayıflattığını ekler (Mumcu & Brieger, 2026).

Üretim sistemlerinde yalın, dijital ve sürdürülebilir paradigmalar arasındaki karşılıklı bağımlılıklar, yalın ve dijital önlemlerin tersi yerine — önce uygulandığında — daha büyük bir sinerji yaratır (Bernhard ve ark., 2026). Uygulama sırasına ilişkin bu bulgu AB sanayi politikası için önemlidir; zira dönüşümlerin hangi sırayla hayata geçirildiğinin önemli olduğunu ve dijital ile yeşil yatırımları tümüyle birbirinin yerine konabilir sayan politikaların kritik tamamlayıcılık etkilerini ıskaladığını gösterir. Birikimli tablo, kazançların yoğunlaştığı, uyum maliyetlerinin ise dağıldığı bir geçiş modelidir. Bu yalnızca teknik bir verimlilik sorunu değil; kimin kazandığı ve kimin ödediğiyle ilgili siyasal bir sorudur. Ve bu yönü göz ardı edildikçe yeşil-dijital gündemin toplumsal meşruiyeti aşınma tehlikesi taşır. İkiz geçişin en az tartışılan riski, bana göre tam da bu meşruiyet açığıdır.

2.5. İkiz Kriz Mi, Yeniden Biçimlenmiş İkiz Geçiş Mi?

Bu unsurlar birlikte değerlendirildiğinde kanıtlar, ikiz kriz hipotezinin yumuşatılmış bir sürümünü destekler. Dijitalleşme ile karbonsuzlaşmanın birbirini baltalaması kaçınılmaz değildir. Ancak birbirini desteklemesi de kendiliğinden gerçekleşmez; bunun için bir dizi zorlu koşulun aynı anda sağlanması gerekir: uyumlu bir düzenleyici yapı, firma düzeyinde dinamik yetkinlikler, etkin aracılar, kurumsal olarak yerleşmiş finansal sistemler ve geri tepme ile dağılım etkilerini açıkça yöneten bir politika tasarımı. AB bugün ekonomisinin bazı kesimlerinde bu koşulların bir bölümünü sağlasa da bunu sistematik biçimde gerçekleştirememektedir. Kanaatimce bu çalışmanın temel katkısı da buradadır: güncel yazının topluca ima ettiği ancak açıkça dile getirmediği sonucu adıyla koyuyor ortaya. Sinerji

söylemi siyaseten çekici; ama ikiz geçişin uygulamadaki gerçeklerini aydınlatmaktan çok üzerini örten bir işlev görüyor. Bu değerlendirme, dijitalleşme veya karbonsuzlaşma hedeflerinin reddedilmesi gerektiği yönünde yorumlanmamalıdır. Aksine, ödünleşimlerin açık biçimde ele alındığı ve uygulama kapasitesinin güçlendirildiği daha tutarlı bir politika çerçevesine ihtiyaç olduğunu göstermektedir.

3. POLİTİKA ÖNERİLERİ: POTANSİYEL İKİZ KRİZDEN TUTARLI İKİZ GEÇİŞE

Yukarıdaki analizden hareketle bu bölüm, AB'nin olası ikiz krizini tutarlı bir ikiz geçişe çevirmek için somut, gerçekçi ve uygulanabilir öneriler sunuyor. Öneriler, yazın taramasında saptanan gerilimleri yansıtan beş başlıkta toplanmıştır.

3.1. Dijital Altyapının Zorunlu Çevresel Muhasebesi

Öncelikle AB; veri merkezlerini, telekomünikasyon ağlarını, yapay zekâ eğitim iş yüklerini ve büyük ölçekli bulut hizmetlerini kapsayan dijital altyapının çevresel muhasebesi için bağlayıcı bir çerçeve kurmalıdır. Bu çerçeve AB Taksonomisi ve Kurumsal Sürdürülebilirlik Raporlama Direktifi ile uyumlu olmalı; enerji tüketimi, su kullanımı ve ürünün üretim sürecinde doğan emisyonlar için tutarlı ölçütler getirmelidir. Hem sağlayıcılara hem de büyük kurumsal kullanıcılara uygulanmalıdır. Enerji geçişi ve dijitalleşmenin malzeme ayak izini azaltma potansiyeli taşıdığı, ancak bu kazanımların üretim kaynaklı kaynak baskısıyla dengelendiği (Islam ve ark., 2026) ve mevcut çerçevelerin geri tepme etkilerini hesaba katmaktaki yetersizliği (Van de Walle & Aerts, 2026) göz önüne alındığında, dijitalleşmenin karbonsuzlaşmayı desteklediğine dair her iddianın inandırıcı olabilmesi için böyle bir muhasebe vazgeçilmezdir.

3.2. KOBİ'ler İçin Entegre İkiz Geçiş Uyum Yolları

İkinci olarak AB; basitleştirilmiş sürdürülebilirlik raporlamasını, dijital olgunluk değerlendirmelerini ve kapasite geliştirme desteğini tek bir idari süreçte birleştiren entegre ikiz geçiş uyum yolları oluşturmalıdır. KOBİ'lerde olgunluk temelli sürdürülebilirlik raporlama modelleri (Sivaiah & Vinodan, 2026) ile yetenek yönetimini, dijitalleşmeyi ve sürdürülebilirliği birbirine bağlayan bütünleştirici çerçeveler (Miśkiewicz, 2026) esas alınarak tasarlanacak bu yollar, hâlihazırdaki dağınık düzenleyici yüklerin üst üste binmesini; firma büyüklüğü ve sektöre göre farklılaşan tek, ölçeklenebilir ve aşamalı bir uyum yörüngesiyle değiştirmelidir.

3.3. Sektöre Özgü Geçiş Sıralaması ve Aracılık Desteği

Üçüncü olarak AB, tamamlayıcı kanıtlara dayanarak dijital, yeşil ve yalın yatırımları sıraya koyan sektöre özgü geçiş sıralaması stratejileri benimsemelidir. Kanıtlar, kalite odaklı yalın

önlemlerin dijital ve sürdürülebilirlik sonuçları üzerinde daha geniş bir etki bıraktığını gösteriyor (Bernhard ve ark., 2026). Bu, sürdürülebilirlik geçişlerinde aracıların rolüne ilişkin bulgularla (Cornish ve ark., 2026) birleştiğinde, sektörel yol haritalarının sanayi dernekleri, bölgesel ajanslar ve sendikalarla birlikte üretildiği bir politika tasarımını destekler. Bu yol haritaları AB tarafından finanse edilen aracılık hizmetlerini şu alanlarda içermelidir: tarım (Kandel ve ark., 2026), tarım-gıda sistemleri (Bandi ve ark., 2026), bakım hizmetleri (Zöllner ve ark., 2026) ve aile işletmesi niteliğindeki imalat firmaları (Forés ve ark., 2026).

3.4. Yetkinlik ve Sermaye Yatırımı: Beceriler, Finans ve Yapay Zekâ Yönetişimi

Dördüncü olarak AB, üç alanda yetkinlik ve sermaye yatırımını belirgin biçimde genişletmelidir: beceriler, finans ve yapay zekâ yönetişimi. Becerilere ilişkin olarak, dinamik yetkinlikler ve yönetsel algılar üzerine araştırmalar (Miśkiewicz, 2026; Sabau-Popa ve ark., 2026), ikiz geçişin ihtiyaçlarıyla uyumlu hedefli mesleki eğitim, yönetici eğitimi ve yaşam boyu öğrenme programlarına yatırımı öne çıkarır. Finans tarafında, dijital finans ve sürdürülebilirlik (Wang ve ark., 2026) ile ESG odaklı dijital strateji (Hussain ve ark., 2026) üzerine çalışmalar, AB düzeyinde şeffaf, erişilebilir ve sürdürülebilirlik koşuluna bağlanmış dijital finans araçlarının geliştirilmesini gerekçelendirir. Yapay zekâ yönetişiminde ise KOBİ'lerde engellerin düzenleyici rolüne (Mumcu & Brieger, 2026) ve gelişmekte olan teknoloji işletmelerinde sorumlu inovasyona (Li ve ark., 2026) dair kanıtlar, yüksek etkili yapay zekâ sistemlerinin önceden (ex-ante) sürdürülebilirlik değerlendirmesine ve sonradan (ex-post) çevresel ve toplumsal denetime tabi tutulduğu bir yönetişim rejimini destekler.

3.5. Dağılım Korumaları ve Uyum Mekanizmaları

Nihayet, AB ikiz geçişe özgü dağılım korumaları tasarlamalıdır. Bu korumalar Adil Geçiş Fonu'nu tamamlayıcı olmalı; dijital dışlanmayı, çevre bölgeleri ve dijital ile yeşil dönüşüm baskısına en çok maruz kalan sektörlerdeki kırılgan işçileri hedeflemelidir. Tüketici tipolojilerine (Turek ve ark., 2026), hizmet sektörlerindeki kültürel ve bölgesel dinamiklere (Seyitoglu, 2026) ve firma düzeyindeki dengesiz sonuçlara (Hein ve ark., 2026; Podevin ve ark., 2026) ilişkin kanıtlar, açık bir dağılım tasarımı olmadan ikiz geçişin mevcut eşitsizlikleri derinleştireceğini gösteriyor. Bu nedenle uyum mekanizmaları; bölgesel dijital ve yeşil altyapı fonlarını, mikro işletmeler için zorunlu benimseme desteğini ve AB kaynaklarının dağıtımına bağlanmış bir toplumsal etki izlemesini içermelidir.

4. SONUÇ

Bu çalışmanın vardığı sonuç nettir: AB'nin ikiz dönüşümünü bugünkü hâliyle uyumlu bir başarı öyküsü olarak sunmak gerçeği eksik yansıtır; onu çatışmalı bir girişim olarak tanımlamak daha tutarlıdır. 2026'da yayımlanan otuz çalışmanın tematik incelemesi, dijitalleşme ile yeşil politikanın Avrupa'da enerji ve malzeme akışları, düzenleyici mimari,

firmaların uyum kapasitesi ve dağılım sonuçları boyunca dört noktada birbiriyle çeliştiğini ortaya koymuştur. Bu çelişkiler, AB'nin bir ikiz geçişten çok bir ikiz kriz üretme riskini görünür kılar. Bununla birlikte buradaki sav, dijitalleşme ile karbonsuzlaşmanın taban tabana zıt olduğu değildir; ikisinin birden gerçekleşmesi, mevcut politika çerçevelerinin henüz tutarlı biçimde sağlayamadığı bir dizi koşula bağlıdır.

Sınırlı rasyonalite, dinamik yetkinlikler, sürdürülebilirlik geçişleri ve Avrupa bütünleşmesinin politik ekonomisi — başlangıçta birbirinden bağımsız görünen bu çerçeveler, incelenen gerilimler üzerinde uygulandığında aynı yere çıktı. Dijitalleşmenin sürdürülebilirliğe yaradığı koşullar, yani iyi yönetişim, sektörel uyum, doğru yetkinlik paketleri, işleyen bir aracılık, erişilebilir finansman ve düşünülmüş bir dağılım tasarımı, hem zorlu hem de AB içinde son derece eşitsiz dağılmış durumda. Önerdiğimiz beş politika tam da bu eksiklere dokunuyor ve Avrupa yönetişimini sıfırdan kurmayı değil, eldeki mimarinin içinde iş görmeyi amaçlıyor.

Elbette bu analizin sınırları var. En başta, ortaya koyduğu şey sistematik bir meta-analiz değil, tematik bir sentez; dolayısıyla bulgularını istatistiksel bir kesinlik iddiasıyla değil, bir yorum çerçevesi olarak okumak gerekir. Seçtiğim otuz çalışma güncel ve konuya yakın olsa da küresel yazının temsilî bir örneklemi sayılamaz. AB'nin varsayımlarını sınarken yer yer AB dışı kanıtlara da başvurdum; bu kıyaslama için aydınlatıcı, ama genelleme yaparken dikkatli olmayı şart koşuyor. Bundan sonrası için en verimli yol, buradaki eleştirel okumayı ampirik olarak sınamaktan geçiyor: üye devletlerin karşılaştırmalı vaka çalışmaları, firmaların ikiz geçişini zaman içinde izleyen boylamsal analizler ve dijital altyapı genişlemesinin çevresel ile toplumsal faturasını rakamlara döken çalışmalar.

Geriye, üzerine tüm tartışmanın düğümlendiği tek bir soru kalıyor: mevcut politika çerçeveleri, dijitalleşme ile yeşil dönüşüm hedefleri arasındaki ödünleşimleri gerçekten yönetebiliyor mu? Bugünkü kanıtlar bu konuda iyimser olmayı zorlaştırıyor. Kaynaklar kıt, zaman sınırlı ve iki gündem aynı bütçeden beslenmektedir. Bu soru açıkça yanıtlanmadıkça ikiz dönüşüm bir temenni olarak kalmaya devam edecektir. Analizden çıkan ilk somut adım şudur: dijital altyapının çevresel maliyetini görünür kılan zorunlu bir muhasebe mekanizması olmadan, dijitalleşmenin yeşil dönüşüme katkı sağladığı iddiası havada kalır. Öncelik bu mekanizmaya verilmelidir.

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TÜRKİYE'DE ÜRETİLEN GELENEKSEL PEYNİR ÇEŞİTLERİ: GASTRONOMİK VE KÜLTÜREL BİR DEĞERLENDİRME

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Özet

Türkiye, sahip olduğu coğrafi konum, kültürel birikim ve geleneksel üretim yöntemleri sayesinde zengin bir peynir çeşitliliğine sahiptir. Geleneksel peynirler; üretim teknikleri, duyusal özellikleri ve kültürel geçmişleri bakımından Türk mutfak kültürünün önemli gastronomik unsurları arasında yer almaktadır. Bu çalışmada Türkiye'de üretilen geleneksel peynir çeşitlerinin gastronomik, kültürel ve fonksiyonel özelliklerinin değerlendirilmesi amaçlanmıştır. Çalışmada peynirlerin üretim yöntemleri, kullanılan süt türleri, olgunlaştırma teknikleri ve yöresel özellikleri incelenmiştir. Ayrıca coğrafi işaretli peynir çeşitleri ele alınarak bu ürünlerin kültürel sürdürülebilirlik, gastronomik mirasın korunması ve yerel değerlerin tanıtılması açısından önemi değerlendirilmiştir. Elde edilen bulgular, Türkiye'nin geleneksel peynir çeşitliliğinin, gastronomik kimliğin korunmasında önemli bir yere sahip olduğunu göstermektedir.

Anahtar Kelimeler: Geleneksel Peynirler, Coğrafi İşaret, Gastronomi, Peynir Çeşitliliği, Türk Mutfak Kültürü

TRADITIONAL CHEESE VARIETIES PRODUCED IN TURKEY: A GASTRONOMIC AND CULTURAL EVALUATION

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Abstract

Türkiye has a rich diversity of cheeses thanks to its geographical location, cultural heritage, and traditional production methods. Traditional cheeses are among the important gastronomic elements of Turkish culinary culture in terms of their production techniques, sensory characteristics, and cultural background. This study aims to evaluate the gastronomic, cultural, and functional properties of traditional cheeses produced in Türkiye. In the study, production methods, milk types, ripening techniques, and regional characteristics of cheeses were examined. In addition, geographically indicated cheeses were discussed and their importance in terms of cultural sustainability, preservation of gastronomic heritage, and promotion of local values was evaluated. The findings indicate that Türkiye's traditional cheese diversity has an important role in preserving gastronomic identity.

Keywords: Traditional Cheeses, Geographical Indication, Gastronomy, Cheese Diversity, Turkish Culinary Culture

GİRİŞ

İnsanlar yaşamlarını sürdürebilmek için gıda temin etmek, hazırlamak ve tüketmek durumundadır (Axelson, 1986). Ancak beslenme yalnızca fizyolojik bir ihtiyaç olarak değerlendirilmemektedir. Gıdalar aynı zamanda bireylerin belirli bir yer veya bölgeye yüklediği kültürel, tarihsel ve turistik anlamların oluşmasında etkili unsurlar arasında yer almaktadır (Fuste-Forne, 2020). Kültür, toplumların tarihsel süreç içerisinde oluşturduğu ve kuşaktan kuşağa aktardığı maddi ve manevi değerlerin bütününü ifade etmektedir (Karaca, 2016). Geleneksel gıdalar, bir toplumun kültürü, yaşam biçimi ve ekonomik yapısına göre şekillenmekte olup kültürel zenginliklerin ortaya konulmasında önemli bir yere sahiptir (Albayrak ve Güneş, 2010). Bu kültürel yapının önemli bir parçası olan geleneksel gıdalar ise toplumların yaşam biçimi, üretim alışkanlıkları ve ekonomik yapıları doğrultusunda şekillenmektedir. Geleneksel hammaddeler kullanılarak uzun yıllardır üretilen, kendine özgü bileşime veya üretim yöntemine sahip, toplum tarafından benimsenmiş ve zaman içerisinde sürekliliğini koruyarak günümüze ulaşmış ürünlerdir (Ötleş ve ark., 2016).

Bölgesel üretim alışkanlıkları, hayvan türleri, süt çeşidi ve geleneksel üretim tekniklerine bağlı olarak ülkenin farklı bölgelerinde çok sayıda yöresel peynir üretilmektedir (Tekinşen ve Tekinşen, 2005). Üretilen bu peynirler; kendilerine özgü aroma, tekstür, görünüm ve lezzet özellikleriyle Türk mutfak kültürünün önemli gastronomik değerleri arasında yer almaktadır (Tekinşen ve Elmalı, 2006). Peynirin Türk kültüründeki geçmişi oldukça eski dönemlere dayanmaktadır. Türkçede peynir için kullanılan ifadelerden birinin ‘udma’ olduğu ve bu kelimenin mayalanan sütün ‘uyuması’ anlamından türediği belirtilmektedir (Durusoy, 2017). Bu durum, peynirin Türk mutfak kültürü içerisinde yalnızca bir besin ürünü değil, aynı zamanda kültürel bir unsur olarak değerlendirildiğini göstermektedir.

Geleneksel peynirler, sahip oldukları üretim yöntemleri, duyusal özellikler ve kültürel geçmişleri ile Türk mutfak kültürünün önemli gastronomik unsurları arasında yer almaktadır. Bu ürünlerin kayıt altına alınması, kültürel sürdürülebilirlik açısından önem taşımaktadır. Bu çalışmada, Türkiye’de üretilen geleneksel peynir çeşitlerinin gastronomik, kültürel ve üretim özellikleri açısından değerlendirilmesi amaçlanmıştır. Ayrıca peynirlerin Türk mutfak kültürü içerisindeki yeri, önemi ve coğrafi işaret kapsamındaki durumları değerlendirilmiştir (Albayrak ve Güneş, 2010; Tekelioğlu, 2019).

1. YÖNTEM

Bu çalışma nitel araştırma yöntemlerinden doküman analizi tekniği kullanılarak hazırlanmıştır. Araştırma kapsamında Türkiye’de coğrafi işaret tesciline sahip geleneksel peynir çeşitleri gastronomik, kültürel ve üretim özellikleri açısından değerlendirilmiştir. Çalışmada yer alan veriler; ulusal ve uluslararası literatür, bilimsel makaleler, tezler, kitaplar ve TÜRKPATENT tarafından yayımlanan coğrafi işaret tescil belgelerinden elde edilmiştir.

Araştırma sürecinde öncelikle Türkiye'de coğrafi işaret tesciline sahip peynir çeşitleri belirlenmiş, ardından bu peynirlerin üretim yöntemleri, kullanılan süt türleri, olgunlaşma teknikleri, duyusal özellikleri ve gastronomik kullanımları incelenmiştir. Ayrıca peynirlerin coğrafi işaret kapsamındaki ayırt edici özellikleri değerlendirilerek geleneksel peynir kültürü içerisindeki yerleri ele alınmıştır. Elde edilen veriler literatür doğrultusunda yorumlanmış ve Türkiye'deki geleneksel peynir çeşitliliğine ilişkin genel bir değerlendirme yapılmıştır. Çalışmanın, Türkiye'nin geleneksel peynir kültürünün kayıt altına alınmasına katkı sağlaması ve ilgili literatüre kaynak oluşturması amaçlanmaktadır.

2. PEYNIRIN FONKSIYONEL ÖZELLIKLERI

Peynir, sütün çeşitli pıhtılaştırıcı etkenleri yardımıyla koagüle edilmesi, peyniraltı suyunun ayrılması ve belirli üretim aşamalarından geçirilerek olgunlaştırılması sonucunda elde edilen besin değeri yüksek bir süt ürünüdür (Yetişmeyen, 1995). İçeriğinde protein, yağ, kalsiyum, fosfor ile A, D, E, K ve B grubu vitaminlerini yoğun şekilde bulundurması nedeniyle insan beslenmesinde önemli bir yere sahiptir (Çakmakçı, 2008; Ayar ve ark., 2006). Ayrıca olgunlaşma sürecinde proteinlerin parçalanması sonucu sindirilebilirliğin artması, peynirin beslenme açısından değerini yükselten unsurlar arasında gösterilmektedir (Yardımcıel, 2010). Düşük laktoz içeriği sayesinde intoleransı bulunan bireyler için de uygun süt ürünleri arasında değerlendirilmektedir (Demirci, 1990). Peynir sahip olduğu protein, mineral ve vitamin içeriği nedeniyle fonksiyonel özellik gösteren gıdalar arasında da değerlendirilmektedir. Fonksiyonel gıdalar, temel beslenme özelliklerinin yanı sıra insan sağlığı üzerinde olumlu etkiler sağlayan ürünler olarak tanımlanmaktadır (Kaur ve Das, 2011).

Peynir çeşitleri; kullanılan hammadde, uygulanan üretim teknolojisi, mikrobiyolojik özellikler ile olgunlaşma süresi ve sıcaklığı gibi birçok faktöre bağlı olarak farklı özellikler göstermektedir (Kosikowski, 1989). Bu faktörlerde meydana gelen değişiklikler, aroma, tekstür, görünüm ve lezzet bakımından birbirinden ayrılan farklı peynir çeşitlerinin ortaya çıkmasına neden olmaktadır. Dünyada yaklaşık 4000 peynir çeşidinin bulunduğu belirtilmektedir (Steele ve Ünlü, 1992). Yüksek besin değerine sahip olan peynir, gastronomik açıdan da önemli bir ürün olarak değerlendirilmektedir. Tüketime hazır bir ürün olması yanında sandviç, hamur işi ve çeşitli yemeklerde dolgu veya çeşni amacıyla kullanılabilmekte, farklı yemeklerin lezzet profilini zenginleştiren önemli bir bileşen olarak öne çıkmaktadır (Fox ve McSweeney, 2017).

3. TÜRKİYE'DE GELENEKSEL PEYNİR ÇEŞİTLİLİĞİ

Türkiye farklı iklim koşulları, bitki örtüsü ve hayvancılık faaliyetleri sayesinde oldukça zengin bir peynir çeşitliliğine sahiptir (Demirci, 2008). Anadolu'daki peynir kültürü tarihsel süreç içerisinde göçler, kültürel etkileşimler ve bölgesel üretim alışkanlıkları doğrultusunda çeşitlenmiştir. Anadolu'ya göç eden Türk boylarının beraberinde getirdiği üretim teknikleri

ve tüketim alışkanlıkları, günümüzde birçok geleneksel peynir çeşidinin oluşumunda etkili olmuştur. Erzurum ve Kars yöresine yerleşen Türkmen topluluklarının tel peynir gibi dayanıklı peynir çeşitlerini bölgeye taşıdığı, Sakarya çevresine yerleşen Abhaz topluluklarının ise Abhaz peynirinin gelişiminde etkili olduğu bilinmektedir. Peynir, Anadolu kültüründe yalnızca temel bir besin ürünü olarak değil aynı zamanda yemek ve tatlı kültürünün önemli bir bileşeni olarak da değerlendirilmektedir. Künefe, höşmerim, Kemalpaşa tatlısı ve peynir helvası gibi geleneksel tatlılarda peynir temel bileşenlerden biri olarak kullanılmaktadır. Osmanlı dönemine ait Matbah-ı Âmire kayıtları, narh defterleri ve terekelerde tulum peyniri, kaşkaval peyniri, dil peyniri ve teleme gibi birçok peynir çeşidinin tüketildiği görülmektedir (Web-1).

Bölgesel üretim alışkanlıkları ve geleneksel üretim yöntemleri, farklı yöresel peynir çeşitlerinin ortaya çıkmasına katkı sağlamaktadır (Hayaloğlu, 2017). Anadolu'da uzun yıllardır sürdürülen geleneksel üretim kültürü, aroma, tekstür ve lezzet bakımından birbirinden ayrılan çok sayıda peynir çeşidinin gelişmesine olanak tanımıştır (Metin, 2010).Türkiye'de üretilen peynirler; kullanılan süt türü, üretim yöntemi ve olgunlaşma koşullarına göre farklı özellikler göstermektedir (Bakırcı,2015). İnek, koyun, keçi ve manda sütünden üretilen peynirler duyusal özellikleri bakımından farklılık göstermekte, özellikle koyun ve keçi sütü kullanılarak üretilen peynirlerin daha yoğun aroma profiline sahip olduğu belirtilmektedir (Akın, 2006). Ayrıca salamura, küflendirme, kurutma ve tulum içerisinde olgunlaştırma gibi yöntemler peynirlerin tekstür ve lezzet özelliklerini doğrudan etkilemektedir (Fox ve McSweeney, 2017).

Türkiye'nin farklı bölgelerinde üretilen geleneksel peynir çeşitleri bulundukları bölgenin kültürel yapısını yansıtmaktadır. Ezine peyniri, Mihaliç peyniri, Van otlu peyniri, Kars kaşarı, civil peyniri ve tulum peyniri Türkiye'nin önemli yöresel peynirleri arasında yer almaktadır (Hayaloğlu ve Özer, 2011). Mihaliç peyniri, Osmanlı döneminden günümüze kadar ulaşan geleneksel peynir çeşitlerinden biridir. Genellikle koyun sütünden üretilmekle birlikte bazı bölgelerde keçi ve inek sütü de kullanılabilmektedir. Sert, gözenekli vve tuzlu yapıya sahip olan Mihaliç peyniri; salata, fırın ürünleri ve çeşitli yemeklerde rendelenerek veya ızgara şeklinde kullanılabilmektedir (Web-2). Van otlu peyniri içerisine katılan aromatik otlar sayesinde kendine has özellik kazanırken, Kars kaşarı uzun olgunlaştırma süreci ile dikkat çekmektedir (Sert ve Akın, 2018). Civil ve çeçil peynirleri ise lifli yapıları ve geleneksel üretim teknikleri ile Karadeniz Bölgesi'nin önemli peynir çeşitleri arasında gösterilmektedir (Tarakçı ve Küçüköner, 2006). Türkiye'de geleneksel peynirler üretim yöntemleri ve olgunlaşma tekniklerine göre farklı gruplar altında değerlendirilmektedir;

3.1. Kaşar ve Benzeri Peynirler

Kaşar peyniri telemesinin haşlanmasıyla üretilen pasta-filata tipi bir peynir çeşididir. Taze veya olgunlaştırılmış şekilde tüketilebilen kaşar peynirinin özellikle tost, pizza ve pide gibi ürünlerde yaygın olarak kullanıldığı belirtilmektedir. (Yaşar, 2007). Türkiye'de özellikle Kars kaşarı uzun olgunlaşma süreci ve yoğun aroması ile öne çıkan önemli yöresel peynir çeşitlerinden biridir. Olgunlaşma sürecinde meydana gelen proteoliz ve lipoliz reaksiyonları peynirin aroma oluşumunda etkili olmaktadır (Çakmakçı ve Çağlar, 1995).

3.2. Salamurada Olgunlaşan Peynirler

Türkiye'de salamurada olgunlaştırılan peynir çeşitleri önemli bir yere sahiptir. Bu peynirlerin en bilineni beyaz peynir olup bazı bölgelerde Edirne peyniri veya teneke peyniri olarak da adlandırılmaktadır. Bunun yanında Ezine, Mihaliç, Urfa, Antep ve Diyarbakır örgü peynirleri de salamurada olgunlaştırılan önemli peynir çeşitleri arasında yer almaktadır. Salamura yöntemi peynirlerin raf ömrünü uzatmakta, mikrobiyal stabilite sağlamaktadır. Ayrıca salamura içerisinde gerçekleşen olgunlaşma süreci peynirlerin lezzet özelliklerini doğrudan etkilemektedir (Hayaloğlu ve ark., 2004; Hayaloğlu ve ark., 2005).

3.3. Otlu ve Baharatlı Peynirler

Van otlu peyniri Türkiye'nin en önemli yöresel peynir çeşitlerinden biri olarak kabul edilmektedir. Van ve çevresinde sirmo, heliz ve kekik gibi aromatik otlar kullanılmaktadır. Kullanılan otlar peynirin aroma profilini zenginleştirmekte ve ürüne kendine özgü duyusal özellikler kazandırmaktadır. Bunun yanında Hatay yöresinde üretilen sürk ve cara peynirleri de baharat ve çeşitli aromatik bileşenler içeren geleneksel peynir çeşitleri arasında yer almaktadır (Hayaloğlu ve Fox, 2008).

3.4. Tulum Peynirleri

Tulum peynirleri, Trakya Bölgesi hariç Türkiye'nin birçok bölgesinde üretilmekle birlikte özellikle Orta ve Doğu Anadolu illerinde yaygın olarak bulunmaktadır. Erzincan Şavak tulumu ve İzmir tulum peyniri en bilinen tulum çeşitleri arasında yer almaktadır. Bunun yanında Çimi tulumu, Divle tulumu, Kargı tulumu, Afyon tulumu, Isparta tulumu, Selçuklu tulumu ve Giresun tulumu gibi yöresel tulum peynirleri de bulunmaktadır. Geleneksel üretimde tulum peynirleri keçi derisinden hazırlanan tulumlarda veya özel depolama alanlarında uzun süre olgunlaştırılmaktadır. Özellikle Erzincan Şavak tulum peynirinin 3-6 ay süreyle mağaralarda olgunlaştırıldığı belirtilmektedir. Tulum peynirleri diğer peynir çeşitlerine göre daha uzun bir olgunlaşma süreci geçirmekte olup bu süre bazı peynirlerde bir yıla kadar uzayabilmektedir. Uzun olgunlaşma süreci peynirlerde proteoliz ve lipoliz reaksiyonlarının gelişmesine katkı sağlamakta, bu durum ürünün aroma ve lezzet özelliklerini doğrudan etkilemektedir. Tulum peynirleri kendine özgü Keskin aroma, hafif acımsı tat ve

yoğun lezzet özellikleriyle dikkat çekmektedir. Peynirin aroma oluşumunda kısa zincirli yağ asitleri, etil esterler, sekonder alkoller ve sülfür bileşiklerinin etkili olduğu belirtilmektedir. Ayrıca olgunlaşma sürecinde mikrobiyal florada değişimler meydana gelmekte; başlangıçta Lactococcus ve Streptococcus türleri baskınken, ilerleyen dönemlerde Lactobacillus ve Enterococcus türlerinin dominant hale geçtiği ifade edilmektedir (Hayaloğlu ve ark., 2007a; Hayaloğlu ve ark., 2007b).

3.5. Ezine Peynirinin Üretim Özellikleri

Ezine peyniri, Çanakkale'nin Ezine ilçesi ve çevresinde üretilen, coğrafi işaret tesciline sahip salamura tipi geleneksel bir peynir çeşididir. Peynir üretiminde bölgenin doğal bitki örtüsü ve iklim koşullarından beslenen koyun, keçi ve inek sütleri belirli oranlarda karıştırılarak kullanılmaktadır. Üretimde koyun sütü %35-45, keçi sütü en az %40 ve inek sütü en fazla %25 oranında yer almaktadır. Ezine peynirinin aroma özelliklerinin oluşmasında Kaz Dağları'nın endemik bitki örtüsünün önemli etkisi bulunmaktadır. Bölgede yetişen mercanköş,kekik, adaçayı, oğul out ve tüylü nane gibi aromatik bitkiler hayvanların beslenmesini etkileyerek süte özgün aroma ve lezzet özellikleri kazandırmaktadır. Peynir üretiminde yalnızca doğal şirden mayası ve deniz tuzu kullanılmakta, herhangi bir katkı maddesi veya starter kültür ilavesi yapılmamaktadır. Üretim süreci mart ayında başlayıp ağustos ayı sonuna kadar devam etmektedir. Sütler 67 °C'de şirden mayası ile mayalanmaktadır. Oluşan pıhtı kesilerek peyniraltı suyunun ayrılması sağlanmakta, ardından cendere bezi yardımıyla baskı uygulanarak teleme oluşumu gerçekleştirilmektedir. Kalıplar halinde kesilen peynirler salamura içerisinde bekletildikten sonra tenekelere yerleştirilmekte ve 2-4 °C'de en az 8 ay süreyle olgunlaştırılmaktadır. Uzun olgunlaşma süreci peynirin kendine özgü aroma, lezzet ve doku özelliklerinin gelişmesinde önemli rol oynamaktadır (Web-3; Web-4)

4. TÜRKİYE'DE COĞRAFİ İŞARETLİ PEYNİRLER VE ÖNEMİ

Türkiye'nin sahip olduğu peynir çeşitliliği ve geleneksel üretim kültürü, bu ürünlerin korunmasını ve ekonomik değerlerinin artırılmasını önemli hale getirmektedir. Türkiye, sahip olduğu coğrafi konum, zengin doğal kaynaklar ile tarihi ve kültürel mirası sayesinde geleneksel gıdalar bakımından oldukça zengin bir ülkedir (Albayrak ve Güneş, 2010; Saygılı ve ark., 2020). Geleneksel gıdaların benzer ürünlerden ayrılması, haksız rekabete karşı korunması, üretim standartlarının sürdürülebilirliğinin sağlanması ve ürün değerinin artırılarak markalaşmasında coğrafi işaret tescili önemli bir rol üstlenmektedir (Albayrak ve Güneş, 2010; Tekelioğlu, 2019). Coğrafi işaretler, belirli bir bölgeye ait olan ve sahip olduğu nitelik, ün veya karakteristik özellikleri bakımından köken aldığı alan ile özdeşleşen ürünleri gösteren işaretlerdir (Tekelioğlu, 2019; Arslaner, 2019).

Türkiye, coğrafi işaret bakımından yüksek potansiyele sahip ülkeler arasında yer almaktadır. Türk Patent ve Marka Kurumu verilerine göre ülkede yaklaşık 3000 ürünün coğrafi işaret tescili alma potansiyeline sahip olduğu belirtilmektedir. 2026 yılı itibarıyla Türkiye'de tescilli coğrafi işaret sayısı 1800'ün üzerine ulaşmış, başvuru süreci devam eden ürün sayısı ise 800'ün üzerinde seyretmektedir. Tescilli ürünler içerisinde gıda ürünleri önemli bir ağırlığa sahiptir. Şekerleme, et ürünleri, içecekler, süt ürünleri, meyve ve sebzeler ile fırıncılık ürünlerini kapsayan gıda grubu, coğrafi işaretli ürünlerin büyük bölümünü oluşturmaktadır. Süt ürünleri kategorisi içerisinde özellikle peynir çeşitleri dikkat çekmektedir. Güncel verilere göre Türkiye'de coğrafi işaret tesciline sahip peynir sayısı 48'e ulaşmıştır. Bunların 30'u mahreç işareti, 18'i ise menşe adı ile koruma altına alınmıştır. Ayrıca süt ürünleri içerisinde peynirler, en fazla coğrafi işaret tesciline sahip ürün gruplarından biri olarak öne çıkmaktadır (Web-5).

Tablo 1. Türkiye'nin Tescilli Peynirlerinin Listesi

İl	Coğrafi İşaretli Peynir	Tescil Yılı	Tescil Türü
Hatay	Antakya Carra Peyniri	2021	Menşe Adı
Hatay	Antakya Küflü Sürkü (Çökeleği)	2018	Mahreç İşareti
Hatay	Antakya Künefelik Peyniri	2021	Mahreç İşareti
Hatay	Antakya Sürkü (Antakya Çökeleği)	2018	Mahreç İşareti
Gaziantep	Antep Peyniri/ Gaziantep Peyniri/ Antep Sıkma Peyniri	2018	Mahreç İşareti
Konya	Atlantı Dedebağ Tulum Peyniri	2023	Mahreç İşareti
Balıkesir	Ayvalık Kelle Peyniri/ Ayvalık Sepet Peyniri	2024	Mahreç İşareti
Ağrı	Ağrı Tulum Peyniri	2024	Mahreç İşareti
İzmir	Bergama Tulum Peyniri	2024	Mahreç İşareti
Diyarbakır	Diyarbakır Örgü Peyniri	2013	Mahreç İşareti
Edirne	Edirne Beyaz Peyniri	2007	Menşe Adı
Kahramanmaraş	Elbistan Kelle Peyniri	2023	Mahreç İşareti
Erzincan	Erzincan Tulum Peyniri	2001	Menşe Adı
Erzurum	Erzurum Civil Peyniri	2009	Mahreç İşareti
Erzurum	Erzurum Küflü Civil Peyniri (Göğermiş Peynir)	2012	Mahreç İşareti
Çanakkale	Ezine Peyniri	2007	Menşe Adı
Gümüşhane	Gümüşhane Deleme Peyniri	2021	Mahreç İşareti

Ardahan	Hanak Tel Peyniri	2024	Menşe Adı
Karaman	Karaman Divle Obruğu Tulum Peyniri	2017	Menşe Adı
Çorum	Kargı Tulum Peyniri	2021	Menşe Adı
Kars	Kars Gravyer Peyniri	2024	Mahreç İşareti
Kars	Kars Kaşarı	2015	Menşe Adı
Balıkesir	Kepsut Bükdere Küflü Katık Peyniri	2025	Mahreç İşareti
Kırklareli	Kırklareli Beyaz Peyniri	2020	Menşe Adı
Kırklareli	Kırklareli Eski Kaşar Peyniri	2023	Menşe Adı
Tekirdağ	Malkara Eski Kaşar Peyniri	2017	Menşe Adı
Balıkesir	Manyas Kelle Peyniri	2020	Mahreç İşareti
Kahramanmaraş	Maraş Parmak/ Sıkma Peyniri	2021	Mahreç İşareti
Bolu	Mengen Peyniri	2023	Mahreç İşareti
Muş	Muş Eski Kaşarı	2023	Mahreç İşareti
Kayseri	Pınarbaşı Uzunyayla Çerkes Peyniri	2021	Menşe Adı
Sakarya	Sakarya Abhaz (Abaza9 Peyniri	2021	Mahreç İşareti
Balıkesir	Savaştepe Mihaliç Kelle Peyniri	2023	Mahreç İşareti
Kayseri	Talas Çörekotlu Çömlek Peyniri	2024	Mahreç İşareti
Şanlıurfa	Urfa Peyniri/ Şanlıurfa Peyniri	2021	Mahreç İşareti
Trabzon	Vakfikebir Külek Peyniri	2021	Mahreç İşareti
Van	Van Otlu Peyniri	2018	Menşe Adı
Yozgat	Yozgat Çanak Peyniri	2017	Mahreç İşareti
Hakkari	Yüksekova Çirek Peyniri	2022	Mahreç İşareti
Rize	Çayeli Koloti Peyniri	2008	Menşe Adı
Çankırı	Çankırı Küpecik Peyniri	2021	Mahreç İşareti
Balıkesir	İvrindi Kelle Peyniri	2022	Mahreç İşareti
İzmir	İzmir Tulum Peyniri	2022	Mahreç İşareti

Kaynak: TÜRKPATENT (2026). Coğrafi İşaretler Portalı.

4.1. Edirne Beyaz Peyniri

Edirne ilinin Meriç, Tunca, Arda ve Ergene havzalarında yetişen süt hayvanlarından elde edilen inek, koyun ve keçi sütlerinin kullanılmasıyla üretilen salamura tipi bir beyaz peynirdir. En önemli ayırt edici özelliklerinden biri üretiminde yalnızca süt, maya ve tuz kullanılmasıdır. Üretim sürecinde süt; klarifikasyon, yağ standardizasyonu ve pastörizasyon işlemlerinden

geçirildikten sonra şirden ile mayalanmaktadır. Oluşan pıhtı kesilerek peyniraltı suyu uzaklaştırılmakta, ardından baskılama işlemi uygulanmaktadır. Daha sonra belirli boyutlarda kesilen peynir telemeleri salamura içerisinde bekletilmekte ve tenekelerde yaklaşık 3 ay süreyle olgunlaştırılmaktadır. Salamura içerisinde gerçekleşen olgunlaşma süreci peynirin kendine ait özelliklerinin oluşumunda etkili olmaktadır (Web-6).

4.2. Erzurum Küflü Civil Peyniri (Göğermiş Peynir)

Erzurum Küflü Civil peyniri (Göğermiş peynir), Erzurum Civil peynirinin didilerek tek başına veya lor ile karıştırılması sonucu doğal küflenme süreciyle elde edilen geleneksel bir peynir çeşididir. Erzurum ve çevresinde yaygın olarak tüketilen bu peynir, kendine özgü yoğun aroması ve küflü yapısı ile dikkat çekmektedir (Çakmakçı ve ark., 2014a; Web-7; Çakmakçı ve ark., 2012a). Fransız Rokfor peynirine benzer lezzet özellikleri gösterdiği belirtilen Küflü Civil peyniri, yağsız sütten üretilmesine rağmen olgunlaşma sırasında meydana gelen biyokimyasal reaksiyonlar nedeniyle daha yoğun ve yağlı bir yapı hissi oluşturmaktadır (Çakmakçı ve ark., 2014b; Çakmakçı ve ark., 2012b; Çakmakçı ve ark., 2015) Göğermiş peynirin üretiminde sade Civil peyniri veya Civil peyniri ile lor peyniri karışımı kullanılmaktadır. Tuzlama işleminin ardından peynirler hava almayacak şekilde plastik bidonlara basılmakta ve fazla suyun uzaklaştırılması sağlanmaktadır. Daha sonra peynirler yaklaşık 8-12 °C sıcaklıkta en az 60 gün süreyle doğal küflenmeye bırakılmaktadır. Üretimde kullanılan lor peyniri, peyniraltı suyunun yüksek sıcaklıkta pıhtılaştırılmasıyla elde edilmekte olup serum proteinleri bakımından zengin olması nedeniyle peynirin biyolojik değerini artırmaktadır. Son yıllarda yapılan çalışmalarda kontrollü küflenmenin sağlanabilmesi amacıyla belirli küf kültürlerinin kullanıldığı belirtilmektedir. Bu durum ürünün standardizasyonu ve güvenli üretimi açısından önem taşımaktadır. Erzurum Küflü Civil peynirinin pH, protein, yağ ve tuz değerlerinin olgunlaşma süresine bağlı olarak değişiklik gösterdiği ifade edilmektedir (Web-6).

5. SONUÇ

Türkiye, sahip olduğu zengin coğrafi yapı, iklim özellikleri, hayvancılık faaliyetleri ve kültürel birikimi sayesinde oldukça geniş bir peynir çeşitliliğine sahiptir. Anadolu'da yüzyıllar boyunca şekillenen peynir üretim kültürü; göçler, bölgesel üretim alışkanlıkları ve kültürel etkileşimlerin etkisiyle gelişmiş, günümüzde farklı üretim teknikleri ve duyusal özelliklere sahip çok sayıda geleneksel peynir çeşidinin ortaya çıkmasına katkı sağlamıştır. Çalışma kapsamında incelenen peynir çeşitlerinin; kullanılan süt türü, üretim yöntemi, olgunlaşma süreci ve coğrafi koşullara bağlı olarak birbirinden ayrıldığı görülmüştür. Özellikle tulum peynirleri, salamurada olgunlaşan peynirler, otlu peynirler ve kaşar tipi peynirler sahip oldukları karakteristik aroma, tekstür ve lezzet özellikleri ile Türk mutfak kültürünün önemli gastronomik değerleri arasında yer almaktadır. Bunun yanında peynirlerin

yalnızca temel bir besin ürünü olmadığı, aynı zamanda yemek kültürü, geleneksel tatlılar ve bölgesel gastronomi açısından da önemli bir yere sahip olduğu belirlenmiştir.

Türkiye'de coğrafi işaret tesciline sahip peynir çeşitlerinin sayısının her geçen yıl artması, geleneksel ürünlerin korunması ve kayıt altına alınması açısından önemli görülmektedir. Coğrafi işaret tescili; ürünlerin özgün üretim yöntemlerinin korunmasına, bölgesel kalkınmanın desteklenmesine ve gastronomi turizmine katkı sağlanmasına yardımcı olmaktadır. Özellikle Ezine Peyniri, Erzincan Tulum Peyniri Van Otlu Peyniri ve Kars Kaşarı gibi peynirler hem ulusal hem de uluslararası düzeyde tanınırlığı yüksek ürünler arasında yer almaktadır. Sonuç olarak Türkiye'nin geleneksel peynir çeşitliliği yalnızca beslenme açısından değil, kültürel mirasın korunması, gastronomik kimliğin sürdürülebilirliği ve yerel değerlerin gelecek nesillere aktarılması açısından da önemli bir potansiyele sahiptir. Bu nedenle geleneksel peynir çeşitlerine yönelik bilimsel çalışmaların artırılması, üretim yöntemlerinin kayıt altına alınması ve coğrafi işaret çalışmalarının desteklenmesi önem taşımaktadır.

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TÜRKİYE'DE ÜRETİLEN PEKMEZ ÇEŞİTLERİ

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Özet

Pekmez, yüksek karbonhidrat, mineral ve vitamin içeriği ile Türkiye'nin en eski geleneksel gıdalarından biridir. Bu çalışmanın amacı, pekmezin tanımı, tarihçesi, besinsel değeri ve sürdürülebilirlik açısından önemini incelemek ve Türkiye'deki zengin bölgesel pekmez çeşitliliğini belgeleyerek bu kültürel mirasın korunmasına katkıda bulunmaktır. Çalışmada, pekmez üretiminin geleneksel yöntemleri ile bu yöntemlerin çevresel, ekonomik ve sosyo-kültürel sürdürülebilirliğe olan katkıları analiz edilmiştir. Ayrıca, Türkiye'nin farklı coğrafi bölgelerinde üretilen, her biri kendine özgü hammadde, üretim tekniği ve organoleptik özelliklere sahip olan başlıca pekmez çeşitleri (Zile Pekmezi, Andırın Andız Pekmezi, Antep Pekmezi, Gürün Dut Pekmezi, Düzce Şeker Kamışı Pekmezi, Şiran Kök Pekmezi, Karapürçek Cennet Hurması Pekmezi vb.) detaylı bir şekilde tanıtılmıştır. Pestil ve cevizli sucuk (orcik/köme) gibi pekmez temelli geleneksel yan ürünlere de değinilmiştir. Araştırma bulguları, pekmezin yalnızca değerli bir besin kaynağı olmakla kalmayıp, aynı zamanda düşük çevresel ayak izi, kırsal ekonomiye desteği ve kültürel kimlik taşıyıcılığı ile bütünleşik bir sürdürülebilirlik modeli sunduğunu ortaya koymaktadır. Geleneksel üretim bilgisinin ve yerel çeşitlerin korunması, bu değerli mirasın gelecek nesillere aktarılması için kritik öneme sahiptir.

Anahtar Kelimeler: Pekmez, Geleneksel Gıda, Sürdürülebilirlik, Kültürel Miras

TYPES OF MOLASSES PRODUCED IN TÜRKİYE

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Abstract

Molasses, with its high carbohydrate, mineral, and vitamin content, is one of Turkey's oldest traditional foods. The aim of this study is to examine the definition, history, nutritional value, and sustainability importance of molasses, and to contribute to the preservation of this cultural heritage by documenting the rich regional molasses varieties in Türkiye. The study analyzes traditional methods of molasses production and their contributions to environmental, economic, and socio-cultural sustainability. Furthermore, the main types of molasses produced in different geographical regions of Türkiye (Zile Molasses, Andırın Andız Molasses, Antep Molasses, Gürün Mulberry Molasses, Düzce Sugarcane Molasses, Şiran Root Molasses, Karapürçek Persimmon Molasses, etc.), each with its own unique raw materials, production techniques, and organoleptic properties, are introduced in detail. Traditional molasses-based by-products such as fruit leather and walnut sausage (orcik/köme) are also discussed. Research findings reveal that molasses is not only a valuable source of nutrition but also offers an integrated sustainability model with its low environmental footprint, support for the rural economy, and role as a carrier of cultural identity. Preserving traditional production knowledge and local varieties is critical for passing on this valuable heritage to future generations.

Keywords: Molasses, Traditional Food, Sustainability, Cultural Heritage

GİRİŞ

Yüksek oranda şeker içermesi nedeniyle güçlü bir enerji kaynağı olan pekmez, Türkiye'de uzun yıllardır üretilen ve kültürel açıdan önemli olan geleneksel gıda ürünlerinden biridir. Üzüm pekmezi Türkiye'nin hemen her bölgesinde üretilse de, üretimi özellikle kırsal alanlarda yoğunlaşmış ve çok eskiye dayanmaktadır. Geçmişte insanların temel besin maddelerinden biri olan pekmez, değişen yaşam koşullarıyla birlikte günümüzde daha az tüketilen bir ürün hâline gelmiştir. Nitekim 1984 yılında Devlet İstatistik Enstitüsü (DİE) tarafından yapılan bir araştırmada, toplu yerleşim alanlarında yaşayan bireylerin %60'ının hiç pekmez tüketmediği belirlenmiştir (Alpar & Saldamlı , 1985).

Günümüzde bu oranın belirli ölçüde yükselmiş olabileceği öngörülmektedir. Buna karşın pekmezin beslenmedeki yeri önemini korumaktadır. Aksine, insan beslenmesi açısından ne denli değerli bir gıda olduğu daha net biçimde anlaşılmıştır. Bunun yanı sıra, gıda ürünlerinin halk sağlığıyla doğrudan ilişkili olması nedeniyle üretim yöntemleri ve kimyasal içerikleri büyük önem taşımaktadır (Batu, 2001).

1. PEKMEZ NEDİR

Pekmez, Türk mutfağında köklü geçmişe sahip geleneksel bir gıda ürünüdür. Üretimi özellikle kırsal alanlarda yaygın olmakla birlikte tarihsel olarak uzun yıllara dayanmaktadır. Geleneksel üretim teknikleri büyük ölçüde korunmuş olsa da, son dönemlerde endüstriyel ölçekte pekmez üreten işletmelerin sayısında artış gözlenmektedir. Geleneksel yöntemde, farklı yollarla elde edilen şıra, pekmez toprağı ilave edilerek kısa süre kaynatılmakta; dinlendirme işleminin ardından süzülerek kazanlarda açık alev üzerinde yoğunlaştırılmaktadır. Bu yöntemle üretilen pekmez genellikle berrak yapıda ve koyu renkli olmaktadır. Koyulaştırma işleminin dikkatli uygulanması, üründe kendine özgü hafif bir karamelizasyon oluştururken, yeterli kontrol sağlanmadığında aşırı karamelizasyon meydana gelmekte ve buna bağlı olarak koyu kahverengi hatta siyaha yakın renkte, yanık tat ve kokuya sahip ürünler ortaya çıkabilmektedir (Kayahan, 1982).

Türkiye'de farklı bölgelerde üretilen ve yörelere göre değişik adlarla bilinen pekmezler; tat, kıvam, renk ve görünüm açısından çeşitlilik göstermekte, aynı zamanda üretim aşamalarında da bazı farklı uygulamalar içermektedir. Bununla birlikte, tüm bu çeşitliliğe rağmen pekmez üretiminin temel prensibi ortaktır. Pekmez, olgun üzümlerin sıkılmasıyla elde edilen şıranın, içerdiği asitliğin ve bulanıklığın giderilmesi amacıyla kalsiyum karbonat bakımından zengin, beyazımsı krem renkte olan ve halk arasında "pekmez toprağı" diye adlandırılan toprak ile muamele edilmesinin ardından, genellikle açık kazan veya tavalar içerisinde ateş üzerinde kaynatılarak yoğunlaştırılması sonucu elde edilen geleneksel bir üründür. Bu işlem sırasında şıranın berraklaşması sağlanmakta ve istenen koyu kıvam ile karakteristik pekmez yapısı oluşmaktadır (Kaya, Akaydın, & Esin, 2012).

Pekmez, kolay sindirilebilir yapısı sayesinde kana hızla karışabilen ve kısa sürede enerji sağlayan önemli bir besin kaynağıdır. Yaklaşık iki yemek kaşığına (20 g) karşılık gelen bir porsiyon pekmez, insan vücudu açısından büyük önem taşıyan yaklaşık 2 mg demir ve 80 mg kalsiyumun yanı sıra 58 kcal enerji sağlamaktadır. Bu özellikleriyle pekmez; büyüme dönemindeki çocuklar, ağır işlerde çalışan bireyler, sporcular ile hamilelik ve emzirme dönemindeki kadınlar için oldukça değerli bir gıda olarak öne çıkmaktadır (Şimşek & Artık , 2002).

Pekmez, yüksek karbonhidrat içeriği sayesinde önemli bir enerji kaynağıdır aynı zamanda demir, kalsiyum gibi mineraller ve çeşitli vitaminler açısından da zengin bir besindir. Türkiye'de üzüm yetiştiriciliğinin yapıldığı birçok bölgede pekmez üretimi yaygın olarak yapılmakta olup, üretimde kullanılan üzüm çeşitleri ve uygulanan geleneksel yöntemler bölgeden bölgeye farklılık göstermektedir. Bu durum, üretilen pekmezlerin hem niteliklerinin hem de adlandırılmalarının çeşitlenmesine neden olmaktadır. Gaziantep'te Rumi ve Dökülgen, Kahramanmaraş'ta Kirkit ve Azezi, ve Çekirdeksiz, Yozgat ve Ankara'da Şıralık, Kırşehir'de Yediveren, Denizli'de Dirmit, Amasya ve Zile'de Narince, Mersin'de Dirmit ve Kadın Parmağı, Çanakkale'de ise Misket ve Keçimemesi üzüm çeşitleri pekmez yapımında yaygın olarak kullanılmaktadır. Bu bölgelerde elde edilen pekmezler Revanda, Bulama, Çalma, Ağda, Ma'sara, Tava balı, Gün balı, Murabba, Nardenk, Ak pekmez ve Ekşi pekmez gibi farklı isimlerle anılmaktadır. 2010–2011 yılı verilerine göre Türkiye'de yaklaşık 4,25 milyon ton yaş üzüm üretilmiş olup, bu üretimin yaklaşık %40'ı kurutmalık olarak değerlendirilirken %35'i taze tüketilmekte, kalan kısmı ise ilk olarak pekmez olmak üzere şarap, pestil ve benzeri ürünlerin üretiminde kullanılmaktadır (Kaya, Akaydın, & Esin, 2012).

Türkiye'de bağcılığın yapıldığı pek çok bölgede pekmez üretilmekle birlikte, kültürel birikim ve üretim geleneği açısından yüksek kaliteli pekmezlerin özellikle Hatay, Tokat (Zile), Kırşehir, Eskişehir, Balıkesir, Kayseri, Antalya, Manisa, Malatya, Gaziantep ve Amasya yörelerinde üretildiği bilinmektedir. Bu bölgelerde elde edilen pekmezler; renk, tat, aroma, kıvam ve depolama dayanıklılığı bakımından farklı özellikler göstermekte ve yöresel adlarla anılmaktadır (Batu , 2020). Bu çalışmada da Türkiye'nin farklı yörelerinde üretilen pekmez çeşitleri ele alınmıştır.

2. PEKMEZİN TARİHÇESİ

Türk milleti, tarihsel süreç boyunca şeker içeren pek çok bitkisel üründen pekmez üretmiş ve bu ürünü hem beslenme hem de saklama amacıyla kullanmıştır. Pekmez üretimi çok eski dönemlere dayanmasına rağmen, bu konuya ilişkin Türkçe yazılı ve bilimsel kaynakların ortaya çıkışı görece geç olmuştur. Pekmezle ilgili literatür çalışmalarının 1940'lı yıllardan itibaren yazılmaya başlandığı görülmektedir. Bu kapsamda 1940 yılında "Üzüm pekmezleri üzerine teknik araştırmalar" başlıklı bir çalışma gerçekleştirilmiş; söz konusu araştırmada

geleneksel pekmez üretim teknikleri ayrıntılı biçimde açıklanmıştır. Ayrıca Türkiye'nin farklı bölgelerinden temin edilen pekmez örnekleri incelenerek bu ürünlerin içerik ve bileşim özellikleri karşılaştırmalı olarak değerlendirilmiştir (Aktan, 1940)

3. SÜRDÜRÜLEBİLİRLİK AÇISINDAN PEKMEZ

Sürdürülebilirlik, günümüz gereksinimlerinin karşılanması sürecinde gelecek kuşakların kendi ihtiyaçlarını karşılama kapasitelerinin korunmasını esas alan bir yaklaşımdır. Çevresel, sosyo kültürel ve ekonomik olarak üç ana bileşene sahip olan bu kavram; gıda sistemleri kapsamında tarımsal üretimden başlayarak işleme, dağıtım ve tüketime kadar uzanan tüm süreçlerde doğal kaynaklar üzerindeki baskının azaltılmasını, ekonomik sürdürülebilirliğin sağlanmasını ve toplumsal ile kültürel değerlerin korunarak gelecek nesillere aktarılmasını sağlamaktadır (FAO, 2014).

Geleneksel ve yerel gıda ürünleri, sürdürülebilir gıda sistemlerinin oluşturulmasında önemli ve çok boyutlu işlevler üstlenmektedir. Bu ürünler çoğunlukla, yüzyıllar boyunca bulundukları coğrafyanın iklim koşullarına ve ekolojik yapısına uyum sağlamış üretim biçimlerine dayanmaktadır. Bu nedenle su, kimyasal gübre ve pestisit gibi dış girdilere olan ihtiyaçları görece daha düşüktür. Söz konusu üretim anlayışı, tarımsal ekosistemler üzerindeki baskıyı azaltırken biyolojik çeşitliliğin korunmasına katkı sunar. Aynı zamanda toprak yapısının ve verimliliğinin sürdürülebilir biçimde iyileştirilmesine, su kaynaklarının daha dengeli ve etkin kullanılmasına olanak tanır. Tüm bu unsurlar, çevresel sürdürülebilirliğin güçlendirilmesi açısından geleneksel ve yerel gıda ürünlerini önemli bir araç haline getirmektedir (Altier, 2020). Ekonomik açıdan değerlendirildiğinde, yerel üretime ve gıdanın yerinde işlenmesine dayalı zincirler, özellikle kırsal bölgelerde yeni istihdam olanaklarının ortaya çıkmasına katkı sağlamaktadır. Bu yapılar, küçük ölçekli üreticilerin pazara erişimini güçlendirerek gelir seviyelerinin artmasına yardımcı olmakta, aynı zamanda bölgesel ekonomilerin tek bir faaliyete bağımlı kalmasını önleyerek ekonomik çeşitliliği desteklemektedir. Sosyo-kültürel sürdürülebilirlik bağlamında ise geleneksel gıda ürünleri, kuşaklar boyunca aktarılan üretim bilgisi, uygulama becerileri ve damak zevkinin somut bir yansımasıdır. Bu ürünler, yerel toplulukların kimliğini şekillendiren önemli unsurlardandır ve gastronomik mirasın korunmasında merkezi bir rol üstlenmektedir. Bu nedenle, geleneksel gıdaların üretilmesi ve günlük yaşamda tüketilmeye devam edilmesi, kültürel mirasın korunması ve gelecek kuşaklara aktarılması açısından önemli bir işlev görmektedir.

Pekmez; Türkiye başta olmak üzere Akdeniz, Orta Doğu ve Orta Asya gibi farklı coğrafyalarda uzun yıllardır üretilen ve tüketilen, üzüm, dut, keçiboynuzu (harnup) ile hurma gibi çeşitli meyvelerin kaynatılarak yoğunlaştırılması sonucu elde edilen geleneksel bir gıda ürünüdür. Doğal üretim süreci sayesinde pekmez, yüksek mineral içeriği ve antioksidan bileşenleriyle beslenme açısından önemlidir. Bununla birlikte pekmezin önemi yalnızca

besleyici özellikleriyle sınırlı olmayıp, sürdürülebilir gıda sistemleri içerisindeki çok boyutlu katkılarıyla da dikkat çekmektedir.

Sürdürülebilirlik perspektifinden değerlendirildiğinde, pekmez üretiminin genellikle küçük ölçekli aile işletmeleri, yerel üreticiler ya da kooperatifler aracılığıyla gerçekleştirildiği görülmektedir. Bu yapı, yerel tarımsal ürünlerin ekonomik değer kazanmasına olanak tanımakta ve özellikle kırsal bölgelerde üreticilerin gelir kaynaklarını çeşitlendirmektedir. Böylece tarımsal faaliyetlerin devamlılığı sağlanırken, kırsal kalkınmaya ve yerel ekonominin güçlenmesine de katkı sunulmaktadır. Aynı zamanda pekmez, ham maddenin bulunduğu bölgede işlenmesi sayesinde üretim–tüketim zincirinin kısalmasına yardımcı olmakta, bu durum taşımacılıktan kaynaklanan çevresel etkilerin azaltılmasını da beraberinde getirmektedir.

Üretim süreci açısından ele alındığında, pekmez yapımı yüksek teknolojiye veya yoğun enerji tüketimine dayalı rafinasyon işlemleri gerektirmemektedir. Geleneksel yöntemlerle gerçekleştirilen bu süreç, görece düşük enerji kullanımıyla tamamlanmakta ve karbon ayak izinin sınırlı kalmasını sağlamaktadır. Bu yönüyle pekmez üretimi, enerji verimliliği ve çevresel etkilerin azaltılması açısından sürdürülebilir üretim anlayışıyla uyum göstermektedir.

Bunun yanı sıra pekmez, günümüzde üretimi azalan veya yok olma riski taşıyan yerel meyve çeşitlerinin değerlendirilmesini teşvik etmesi bakımından da önemlidir. Özellikle yerli üzüm çeşitleri gibi bölgeye özgü tarımsal genetik kaynakların kullanımını destekleyerek tarımsal biyolojik çeşitliliğin korunmasına katkı sağlamaktadır. Aynı zamanda pekmez, geleneksel üretim bilgisi, yerel uygulamalar ve kültürel hafıza ile doğrudan ilişkili olması nedeniyle geleneksel beslenme kültürünün yaşatılmasına aracılık etmektedir.

Sonuç olarak pekmez; çevresel etkileri görece düşük üretim süreci, kırsal ekonomiye sağladığı katkılar ve kültürel mirasın korunmasındaki rolüyle sürdürülebilirliğin ekonomik, çevresel ve sosyo-kültürel boyutlarını bir araya getiren önemli bir geleneksel gıda ürünü olarak değerlendirilmektedir.

4. TÜRKİYE'DEKİ PEKMEZ ÇEŞİTLİLİĞİ VE BÖLGESEL ÖZELLİKLERİ

Türkiye, coğrafi ve iklimsel çeşitliliği sayesinde pekmez üretiminde oldukça zengin bir geleneksel ürün yelpazesine sahiptir. Bu zenginlik, farklı bölgelerde yetişen yerli meyve çeşitlerinin kullanılmasından kaynaklanmaktadır. Göğüş, Kolsarıcı ve Fıratlıgil (2022), üzüm pekmezinin yanı sıra dut, keçiboynuzu (harnup), andız, hurma, incir ve elma gibi pek çok meyveden pekmez üretildiğini ve her birinin kendine has geleneksel üretim aşamaları (toprakla durultma, kül ilavesi, özel kazanlarda kaynatma) olduğunu belirtmektedir. Her bir pekmez türü, hammaddesinin yetiştiği mikro-klimadan ve bu geleneksel üretim

tekniklerinden dolayı karakteristik bir renk, kıvam, aroma ve besin profiline sahiptir. Bu çeşitlilik, Türkiye'nin tarımsal biyoçeşitliliğinin ve yöresel gastronomi bilgisinin somut bir ifadesidir.

Bu geleneksel ürünlerin sürdürülebilirliği, üretim süreçlerinin devamlılığına ve yerel pazarlardaki değer zincirlerinin güçlenmesine bağlıdır. Yılmaz ve Karaman'ın (2021) Ege Bölgesi'nde yaptığı araştırma, pekmez üretiminin çoğunlukla aile işletmeleri tarafından, sınırlı ölçekte ve geleneksel yöntemlerle yapıldığını, bu durumun ise pazarlama ve standardizasyon gibi konularda zorluklar yarattığını ortaya koymaktadır. Ancak aynı çalışma, tüketicilerin otantik ve doğal geleneksel ürünlere yönelik artan ilgisinin, bu ürünler için bir pazar fırsatı oluşturduğuna da işaret etmektedir. Dolayısıyla, Türkiye'deki pekmez çeşitliliğini korumak ve sürdürülebilir kılmak, yalnızca bir gıda ürününü değil, onunla ilişkili tüm ekolojik, ekonomik ve kültürel değerler sistemini korumak anlamına gelmektedir.

4.1. ZİLE PEKMEZİ

Pekmez, üzüm, dut, şeker pancarı, elma, erik ve karpuz gibi şeker oranı yüksek olan meyvelerden elde edilebilen geleneksel bir gıda ürünüdür. Zile pekmezi taze üzümden üretilen özel bir pekmez çeşididir. Üretim sürecinde üzüm şırasının asitliği kalsiyum karbonat veya sodyum karbonat kullanılarak azaltılmakta; tanen–jelatin ve uygun enzimler yardımıyla durultma işlemi uygulanmaktadır. Ardından ürün, tekniğine uygun olarak vakum altında ya da açık sistemde koyulaştırılmaktadır. Koyulaştırma aşamasından sonra yumurta akı ile ağartma işlemi yapılmakta; isteğe bağlı olarak çöğen, bal ve/veya bal peteği, süt, süt tozu ve/veya yoğurt gibi bileşenler ilave edilerek karıştırılmaktadır. Bu işlemler sonucunda koyu kıvamlı, açık renge sahip ve beyaza yakın görünümde bir pekmez elde edilmekte olup, söz konusu özellikleriyle diğer pekmez çeşitlerinden ayrılmaktadır (Zile Ticaret Borsası , 2009).

Zile pekmezi üretiminde ilk aşamada tatlı karakterde sıvı bir pekmez elde edilmesi gerekmektedir. Bu pekmezin kuru madde oranının %70'in üzerinde, tercihen %80–85 düzeylerinde olması uygun görülmektedir. Günümüzde bazı yörelerde geleneksel yöntemler kullanılarak beyaz renkli katı üzüm pekmezi üretimi sürdürülmektedir. Ancak Tokat'ın Zile ilçesinde üretilen bu ürün, yöreyle özdeşleşerek "Zile Pekmezi" adıyla anılmaktadır. "Zile Pekmezi" markasının Türkiye'de tanınmasında Özkaleli firmasının önemli bir rolü bulunmaktadır. Söz konusu firma, son 10–15 yıldır modern üretim tesislerinde vakum teknolojisini kullanarak yaklaşık %70 kuru madde içeren sıvı pekmez üretimi gerçekleştirmektedir. Bunun yanı sıra, bu sıvı pekmez hammadde olarak kullanılarak, adını yöreden alan beyaz katı pekmez üretimi de yapılmaktadır. Üretim süreçlerinin modernleşmesi ve ürün işleme tekniklerindeki gelişmelere yönelik gerçekleştirilen çalışmaların bu alana belirli ölçüde katkı sağladığı düşünülmektedir. Zile'de üretilen katı pekmez, daha yumuşak

yapısı, kendine özgü aroması ve tahin sarısından daha açık rengi sayesinde diğer pekmez türlerinden ayrılarak özel bir üne sahip olmuştur (Batu, 2006)

4.2. ANDIRIN ANDIZ PEKMEZİ

Andırın andız pekmezi, Servigiller (Cupressaceae) familyasına ait andız bitkisinin (Juniperus drupacea L.) kozalaklarından elde edilen pekmez türüdür. Ürün, kırmızıya çalan koyu kahverengi bir renge sahiptir. Andız ağacı yaklaşık 25 metreye kadar boylanabilmekte olup, kozalakları iki yılda bir olgunlaşmaktadır. Pekmez üretiminde, yüzeyi gümüşi renkli mumsu bir tabaka ile kaplı, mor, kahverengi ya da kırmızı tonlarda olgunlaşmış kozalaklar tercih edilmektedir; yeşil renkli kozalaklar ise olgunlaşmamış kabul edilmektedir. Andız kozalaklarının olgunlaşma dönemi genellikle eylül ve ekime denk gelmektedir. Kozalakların ortalama ağırlığı yaklaşık 5,55 g, uzunluğu 24,87 mm ve çapı 22,74 mm olarak bildirilmektedir. Yaklaşık 6 kg andız kozalaklarından 1 kg pekmez elde edilebilmektedir (KMB, 2024).

4.3. ANTEP PEKMEZİ / GAZİANTEP PEKMEZİ

Antep Pekmezi, Gaziantep'te üretilen, macun benzeri kıvama ve amber tonlarında bir renge sahip geleneksel bir katı üzüm pekmezidir. Sürülebilir yapısı sayesinde ekmek üzerinde tüketilebildiği gibi, ısıtılarak şurup formunda da kullanılabilmektedir. Geçmişten günümüze Gaziantep ile özdeşleşmiş gıda ürünlerinden biri olduğu, halk arasında kullanılan "Gideceğin yer Antep, yiyeceğin pekmez" ifadesiyle de anlaşılmaktadır. Bu pekmez türü, ağırlıklı olarak Dökülgen üzüm çeşidinden elde edilmektedir. Üretim sürecinde üzümden öncelikle sıvı pekmez hazırlanmakta, ardından uygulanan özel işlemlerle bu sıvı ürün katı kıvama dönüştürülmektedir. Antep pekmezini benzerlerinden ayıran temel özellik de bu katılaştırma aşamasında uygulanan geleneksel yöntemlerdir (Gaziantep Ticaret Borsası, 2020).

4.4. BELEN KÖMÜRÇUKURU PEKMEZİ

Belen Kömürçukuru Pekmezi üretiminde gıda ile temasa uygun araç ve ekipmanlar kullanılır ve genellikle yörede yetiştirilen üzümler tercih edilir. Hasat edilen üzümler ayıklanıp yıkandıktan sonra, yaklaşık 200 kilogram üzüm için gıda mevzuatına uygun 2–3 kilogram kalsiyum karbonat eklenerek işleme alınır. Üzümler önce mekanik olarak ezilir, ardından tahta teknelerde ezme işlemine devam edilerek elde edilen üzüm suyu kalaylı bakır kazanlarda kaynatılır. Kaynatma sonrası üzüm suyu bir süre dinlendirilir, ılık hâlde süzülerek posasından ayrılır ve istenilen kıvam elde edilinceye kadar yeniden kaynatılır; bu süreçte karıştırma işlemi düzenli olarak yapılır. Kıvam alan pekmez tahta teknelere alınarak yaklaşık iki gün dinlendirilir ve bu süre boyunca belirli aralıklarla çırpılarak renginin açılması ve kendine özgü kıvamını kazanması sağlanır. Son aşamada pekmez, ambalajlara doldurulmadan önce az

miktarda önceden hazırlanmış katı pekmezle homojen şekilde karıştırılarak ambalaj içinde ideal katılaşmanın tamamlanması sağlanır (İskenderun Ticaret ve Sanayi Odası, 2021).

4.5. DÜZCE ŞEKER KAMIŞI PEKMEZİ

Düzce Şeker Kamışı Pekmezi, şeker kamışı bitkisinden elde edilen öz suyun kaynatılarak yoğunlaştırılmasıyla üretilen, koyu renkli ve akışkan yapıda bir pekmezdir. Bölgenin iklim özellikleri sayesinde şeker kamışı, ilave sulamaya ihtiyaç duymadan yetişebilmektedir. Hasattan sonra hızlı şekilde bozulabilen bu bitkinin kısa sürede işlenmesi gerektiğinden, pekmez üretiminde taze şeker kamışı kullanılır. Yörede uzun yıllardır süregelen üretim pratiği, şeker kamışının uygun zamanda işlenmesine ve ürünün kendine özgü özellikler kazanmasına olanak sağlar. Geçmişi eskiye dayanan bu üretim yöntemi, belirli bir ustalık ve deneyim gerektirmekte olup zamanla bölgeyle bütünleşmiş geleneksel bir gıda ürünü hâline gelmiştir (Düzce İl Tarım Ve Orman Müdürlüğü, 2021).

4.6. GÜRÜN DUT PEKMEZİ

Gürün Dut Pekmezi, yüksek rakımlı alanlarda yetişen beyaz dut meyvelerinden elde edilen, katkı maddesi içermeyen doğal bir pekmezdir. Yaklaşık 1200–1400 metre rakımda yetişen dut ağaçlarında, haziran ayı başından ağustos ayı sonuna kadar süren hasat döneminde toplanan meyveler kullanılır. Pekmez üretimi, Morus alba türü beyaz dutların haşlanarak ya da haşlanmadan işlenmesiyle iki farklı yöntemle gerçekleştirilebilir. Yüksek rakım koşulları nedeniyle dut ağaçlarında çiçeklenme ve meyve olgunlaşma süresi uzamakta, bu durum meyvede şeker oranının artmasına ve kalite özelliklerinin gelişmesine katkı sağlamaktadır. Gece ve gündüz arasındaki belirgin sıcaklık farkı da meyve oluşum süresini uzatarak dutun doğal tatlılığını artırır. Elde edilen pekmez koyu kahverengi, homojen yapılıdır; yabancı koku içermez ve acı ya da ekşi tat barındırmaz. Ürünün kül oranı %2,5'i geçmezken, HMF değeri en fazla 100 mg/l, toplam şeker oranı en fazla %66 ve kuru madde miktarı ise en az %72 düzeyindedir (Gürün Kaymakamlığı, 2021).

4.7. HASENİK PEKMEZİ

Hasenik Pekmezi, oval taneli, sarı-yeşil renkli, ince kabuklu, sulu ve tatlı özelliklere sahip yerel bir üzüm çeşidinden, geleneksel üretim yöntemleri kullanılarak elde edilen bir pekmezdir. Açık ile koyu kahverengi arasında değişen renge sahip olan ürün, kıvamlı ve akışkan bir yapı gösterir. Hasenik adı, Ovacık Köyü'nün eski adından gelmekte olup bu pekmez, uzun yıllardır yörede üretilen ve yerel mutfak kültüründe önemli bir yere sahip geleneksel bir gıda ürünü olarak bilinmektedir. Üretimi ve tüketimi zamanla yöre halkının ekonomik ve kültürel yaşamının bir parçası hâline gelmiştir (Hilvan Yerel Eylem Grubu Derneği, 2025).

4.8. KARAPÜRÇEK CENNET HURMASI PEKMEZİ

Karapürçek Cennet Hurması Pekmezi, olgunlaşmış Trabzon hurması meyvelerinin geleneksel yöntemlerle işlenmesiyle elde edilen bir pekmezdir. Üretimde Fuyu, Hana Fuyu ve Hachiya çeşitlerine ait meyveler kullanılır. Hasat edilen meyveler odun ateşinde açık kazanlarda kaynatılır, süzülür, bir süre dinlendirilir ve istenilen kıvam elde edilinceye kadar tekrar kaynatma işlemine tabi tutulur. Halk arasında "cennet hurması" olarak bilinen bu meyveden elde edilen pekmez, koyu kahverengi renkte, bulanık görünümlü ve akışkan kıvamlıdır. Uzun yıllardır üretilen bu pekmez, zamanla yerel mutfak kültüründe önemli bir yer edinmiş geleneksel bir ürün olarak bilinmektedir (Karapürçek Kaymakamlığı, 2023).

4.9. KARNAVAS DUT PEKMEZİ

Karnavas dut pekmezi üretimi, dut meyvelerinin olgunlaşmasıyla birlikte haziran ayının ilk haftalarında başlar ve yaklaşık beş hafta boyunca devam eder. Bu süre içinde dut ağaçları, iklim koşullarına bağlı olarak birkaç günde bir olmak üzere çok sayıda kez hasat edilir. İlk toplanan dutlar genellikle taze tüketim için ayrılırken, sonraki hasatlarda elde edilen tam olgun meyveler pekmez yapımında kullanılır. Toplanan dutlar ayıklanarak olgunlaşmamış meyveler ve yabancı maddeler temizlenir, ardından kazanlara alınarak belirli oranda su eklenir ve odun ateşinde kaynatılır. Isıl işlemden geçirilen dutlar preslenerek öz suyu çıkarılır, elde edilen şıra süzülür ve açık kazanlarda sürekli karıştırılarak koyulaştırılır. Koyulaştırma süresi şıra miktarına göre değişmekle birlikte, istenilen kıvam elde edildiğinde işlem sonlandırılır. Pekmez daha sonra başka kaplara alınarak karıştırılıp havalandırılır, bu aşamada fazla suyun buharlaşması sağlanır ve ürün parlak bir görünüm kazanana kadar karıştırmaya devam edilir. Üretim sürecinde yalnızca dut ve su kullanılır, herhangi bir katkı maddesi eklenmez. Son aşamada elde edilen pekmez ambalajlanarak depolanır (Ormanağzı Köyü Muhtarlığı, 2005).

4.10. SENİRKENT ÜZÜM PEKMEZİ

Senirkent üzüm pekmezi, geleneksel yöntemler kullanılarak üretilen bir üründür. Üretimde Dimrit üzüm çeşidinden hasat edilen üzümler geniş gözenekli çuvallara doldurulur ve ezme işlemiyle üzüm şırası elde edilir. Çıkarılan şıra geniş bakır kazanlara alınır ve ekşilik ile asiditenin giderilmesi amacıyla belirli oranda pekmez toprağı eklenerek kaynatılır; kaynama sırasında yüzeyde oluşan köpükler kepçe yardımıyla uzaklaştırılır. Kaynatma işlemi tamamlandıktan sonra üzüm şırası, toprak ve diğer tortuların dibe çökmesi için yaklaşık bir gün dinlendirilir. Dinlenen şıra süzülerek tekrar büyük bakır kazanlara alınır ve koyu bir kıvam oluşuncaya kadar kaynatma işlemine devam edilir. Bu aşamada da yüzeyde oluşan köpükler alınarak ürünün berraklığı sağlanır. Pekmezin kıvamı, geleneksel yöntemle tahta kaşık yardımıyla kontrol edilir; damlatılan pekmezin dağılmaması uygun kıvama ulaşıldığını gösterir. Kıvamı tamamlanan pekmez ateşten alınarak soğutulur ve sırçalı çömlek ya da cam

kaplara doldurulur. Uygun koşullarda, güneş ışığından uzak ve oda sıcaklığında muhafaza edildiğinde yaklaşık bir yıl boyunca saklanabilir (Senirkent Belediyesi, 2022).

4.11. SİVAN DUT PEKMEZİ

Sivan Dut Pekmezi, uzun yıllardır dut yetiştiriciliğinin yapıldığı bir bölgede elde edilen beyaz dut meyvelerinden üretilen geleneksel bir pekmezdir. Yörede yaklaşık bir asrı aşan dut üretim geleneği bulunmakta olup, günümüzde hâlen verim veren çok sayıda yaşlı dut ağacı mevcuttur. Üretimde Morus alba türü beyaz dutlar kullanılır ve bu meyveler haziran ile temmuz aylarında tam olgunluğa ulaştığında hasat edilir. Toplanan dutlardan elde edilen öz su, kazanlarda kaynatılarak fazla suyun buharlaştırılması sağlanır ve ürün istenilen yoğunluğa ulaşıncaya kadar koyulaştırılır. Dut bahçelerinde yalnızca doğal gübreler tercih edilir, kimyasal ilaçlama yapılmaz ve bu durum meyvenin doğal yapısının korunmasına katkı sağlar. Hasat sırasında dutların yere temas etmemesi için bez veya benzeri örtüler kullanılır. Pekmez üretiminde kaynatma işlemi odun ateşinde gerçekleştirilir; özellikle meşe odunu tercih edilerek dengeli bir ısı sağlanır ve is oluşumunun önüne geçilir. Bu yöntemler sayesinde elde edilen pekmez, doğal yapısını ve kendine özgü özelliklerini koruyan geleneksel bir ürün niteliği taşır. (Bingöl İl Tarım ve Orman Müdürlüğü, 2021)

4.12. ŞİRAN KÖK PEKMEZİ

Şiran kök pekmezi üretiminde, yüksek rakımlı bölgelerde yetiştirilen şeker pancarları kullanılır. Bu alanlarda bulunan organik madde bakımından zengin, derin yapılı, kolay ısınabilen tınlı ve tınlı-kireçli topraklar pancar yetiştiriciliği için elverişlidir. Ilıman iklim koşullarında pancar verimi artarken şeker oranı görece düşük kalmakta, daha sert karasal iklim koşullarında ise kök verimi azalmasına rağmen şeker oranı yükselmektedir; bu durum kök pekmezinin besin içeriğine doğrudan yansımaktadır. Üretim için seçilen pancar kökleri, yüzeyleri düzgün olanlar arasından tercih edilir ve üzerlerindeki çamur, toprak, taş, kök parçaları gibi yabancı maddeler sert fırçalarla temizlenir. Ardından pancarlar akan su altında tek tek yıkanarak yüzey renkleri açılıncaya kadar arındırılır. Temizlenen köklerin kabukları ince bir tabaka hâlinde soyulur ve yaklaşık 50 × 50 mm boyutlarında küpler şeklinde doğranır; parça boyutu küçüldükçe verim artmakla birlikte süzme işleminin zorlaştığı dikkate alınır. Doğranan pancarlar bir kazana alınarak ağırlıklarının yaklaşık üç katı kadar su eklenir ve 30–45 dakika süreyle kaynatılır. Elde edilen karışım, farklı gözenek genişliğine sahip elekler ve bez yardımıyla süzülerek posasından ayrılır. İnce süzüntü geniş ağızlı kazanlara aktarılır ve sürekli karıştırılarak koyu, akışkan bir yapı kazanana kadar kaynatma işlemine devam edilir (Kelkit Ticaret ve Sanayi Odası, 2024).

4.13. KAYISI PEKMEZİ

Kayısı, Türkiye tarımında önemli bir yere sahip olan meyve türlerinden biridir. Ülkemizde kayısı yetiştiriciliği uzun yıllardır sürdürülmekte olup, üretim miktarı zaman içinde belirgin bir artış göstermiştir. 1934 yılında yaklaşık 1.500 ton düzeyinde olan kayısı üretimi, günümüzde yaklaşık 120 bin tona ulaşmıştır. Türkiye'deki yaş kayısı üretiminin yaklaşık %50'si Malatya ilinde gerçekleştirilmektedir. Sahip olduğu ağaç sayısı ile yaş ve kuru kayısı üretim kapasitesi göz önünde bulundurulduğunda Malatya, yalnızca ülkemizin değil, dünya genelinde de önde gelen kayısı üretim merkezleri arasında yer almaktadır.

2004 yılı verilerine göre Malatya'da bulunan yaklaşık 6.776.900 kayısı ağacından 84.706 ton civarında yaş kayısı elde edilmiştir. Bu üretimin yaklaşık %90–94'lük bölümü kurutularak ihraç edilmekte, kalan kısmı ise taze tüketimin yanı sıra reçel, marmelat, nektar ve pekmez gibi ürünlerin yapımında değerlendirilmektedir.

Türkiye'de kayısı tarımı Malatya dışında Kahramanmaraş, Kayseri, Elazığ, Mersin (İçel), Erzincan, Konya, Ankara, Sivas ve Nevşehir illerinde de yapılmaktadır. Bu iller arasında Malatya, Elazığ ve Sivas'ta daha çok kurutmalık kayısı üretimi öne çıkarken, diğer bölgelerde sofralık kayısı yetiştiriciliği ağırlık kazanmaktadır. Son yıllarda ise Kahramanmaraş'ın Elbistan, Elazığ'ın Baskil, Sivas'ın Gürün ve Adıyaman'ın Gölbaşı ilçelerinde kuru kayısı üretimine yönelik çok sayıda yeni bahçe tesis edilmiştir (Kırmacı, Akbulut, & Batu, 2007).

4.14. PESTİL

Pestil, Türkiye'de üretilen ve çoğunlukla kış aylarında tüketilmek üzere hazırlanan, yüksek enerji içeriği ile vitamin bakımından zengin geleneksel gıdalarımızdan biridir. İçeriğinde bulunan üzüm şırası ve pekmez sayesinde önemli miktarda mineral ve vitamin barındıran pestil, besleyici değeri yüksek bir ürün olup özellikle enerji ihtiyacı fazla olan bireyler için uygun bir besin olarak değerlendirilmektedir. Bunun yanı sıra pestil; yalnızca kalori sağlayan, besin değeri düşük ve dengesiz beslenmeye neden olabilen şekerleme, gazlı içecek, cips ve bisküvi gibi hazır gıdalara alternatif olarak tüketilmesi önerilen doğal bir üründür. Geleneksel yöntemlerle üretilen ve son yıllarda küçük ölçekli işletmelerde üretimi artmaya başlayan pestil hakkında bilimsel yayınların sınırlı sayıda olması, bu ürünün yeterince tanınmasını ve değerlendirilmesini zorlaştırmaktadır. Bileşiminde yer alan pekmez ve nişasta nedeniyle pestil, iyi bir karbonhidrat ve enerji kaynağı olmasının yanı sıra demir, kalsiyum, fosfor, potasyum ve magnezyum gibi mineraller ile B grubu vitaminlerinden tiamin (B1) ve B6 vitamini açısından da önemli bir besindir. Gıda sanayisinin önemli alanlarından biri olan şeker ve şekerli ürünler sektörü ise üretim kapasitesini her geçen gün artırmaktadır. Ancak bu sektöre ait ürünlerle ilgili bugüne kadar özel bir gıda kodeksinin yayımlanmamış olması nedeniyle, yapılan denetimler Gıda Kodeksi Yönetmeliği'nin genel hükümleri ve mevcut standartlar doğrultusunda gerçekleştirilmektedir (Batu, Cemal , Çatak, & Şahin, 2007).

4.15. CEVİZLİ SUCUK (ORCİK, KÖME)

Orcik, Türkiye'de oldukça popüler bir tatlıdır ve genellikle üzüm ile dut gibi meyvelerden üretilir. Besin değeri açısından oldukça zengin olan orcik; karbonhidratlar, antioksidanlar, diyet lifi, vitaminler ve mineraller açısından faydalı bir atıştırmalıktır. Son dönemde bazı üreticiler şeker pancarı pekmezini kullanarak da orcik üretmeye başlamıştır. Gümüşhane'de daha çok "köme" adıyla bilinen orcik, Türkiye'nin doğu bölgelerinde ise bandırma, cevizli sucuk, kedi bacağı, Maraş sucuğu, orjik veya şeker sucuk gibi isimlerle anılır. Sucuk, genellikle taze üzüm şırası veya üzüm şırası ile karıştırılmış şekerin nişasta ile kaynatılması ve ardından badem, ceviz, fındık ya da fıstık gibi kuruyemişlerin bu karışıma defalarca batırılıp kurutulmasıyla hazırlanır. Benzer geleneksel ürünler dünya genelinde de bulunmaktadır. Özellikle kuzey ülkelerinde "çörçkela" (churchkhela) adıyla bilinen bu tatlılar, erik, incir, kayısı gibi meyvelerden yapılan karışıma ipe dizilen badem, ceviz veya fındık gibi yemişlerin batırılıp kurutulmasıyla elde edilir (Demir, Şenocak, Baykalır, & Arslan, 2025).

5. SONUÇ

Bu çalışma, Türkiye'nin geleneksel gıda kültürünün en önemli örneklerinden biri olan pekmezin, yalnızca besleyici bir ürün olmanın ötesinde çok yönlü bir değer taşıdığını ortaya koymaktadır. İçerdiği yüksek oranda karbonhidrat, vitamin ve mineral sayesinde, özellikle büyüme çağındaki çocuklar, hamile ve emziren kadınlar, aktif sporcular ve ağır işlerde çalışanlar için önemli bir enerji ve besin kaynağı olan pekmez, aynı zamanda sürdürülebilir gıda sistemlerinde de kritik bir role sahiptir.

Pekmez üretimi, geleneksel yöntemleriyle çevresel sürdürülebilirliğe katkı sağlar. Düşük teknolojiye dayalı ve minimal enerji gerektiren bu üretim süreci, kimyasal girdilere ihtiyaç duymadan gerçekleştirilebilir ve atık oluşumunu sınırlı düzeyde tutar. Ekonomik açıdan değerlendirildiğinde ise, özellikle küçük aile işletmeleri ve kooperatifler aracılığıyla kırsal ekonomiyi destekler, yerel istihdam yaratır, üreticilerin gelirlerini çeşitlendirir ve bölgesel kalkınmaya katkı sunar. Bunun yanı sıra, pekmez üretimi ve tüketimi, kuşaklar boyunca aktarılan bilgi birikimi, damak zevki ve sosyal alışkanlıklar sayesinde kültürel mirasın korunmasına da önemli katkılar sağlamaktadır.

Araştırmada detaylı biçimde incelendiği üzere, Türkiye'nin farklı coğrafi bölgeleri (Zile, Andırın, Gaziantep, Gürün, Düzce, Şiran, Karapürçek, Senirkent, Sivan gibi) kendi özgün hammaddeleri (üzüm, dut, andız, şeker kamışı, cennet hurması, şeker pancarı vb.) ve geleneksel üretim yöntemleriyle eşsiz pekmez çeşitliliğine sahiptir. Pestil ve cevizli sucuk (orcik/köme) gibi yan ürünler, bu çeşitliliğin ve yerel yaratıcılığın somut örneklerindendir. Bu durum, Türkiye'nin hem tarımsal biyoçeşitliliğinin hem de gastronomik hafızasının canlı bir göstergesidir.

Öte yandan, modern yaşamın getirdiği değişen tüketim alışkanlıkları, kentleşme ve geleneksel bilginin kuşaktan kuşağa aktarılmasındaki zorluklar, bu değerli kültürel mirasın devamlılığını tehdit etmektedir. Bu nedenle, pekmez ve onunla ilişkili ürünlerin korunması ve sürdürülebilir hale getirilmesi için kapsamlı stratejilere ihtiyaç vardır. Yerel çeşitlerin ve geleneksel üretim bilgilerinin belgelenmesi, coğrafi işaretleme gibi koruma yöntemleriyle desteklenmesi, üreticilerin modern pazarlama ve standartlaşma süreçlerinde güçlendirilmesi ve tüketicilerde farkındalık yaratılması bu sürecin temel unsurlarını oluşturmaktadır.

Sonuç olarak, pekmez Türkiye'nin kültürel kimliğinin ayrılmaz bir parçasıdır. Bu değerli geleneğin korunması, yalnızca bir gıda ürününü değil; onunla bağlantılı ekolojik dengeyi, kırsal ekonomik yapıyı ve kuşaklar boyunca biriken kültürel bilgi birikimini de gelecek nesillere taşımak anlamına gelmektedir. Bu çalışma, pekmezin çok boyutlu değerine dair farkındalığı artırmayı, geleneksel üretim bilgisini ve kültürel mirası korumayı ve sürdürülebilir bir gelecek oluşturmayı hedeflemektedir.

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TÜRKİYE'DE ÜRETİLEN SİRKE ÇEŞİTLERİ VE ÜRETİM YÖNTEMLERİ

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Özet

Sirke, tarih boyunca hem gıda muhafazasında hem de gastronomik uygulamalarda kullanılan en önemli fermantasyon ürünlerinden biridir. Temel olarak etil alkolün asetik asit bakterileri tarafından oksidasyonu sonucu elde edilen sirke; organik asitler, fenolik bileşikler, vitaminler, mineraller ve aroma maddeleri bakımından zengin bir yapıya sahiptir. Türkiye, sahip olduğu tarımsal çeşitlilik sayesinde üzüm, elma, dut, alıç, nar, keçiboynuzu, hünnap, incir ve çeşitli yabani meyvelerden farklı sirke türlerinin üretildiği önemli ülkeler arasında yer almaktadır. Bu çalışmada sirkenin tarihsel gelişimi, kimyasal yapısı ve üretim teknolojileri ele alınmış; geleneksel ve endüstriyel üretim yöntemleri karşılaştırmalı olarak değerlendirilmiştir. Ayrıca Türkiye'de üretilen sirke çeşitleri; üretim yöntemleri, yöresel özellikleri, duyusal nitelikleri ve fonksiyonel bileşenleri açısından incelenmiştir. Çalışmada özellikle doğal fermantasyon yöntemiyle üretilen geleneksel sirkelerin fenolik bileşikler ve aroma profili bakımından daha zengin olduğu belirlenmiştir. Bunun yanı sıra coğrafi işaret potansiyeli taşıyan yöresel sirke çeşitleri değerlendirilmiş ve bu ürünlerin gastronomik miras açısından önemi ortaya konulmuştur. Sonuç olarak Türkiye'nin sirke üretim kültürü hem geleneksel gıda teknolojileri hem de gastronomi turizmi açısından önemli bir potansiyele sahiptir.

Anahtar Kelimeler: Sirke, Fermantasyon, Geleneksel Üretim, Gastronomi, Coğrafi İşaret

VINEGAR VARIETIES AND PRODUCTION METHODS IN TÜRKİYE

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Abstract

Vinegar is one of the oldest fermented products used throughout history both for food preservation and gastronomic purposes. It is mainly produced through the oxidation of ethyl alcohol by acetic acid bacteria and contains various organic acids, phenolic compounds, vitamins, minerals, and aroma components. Owing to its rich agricultural diversity, Türkiye is among the leading countries producing different types of vinegar from grapes, apples, mulberries, hawthorn, pomegranate, carob, jujube, figs, and various wild fruits. In this study, the historical development, chemical composition, and production technologies of vinegar were examined, and traditional and industrial production methods were comparatively evaluated. Furthermore, vinegar varieties produced in Türkiye were analyzed in terms of production techniques, regional characteristics, sensory properties, and functional components. The study revealed that traditionally fermented vinegars have richer phenolic compounds and aroma profiles compared to industrial products. In addition, regional vinegars with geographical indication potential were evaluated, emphasizing their significance in terms of gastronomic heritage. As a result, Türkiye's vinegar production culture has significant potential for both traditional food technologies and gastronomy tourism.

Keywords: Vinegar, Fermentation, Traditional Production, Gastronomy, Geographical Indication

GİRİŞ

Fermantasyon teknolojileri insanlık tarihindeki en eski gıda işleme yöntemlerinden biridir. Bu yöntem yalnızca ürünün raf ömrünü uzatmakla kalmamış, aynı zamanda yeni aromatik ve fonksiyonel ürünlerin ortaya çıkmasına olanak sağlamıştır. Sirke de fermantasyon temelli ürünler arasında önemli bir yere sahiptir. Sirke; şeker içeren hammaddelerin önce maya aktivitesi ile etil alkole, daha sonra asetik asit bakterileri yardımıyla asetik aside dönüştürülmesi sonucu oluşan bir fermantasyon üründür (Solieri, L., Giudici, P., 2009). Sirke üretiminde kullanılan hammadde ürünün aroma profilini, fenolik yapısını, organik asit kompozisyonunu ve duyusal karakterini doğrudan etkilemektedir (Tesfaye, W., vd., 2002).

Türkiye; zengin tarımsal biyoçeşitliliği, farklı bitki türleri ve köklü mutfak kültürü sayesinde dünya üzerinde en çeşitli ve özgün sirke profillerine sahiptir (Budak, H. N.,2010). Karadeniz'de yabani meyveler, İç Anadolu'da üzüm ve elma, Güneydoğu Anadolu'da nar, Ege'de üzüm bazlı üretimler dikkat çekmektedir. Son yıllarda tüketicilerin doğal ve fonksiyonel ürünlere yönelmesiyle geleneksel yöntemlerle üretilen sirkelere olan ilgi artmıştır. Bu durum hem yerel ekonomilerin desteklenmesine hem de gastronomik mirasın korunmasına katkı sağlamaktadır. Türkiye'de geleneksel sirke üretimi çoğunlukla ev tipi veya küçük ölçekli işletmelerde yürütülmektedir. Üretiminde doğal fermantasyon süreçleri ve sirke anası kullanımı öne çıkmaktadır. Endüstriyel üretiminde ise, submerged sistemler, asetatör teknolojileri ve kontrollü fermantasyon uygulamaları tercih edilmektedir. Her yöntemin ürün kalitesi, aroma profili, fenolik içerik ve üretim süreci açısından önemli farklılıklar göstermektedir.

Bu derleme çalışması ile, literatürdeki sirke üretim tekniklerini tüm boyutlarıyla inceleyerek, Türkiye'de üretilen tüm yöresel, endüstriyel ve coğrafi işaretli sirke çeşitlerini hammaddeleri ile bölgesel özellikleri açısından tek tek değerlendiren, yapısal bir çerçeve sunmaktır.

1. KAVRAMSAL ÇERÇEVE

Sirke, Türk Gıda Kodeksi Fermente ve Aromalandırılmış Sirke Tebliği'ne göre tarımsal kökenli sıvıların önce alkol, ardından asetik asit fermantasyonuna uğratılmasıyla elde edilen fermente bir üründür (T.C. Tarım ve Orman Bakanlığı, 2026). Üzüm gibi bünyesinde şeker bulunduran kuru ve yaş meyvelerin veya şıraların belirli işlemlerden geçmesi ile oluşmaktadır (Gülcü, M., 2012). Temel bileşeni asetik asit olup genellikle toplam asitlik %4-6 arasında değişmektedir. Sirkenin kimyasal bileşimi kullanılan hammaddenin türüne, fermantasyon yöntemine ve olgunlaştırma koşullarına bağlı olarak değişim göstermektedir. Sirke bileşiminde; asetik asit, malik asit, sitrik asit, tartarik asit, fenolik bileşikler, flavonoidler, vitaminler, mineraller, uçucu aroma bileşenleri, amino asitler bulunmaktadır. Özellikle meyve

bazlı sirkelerde antioksidan kapasitesi yüksek olup, toplam fenolik madde miktarı önemli bir kalite kriteri olarak değerlendirilmektedir (Şengül, Y., Kılıç, G., 2019).

Fermantasyonun sürecinin başlatılması ile ilgili, literatürde üç temel yöntem bulunmaktadır. İlki, ortamdaki doğal mikroflora ile kendiliğinden gerçekleşen fermantasyondur. Geleneksel, ev tipi üretim olarak bilinmektedir. İkincisi, bir önceki başarılı sirke üretiminden alınan sirke anası veya pastörize edilmemiş aktif sirkenin yeni şıraya eklendiği yöntemdir. Üçüncüsü ise, laboratuvar ortamında izole edilerek geliştirilmiş, etkisi bilinen starter kültürlerin kullanıldığı, çevresel etkilerin kontrol edilebildiği endüstriyel fermantasyon yöntemidir. Üretim hızına, makineleşme düzeyine ve uygulanan teknolojik altyapıya göre sirke üretimi, geleneksel (yavaş) ve endüstriyel (hızlı) yöntem olarak ikiye ayrılmaktadır.

1.1. Geleneksel ve Yavaş Fermantasyon Yöntemleri

Geleneksel yöntemler, mikrobiyal floranın ana ürünle, uzun süreli ve düşük hızla etkileşime girdiği, fermantasyon süresinin haftalardan yıllara kadar uzayabildiği eski bir yöntemdir. Bu yöntemin avantajı, uzun bekleme süresi boyunca alkoller, aldehitler ve organik asitler arasında gerçekleşen reaksiyon sayesinde yüksek seviyede aroma içeren, karmaşık profilli sirkelerin elde edilmesini sağlamaktadır.

Basit yavaş yöntem, Türkiye'de özellikle yerel şarap üreticileri, bağcılar ve ev üreticileri tarafından sıklıkla uygulanan bir yöntemdir. Bu yöntemde fermantasyon kabı olarak genellikle tahta fıçılar, ahşap tanklar veya büyük cam damacanalar kullanılmaktadır. Spontan floranın veya doğal sirke anasının işlev gördüğü bu süreçte fermantasyonun kontorlü oldukça zordur ve her zaman istenmeyen mikroorganizmalarla (bozulma yapan küfler veya zararlı laktik floralar) kontaminasyon riski barındırmaktadır (Tangüler, H., vd., 2021).

Bu yöntemde:

- Hammadde hazırlama
- Şekerli ortamın oluşturulması
- Alkol fermantasyonu
- Asetik asit fermantasyonu
- Olgunlaştırma
- Filtrasyon ve şişeleme

Bu yöntemde, sirke anası adı verilen selülozik yapı büyük önem taşımaktadır (Yıdız, E., Coşkun, H., 2019). Geleneksel yöntemle üretiminde sirkenin aroma profilinin zengin olması, yüksek fenolik içeriğe sahip olması ve doğal fermantasyon süreci geçirmesi en büyük avantajlarındandır. Ancak uzun süreli üretimi, standart kalite sağlamını zorluğu ve düşük üretim kapasitesi gibi zorlukları bulunmaktadır. Türkiye'de küçük üreticilerin veya çok yaygın olmayan özel sirkelerin üretiminde geleneksel yöntem kullanılmaktadır.

1.2. Endüstriyel, Hızlı Fermantasyon Yöntemi

Endüstriyel üretimde hızlı ve kontrollü fermantasyon sistemleri kullanılmaktadır. Çabuk usül, Alman metodu veya Jeneratör Yöntemi olarak bilinen sistem, bugün Türkiye'deki geniş kapasiteli sirke işletmelerinde en yaygın kullanılan teknolojik fermantasyon yöntemidir (Gülcü, M., 2012). Bu sistem, asetik asit bakterilerine devasa bir tutunma ve oksidasyon yüzeyi sağlamak amacıyla özel olarak tasarlanmıştır. Sistemde genellikle 0,8 ila 3 metre çapında ve 2 ila 12 metre yüksekliğinde üç ana bölümden oluşan, ağaçtan veya paslanmaz çelikten imal edilmiş devasa silindirik tanklar kullanılmaktadır (Şahin, O. I., t.y.). Üretim mekanizmasında sıvı şıra en üst bölümdeki hareketli püskürtme başlıklarından aşağıya doğru bir sistemle verilmektedir. Sıvı, tankın orta kısmından aşağıya doğru süzülürken, alt ve yan kenarlardaki deliklerden doğal bir hava akımıyla sisteme giren oksijenle maksimum düzeyde temas etmektedir (Gülcü, M., 2012). Sıvı ile akımın ters akım prensibi geniş yüzeylerdeki bakteriler, alkolü hızlı bir şekilde asetik aside oksitlemektedir. En alt kısımda toplanan henüz olgunlaşmamış sirke, istenilen konsantrasyona ulaşana kadar sistem devamlı çalışmaktadır. Alkolün asetik aside dönüşümü ısı verdiğinden, tank içindeki sıcaklık devamlı yükselme eğilimindedir. Bakterilerin termal strese girip ölmesini engellemek için sistem, soğutma sistemleri ile 29-30°C seviyesinde hassas bir şekilde sabit tutulmaktadır (Gülcü, M., 2012).

Submers yöntemi (derin kültür veya asetatör yöntemi) ise, modern endüstriyel sirke üretiminin ulaştığı en teknolojik sistem kabul edilmektedir. Bu yöntemle tankın içerisinde herhangi bir katı dolgu maddesi kullanılmamaktadır. Asetik asit bakterileri sıvı şıranın içine homojen olarak dağıtılarak, serbest bir süspansiyon halinde bulunmaktadır. Sistemin tabanından sürekli ve yoğun oksijen basılarak sıvının içine difüze olması sağlanmaktadır. Bu sistem ile, üretim haftalar yerine günler veya saatler içinde tamamlanmaktadır. Bu tanklarda verim ve standardizasyon en üst düzeydedir. Ancak elde edilen sirkenin içeriği, geleneksel yönteme göre çok daha yüzeysel kalabilmektedir (Gülcü, M., 2012).

1.3. Türkiye'de Üretilen Sirke Çeşitleri

Türkiye coğrafyası, sahip olduğu iklim çeşitliliği sayesinde sirke fermantasyonunda kullanılabilecek çok sayıda meyve, sebze, kök ve bitkisel kaynağa sahiptir. Meyse sirkesi üretiminde başta üzüm ve elma hammadde olarak öne çıkmaktadır. İncir, dut, nar, vişne, armut, erik gibi meyvelerden de özgün sirkeler üretilmektedir. Sebze sirkelerinde ise, özellikle domates ve soğan gibi hammaddeler kullanılmaktadır. Ancak sebzelerin doğal şeker oranları sirkeleşmeye yetecek alkolü üretmek için düşük olduğundan, oranı yüksek meyve ekstreleri ilave edilerek fermantasyon desteklenmektedir. Aşağıda Türkiye'de üretilen sirke çeşitleri bölgesel ve yapısal özellikleri ile incelenmiştir.

1.3.1. Üzüm Sirkesi

Üzüm sirkesi, Türkiye'de en yaygın üretilen sirke türüdür. Hammaddesi genellikle siyah veya beyaz üzüm çeşitlerinden oluşmaktadır. Ege bölgesi, İç Anadolu ve Güneydoğu Anadolu üzüm sirkesi üretiminde öne çıkan bölgeler arasındadır. Üretimden önce üzüm şırası fermantasyona bırakılmakta, oluşan etanol daha sonra asetik asit bakterileri tarafından oksitlenmektedir. Bu sirkenin yapısal özellikleri; yüksek organik asit içeriği, aroma profilinin dengeli olması ve antioksidan bileşiklerce zengin yapısı ile ön plana çıkmaktadır (Budak, H. N., 2010). Türk mutfağında salata, turşu, sos ve et marinasyonlarında sıklıkla kullanılmaktadır.

1.3.2. Elma Sirkesi

Elma sirkesi, Türkiye'de en fazla tüketilen sirke çeşitlerinden biridir. Özellikle Isparta, Niğde, Karaman ve Bursa çevresinde üretimi yapılmaktadır. Elma sirkesi malik asit bakımından zengin olup hafif aromatik yapısı nedeniyle tüketiciler tarafından yoğun ilgi görmektedir (Budak, H. N., 2010). Geleneksel üretiminde doğal fermantasyon tercih edilirken endüstriyel üretimde kontrollü fermantasyon sistemleri kullanılmaktadır. Taşıdığı fonksiyonel özellikleri sebebiyle, sağlık odaklı tüketimde önemli bir yere sahiptir (Tangüler, H., vd., 2021).

1.3.3. Dut Sirkesi

Dut sirkesi özellikle Doğu Anadolu ve İç Anadolu bölgelerinde geleneksel yöntemle üretilmektedir (Şengül, Y., Kılıç, G., 2018). Beyaz dut ve karadut çeşitleri kullanılmaktadır. Dut sirkesinin özellikleri; yüksek fenolik madde, antimikrobiyal özellik, antioksidan kapasitesi ve koyu renkli, yoğun bir yapıya sahiptir.

1.3.4. Alıç Sirkesi

Alıç sirkesi Türkiye'de son yıllarda popülerliği artan geleneksel ürünlerden biridir (Yıldız, E., Coşkun, H., 2019). Özellikle İç Anadolu ve Doğu Anadolu bölgelerinde üretilmektedir. Alıç meyvesi yüksek antioksidan kapasiteye sahip olup sirkeye buruk bir tat katmaktadır. Başlıca özellikleri; yoğun aroma, yüksek fenolik içerik ve düşük pH'ıyla bilinmektedir.

1.3.5. Gilaburu Sirkesi

Kayseri yöresine özgü, salkımlar halinde kırmızı meyveler veren gilaburu çalısı, böbrek fonksiyonları üzerinde olumlu etkileriyle bilinen geleneksel bir meyvedir. Gilaburu meyvesinin fermente edilmesiyle elde edilen sirke, tamamen yerel ve fonksiyonel bir üründür. Fermantasyon sonucu asetik asit ile birleştiğinde son derece buruk, kestin ve tedavi edici algısı yüksek bir lezzet profiline sahiptir (Yanardağ Karabulut, Ş., Kaynarca, G. B., 2014).

1.3.6. Gül Sirkesi

Gül sirkesi, Türkiye'ye özgü ve tarihsel kökeni olan, çoğunlukla Isparta ve Burdur yörelerinde yetiştirilen Rosa damascena (şam gülü) türünden elde edilen bir fermantasyon ürünüdür (JOGHAT, 2024). Üretim sürecinde; hasat edilen taze gül bitkisinin taç yaprakları ayrılır, bu yapraklar şeker ilave edilmiş su çözeltisi ile karıştırılarak geleneksel yöntemle fermente edilmektedir. Uzun süre yıllandırılmaktadır (Ertürkmen, P., 2024).

1.3.7. Pirinç Sirkesi

Türkiye'de geleneksel yerel pirinçler kullanılarak üretilmiş ve kalitesi bilimsel platformlarda test edilmiştir. Tokat bölgesinde yapılan bir araştırmada; Türkiye'de üretilen pirinç sirkesinin toplam asitlik miktarının, TS 1880 EN 13188 Türk Standardında belirtilen alt limit olan 40 g/L'nin çok üzerinde bir değere ulaştığı ve ticari standarda tam uyum gösterdiği kanıtlanmıştır (Bayram, M., vd., 2018).

1.3.8. Nar Sirkesi

Nar sirkesi özellikle Akdeniz ve Güneydoğu Anadolu bölgelerinde üretilmektedir. Narın yüksek antioksidan kapasitesi sirkeye de geçmektedir. Bu sirke; fenolik bileşik bakımından zengin, kırmızı renk pigmentli ve mutfakta kullanım alanı oldukça geniştir. Nar sirkesi, diğer kırmızı meyvelere göre antioksidan aktivitesi en iyi olandır (Ergin, S. Ö., 2019).

1.3.9. Keçiboynuzu Sirkesi

Akdeniz bölgesinde üretilen keçiboynuzu sirkesi yoğun aromalı yapıya sahiptir. Lif ve mineral içeriği nedeniyle fonksiyonel bir ürün olarak değerlendirilmektedir. Keçiboynuzu meyveleri kırılıp suda bekletilerek, istenen aromaya ulaştığında keçiboynuzu suyu sirke üretimine hazır hale gelmektedir (Sarıbahçe, t.y.). Geleneksel yöntemle üretilmektedir.

1.3.10. Hünnap Sirkesi

Hünnap meyvesinden üretilen sirke, özellikle İç Anadolu ve Batı Karadeniz'de küçük ölçekli üreticiler tarafından yapılmaktadır (Ede, A., 2023).

1.3.11. İncir Sirkesi

Ege bölgesinde yaygın olan incir sirkesi, yüksek şeker içeriği nedeniyle yoğun fermantasyon potansiyeline sahiptir. Kendine özgü aromatik profili bulunmaktadır. Bağırsak florasını düzenleyen, bağışıklığı güçleniren ve metabolizmaya hızını destekleyen zengin bir antioksidan ile probiyotik kaynağıdır. (Kılıç, G., 2017).

1.4. Türkiye'de Mahreç ve Menşe İşaretli Sirkeler

Türkiye'de çok sayıda geleneksel sirke çeşidi bulunmasına rağmen coğrafi işaret tescili alan sirke sayısı sınırlıdır (Türk Palent ve Marka Kurumu, 2026). Bu durumun temel nedeni üretimin küçük ölçekli olması ve standardizasyon sorunlarıdır. Aşağıda geleneksel yöntemle üretilen coğrafi işaret almış sirkeler:

1.4.1. Safranbolu Yazıköy Üzüm Sirkesi

Batı Karadeniz'in tarihsel kenti Karabük ile özdeşleşen ve geleneksel reçetelerle köy halkı tarafından üretilen Safranbolu Yaziköy Üzüm Sirkesi, yörenin özelliklerini yansıtan önemli ürünlerinden biridir (Safranbolu Birlik Haber, 2024). Yerel üzümlerin uzun süreli yavaş fermantasyonuyla üretilen bu sirke, yapımının her aşamasında sabır gerektiren ve bölge ekonomisine entegre edilmiş bir üründür (TÜRKPATENT, 2026a). TÜRKPATENT'in 2 Şubat 2026 tarihli ve 214 sayılı resmi bülteninde yayımlanarak tescil aşamasında kritik bir süreci geride bırakan bu sirke (TÜRKPATENT, 2026b), Karabük coğrafyası ile çok güçlü bir ün bağına sahiptir (TÜRKPATENT, 2026a). Ürünün kalite kontrolü ve denetimi; Safranbolu Ticaret ve Sanayi Odası koordinatörlüğünde, Karabük ve Safranbolu İlçe Tarım ve Orman Müdürlüklerinin katılımıyla en az üç kişiden oluşan resmi bir denetim mercii tarafından yılda en az bir defa gerçekleştirilecektir. Denetim parametreleri arasında; mahreç işareti ambleminin doğru kullanımı, üretim aşamalarının geleneksel metodolojiye uygunluğu, muhafaza ve ambalajlama koşullarının uygunluğu yer almaktadır (TÜRKPATENT, 2026a).

1.4.2. Şile Kestane Balı Sirkesi

Şile Ketane Balı Sirkesi, bir diğer coğrafi işaretli ürün olan ''Şile Kestane Balı''nın seyreltilerek fermente edilmesiyle, İstanbul'un Şile ilçesinde yerel üreticiler tarafından üretilmektedir (Tokatlı, C., 2024). Kestane balının genetik yapısından gelen yüksek prolin aminoasiti, düşük pH, yoğun fenolik asitler ve odunsu, acı yapı sirkeleşme sürecinden sonra kompleks bir balzamik profile dönüşmektedir.

Bu sirkenin uluslararası başarısı, İtalya merkezli Slow Food tarafından biyoçeşitliliği korumak amacıyla oluşturulan Nuh'un Ambarı (Ark of Taste) listesine dahil edilmiştir. Bu tescil, Şile Kestane Balı Sirkesi'nin kültürel ölçekte tanınmasını sağlamıştır (Tokatlı, C., 2024).

1.4.3. Düzce Elma Sirkesi

Düzce yöresinde, İl Gıda Tarım ve Hayvancılık Müdürlüğü'nün koordinasyonunda yürütülen 2017'den bu yana takip edilen, kalite ve ünü itibariyle il ile özdeşleşmiş olan Düzce Elma Sirkesi, coğrafi işaret türü olarak ''Menşe'' işareti TÜRKPATENT sisteminde değerlendirme aşamasındadır (Düzce İl Tarım ve Orman Müdürlüğü, 2017). Tescil onaylandığında, yörenin

yetişen elmaların kendine has şıra özellikleri ile yerel mikrobiyal floranın yasal bir çerçevede standartlaştırılmış olacaktır.

2. SONUÇ

Sirke; tarımsal kimyanın, mikrobiyal yapının ve insan işçiliğinin binlerce yıllık evriminin sonucudur. Türkiye içinde gastronomi ve kültürel mirası yansıtan, önemli bir yere sahip geleneksel fermente ürünlerden biridir. Üzüm ve elma sirkeleri başta olmak üzere çok sayıda meyve bazlı sirke çeşidi Anadolu'nun farklı bölgelerinde üretilmektedir. Geleneksel yöntemlerle üretilen sirkeler aroma profili, fenolik içerik ve kültürel değer bakımından öne çıkarken; endüstriyel üretim sistemleri standardizasyon ve yüksek üretim kapasitesi sağlamaktadır.

Türkiye'de yöresel sirke çeşitlerinin coğrafi işaret sistemleriyle korunması hem gastronomi mirasının sürdürülebilirliği hem de kırsal kalkınma açısından büyük önem taşımaktadır. Özellikle alıç, dut, nar ve üzüm sirkeleri gelecekte ulusal ve uluslararası gastronomi pazarında önemli potansiyel taşıyan ürünler arasındadır. Ayrıca fonksiyonel beslenmenin trendl haline gelmesi ve toplum tarafından ilginin artmasıyla birlikte fermantasyon yöntemiyle üretilen geleneksel sirkelere olan ilginin gelecekte daha da artacağı öngörülmektedir.

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TARLADAN POLİTİKAYA: AVRUPA BİRLİĞİ ORTAK TARIM POLİTİKASININ DÖNÜŞÜMÜ-ÇEVRESEL SÜRDÜRÜLEBİLİRLİK, EKONOMİK KAYGILAR VE SİYASAL STRATEJİLER EKSENİNDE BİR LİTERATÜR İNCELEMESİ

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Özet

Avrupa Birliği (AB), tarım ekonomisinde bütünleşme projesini geliştirerek; geniş kapsamlı, önemli ve yüksek mali kaynaklar ile şekillenen Ortak Tarım Politikası'nı (OTP) uygulamaya almıştır.

AB'nin Ortak Tarım Politikası (OTP), 1962'deki kuruluşundan bu yana, basit bir tarımsal destek mekanizması olmaktan çok daha öteye evrilmiştir. Bugün politika, ekonomik entegrasyon, sosyal uyum ve siyasi stratejinin kesiştiği çok boyutlu bir konumdadır. Bu çalışma bu dönüşümü çevresel sürdürülebilirlik, ekonomik kaygılar ve siyasi stratejiler açısından incelemektedir.

Çalışma kapsamında taraması yapılan literatürde, OTP'nın 2000'li yıllardan bu yana, özellikle 11 Aralık 2019' da açıklanan Avrupa Yeşil Mutabakatı (EGD - European Green Deal) kapsamında getirilen çevre reformu gündemiyle, önemli bir yapılanma geçirdiğini ortaya konulmaktadır. İklim değişikliğiyle mücadele, biyoçeşitliliğin korunması ve karbon emisyonlarının azaltılması gibi hedefler, OTP'nın güncel öncelik çerçevesinin merkezine yerleşmiştir.

Bu durum Ortak Tarım Politikası'nın AB bütçesindeki tarihsel olarak baskın payının, yalnızca ekonomik bir alan olmaktan ziyade stratejik açıdan hayati bir alan olarak konumlanmasını yansıtmaktadır. Bu bağlamda politika, üye devletlerin farklı çıkarlarını uzlaştırmak için tasarlanmış siyasi bir uzlaşma aracı olarak yorumlanmaktadır.

Sonuç olarak, Ortak Tarım Politikası'nın (OTP) sahadan politika masasına dönüşümü, çevresel, ekonomik ve siyasi boyutların iç içe geçtiği karmaşık bir dinamiği yansıtmaktadır. Bu çalışma, bu boyutları bütüncül ve eleştirel bir bakış açısıyla inceleyerek mevcut literatüre katkıda bulunmayı amaçlamaktadır.

Anahtar Kelimeler: Ortak Tarım Politikası, Avrupa Yeşil Mutabakatı, Çevresel Sürdürülebilirlik, AB Tarım Reformu, Siyasi Strateji

FROM FIELD TO POLITICS: THE TRANSFORMATION OF THE EUROPEAN UNION COMMON AGRICULTURAL POLICY: A LITERATURE REVİEW ON ENVIRONMENTAL SUSTAINABILITY, ECONOMIC CONCERNS AND POLITICAL STRATEGIES

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Abstract

The European Union (EU) has developed an integration project in the agricultural economy and implemented the Common Agricultural Policy (CAP), which is comprehensive, significant, and shaped by substantial financial resources.

The European Union's (EU) Common Agricultural Policy (CAP) has evolved far beyond a simple agricultural support mechanism since its establishment in 1962. Today, it occupies a multifaceted position at the intersection of economic integration, social conformity, and political strategy. This study examines this transformation in terms of environmental sustainability, economic concerns, and political strategies.

The literature review conducted for the study reveals that the Common Agricultural Policy (CAP) has undergone significant restructuring since the 2000s, particularly with the environmental reform agenda introduced under the European Green Deal (EGD) announced on December 11, 2019. Goals such as combating climate change, conserving biodiversity, and reducing carbon emissions have become central to the current priorities of the Common Agricultural Policy.

This argues that the historically dominant share of the Common Agricultural Policy (CAP) in the EU budget reflects its positioning not merely as an economic area, but as a strategically vital one. In this context, the policy is interpreted as a political compromise tool designed to reconcile the differing interests of member states.

In conclusion, the transformation of the Common Agricultural Policy (CAP) from the field to the policy table reflects a complex dynamic in which environmental, economic, and political dimensions are deeply intertwined. This study aims to contribute to the existing literature by examining these dimensions from a holistic and critical perspective.

Keywords: Common Agricultural Policy, European Green Deal, Environmental Sustainability, EU Agricultural Reform, Political Strategy

GİRİŞ

Toplumların en temel gereksinimi olan besin tedarikini güvence altına alan tarım, küresel ölçekte tüm devletler için hayati ve stratejik bir odak noktasıdır. Sektör, gıda sağlamanın ötesinde endüstriyel üretime girdi temin etmekte, iş gücü piyasasına ciddi istihdam katkısı sunmakta ve makroekonomik istikrarı desteklemektedir. Ancak tarımsal üretim; iklimsel değişimler, doğal yıkımlar ve piyasalardaki konjonktürel dalgalanmalar gibi öngörülmesi güç pek çok dışsal faktöre karşı son derece hassastır. Bu yapısal kırılganlıklar ve barındırdığı yüksek risk profili nedeniyle, tarımda sürdürülebilirliği yakalamak adına üretimin proaktif politikalarla takip edilmesi ve etkin destek mekanizmalarıyla yönlendirilmesi bir zorunluluktur.

İkinci Dünya Savaşı'nın öncesi ve sonrasındaki dönemde Avrupa'da baş gösteren gıda tedariki krizleri, tarım sektörünün jeostratejik ağırlığını net bir şekilde gözler önüne sermiştir. Bu kırılgan süreçte, kıta ülkeleri hem iktisadi hem de siyasi entegrasyon vizyonları çerçevesinde dayanışmayı derinleştirmiş; tarımsal faaliyetlerde tek bir çatı altında hareket edebilmek adına kapsamlı bir ortak tarım politikası inşa etmişlerdir. Yaşanan bu tarihsel dönüşüm, tarımın toplumsal refahın sürdürülebilirliği ve makroekonomik dengelerin korunması bakımından ne denli hayati bir enstrüman olduğunu kanıtlar niteliktedir (Özkan ve Karaköy, 2018).

Tarımda sürdürülebilirliği hedefleyen AB, tarım ekonomisinde bütünleşme projesini geliştirerek; geniş kapsamlı, önemli ve yüksek mali kaynaklar ile şekillenen Ortak Tarım Politikası'nı (OTP) uygulamaya almıştır.

İlk yıllarda çiftçi gelirlerini ve tarımda verimliliği artırmak amacıyla hayata geçirilmiş olan OTP, günümüzde ekonomik entegrasyon, sosyal uyum ve siyasi stratejinin kesiştiği çok boyutlu bir politikaya dönüşmüştür. Bu çalışma bu dönüşümü çevresel sürdürülebilirlik, ekonomik kaygılar ve siyasi stratejiler açısından incelemektedir.

1. ORTAK TARIM POLİTİKASI'NIN (OTP) TARİHSEL EVRİMİ

Temelleri 1962 yılında atılan Ortak Tarım Politikası (OTP), Avrupa Birliği bünyesindeki üreticiler ile kıta toplumu arasında köprü görevi gören stratejik bir mutabakattır. Söz konusu politikanın öncelikli hedefleri; tarımsal üretimde verimlilik artışı yakalamak, bu sayede hem tüketicilerin makul maliyetlerle kesintisiz gıdaya ulaşmasını güvence altına almak hem de AB sınırları içindeki çiftçilerin refah seviyesini ve ekonomik sürdürülebilirliğini korumaktır.

Birlik düzeyinde merkezi olarak idare edilen ve finansmanı AB'nin genel bütçesinden karşılanan OTP, tüm üye ülkeleri kapsayan kolektif bir stratejidir. Geride kalan yarım asırlık süreçten sonra, söz konusu politikanın günümüzde çok daha karmaşık küresel krizlerle yüzleşmesi gerekmektedir. Bu tehditlerin merkezinde gıda arz güvenliği yer almaktadır; nitekim 2050 yılına gelindiğinde 9 milyara ulaşması beklenen dünya nüfusunun besin

ihtiyacını karşılayabilmek adına küresel tarımsal çıktının iki katına çıkarılması bir zorunluluktur. Bu devasa sorumluluğun yanı sıra; iklim kriziyle mücadele, kıt doğal kaynakların ekolojik dengeler gözetilerek idare edilmesi ve AB sınırlarındaki kırsal ekosistemlerin korunarak yerel ekonomilerin dinamizmini sürdürmesi de politikanın diğer öncelikli sınavlarıdır.

Söz konusu politikanın 2013 yılında geçirdiği kapsamlı reform süreci, öncelikli ekseni çevre dostu tarımsal faaliyetlere, bilimsel araştırmalara ve kurumsal bilgi paylaşımına kaydırmıştır. Bu dönüşümle birlikte, üreticiler için daha hakkaniyetli bir mali destek mekanizmasının kurulması ve çiftçilerin tarımsal gıda arz zincirindeki sosyo-ekonomik konumlarının daha dirençli hale getirilmesi hedeflenmiştir.

2023-2027 dönemini hedefleyen güncel OTP uygulamaları, 1 Ocak 2023 itibarıyla resmi olarak uygulamaya konmuştur. AB üyesi 27 ülkedeki üreticilere ve kırsal bölge aktörlerine sağlanacak teşviklerin hukuki zeminini, OTP 2023-27 yasal mevzuatı ile Avrupa Komisyonu tarafından yürürlüğe konan OTP Stratejik Planları oluşturmaktadır. Kabul edilen bu ulusal planlar; Avrupa Yeşil Mutabakatı, Tarladan Sofraya Stratejisi ve Biyoçeşitlilik Stratejisi gibi makro politikaların çevresel ve sürdürülebilirlik hedeflerini doğrudan destekleyecek şekilde dizayn edilmiştir.

Günümüzde kırsal bölgeler; gıda arzının sürdürülebilirliği, iklim değişikliğinin etkileri, ekonomik büyümenin desteklenmesi ve istihdam olanaklarının artırılması gibi birçok önemli sorunla karşı karşıya bulunmaktadır. Bu çerçevede Avrupa Birliği, kırsal kalkınmayı yalnızca tarımsal üretimin geliştirilmesine yönelik bir politika alanı olarak değil, aynı zamanda kırsal toplumlarda akıllı, sürdürülebilir ve kapsayıcı kalkınmanın sağlanmasında temel bir araç olarak değerlendirmektedir. Bu nedenle kırsal kalkınma politikaları, bölgesel farklılıkların azaltılması ve kırsal yaşamın güçlendirilmesi açısından stratejik bir öneme sahiptir (Avrupa Birliği Türkiye Delegasyonu, 2023).

Avrupa Birliğinin Ortak Tarım Politikası (OTP) hem tarımın son derece hayati bir işlev olması, hem de AB bütçesinin büyük bir kısmının (OTP)'ye ayrılması nedeniyle ayrı bir önem taşımaktadır.

AB, OTP kapsamında yer alan tarım ürünleri ana başlıklar itibarıyla toplam 20 kalemde toplanmaktadır. OTP kapsamında yer alan tarım ürünleri; tahıllar, şeker, yağlı tohumlar, şarap, meyve ve sebzeler, hayvan yemleri, keten ve kendir elyafı, pamuk, patates, süt ve süt ürünleri, yumurta, büyükbaş hayvanlar, et, ipek böceği, balık, bitkisel yağlar, zeytinyağı, tütün, şerbetçi otu ve tohumluklardır.

Roma Antlaşması'nın 39. maddesinde, Ortak Tarım Politikası'nın (OTP) temel hedefleri; tarımsal verimliliğin artırılması, tarım sektöründe çalışanların gelir ve yaşam koşullarının

iyileştirilmesi, piyasalarda istikrarın sağlanması, gıda arzının güvence altına alınması ve tüketicilerin tarımsal ürünlere makul fiyatlarla erişebilmesi olarak belirlenmiştir. Ancak Avrupa Birliği'nin ekonomik, sosyal ve çevresel yapısında meydana gelen değişimler doğrultusunda OTP'nin kapsamı zamanla genişlemiş ve yeni öncelikler kazanmıştır (Çukurçayır, 2010).

Günümüzde OTP'nin başlıca amaçları arasında, Birlik içerisindeki tarımsal piyasaların bütünleştirilmesi ve üye ülkeler arasındaki tarım ticaretinin geliştirilmesi yer almaktadır. Bunun yanı sıra çiftçilerin gelir düzeylerinin korunması, tarımsal faaliyetlerden elde edilen kazançların sürdürülebilir hâle getirilmesi, gıda güvenliği ile ürün kalitesinin güvence altına alınması ve tüketicilerin uygun fiyatlı ürünlere erişiminin desteklenmesi önemli hedefler arasındadır.

Politika aynı zamanda Avrupa Birliği'nin küresel ticaret sistemine uyumunu güçlendirmeyi, dünya genelindeki gıda sorunlarının çözümüne katkı sunmayı, çevresel sürdürülebilirliği tarım politikalarının ayrılmaz bir unsuru hâline getirmeyi ve tarım sektörünün uluslararası rekabet gücünü artırmayı amaçlamaktadır. Kırsal bölgelerde ekonomik çeşitliliğin sağlanması, yeni istihdam alanlarının oluşturulması ve tarım mevzuatının daha sade ve uygulanabilir bir yapıya kavuşturulması da OTP'nin güncel hedefleri arasında yer almaktadır.

Bu hedeflerin hayata geçirilmesi üç temel ilkeye dayanmaktadır. Bunlardan ilki Tek Pazar, ikinci temel ilke olan Topluluk Tercihi, Üçüncü ilke ise Mali Dayanışma (Ortak Finansman) ilkesidir (Tan ve Dellal, 2003).

1.1. Tek Pazar İlkesi

Ortak Tarım Politikası'nın temel dayanaklarından biri olan Tek Pazar İlkesi, tarım ürünlerinin Avrupa Birliği üyesi ülkeler arasında herhangi bir ticari engelle karşılaşmadan serbestçe dolaşabilmesini öngörmektedir. Bu kapsamda üye devletler arasındaki gümrük vergileri, miktar kısıtlamaları ve benzeri ticaret engelleri kaldırılarak ortak bir tarım pazarı oluşturulması amaçlanmıştır. Böylece tarımsal ürünlerin Birlik genelinde aynı ekonomik alan içerisinde işlem görmesi hedeflenmiştir. İlk dönemlerde fiyatların belirlenmesinde piyasa koşullarından çok idari düzenlemeler etkili olmuş, bu nedenle ürün grupları arasında farklı fiyat uygulamaları ortaya çıkmıştır. Ayrıca 1970'li yıllarda yaşanan döviz kuru dalgalanmalarının ortak pazar üzerindeki olumsuz etkilerini azaltmak amacıyla "yeşil kur" olarak adlandırılan özel bir döviz sistemi uygulanmış ve ortak piyasa düzeninin korunmasına çalışılmıştır (Erdoğan, 2015: 42).

1.2. Topluluk Tercihi İlkesi

Topluluk Tercihi İlkesi, Avrupa Birliği tarım sektörünü dış rekabete karşı korumayı amaçlayan bir yaklaşımdır. Bu ilke doğrultusunda Birlik sınırları dışından gelen tarım

ürünlerine çeşitli koruyucu önlemler ve yüksek gümrük vergileri uygulanmıştır. Amaç, AB içerisindeki üreticilerin daha düşük maliyetli ithal ürünler karşısında gelir kaybına uğramasını önlemek ve iç üretimi desteklemektir. Zaman içerisinde küresel ticaret kurallarının gelişmesi ve uluslararası rekabetin önem kazanmasıyla birlikte bu korumacı yaklaşım kademeli olarak yumuşatılmış, dış ticareti sınırlandıran uygulamaların azaltılmasına yönelik reformlar gerçekleştirilmiştir (Nazlı ve Küden, 2012).

1.3. Ortak Mali Sorumluluk İlkesi

OTP'nin uygulanabilmesi için gerekli finansmanın tüm üye ülkeler tarafından ortak şekilde karşılanması Ortak Mali Sorumluluk İlkesi'nin temelini oluşturmaktadır. Bu anlayışa göre tarım politikalarının mali yükü belirli ülkelerin üzerinde bırakılmamakta, Birlik bütçesi aracılığıyla paylaşılmaktadır. Bu amaçla 1962 yılında kurulan Avrupa Tarımsal Yönlendirme ve Garanti Fonu (FEOGA), OTP harcamalarının finansmanında önemli bir araç olarak kullanılmıştır. Daha sonra fon, Garanti ve Yönlendirme olmak üzere iki ayrı bölüm hâline getirilmiştir. Garanti Bölümü, piyasa düzenlemeleri ve fiyat destekleri gibi harcamaları finanse ederken; Yönlendirme Bölümü tarımsal yapıların modernizasyonu, kırsal kalkınma ve yapısal dönüşüm projelerine kaynak sağlamıştır (Nazlı ve Küden, 2012).

2. ORTAK TARIM POLİTİKASININ AMAÇLARI

Ortak Tarım Politikası, Avrupa tarım sektörünün sürdürülebilir biçimde gelişmesini sağlamak amacıyla çok yönlü hedefler üzerine kurulmuştur. Bu kapsamda tarımsal üretimde verimliliğin artırılması, modern üretim tekniklerinin yaygınlaştırılması ve üretim faktörlerinin daha etkin kullanılması temel öncelikler arasında yer almaktadır. Ayrıca tarım piyasalarında istikrarın sağlanması, gıda arz güvenliğinin korunması ve tüketicilerin yeterli miktarda ürüne ulaşabilmesi amaçlanmaktadır.

Politikanın bir diğer önemli hedefi, tarımla geçimini sağlayan kesimlerin gelir düzeyini yükseltmek ve yaşam koşullarını iyileştirmektir. Bunun yanında işgücünün daha verimli değerlendirilmesi, tarımsal ürün fiyatlarında aşırı dalgalanmaların önlenmesi ve üye ülkeler arasında adil rekabet koşullarının oluşturulması da OTP'nin öncelikleri arasında bulunmaktadır. Tüketicilerin kaliteli gıda ürünlerine makul fiyatlarla erişebilmesi de politikanın sosyal boyutunu oluşturmaktadır (Çukurçayır, 2010).

2.1. Yeşil Dönüşüm Sürecinde Ortak Tarım Politikası

2000'li yıllardan itibaren Avrupa Birliği, Ortak Tarım Politikası'nı çevresel sürdürülebilirlik hedefleri doğrultusunda yeniden şekillendirmeye başlamıştır. Bu süreçte iklim değişikliğiyle mücadele, doğal kaynakların korunması, biyolojik çeşitliliğin desteklenmesi ve çevre dostu üretim uygulamalarının yaygınlaştırılması ön plana çıkmıştır. Avrupa Birliği, bu dönüşümü

tarımsal faaliyetlerin çevre üzerindeki baskısını azaltmak ve daha sürdürülebilir bir üretim modeli oluşturmak amacıyla yürütmektedir (Çakan, 2025).

2.2. Günümüzde Ortak Tarım Politikasının Temel Unsurları

Güncel OTP yapısı, üretim miktarına bağlı olmayan doğrudan gelir destekleri üzerine kurulmuştur. Çiftçilerin desteklerden yararlanabilmesi için çevre, gıda güvenliği, hayvan sağlığı ve refahı gibi alanlarda belirlenen standartlara uymaları gerekmektedir. Bu uygulama "çapraz uyum" sistemi olarak adlandırılmaktadır. Ayrıca kırsal kalkınma politikalarına ayrılan kaynaklar artırılmış, büyük ölçekli işletmelere yapılan doğrudan ödemelerde belirli oranlarda kesintiye gidilerek kaynakların daha dengeli dağıtılması hedeflenmiştir. Bunun yanında, bütçe kaynaklarının etkin kullanımını sağlamak amacıyla mali disiplin mekanizmaları geliştirilmiş ve tarımsal destek sisteminin daha sürdürülebilir hâle getirilmesi amaçlanmıştır (Eraktan ve Ören, 2009).

2.3. Ortak Tarım Politikasının Çevresel Etkileri

Avrupa Birliği, iklim değişikliği, doğal kaynakların tükenmesi, çevre kirliliği ve biyolojik çeşitlilik kayıpları gibi küresel çevre sorunlarına karşı son yıllarda kapsamlı politikalar geliştirmiştir. Bu dönüşümün temelini, 2019 yılında ilan edilen Avrupa Yeşil Mutabakatı oluşturmaktadır. Söz konusu strateji; 2050 yılına kadar iklim nötrlüğünün sağlanmasını, ekonomik büyümenin doğal kaynak tüketiminden ayrıştırılmasını, döngüsel ekonomi uygulamalarının yaygınlaştırılmasını ve çevresel sürdürülebilirliğin tüm politika alanlarına entegre edilmesini hedeflemektedir. Bu doğrultuda enerji, sanayi, ulaştırma ve tarım gibi çevresel etkisi yüksek sektörlerde önemli reformlar gündeme gelmiştir.

Tarım sektörü, doğal kaynaklarla doğrudan ilişkili olması ve çevre üzerinde önemli etkiler yaratması nedeniyle yeşil dönüşüm sürecinin merkezinde yer almaktadır. Günümüzde tarım yalnızca gıda üretimiyle ilişkilendirilen bir faaliyet alanı olmaktan çıkmış; iklim değişikliğiyle mücadele, sera gazı emisyonlarının azaltılması, toprak verimliliğinin korunması ve biyolojik çeşitliliğin desteklenmesi gibi hedeflerin gerçekleştirilmesinde de stratejik bir rol üstlenmiştir. Bu nedenle Avrupa Birliği'nin Ortak Tarım Politikası (OTP), ekonomik ve sosyal işlevlerinin yanında çevresel sürdürülebilirliği destekleyen temel politika araçlarından biri hâline gelmiştir. Son yıllarda OTP kapsamında yapılan reformlar, çevre dostu üretim yöntemlerinin teşvik edilmesi ve tarımsal faaliyetlerin ekosistem üzerindeki baskısının azaltılması yönünde şekillenmektedir (Çakan, 2025).

2.4. Ortak Tarım Politikasının Siyasi Etkileri

1962 yılında uygulamaya konulan Ortak Tarım Politikası, ilk aşamada tarımsal üretimin artırılması, çiftçi gelirlerinin güvence altına alınması ve tüketicilerin yeterli gıdaya uygun fiyatlarla ulaşabilmesi gibi hedeflere odaklanmıştır. Bununla birlikte, politikanın ortaya

çıkışında yalnızca ekonomik gerekçeler değil, Avrupa'nın savaş sonrası dönemde karşı karşıya kaldığı gıda güvenliği sorunları ve kırsal nüfusun siyasi ağırlığı da etkili olmuştur.

Uzun yıllar boyunca Avrupa Birliği bütçesinin önemli bir kısmının OTP'ye ayrılması, tarım sektörünün Birlik açısından stratejik bir öneme sahip olduğunu göstermektedir. Tarımın bütçe içerisindeki yüksek payı, OTP'nin yalnızca üretim ve gelir desteği sağlayan bir mekanizma olmadığını, aynı zamanda Avrupa bütünleşmesini güçlendiren siyasi bir araç olarak değerlendirildiğini ortaya koymaktadır. Bu yönüyle politika, üye devletler arasında dayanışmanın artırılmasına ve ortak Avrupa kimliğinin geliştirilmesine katkı sağlayan önemli unsurlardan biri olarak kabul edilmektedir (Çakan, 2025).

2.5. Ortak Tarım Politikasının Ekonomik Etkileri

Ortak Tarım Politikası, Avrupa bütünleşme sürecinin ekonomik ve sosyal boyutlarını bir araya getiren en önemli politika alanlarından biridir. Temelleri 1958 yılında Roma Antlaşması ile atılan bu politika, kurucu ülkeler arasındaki tarımsal farklılıkları azaltmak ve ortak pazarın etkin işleyişini desteklemek amacıyla geliştirilmiştir.

1950'li yıllarda Avrupa ülkelerinde tarım sektörü büyük ölçüde devlet müdahaleleriyle yönlendirilmekteydi. Ancak ülkeler arasında farklı destekleme sistemlerinin uygulanması, ortak pazarın serbest dolaşım ve rekabet ilkeleriyle uyumsuzluk yaratıyordu. Bu nedenle OTP, ulusal tarım politikalarının ortak bir çerçevede birleştirilmesini sağlayarak tarım sektöründe bütünleşik bir yapı oluşturmayı amaçlamıştır.

Politikanın uygulanmasıyla birlikte tarımsal üretimde verimlilik artışı sağlanmış, çiftçi gelirleri desteklenmiş ve üye ülkeler arasında daha dengeli bir tarım piyasası oluşturulmuştur. Ayrıca OTP, Avrupa Birliği'nin ekonomik bütünleşmesini güçlendiren ve ortak pazarın işleyişine katkı sunan temel mekanizmalardan biri hâline gelmiştir. Tarım sektörünün ekonomik öneminin yanı sıra kırsal istihdam ve sosyal refah üzerindeki etkileri de OTP'nin Avrupa entegrasyon sürecinde ayrıcalıklı bir konuma sahip olmasını sağlamıştır (Çakan, 2025).

3. AMAÇ VE METODOLOJİ

Bu çalışmanın amacı, Avrupa Birliği Ortak Tarım Politikası'nın (OTP) kuruluşundan günümüze geçirdiği dönüşümü çevresel sürdürülebilirlik, ekonomik kaygılar ve siyasi stratejiler ekseninde değerlendirmek ve politika reformlarının tarım sektörü üzerindeki etkilerini ortaya koymaktır. Çalışmada özellikle Avrupa Yeşil Mutabakatı sonrasında OTP'nin değişen öncelikleri incelenmiş; çevresel hedeflerin, ekonomik sürdürülebilirliğin ve siyasi bütünleşmenin politika üzerindeki yansımalar incelenmiştir.

Bir araştırma yöntemi olarak genel literatür taraması, önceki çalışmaları ve araştırmaları toplayıp sınıflandırmanın ve sentezlemenin az veya çok sistematik bir yoludur (Snyder, 2019; Turan, 2019). Bu çalışmada araştırma konusu ve anahtar kelimeler belirlendikten sonra literatürdeki güvenilir akademik kaynaklar, AB Raporları ve kurumsal dokümanlar taranarak seçilmiş, analiz edilmiş ve nihayetinde sentezlenen literatür bilgisi başlıklar altında sınıflandırılarak bulgular ortaya konulmuştur (Pare ve Kitsiou, 2016; Turan, 2019; Snyder, 2019. Özellikle Çukurçayır (2010), Nazlı ve Küden (2012), Erdoğan (2015), Özkan ve Karaköy (2018), Çakan (2025) ve Avrupa Birliği Türkiye Delegasyonu (2023) tarafından ortaya konulan değerlendirmeler karşılaştırmalı olarak analiz edilmiştir.

Bu çalışma ile AB'nin Ortak Tarım Politikası'nın (OTP) Tarladan Politikaya stratejik dönüşümü; OTP'nin tarihsel süreçteki evrimi, ilkeleri ve amaçları ile çevresel sürdürülebilirlik, ekonomik kaygılar ve siyasal stratejiler başlıkları altında tematik olarak değerlendirilmiş ve literatüre katkı sağlayan bulgulara ulaşılmıştır. Literatür taramalarında birçok ampirik çalışmadan elde edilen bakış açılarını karşılaştırmalı olarak inceleyip, bütüncül olarak sentezleyerek ikna edici bulgular ortaya konulmaktadır (Snyder, 2019).

4. BULGULAR

Literatür incelemesi sonucunda Ortak Tarım Politikası'nın başlangıçta gıda arz güvenliğini sağlamak, tarımsal verimliliği artırmak ve çiftçi gelirlerini korumak amacıyla oluşturulduğu; ancak zaman içerisinde çok boyutlu bir politika aracına dönüştüğü görülmüştür. Çukurçayır'a (2010) göre OTP'nin kapsamı ekonomik, sosyal ve çevresel ihtiyaçlar doğrultusunda genişlemiş ve yeni politika alanlarını içerecek şekilde gelişmiştir.

İncelenen çalışmalar, OTP'nin Avrupa bütünleşmesinin ekonomik temel taşlarından biri olduğunu göstermektedir. Politika sayesinde tarımsal üretimde verimlilik artışı sağlanmış, çiftçi gelirleri desteklenmiş ve ortak tarım pazarının işleyişi güçlendirilmiştir (Çakan, 2025). Bunun yanında OTP, kırsal kalkınmayı destekleyen önemli bir araç hâline gelmiş ve kırsal bölgelerde ekonomik çeşitliliğin artırılmasına katkı sunmuştur (Avrupa Birliği Türkiye Delegasyonu, 2023).

Çevresel boyutta ise özellikle Avrupa Yeşil Mutabakatı sonrasında OTP'nin önemli ölçüde yeniden yapılandırıldığı görülmektedir. Çakan'ın (2025) çalışmasına göre iklim değişikliğiyle mücadele, biyolojik çeşitliliğin korunması, sera gazı emisyonlarının azaltılması ve çevre dostu üretim yöntemlerinin yaygınlaştırılması politika reformlarının merkezine yerleşmiştir. Günümüzde doğrudan gelir destekleri, çevresel şartlara bağlı hâle getirilmiş ve sürdürülebilir üretim uygulamaları teşvik edilmeye başlanmıştır.

Siyasi açıdan değerlendirildiğinde OTP'nin yalnızca bir tarım politikası olmadığı, aynı zamanda Avrupa Birliği içerisinde dayanışmayı güçlendiren ve üye ülkeler arasındaki çıkar

farklılıklarını uzlaştıran stratejik bir politika aracı olduğu anlaşılmaktadır. Politikanın AB bütçesindeki yüksek payı, tarımın ekonomik öneminin yanı sıra siyasi ve stratejik önemini de ortaya koymaktadır (Çakan, 2025).

4.1. Karşılaşılan Zorluklar ve Problemler

Literatürde OTP'nin karşı karşıya olduğu en önemli sorunlardan birinin çevresel hedefler ile ekonomik sürdürülebilirlik arasında denge kurmak olduğu vurgulanmaktadır. Avrupa Yeşil Mutabakatı kapsamında getirilen çevresel yükümlülükler, bazı üreticiler açısından maliyet artışlarına neden olmakta ve çiftçilerin gelir düzeyleri üzerinde baskı oluşturabilmektedir (Çakan, 2025).

Bir diğer önemli sorun, Avrupa Birliği üyesi ülkelerin tarımsal yapı ve önceliklerindeki farklılıklardır. OTP'nin tüm üye ülkeler için ortak kurallar belirlemesi, zaman zaman ulusal çıkarlar ile Birlik hedefleri arasında uyumsuzluklara yol açabilmektedir. Bu durum politika reformlarının uygulanmasında çeşitli zorluklar ortaya çıkarmaktadır (Nazlı ve Küden, 2012).

Literatürde ayrıca küresel rekabet baskısı, gıda arz güvenliğinin korunması, iklim değişikliğinin tarımsal üretim üzerindeki etkileri ve kırsal bölgelerde nüfusun azalması gibi sorunların OTP'nin geleceğini şekillendiren temel risk alanları olduğu belirtilmektedir (Avrupa Birliği Türkiye Delegasyonu, 2023). Artan üretim maliyetleri ve zaman zaman ortaya çıkan çiftçi protestoları da çevresel reformların sahadaki uygulanabilirliği konusunda tartışmalara neden olmaktadır.

Sonuç olarak literatür, OTP'nin gelecekteki başarısının çevresel sürdürülebilirlik hedefleri ile çiftçi gelirlerinin korunması, kırsal kalkınmanın desteklenmesi ve Avrupa Birliği'nin gıda güvenliğinin sürdürülmesi arasında dengeli bir politika yaklaşımının geliştirilmesine bağlı olduğunu ortaya koymaktadır.

5. SONUÇ

Avrupa Birliği Ortak Tarım Politikası (OTP), 1962 yılında gıda arz güvenliğini sağlamak, çiftçi gelirlerini korumak ve tarımsal verimliliği artırmak amacıyla oluşturulmuş olup, zaman içerisinde değişen ekonomik, sosyal ve çevresel koşullara uyum sağlayacak şekilde sürekli olarak reforme edilmiştir. Başlangıçta ağırlıklı olarak üretim ve piyasa odaklı bir yapıya sahip olan OTP, günümüzde sürdürülebilirlik, iklim değişikliğiyle mücadele, biyolojik çeşitliliğin korunması ve kırsal kalkınmanın desteklenmesi gibi çok boyutlu hedefleri bünyesinde barındırmaktadır.

Özellikle Avrupa Yeşil Mutabakatı ve Tarladan Sofraya Stratejisi doğrultusunda gerçekleştirilen son reformlar, tarım politikalarının yalnızca ekonomik büyüme ve üretim artışı ekseninde değil, aynı zamanda çevresel sorumluluk ve toplumsal sürdürülebilirlik

perspektifinde de şekillendiğini göstermektedir. Bununla birlikte OTP, Avrupa Birliği'nin bütünleşme sürecinde ortak pazarın işleyişini destekleyen, kırsal bölgelerde ekonomik canlılığı koruyan ve üye ülkeler arasında tarımsal uyumu sağlayan temel politika araçlarından biri olmayı sürdürmektedir.

Sonuç olarak Ortak Tarım Politikası, günümüzde ekonomik, çevresel ve siyasi boyutları iç içe geçmiş kapsamlı bir yönetişim mekanizması hâline dönüşmüş olup, Avrupa Birliği'nin sürdürülebilir kalkınma hedeflerine ulaşmasında stratejik bir rol üstlenmektedir. Konuyla ilgili gelecek çalışmalarda; Türkiye Tarım Politikası uygulamaları ile OTP uygulamalarını karşılaştırarak ülkemizde sürdürülebilir toprak-sürdürülebilir tarım-ve-sürdürülebilir kalkınmaya yönelik çözüm önerileri sunan araştırmalara yer verilmesi gerektiği düşünülmektedir.

6. ÖZGÜN DEĞERLENDİRME

Ortak Tarım Politikası üzerine yapılan değerlendirmeler çoğunlukla çevresel sürdürülebilirlik veya çiftçi destekleri ekseninde yürütülmektedir. Ancak OTP'nin yalnızca bir tarım politikası olarak ele alınması, politikanın sahip olduğu çok katmanlı yapının göz ardı edilmesine neden olmaktadır. Bu çalışma kapsamında OTP'n in çevresel, ekonomik ve siyasi boyutlarının birlikte değerlendirilmesi, politikanın Avrupa Birliği açısından çok daha geniş bir stratejik anlam taşıdığını ortaya koymaktadır.

AB'nin son yıllarda uygulamaya koyduğu yeşil dönüşüm politikaları çevresel hedefleri ön plana çıkarmakla birlikte, bu dönüşüm aynı zamanda küresel rekabet gücü, gıda arz güvenliği ve kırsal istikrar açısından yeni tartışmaları da beraberinde getirmektedir.

Özellikle artan üretim maliyetleri, çiftçi protestoları ve küresel tarım piyasalarındaki rekabet baskısı dikkate alındığında, çevresel hedeflerle ekonomik sürdürülebilirlik arasında hassas bir denge kurulması gerekmektedir. Bu çerçevede OTP'nin gelecekteki başarısı, yalnızca karbon emisyonlarını azaltma veya çevresel performansı artırma kapasitesine değil; aynı zamanda Avrupa çiftçisinin gelir düzeyini koruyabilmesine, kırsal bölgelerde yaşam kalitesini sürdürebilmesine ve Avrupa Birliği'nin gıda egemenliğini güçlendirebilmesine bağlı olacaktır. Dolayısıyla OTP, günümüzde sadece bir tarım politikası değil, Avrupa Birliği'nin ekonomik dayanıklılığını, siyasi bütünlüğünü ve çevresel vizyonunu aynı anda şekillendiren stratejik bir yönetişim aracı olarak değerlendirilmelidir.

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CORPORATE SUSTAINABILITY PRACTICES in THE COSMETICS INDUSTRY: A CASE STUDY ON FLORMAR

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Abstract

The aim of this study is to examine the corporate sustainability practices of Flormar, a company operating in the cosmetics industry, through environmental, social, and governance dimensions. The study was designed as a single case study within the scope of a qualitative research approach. The data sources of the study consist of Flormar's 2024 Sustainability Report and information obtained through an interview conducted with Flormar representatives. Flormar's 2024 Sustainability Report covers the period between January 1 and December 31, 2024 and was prepared in alignment with the Global Reporting Initiative (GRI) Standards and the Sustainable Development Goals (SDGs). The report emphasizes that sustainability is considered not merely as a target, but as a fundamental component of the company's way of doing business.

The findings indicate that Flormar structures its sustainability approach around the axes of "Better Formulation, Better Packaging, and Better Production," while addressing its sustainability goals through the dimensions of people, product, and planet. In this context, clean product development, increasing the use of recycled plastic, energy efficiency, water management, waste management, zero-waste practices, carbon footprint reduction, biodiversity, employee well-being, women's employment, and sustainable supply chain management emerge as key areas of practice.

The study concludes that the Flormar case demonstrates how sustainability in the cosmetics industry can be evaluated not only as environmental compliance or corporate social responsibility, but also as a strategic management approach integrated with product development, packaging design, resource efficiency, supply chain management, employee welfare, gender equality, and corporate governance. In this respect, the study presents an illustrative case of how sustainability practices can be institutionalized at the sectoral level.

Keywords: Corporate Sustainability, Green Management, Cosmetics Industry, Sustainable Supply Chain, Flormar, Case Study

KOZMETİK SEKTÖRÜNDE KURUMSAL SÜRDÜRÜLEBİLİRLİK UYGULAMALARI: FLORMAR ÜZERİNE BİR ÖRNEK OLAY İNCELEMESİ

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Özet

Bu çalışmanın amacı, kozmetik sektöründe faaliyet gösteren Flormar'ın kurumsal sürdürülebilirlik uygulamalarını çevresel, sosyal ve yönetsel boyutlarıyla incelemektir. Çalışma, nitel araştırma yaklaşımı kapsamında tekil örnek olay incelemesi olarak tasarlanmıştır. Araştırmanın veri kaynaklarını Flormar 2024 Sürdürülebilirlik Raporu ile Flormar yetkilileriyle gerçekleştirilen mülakat kapsamında elde edilen bilgiler oluşturmaktadır. Flormar 2024 Sürdürülebilirlik Raporu'nun 1 Ocak-31 Aralık 2024 dönemini kapsadığı ve GRI Standartları ile Sürdürülebilir Kalkınma Amaçları'na uyumlu olarak hazırlandığı belirtilmektedir. Raporda sürdürülebilirliğin yalnızca bir hedef değil, iş yapış biçiminin temel unsurlarından biri olarak ele alındığı vurgulanmaktadır.

Bulgular, Flormar'ın sürdürülebilirlik yaklaşımını "Daha İyi Formülasyon, Daha İyi Ambalaj ve Daha İyi Üretim" ekseninde yapılandırdığını; sürdürülebilirlik hedeflerini ise insan, ürün ve gezegen boyutları üzerinden ele aldığını göstermektedir. Bu kapsamda temiz içerikli ürün geliştirme, geri dönüştürülmüş plastik kullanımının artırılması, enerji verimliliği, su yönetimi, atık yönetimi, sıfır atık uygulamaları, karbon ayak izinin azaltılması, biyoçeşitlilik, çalışan refahı, kadın istihdamı ve sürdürülebilir tedarik zinciri yönetimi öne çıkan uygulama alanlarıdır. Flormar yetkilileriyle gerçekleştirilen görüşmede de sürdürülebilirliğin yalnızca bir departman faaliyeti değil, iş sağlığı ve güvenliğinden çevresel yatırımlara, teknik projelerden ürün tasarımına kadar tüm faaliyetlere entegre edilen kurumsal bir sistem olarak ele alındığı görülmektedir.

Çalışma sonucunda, Flormar örneğinin kozmetik sektöründe sürdürülebilirliğin yalnızca çevresel uyum veya sosyal sorumluluk faaliyeti olarak değil; ürün geliştirme, ambalaj tasarımı, kaynak verimliliği, tedarik zinciri, çalışan refahı, toplumsal cinsiyet eşitliği ve kurumsal yönetişimle bütünleşen stratejik bir yönetim yaklaşımı olarak değerlendirilebileceğini ortaya koyduğu sonucuna ulaşılmıştır. Bu yönüyle çalışma, sürdürülebilirlik uygulamalarının sektörel düzeyde nasıl kurumsallaştırılabileceğine ilişkin örnek bir vaka sunmaktadır.

Anahtar Kelimeler: Kurumsal Sürdürülebilirlik, Yeşil Yönetim, Kozmetik Sektörü, Sürdürülebilir Tedarik Zinciri, Flormar, Örnek Olay İncelemesi

INTRODUCTION

Sustainability has become a strategic management issue for contemporary firms, extending beyond environmental compliance to include economic, social, and governance-related responsibilities. In this perspective, corporate sustainability requires firms to create long-term value while simultaneously considering environmental protection, social responsibility, stakeholder expectations, and responsible governance (Dyllick & Hockerts, 2002). Increasing concerns about climate change, resource scarcity, waste generation, packaging intensity, consumer awareness, and regulatory pressures have encouraged firms to integrate sustainability into product development, production processes, supply chain management, human resource practices, and corporate decision-making.

The cosmetics industry represents an important context for examining corporate sustainability because of its close connection with product formulation, packaging materials, raw material sourcing, production processes, product safety, ethical principles, and consumer sensitivity. Sustainability in this sector is not limited to reducing environmental impacts; it also involves clean formulation, responsible packaging, resource efficiency, cruelty-free practices, transparent communication, employee well-being, and sustainable supply chain management. Bom et al. (2019) emphasize that sustainability in the cosmetics industry should be addressed across the life cycle of cosmetic products, including ingredients, formulation, packaging, production, use, and end-of-life stages.

Circular economy is also closely related to sustainability practices in the cosmetics industry. It focuses on reducing resource use, extending product and material life cycles, increasing recycling and reuse, and minimizing waste generation (Bocken et al., 2016; Geissdoerfer et al., 2017). In this respect, sustainable packaging, recycled plastic use, waste reduction, water and energy efficiency, and responsible production practices are key areas through which cosmetics companies can operationalize sustainability.

Within this context, Flormar offers a relevant case for examining how sustainability practices can be institutionalized in the cosmetics industry. Flormar's 2024 Sustainability Report indicates that the company frames sustainability not merely as a target, but as an integral part of the way it conducts business. The report structures the company's sustainability approach around three strategic axes: "Better Formulation, Better Packaging, and Better Production," while addressing its sustainability goals through the dimensions of people, product, and planet (Flormar, 2024). These dimensions reflect a holistic approach that integrates environmental, social, and governance-related sustainability practices.

The aim of this study is to examine Flormar's corporate sustainability practices through environmental, social, and governance dimensions and to present an illustrative case of how sustainability can be institutionalized in the cosmetics industry. The study is designed as a

single case study within a qualitative research approach. The data sources consist of Flormar's 2024 Sustainability Report and information obtained through a semi-structured interview conducted with Flormar representatives. In this respect, the study aims to show that sustainability in the cosmetics industry can be understood not only as environmental compliance or corporate social responsibility, but also as a strategic management approach integrated with product development, packaging design, resource efficiency, employee well-being, supply chain management, and corporate governance.

1. CONCEPTUAL FRAMEWORK

Corporate sustainability refers to the integration of economic, environmental, and social responsibilities into firms' strategic decision-making processes. Rather than focusing only on short-term financial performance, this approach emphasizes long-term value creation, responsible resource use, stakeholder expectations, and social contribution (Dyllick & Hockerts, 2002). In this respect, sustainability has become a strategic management approach closely related to competitiveness, corporate reputation, risk management, and stakeholder relations.

In the cosmetics industry, sustainability is particularly important because of the sector's close connection with product formulation, packaging materials, raw material sourcing, production processes, product safety, and consumer sensitivity. Sustainable cosmetics practices include clean formulation, responsible packaging, waste reduction, energy and water efficiency, ethical production, and supply chain responsibility. Bom et al. (2019) argue that sustainability in cosmetics should be considered across the life cycle of products, from ingredients and formulation to packaging, production, use, and end-of-life stages.

Circular economy provides a useful perspective for understanding sustainability practices in this sector. It focuses on reducing resource consumption, extending product and material life cycles, increasing reuse and recycling, and minimizing waste generation (Bocken et al., 2016; Geissdoerfer et al., 2017). Accordingly, sustainable packaging, recycled material use, waste management, and resource efficiency can be considered key components of corporate sustainability in the cosmetics industry.

Within this conceptual framework, Flormar's sustainability practices are examined through three main dimensions: environmental, social, and governance-related sustainability. Environmental sustainability includes energy efficiency, water management, waste management, packaging transformation, carbon footprint monitoring, and biodiversity practices. Social sustainability covers women's employment, employee well-being, employee engagement, training, and social contribution. Governance-related sustainability includes sustainability governance, transparency, traceability, risk management, stakeholder communication, and sustainable supply chain management. Flormar's 2024 Sustainability

Report frames the company's sustainability strategy around "Better Formulation, Better Packaging, and Better Production," while addressing its goals through the dimensions of people, product, and planet (Flormar, 2024).

2. METHODOLOGY

This study was designed as a single case study within a qualitative research approach. The case study design was considered appropriate because the study aims to examine Flormar's corporate sustainability practices in their sectoral and organizational context. In this regard, Flormar was selected as the case because it operates in the cosmetics industry and integrates sustainability practices into product development, packaging design, production processes, supply chain management, employee well-being, and corporate governance.

The data sources of the study consist of Flormar's 2024 Sustainability Report and information obtained through a semi-structured interview conducted with Flormar representatives. The sustainability report was used to identify the company's sustainability strategy, goals, performance indicators, and main areas of practice for the period between January 1 and December 31, 2024. The interview data were used to better understand how sustainability practices are reflected in organizational processes, environmental management, social practices, and supply chain activities.

The data were analyzed through document analysis and descriptive analysis. First, Flormar's 2024 Sustainability Report was examined in detail. Then, the information obtained from the interview was compared with the report findings in order to provide a more comprehensive interpretation. During the analysis, the findings were classified under three main themes: environmental sustainability, social sustainability, and governance-related sustainability.

Data triangulation was used to strengthen the credibility of the study. Accordingly, the official sustainability report and interview data were evaluated together rather than relying on a single data source. However, since the study focuses on a single company, the findings are not intended to be generalized to the entire cosmetics industry. Instead, the study offers an illustrative case of how corporate sustainability practices can be structured and institutionalized within a cosmetics company.

3. FINDINGS

Within the scope of the study, Flormar's sustainability practices were examined through environmental, social, and governance-related dimensions. The findings obtained from Flormar's 2024 Sustainability Report and the semi-structured interview with Flormar representatives indicate that the company approaches sustainability not only as an environmental management issue, but also as a holistic management approach integrated with

product development, packaging design, production processes, employee well-being, supply chain management, digitalization, stakeholder communication, and corporate governance.

3.1. Corporate Sustainability Approach

The findings indicate that Flormar places sustainability at the center of its business model and treats it as a key component of corporate strategy. Flormar's 2024 Sustainability Report shows that the company structures its sustainability approach around three strategic axes: "Better Formulation, Better Packaging, and Better Production" (Flormar, 2024). This framework suggests that sustainability is not limited to reducing post-production environmental impacts, but is addressed across different stages of the value chain, including product formulation, packaging design, production technologies, and resource management.

Flormar's sustainability goals are organized under three main dimensions: people, product, and planet. The people dimension emphasizes diversity, inclusion, employee well-being, and responsible supply chain practices. The product dimension focuses on clean products and circular packaging, while the planet dimension highlights climate action, resource management, and biodiversity. This structure demonstrates that Flormar approaches sustainability as an integrated system combining environmental, social, and governance-related priorities.

The interview findings also support this interpretation. According to the information obtained from Flormar representatives, sustainability is not regarded as the responsibility of a single department; rather, it is integrated into occupational health and safety, environmental investments, technical projects, product design, logistics activities, human resources, and supply chain practices. This indicates that sustainability at Flormar is not only an operational practice, but also a strategic and cultural management principle embedded in the organization.

3.2. Environmental Sustainability Practices

The findings show that Flormar's environmental sustainability practices mainly focus on energy efficiency, water management, waste management, emissions monitoring, packaging transformation, and biodiversity. In its environmental approach, the company prioritizes resource efficiency, waste reduction, carbon footprint monitoring, and the minimization of environmental impacts in production processes.

In terms of energy efficiency, Flormar monitors energy consumption and implements technical improvements in production processes. The company has introduced practices such as automation, low-consumption equipment, heat recovery, and process optimization. One notable example is the replacement of resistance heating systems consuming 90 kW per hour with a water battery system, which resulted in approximately 19,000 kW of annual electricity savings (Flormar, 2024).

Water management is another important area of Flormar's environmental sustainability practices. The company implemented waterless urinals at the factory location, achieving approximately 150 tons of annual water savings. In addition, technical improvements in water filtration systems provided approximately 60 m³ of annual water savings. These practices indicate that Flormar treats water not only as an operational resource, but also as a strategic component of environmental responsibility.

Waste management and packaging transformation also constitute key components of Flormar's environmental sustainability approach. The interview findings indicate that waste is classified into categories such as cosmetic waste, recyclable waste, hazardous waste, and non-hazardous waste. The company also aims to expand zero-waste practices beyond production facilities to retail points. In packaging, Flormar has taken steps to reduce plastic use, increase recycled packaging materials, adopt more minimal labeling systems, and encourage reusable alternatives within the factory.

Flormar also monitors its carbon footprint by tracking Scope 1, Scope 2, and Scope 3 emissions. The report indicates that a large share of total emissions is associated with Scope 3 emissions, suggesting that the company considers not only direct operational emissions, but also indirect impacts related to the value chain. In addition, biodiversity practices such as insect hotel and permaculture projects show that Flormar's environmental sustainability approach is not limited to energy, water, and waste management, but also includes the protection of natural life and ecosystem balance.

3.3. Social Sustainability Practices

The findings show that Flormar's social sustainability practices focus on women's employment, diversity and inclusion, employee engagement, employee well-being, training and development, and social contribution. The company approaches social sustainability not only as a human resources issue, but also as a broader responsibility related to gender equality, employee participation, and social impact.

According to Flormar's 2024 Sustainability Report, the company has 1,022 employees, 830 of whom are women. Accordingly, women represent 81.2% of the total workforce. The report also indicates that 54% of managerial positions are held by women, showing that women's representation is strong not only in employment but also in management roles. In addition, the company's target of reaching 50% women representation in senior management by 2030 reflects its long-term commitment to gender equality (Flormar, 2024).

Employee engagement is another important component of Flormar's social sustainability approach. In 2024, the company received 51 employee suggestions, 25 of which were implemented. The employee engagement score was reported as 78%, while the employee

turnover rate decreased from 45% in 2021 to 39% in 2024. These findings suggest that Flormar supports employee participation and aims to strengthen organizational commitment.

The interview findings also indicate that Flormar supports employee well-being through career opportunities, internal training programs, flexible working practices, and work-life balance arrangements. In addition, the company carries out social contribution activities in areas such as education, disaster support, and support for young women. These practices show that social sustainability at Flormar extends beyond internal employee practices and includes broader social responsibility initiatives.

3.4. Managerial Sustainability and Supply Chain Practices

The findings indicate that Flormar's governance-related sustainability practices focus on transparency, traceability, ethical principles, risk management, stakeholder engagement, and sustainable supply chain management. Flormar's 2024 Sustainability Report states that the company's corporate governance approach is based on fairness, transparency, accountability, and responsibility. This shows that sustainability is not limited to environmental and social practices, but is also integrated into decision-making and governance processes.

Flormar has an institutional structure for sustainability governance. The report indicates that sustainability activities are supported by top management and monitored through a sustainability committee. This structure helps coordinate sustainability strategies, follow implementation processes, and spread sustainability practices across different departments.

Risk management is another important component of Flormar's governance approach. The company identifies operational, environmental, social, and governance-related risks and evaluates them according to probability and severity. This suggests that sustainability management is integrated with corporate risk management rather than being treated as a separate activity.

Sustainable supply chain management also plays a central role in Flormar's sustainability approach. The interview findings show that the company requests clean-content raw materials from suppliers, encourages sustainable packaging practices, applies supplier codes of conduct, and evaluates supplier sustainability performance through questionnaires. In this respect, Flormar's supply chain practices support traceability, ethical sourcing, and environmental responsibility.

Digitalization and data management also emerge as supportive elements of governance-related sustainability. The interview findings suggest that digital infrastructure, customer data analytics, and faster operational processes have become important areas of development. Overall, these findings show that Flormar institutionalizes sustainability through governance

mechanisms, supplier management, risk assessment, data monitoring, and cross-functional coordination.

4. CONCLUSION AND EVALUATION

This study examined Flormar's corporate sustainability practices through environmental, social, and managerial dimensions in the context of the cosmetics industry. The findings obtained from Flormar's 2024 Sustainability Report and the semi-structured interview with Flormar representatives show that the company does not treat sustainability merely as environmental compliance or corporate social responsibility. Rather, sustainability is positioned as a strategic management approach integrated into product development, packaging design, production processes, resource efficiency, employee well-being, supply chain management, and corporate governance.

The findings indicate that Flormar's sustainability approach is structured around "Better Formulation, Better Packaging, and Better Production" and linked to the dimensions of people, product, and planet (Flormar, 2024). This structure is consistent with the view that corporate sustainability requires firms to create long-term value by integrating economic, environmental, and social responsibilities into strategic decision-making processes (Dyllick & Hockerts, 2002). In the environmental dimension, Flormar's practices such as energy efficiency, water savings, waste management, emissions monitoring, recycled packaging, and biodiversity initiatives show that sustainability is embedded in different stages of the value chain.

The social and managerial findings also demonstrate that Flormar approaches sustainability as a multidimensional system. Women's employment, employee engagement, training, well-being practices, and social contribution activities reflect the human-oriented side of sustainability. In addition, sustainability governance, risk management, traceability, supplier evaluation, ethical sourcing, and digital data management show that sustainability is supported by managerial mechanisms and supply chain practices. These findings are also compatible with the broader sustainability literature in the cosmetics industry, which emphasizes product life cycle, formulation, packaging, production, use, and end-of-life stages (Bom et al., 2019), as well as circular economy principles such as reuse, recycling, resource efficiency, and waste reduction (Bocken et al., 2016; Geissdoerfer et al., 2017).

Overall, the Flormar case shows that sustainability in the cosmetics industry can be institutionalized as a holistic management approach rather than being limited to isolated environmental practices. However, the study has some limitations. Since it focuses on a single company, the findings cannot be generalized to the entire cosmetics industry. In addition, the study is limited to Flormar's 2024 Sustainability Report and interview data. Future studies may compare the sustainability practices of different cosmetics brands, examine consumer

perceptions of sustainable cosmetics, or investigate how employees and suppliers participate in sustainability-oriented transformation processes.

Declaration: During the preparation of this study, ChatGPT was used to support the linguistic coherence of the text and to assist with English-Turkish and Turkish-English translation processes.

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GÜNEY KAFKASYA'DAKİ YENİ STATÜKO KARŞISINDA AVRUPA BİRLİĞİ'NİN KARABAĞ POLİTİKASI

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Özet

Bu çalışma, 2020 savaşı ve 2023 Karabağ'ın Azerbaycan kontrolüne geçmesiyle köklü biçimde değişen güç dengesi karşısında Avrupa Birliği'nin (AB) bölgesel politikasını eleştirel bir perspektiften incelemektedir. Araştırma, AB'nin Güney Kafkasya'daki çatışma çözüm kapasitesini ve normatif dış politika araçlarının etkinliğini sorgulamaktadır.

Çalışmada AB'nin Karabağ meselesine yaklaşımının üç temel gerilim ekseninde şekillendiği ileri sürülmektedir. Bunlardan ilki enerji güvenliği çıkarları ile insan hakları normları arasındaki çelişki, ikinci egemenlik ilkesi ile azınlık hakları söylemi arasındaki gerilim ve sonuncu ise Rusya'nın bölgesel etkisinin gerilemesiyle oluşan güç boşluğunu doldurmaya yönelik AB'nin stratejik kapasitesizliği olarak tanımlanmaktadır. Bu bağlamda, AB İzleme Misyonu'nun (EUMA) Ermenistan'a konuşlandırılması ve Brüksel'de yürütülen barış görüşmeleri, AB'nin bölgedeki yeniden konumlanma çabasının somut göstergeleri olarak değerlendirilmektedir.

Nitel yöntemin benimsendiği bu araştırmada birincil kaynaklar olarak AB Konseyi kararları, Yüksek Temsilci açıklamaları ve Avrupa Parlamentosu raporları, ikincil kaynaklar olarak ise uluslararası ilişkiler ve Avrupa çalışmaları literatürü kullanılmaktadır. Analitik çerçeve, normatif güç Avrupa (Normative Power Europe) kuramı ile jeopolitik realizm yaklaşımının sentezine dayanmaktadır.

Anahtar Kelimeler: Çatışma Çözümü, AB Dış Politikası, Güney Kafkasya, Karabağ Çatışması

THE EUROPEAN UNION'S POLICY ON KARABAKH IN THE FACE OF THE NEW STATUS QUO IN THE SOUTH CAUCASUS

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Abstract

This study critically examines the European Union's regional policy in the face of the fundamentally altered balance of power brought about by the 2020 war and the transfer of Nagorno-Karabakh to Azerbaijani control in 2023. The research questions the EU's conflict resolution capacity in the South Caucasus and the effectiveness of its normative foreign policy instruments.

The study argues that the EU's approach to the Nagorno-Karabakh issue has been shaped along three core axes of tension. The first is the contradiction between energy security interests and human rights norms; the second is the tension between the principle of sovereignty and the discourse on minority rights; and the third is the EU's strategic incapacity to fill the power vacuum created by Russia's declining regional influence. In this context, the deployment of the EU Monitoring Mission (EUMA) to Armenia and the peace negotiations conducted in Brussels are assessed as concrete indicators of the EU's efforts to reposition itself in the region.

Employing a qualitative methodology, the study draws on EU Council decisions, High Representative statements, and European Parliament reports as primary sources, while the secondary sources consist of the international relations and European studies literature. The analytical framework is grounded in a synthesis of Normative Power Europe theory and the geopolitical realist approach.

Keywords: Conflict Resolution, EU Foreign Policy, South Caucasus, Karabakh Conflict

MACROECONOMIC EFFECTS OF DIGITALIZATION ON ECOLOGICAL SUSTAINABILITY: EVIDENCE FROM TURKIYE

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Abstract

This study examines the impact of digitalization on ecological sustainability in Türkiye. In the study, the Load Capacity Factor (LCF), representing ecological sustainability, was used as the dependent variable, while the internet user rate, representing digitalization, was included in the model as the main independent variable. In addition, economic growth and trade openness variables were used as control variables. First, the stationarity properties of the variables were examined with the help of unit root tests. Since the variables were stationary at different levels, the ARDL bounds testing approach was preferred to investigate the long-run relationships. The results of the bounds test revealed the existence of a cointegration relationship among the variables. According to the long-run coefficient estimates, an increase in the number of internet users positively affects ecological sustainability and reduces the ecological footprint. Similarly, economic growth was also found to support ecological sustainability in the long run. On the other hand, trade openness was found to have an increasing effect on the ecological footprint. The findings indicate that digitalization is an important tool for environmental sustainability. In this context, supporting digital transformation policies and promoting environmentally friendly technologies are of great importance in line with Türkiye's sustainable development goals.

Keywords: Ecological Sustainability, Digitalization, Information Technology, Trade Openness

DİJİTALLEŞMENİN EKOLOJİK SÜRDÜRÜLEBİLİRLİK ÜZERİNDEKİ MAKROEKONOMİK ETKİLERİ: TÜRKİYE ÖRNEĞİ

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Özet

Bu çalışmada Türkiye'de dijitalleşmenin ekolojik sürdürülebilirlik üzerindeki etkisi incelenmiştir. Çalışmada ekolojik sürdürülebilirliği temsil eden yük kapasite faktörü (LCF) bağımlı değişken olarak kullanılırken, dijitalleşmeyi temsil eden internet kullanıcı oranı temel bağımsız değişken olarak modele dahil edilmiştir. Ayrıca ekonomik büyüme ve ticari açıklık değişkenleri kontrol değişkeni olarak kullanılmıştır. Çalışmada öncelikle değişkenlerin durağanlık özellikleri birim kök testleri yardımıyla incelenmiştir. Değişkenlerin farklı düzeylerde durağan olmaları nedeniyle uzun dönem ilişkilerin incelenmesinde ARDL sınır testi yaklaşımı tercih edilmiştir. Yapılan sınır testi sonucunda değişkenler arasında eşbütünleşme ilişkisinin bulunduğu belirlenmiştir. Uzun dönem katsayı tahminlerine göre internet kullanıcı sayısındaki artışın ekolojik sürdürülebilirliği olumlu yönde etkilediği ve ekolojik ayak izini azalttığı tespit edilmiştir. Benzer şekilde ekonomik büyümenin de uzun dönemde ekolojik sürdürülebilirliği desteklediği görülmüştür. Buna karşın ticari açıklığın ekolojik ayak izi üzerinde artırıcı etkiye sahip olduğu sonucuna ulaşılmıştır. Elde edilen bulgular, dijitalleşmenin çevresel sürdürülebilirlik açısından önemli bir araç olduğunu ortaya koymaktadır. Bu bağlamda Türkiye'de sürdürülebilir kalkınma hedefleri doğrultusunda dijital dönüşüm politikalarının desteklenmesi ve çevre dostu teknolojilerin yaygınlaştırılması önem arz etmektedir.

Anahtar Kelimeler: Ekolojik Sürdürülebilirlik, Dijitalleşme, Bilgi Teknolojisi, Ticari Açıklık

INTRODUCTION

In recent years, the digital transformation process accelerating in Türkiye has generated significant effects not only on the economic and social structure but also on environmental sustainability. Developments in information and communication technologies, the widespread use of the internet, the expansion of digital platform economies, and the increase in data-driven production processes have transformed the economic performance of countries while also producing environmental consequences. In particular, examining the environmental impacts of digitalization in line with sustainable development goals has become increasingly important for both policymakers and academic circles. Today, digitalization is considered not only as a factor supporting economic growth but also as a strategic tool that promotes sustainability in areas such as energy efficiency, optimization of resource use, reduction of carbon emissions, and enhancement of environmental awareness.

Since the Industrial Revolutions, economic growth processes have often progressed alongside increased consumption of natural resources and environmental degradation. Production systems based on fossil fuel consumption, rapid urbanization, expanding industrial activities, and the growth of global trade volume have led to an increase in the ecological footprint and have threatened environmental sustainability. In this process, traditional economic growth models have been observed to intensify pressure on the environment, bringing the concept of sustainable development to the forefront. The sustainable development approach aims to achieve economic growth without compromising environmental quality. Therefore, analyzing the impact of next-generation technological transformations such as digitalization on environmental sustainability has become an important field of research.

The environmental effects of digitalization are addressed in the literature from various perspectives. According to one view, digital technologies increase energy efficiency and reduce environmental pressure through smart production systems, energy-saving applications, remote working models, and environmentally friendly innovations. In particular, the widespread adoption of internet technologies enables physical processes to be transferred into digital environments, reduces transportation needs, and optimizes resource use, thereby supporting environmental sustainability. Data analytics, decision support systems, artificial intelligence-based management applications, and enterprise information systems developed within the field of information systems also contribute to more efficient resource management in businesses. Through these systems, energy consumption, production processes, and logistics activities can be planned more efficiently, making it possible to reduce the environmental impacts of businesses. Furthermore, digital management systems enable more effective measurement of sustainability performance, analysis of environmental risks, and implementation of green transformation policies. On the other hand, factors such as the energy consumption of digital infrastructures, the high electricity demand of data centers, and the

increase in electronic waste indicate that digitalization may also have negative environmental effects. Therefore, empirically examining the relationship between digitalization and environmental sustainability at the country level is of great importance.

Türkiye is among the developing countries that have accelerated the process of digital transformation. The increase in internet usage rates, the widespread adoption of e-government applications, the expansion of digital trade volume, and the growth of technology investments have significantly enhanced Türkiye's digitalization performance. However, in line with Türkiye's economic growth objectives, the increasing demand for energy, the expansion of foreign trade volume, and the rise in industrial production also bring various risks in terms of environmental sustainability. Therefore, examining the impact of digitalization on ecological sustainability in Türkiye provides important insights for the development of sustainable development policies.

This study analyzes the macroeconomic effects of digitalization on ecological sustainability in Türkiye. In the study, the load capacity factor representing ecological sustainability is used as the dependent variable, while the internet user rate representing digitalization is included in the model as the main independent variable. In addition, economic growth and trade openness variables are employed as control variables. The main objective of the study is to reveal the long-term effects of digitalization on environmental sustainability and to develop policy recommendations for Türkiye. Within this framework, econometric analyses are utilized in the study. The findings indicate that an increase in the number of internet users supports ecological sustainability and reduces the ecological footprint. In contrast, trade openness is found to increase environmental pressure. The study is expected to contribute to the literature by examining the relationship between digitalization and environmental sustainability specifically in the case of Türkiye, while also providing guidance for policymakers.

1. LITERATURE

The relationship between digitalization and environmental sustainability has become one of the major research areas in the fields of economics, environmental economics, management information systems, and sustainable development literature in recent years. Rapid developments in information and communication technologies have transformed many areas ranging from production processes and public administration to trade and individual life, while also generating environmental impacts (Roztocki et al., 2019). In particular, the widespread use of the internet, the advancement of smart technologies, big data analytics, artificial intelligence applications, and the expansion of digital platform economies have created both direct and indirect effects on energy consumption, carbon emissions, and the use of natural resources (Bieser et al., 2018; Charfeddine & Kahia, 2021). For this reason, whether

digitalization supports environmental sustainability has become a widely debated issue in the literature.

There are differing perspectives in the literature regarding the effects of digitalization on environmental sustainability. According to the first perspective, digitalization improves environmental quality by increasing energy efficiency (Kwiliński et al., 2023). In particular, smart production systems, automation technologies, online services, remote working models, and digital data management systems (Goel et al., 2024) help optimize resource use and reduce environmental pressures (Yılmaz & Öztürkmen, 2018). Through information technologies, more effective planning of production processes, better control of energy consumption, and optimization of logistics operations contribute to sustainable development goals. Furthermore, the reduction in paper usage, the transfer of physical processes into digital environments, and the decrease in transportation needs are also considered among the factors supporting environmental sustainability.

From the perspective of digitalization and information systems literature, digital technologies are seen to strengthen the concept of sustainable management. Enterprise resource planning systems, decision support systems, big data analytics, and artificial intelligence-based management applications enable businesses to manage energy consumption more effectively (Rojek et al., 2025; Aktürk, 2026). In particular, through a data-driven management approach, businesses are able to measure their environmental performance, monitor their carbon footprints, and implement sustainability policies more effectively. In addition, digital management systems make significant contributions to the development of green logistics practices and the reduction of environmental impacts within supply chain processes. Therefore, digitalization is considered not only a technological transformation but also a strategic factor that supports sustainable management practices.

However, there are also studies in the literature arguing that digitalization may generate negative environmental impacts (Chen et al., 2020). The high energy consumption of data centers, the increase in electronic waste, the intensive use of natural resources in the production of digital devices (Siddik et al., 2021), and rising electricity consumption are considered among the environmental costs of digitalization. Particularly in developing countries, the fact that energy production largely depends on fossil fuels makes the environmental impacts of digital technologies more complex (Mirza et al., 2024). Therefore, it is emphasized that the environmental effects of digitalization should be analyzed by taking into account countries' economic structures, energy policies, and levels of technological development.

In recent years, indicators such as the ecological footprint and the load capacity factor have been widely used to measure ecological sustainability (Świąder et al., 2020). The load

capacity factor is regarded as one of the more comprehensive indicators of environmental sustainability because it reflects the relationship between a country's biocapacity and its ecological footprint. Although the number of studies examining the relationship between digitalization and ecological footprint has increased in the literature, empirical studies focusing on the load capacity factor remain limited. This constitutes one of the aspects through which the present study contributes to the literature.

In the case of Türkiye, the digital transformation process has accelerated significantly in recent years. The increase in internet usage rates, the widespread adoption of e-government applications, the growth of digital trade volume, and rising investments in information technologies have substantially improved Türkiye's digitalization performance. However, increasing economic growth, industrialization, and trade openness also bring various risks in terms of environmental sustainability. In this context, examining the impact of digitalization on ecological sustainability in Türkiye through econometric methods provides important insights for both the academic literature and policymakers. This study aims to contribute to the literature by analyzing the effects of digitalization, economic growth, and trade openness on ecological sustainability in the case of Türkiye.

2. METHOD, DATA, AND ANALYSIS

In the empirical section of the study, annual data covering the period 2003–2024 were utilized. The load capacity factor was used as the dependent variable, while internet users were included as the independent variable. Economic growth and trade openness were employed as control variables. In this section, the dataset, model specifications, and empirical methods used to examine the relationship among economic growth, trade openness, and internet users within the framework of the study are presented.

$$LCF_t = f(IU_t, GDP_t, TO_t)$$

$$LCF_t = \beta_0 + \beta_1 IU_t + \beta_2 GDP_t + \beta_3 TO_t$$

The variables used in the analysis section and their descriptions are provided in Table 1.

Table 1. Description of the Variables in the Model

Country/ Period	Variables	Explanations	Shorts	Source
Türkiye 2003-2024	Load Capacity Factor	Per capita biocapacity & ecological footprint (gha): Indicators used in LCF calculations (global hectares per person)	LCF	Global Footprint Network
	Internet User	Internet Users-Bağımsızdeğ-% of population	IU	World Bank
	Economic Growth	GDP per capita (constant 2015 US$)	GDP	World Bank
	Trade Openness	Trade openness-(% of GDP)	CO_2	World Bank

The variables included in the analysis were log-transformed, and the descriptive statistics are presented in Table 2.

Table 2. Descriptive Statistics

	lLCF	lIU	lGDP	lTO
Mean	-0.701	3.783	9.232	3.992
Median	-0.735	3.883	9.252	3.965
Maximum	-0.457	4.469	9.641	4.380
Minimum	-0.828	2.512	8.778	3.830
Std. Dev.	0.113	0.610	0.250	0.148
Skewness	0.861	-0.786	-0.037	1.007
Kurtosis	2.621	2.489	1.919	3.287
Jarque-Bera	2.853	2.509	1.075	3.799
Probability	0.241	0.285	0.584	0.149
Observations	22	22	22	22

2.1. Unit Root and Stationarity Analysis

Stationarity is of great importance in econometric analyses. In this section, stationarity is examined using unit root tests, and the results are presented in Table 3.

Table 3. Results of Unit Root Analysis

H_0: Seri durağan değildir (Birim kök içermektedir)					
	Model	**ADF**		**PP**	
		Düzeyde	**I. Farkta**	**Düzeyde**	**I. Farkta**
lLCF	C	-3.407(0.025**)	-4.212(0.004***)	-4.228(0.003***)	-4.333(0.003***)
	CT	-2.146(0.492)	-4.437(0.012**)	-1.805(0.665)	-9.193(0.001***)
lIU	C	-4.421(0.002***)	-2.752(0.083*)	-5.213(0.001***)	-2.664(0.097*)
	CT	-1.775(0.678)	-3.734(0.074*)	-1.333(0.850)	-3.581(0.057*)
lGDP	C	-0.845(0.784)	-3.839(0.009***)	-0.843(0.785)	-4.701(0.001***)
	CT	-3.782(0.039**)	-3.716(0.044**)	-3.034(0.146)	-4.419(0.011**)
lTO	C	-0.664(0.832)	-4.646(0.001***)	-1.681(0.425)	-3.066(0.498)
	CT	-3.593(0.056**)	-4.269(0.016**)	-1.864(0.636)	-2.931(0.174)

C: Constant model, CT: Constant and trend model. In the ADF test, the maximum lag length was set to 5, and the optimal lag length was determined according to the Schwarz Information Criterion. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

2.2. ARDL Bounds Test

In order to perform the ARDL bounds test, it is first necessary to determine the appropriate lag length. In this study, the optimal lag length was determined as 3. The lag lengths are presented in Table 4.

Table 4. Determining the Optimal Delay Length

Lag	**FPE**	**AIC**	**SC**	**HQ**
0	8.860	-7.190	-6.991	-7.156
1	3.590	-12.749	-11.754	-12.580
2	1.170	-14.148	-12.358	-13.845
3	2.790*	-18.777*	-16.192*	-18.340*

In line with the determined lag length, the appropriate ARDL model was selected according to the Akaike Information Criterion, and the results are presented in Figure 1. Based on the Akaike Information Criterion, the optimal ARDL model was identified as ARDL(3, 1, 3, 3).The results of the ARDL bounds test, which is used to determine the existence of a cointegration relationship, are presented in Table 5.

Table 5. Results of the ARDL Bounds

F Bounds Test H_0**: No cointegration**				
k	**F-statistic**	**Level of importance**	**Lower limit**	**Upper limit**
3	10.002	10%	2.37	3.2
		5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66

As shown in Table 5, the calculated F-statistic value is above the upper bound at all significance levels. Therefore, the null hypothesis stating that there is no cointegration relationship is rejected, and the existence of a cointegration relationship among the variables is confirmed. Once cointegration is established, both long-run and short-run relationships can be examined. The long-run results calculated based on the ARDL(3,1,3,3) model are presented in Table 6.

Table 6. Long-Term Coefficients

Değişken	**Coeff.**	**S.H**	**t-stat.**	**p-value**
lIU	-0.172	0.013	-12.607	0.001***
lGDP	-0.177	0.034	-5.180	0.003***
lTO	0.261	0.026	9.898	0.001***

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

As shown in Table 6, the long-run coefficients of the variables are statistically significant. The findings indicate that the number of internet users and gross domestic product negatively affect the load capacity factor (LCF) in the long run, and since the effect is negative, ecological sustainability deteriorates. Accordingly, a 1% increase in internet users leads to a 0.172% decrease in the LCF, while a 1% increase in gross domestic product reduces the LCF by 0.177%. In contrast, a 1% increase in trade openness results in a 0.261% increase in the LCF. These results suggest that increases in internet usage and economic growth negatively affect ecological sustainability in the long run, whereas trade openness supports ecological sustainability.

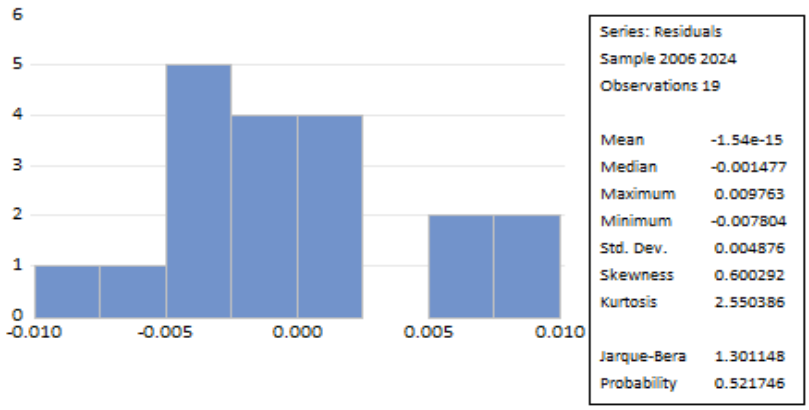
In developing economies such as Türkiye, increasing internet usage may lead to higher electricity consumption, greater use of data centers, increased consumption of electronic devices, and a rising demand for digital infrastructure energy. If energy production largely depends on fossil fuels, digitalization may worsen environmental conditions during its initial stages. This finding is actually consistent with part of the existing literature. Therefore, the

fact that digitalization in Türkiye has not yet been sufficiently supported by environmentally friendly energy infrastructure may have caused the increase in internet usage to raise energy consumption and carbon-intensive activities. This situation indicates that digitalization may generate negative effects on ecological sustainability in the short and medium term. Nevertheless, most studies in the literature argue that digitalization, internet usage, and technological development improve energy efficiency and support sustainability.

2.3. Model Assumptions

The reliability of the analysis results obtained from the established model can be assessed by checking whether certain key assumptions are satisfied. Meeting these assumptions indicates that the results are reliable. In this section of the study, the test results for the assumptions of the estimated ARDL(3,1,3,3) model will be presented. The normality assumption was tested using the Jarque-Bera test statistic, and the results are shown in Figure 1.

Şekil 1. Normallik Sınaması Sonucu



As can be seen from Figure 1, the probability value being greater than the 0.05 significance level indicates that the null hypothesis, stated as “the error terms are normally distributed,” cannot be rejected. In other words, the errors satisfy the normality assumption. The results of the autocorrelation test are presented in Table 7. The fact that the probability value is greater than the 0.05 significance level means that the null hypothesis of “no autocorrelation” cannot be rejected. Therefore, the assumption of no autocorrelation is satisfied.

Table 7. Breusch-Godfrey Serial Correlation LM Test Results

F-statistic	0.302	p-değeri	0.961
Obs R-squared	8.371		

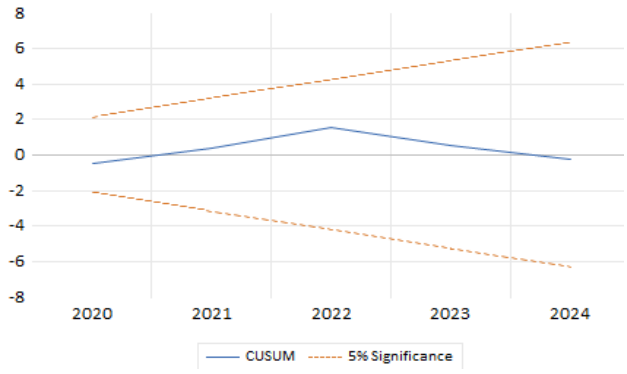
The correctness of the model's mathematical form was determined using the Ramsey RESET test. The test results are presented in Table 9. The fact that the probability value is greater than the 0.05 significance level indicates that the null hypothesis, "the model's mathematical form has been correctly specified," cannot be rejected. In other words, there is no specification error in the functional form of the model.

Table 9. Ramsey Reset Test Results

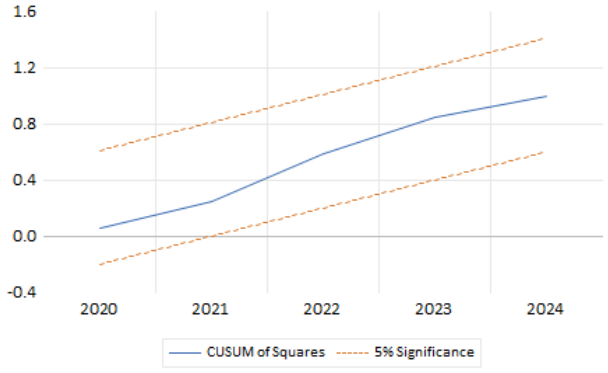
	Value	**p-value.**
t-statistic	2.126	0.102
F-statistic	4.520	0.102

The results of the CUSUM and CUSUMSQ tests, performed to determine the stability of the model's long-run coefficients, are presented in Figure 2 and Figure 3.

Şekil 2. CUSUM Test Sonucu



Şekil 3. CUSUMSQ Test Sonucu



The CUSUMSQ test is more sensitive than the CUSUM test. When Figures 2 and 3 are examined, it is observed that the plotted curves remain within the critical boundaries. This situation indicates that the estimation results are stable.

3. CONCLUSION

This study analyzes the impact of digitalization on ecological sustainability in Türkiye using data covering the period 2003–2024. The load capacity factor, representing ecological sustainability, is used as the dependent variable, while the internet user rate, representing digitalization, is included in the model as the main independent variable. In addition, economic growth and trade openness are employed as control variables. The ARDL bounds testing approach is used to determine the long-run relationships among the variables.

The empirical results indicate the existence of a cointegration relationship among the variables. According to the long-run coefficient estimates, an increase in the number of internet users has a positive effect on ecological sustainability and reduces environmental pressure. This finding suggests that digitalization can contribute to sustainable development through optimizing resource use, improving energy efficiency, and promoting environmentally friendly practices. Similarly, economic growth is found to support ecological sustainability in the long run. In contrast, trade openness is observed to have an increasing effect on the ecological footprint. This result indicates that an expansion in foreign trade volume may lead to higher energy consumption and greater environmental pressure.

The findings of the study highlight that digital transformation policies are important not only in terms of economic growth but also in terms of environmental sustainability. In this regard, it is essential to promote environmentally friendly information technologies in Türkiye, increase the use of renewable energy, and encourage investments in sustainable digital infrastructure. Furthermore, policymakers should develop regulations aimed at reducing the environmental impacts of trade activities, which is critical for achieving sustainable development goals. This study is expected to contribute to the literature by examining the relationship between digitalization and environmental sustainability in the case of Türkiye and to provide guidance for future research.

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YEŞİL ENERJİ Mİ YOKSA GİZLİ KORUMACILIK MI? AVRUPA BİRLİĞİ'NİN YEŞİL MUTABAKATI'NIN JEOEKONOMİK YÜZÜ

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Özet

Avrupa Birliği'nin Karbon Sınır Düzenleme Mekanizması (CBAM) ile desteklenen Yeşil Mutabakatı, Dünya Ticaret Örgütü'nün kurulmasından bu yana küresel ticaret rejiminin en önemli yeniden yapılanmalarından birini temsil etmektedir. Resmi olarak karbon kaçağını önlemek ve ithal edilen emisyonların fiyatını AB Emisyon Ticaret Sistemi kapsamında üretilen emisyonlarla uyumlu hale getirmek için tasarlanmış bir iklim aracı olarak çerçevelenen CBAM, aynı zamanda Avrupa üreticileri lehine rekabet avantajını yeniden dağıtan jeoekonomik bir araç olarak da işlev görmektedir. Bu makale, CBAM'ın hem çevresel yönetişim aracı hem de stratejik sanayi politikası aracı olarak ikili doğasını inceliyor ve AB'nin amiral gemisi iklim politikasının "yeşil güç" mü yoksa "gizli korumacılık" mı olduğunu sorguluyor. 2025 ve 2026 yılları arasında yayınlanan son ampirik ve teorik araştırmaların odaklanmış bir incelemesinden yararlanan makale, CBAM'ı iklim politikası, ticaret teorisi ve yeşil geçişin siyasi ekonomisinin kesişim noktasında konumlandıran analitik bir çerçeve geliştiriyor. Bulgular, CBAM'ın oldukça asimetrik sonuçlar ürettiğini göstermektedir: Ortak ülkeler üzerindeki makroekonomik etkiler toplamda mütevazı kalırken, sektörel aksama, özellikle Çin, Hindistan, Türkiye, Mısır ve Endonezya gibi ticarete bağımlı gelişmekte olan ekonomilerin karbon yoğun sektörlerinde (özellikle çelik, çimento, alüminyum ve gübre) ciddi boyutlardadır. Mekanizma, uyum maliyetleri, kurumsal uyum ve dağıtım eşitsizliği olmak üzere üçlü bir yük oluştururken, aynı zamanda asimetrik ticaret bağımlılığı koşulları altında yeşil inovasyonu ve Güney-Güney işbirliğini de hızlandırmaktadır. Makale, CBAM'ın meşruiyetinin, karbonsuzlaştırmayı ilerletip ilerletmediğine değil (ki ilerletmektedir), AB'nin bunu gelir geri dönüşümü, teknoloji transferi ve ortak ancak farklılaştırılmış sorumluluklar ilkesiyle tutarlı farklılaştırılmış muamele gibi güvenilir önlemlerle tamamlayıp tamamlamadığına bağlı olduğunu savunmaktadır. İklim hedefini ticaret eşitliğiyle uzlaştırmak için somut, uygulanabilir politika önerileri sunulmaktadır.

Anahtar Kelimeler: Karbon Sınır Düzenleme Mekanizması, Avrupa Yeşil Mutabakatı, Jeoekonomi, Karbon Kaçağı, Yeşil Korumacılık, İklim-Ticaret İlişkisi

GREEN POWER OR HİDDEN PROTECTİONİSM? THE GEOECONOMİC FACE OF THE EUROPEAN UNİON'S GREEN DEAL

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Abstract

The European Union's Green Deal, anchored by the Carbon Border Adjustment Mechanism (CBAM), represents one of the most consequential reconfigurations of the global trade regime since the establishment of the World Trade Organization. Officially framed as a climate instrument designed to prevent carbon leakage and align the price of imported emissions with those generated under the EU Emissions Trading System, CBAM simultaneously functions as a geoeconomic device that redistributes competitive advantage in favor of European producers. This paper investigates the dual nature of CBAM—as both an environmental governance tool and an instrument of strategic industrial policy—and asks whether the EU's flagship climate policy constitutes "green power" or "hidden protectionism." Drawing on a focused review of recent empirical and theoretical scholarship published between 2025 and 2026, the paper develops an analytical framework that situates CBAM at the intersection of climate policy, trade theory, and the political economy of the green transition. Findings indicate that CBAM produces highly asymmetric outcomes: while macroeconomic effects on partner countries remain modest in aggregate terms, sectoral disruption is severe in carbon-intensive industries—particularly steel, cement, aluminum, and fertilizers—of trade-dependent developing economies such as China, India, Turkey, Egypt, and Indonesia. The mechanism creates a triple burden of compliance costs, institutional adjustment, and distributional inequality, while also catalyzing green innovation and South-South cooperation under conditions of asymmetric trade dependence. The paper argues that CBAM's legitimacy depends not on whether it advances decarbonization—it does—but on whether the EU complements it with credible measures of revenue recycling, technology transfer, and differentiated treatment consistent with the principle of common but differentiated responsibilities. Concrete, implementable policy recommendations are offered to reconcile climate ambition with trade equity.

Keywords: Carbon Border Adjustment Mechanism, European Green Deal, Geoeconomics, Carbon Leakage, Green Protectionism, Climate-Trade Nexus

GİRİŞ

İklim politikası ve ticaret politikası, akademisyenler ve uygulayıcılar tarafından uzun süredir ayrı alanlar olarak ele alınırken, Avrupa Birliği'nin dış sınırında tek bir düzenleyici sürekliliğe dönüştü. Avrupa Yeşil Mutabakatı ve özellikle de Ocak 2026'da kesin aşamasına giren operasyonel temel taşı olan Karbon Sınır Ayarlama Mekanizması (CBAM), AB'yi normatif bir iklim liderinden küresel karbon piyasalarında fiyat belirleyici bir konuma dönüştürdü. İthal edilen demir ve çelik, çimento, alüminyum, gübre, elektrik ve hidrojenin gömülü emisyonlarına bir ücret uygulayarak, Birlik iç karbon fiyatını tedarik zincirleri boyunca ihraç ediyor ve tek pazarına erişim koşullarını yeniden yazıyor (Garganese, 2025; Paek & Kim, 2026). Bu hamlenin jeoekonomik önemi abartılamaz. CBAM, bağlayıcı parasal etkileri olan ilk büyük ölçekli sınır ötesi iklim politikası uygulamasıdır ve sanayi politikası, enerji güvenliği ve karbonsuzlaştırmanın yapısal olarak iç içe geçtiği bir anda ortaya çıkmaktadır. Bu mekanizma, dolayısıyla çevresel ekonominin çok ötesine geçen bir soruyu gündeme getiriyor: Yeşil Mutabakat, dünyanın geri kalanını Paris Anlaşması'na uygun hedeflere doğru çeken hayırsever bir iklim kulübü olan gerçek bir "yeşil güç" uygulaması mı, yoksa iklim gerekliliği söylemi altında Avrupa'nın endüstriyel rekabet gücünü pekiştiren sofistike bir "gizli korumacılık" biçimi mi (Zhang & Sovacool, 2025; Al-Sulaiti, 2026)

2023'ten bu yana CBAM'a yönelik akademik ilginin patlamasına rağmen, mevcut literatür bu makalenin ele almayı amaçladığı üç iç içe geçmiş boşluğu sergilemektedir. Birincisi, mevcut çalışmaların büyük çoğunluğu, toplam refah ve ticaret etkilerini nicelleştiren ancak kimin kazanıp kimin kaybettiğini belirleyen siyasi ekonomi ve dağıtım mantığını nadiren sorgulayan Hesaplamalı Genel Denge (CGE) ve Küresel Ticaret Analizi Projesi (GTAP) simülasyonlarına dayanmaktadır (Wang, C. C., vd., 2026; Wang, E. C., vd., 2026; Yue vd., 2025; Liou vd., 2025). İkincisi, Çin, Hindistan ve Körfez ülkeleri üzerindeki etkileri inceleyen ülke bazlı çalışmaların sayısı giderek artmasına rağmen, CBAM'ı daha geniş bir AB sanayi politikası mimarisi içinde stratejik bir araç olarak çerçeveleyen karşılaştırmalı jeoekonomik okumalar hala azdır; Çoğu çalışma, mekanizmayı ya bir iklim aracı ya da bir ticaret aracı olarak ele alıyor, ancak nadiren ikisini birden aynı anda ele alıyor (Abel, 2026; Hermawan vd., 2026; Kamal vd., 2025). Üçüncüsü, literatür henüz 2025-2026 yıllarında ortaya çıkan hızlı doktrinsel, yasal ve ampirik çalışmaları (Avrupa Komisyonu'nun Temiz Sanayi Anlaşması, DTÖ hukuku kapsamındaki yasal uyumluluk tartışmaları ve karbona karşı savunmasız ekonomilerden ortaya çıkan firma düzeyindeki kanıtlar dahil) tek bir argüman çerçevesine entegre etmemiştir. Bu makale, tam olarak bu ayrılıkları birleştirerek önceki araştırmalardan farklılaşıyor: CBAM'ı, iklim etkinliği stratejik ve dağıtım sonuçlarından ayrılamaz bir jeoekonomik yapıt olarak ele alıyor.

Bu analitik boşluğun giderilmemesinin maliyeti hiç de önemsiz değildir. Eğer politika yapıcılar, akademisyenler ve ticaret ortakları CBAM'ı ya tamamen çevresel bir önlem ya da

üstü örtülü bir gümrük vergisi olarak ele almaya devam ederlerse, üç zararlı sonuç ortaya çıkabilir. Birincisi, iklim işbirliği aşınabilir. CBAM'ı korumacılık olarak yanlış nitelendirmek, büyük ticaret ortaklarının misilleme önlemlerini meşrulaştırabilir; ekonometrik kanıtlar zaten bu önlemlerin AB ekonomisine zarar vereceğini ve iklim açısından telafi edici faydalar sağlamayacağını göstermektedir (Wang vd., 2025b; Perdana vd., 2026). İkincisi, politikanın çevresel etkinliği de tehlikeye girebilir. Kimya, çelik ve tedarik zinciri ağlarındaki karbon kaçağına ilişkin çalışmalar, CBAM'ın emisyon kapsamının eksik olduğunu, geçişsel tasarımının öngörülebilirlik arbitrajı yarattığını ve tamamlayıcı önlemler olmadan emisyonları azaltmak yerine sadece yeniden konumlandırabileceğini ortaya koymaktadır (Minten vd., 2025; Paek & Kim, 2026; Nagao vd., 2026). Üçüncüsü, CBAM'da örtük olarak bulunan dağıtım adaletsizliği—düşük gelirli, karbon yoğun ekonomilerdeki firmaların en büyük uyum yükünü üstlenirken AB üreticilerinin rekabet avantajı elde etmesi—çok taraflı iklim yönetişiminin daha geniş projesini gayrimeşru hale getirebilir. Başka bir deyişle, CBAM'ın jeoekonomik yüzünü haritalandırmadaki başarısızlık sadece akademik bir ihmal değil; etkili ve meşru iklim ticareti politikasının tasarımını doğrudan kısıtlamaktadır.

Bu bağlamda, mevcut çalışma iki yönlü bir amacı takip etmektedir. Birinci amacı, AB Yeşil Mutabakatı'nın jeoekonomik bir aracı olarak CBAM'ın bütünleşik, teorik temellere dayalı bir okumasını sunmaktır; bu araç aynı anda karbonsuzlaştırmayı ilerletmekte, endüstriyel rekabet gücünü yeniden yapılandırmakta ve AB'nin dış ilişkilerini yeniden şekillendirmektedir. İkinci amacı ise, en son ampirik kanıtlara dayanarak, CBAM'ın etkilerinin en iyi şekilde "yeşil güç" (meşru bir iklim kulübü) veya "gizli korumacılık" (iklim kılıfına bürünmüş stratejik bir ticaret engeli) olarak nitelendirilip nitelendirilmediğini değerlendirmektir. Makalenin ana bulguları şu şekilde özetlenebilir: CBAM, ölçülebilir, ancak mütevazı düzeyde karbon kaçağında azalmalar yaratmakta ve bazı ihracatçı ülkelerde yeşil yatırımları hızlandırmaktadır (Liou vd., 2025; Lin & Zhao, 2026); Ancak, sektörel etkileri oldukça asimetriktir ve Çin, Hindistan, Türkiye ve Endonezya gibi ülkelerdeki demir-çelik, çimento ve gübre sektörlerini orantısız bir şekilde etkilemektedir (Wang, E. C., vd., 2026; Li vd., 2026; Hermawan vd., 2026). Daha da önemlisi, politikanın dağıtım mantığı—ücretsiz izinlerin ancak 2034'ten sonra kademeli olarak kaldırılması, dar sektörel kapsam ve sınırlı teknoloji transferi hükümleri—mevcut AB endüstrilerini ayrıcalıklı kılarken uyum maliyetlerini ihraç eden bir tasarımı ortaya koymaktadır (Bye vd., 2025; Wang vd., 2025b). Bu nedenle makale, CBAM'ın ne tamamen yeşil enerji ne de tamamen korumacılık olmadığını, aksine nihai karakteri AB'nin bundan sonra ne yapacağına bağlı olacak hibrit bir jeoekonomik araç olduğunu savunmaktadır.

Bu makale, iklim-ticaret ilişkisi üzerine hızla büyüyen literatüre dört katkı sunmaktadır. Teorik olarak, mekanizmanın çevresel, rekabetçi ve dağıtım boyutlarını birbirinden ayıran birleşik bir "jeoekonomik CBAM" çerçevesi geliştirmek için politik ekonomi, iklim kulübü teorisi ve stratejik ticaret teorisinden elde edilen bilgileri bütünleştirir (Yue vd., 2025; Liou

vd., 2025; Zhang & Sovacool, 2025). Ampirik olarak, CBAM'ın bölgeler ve sektörler genelindeki beklenen etkilerinin güncel bir haritasını sağlamak için 2025-2026 yıllarında yayınlanan en son nicel kanıtları (CGE ve GTAP simülasyonları, yaşam döngüsü değerlendirmeleri, sistem dinamikleri modelleri, oyun teorisi analizleri ve firma düzeyindeki anketler dahil) sentezler (Lu vd., 2026; Minten vd., 2025; Wang vd., 2025a; Kamal vd., 2025). Kavramsal olarak, iklim-arası iklim politikalarının tek bir boyutta –iklim hedefleri veya ticaret adaleti– değil, ikisi arasındaki dinamik etkileşimde değerlendirilmesi gerektiği argümanını ileri sürmektedir; bu etkileşim, politikanın uzun vadeli meşruiyetini ve etkinliğini birlikte belirler. Son olarak, bu içgörüleri AB'ye, ticaret ortaklarına ve çok taraflı iklim-ticaret mimarisine yönelik somut, uygulanabilir politika önerilerine dönüştürmektedir.

Makalenin geri kalanı şu şekilde düzenlenmiştir: Bölüm 2, CBAM'ı iklim-ticaret ilişkisi, jeoekonomi ve yeşil sanayi politikasının politik ekonomisi üzerine daha geniş literatür içinde konumlandırarak kavramsal ve analitik çerçeveyi geliştirir. Bölüm 3, CBAM'ın ekonomik, çevresel ve dağıtım etkilerine ilişkin son ampirik kanıtları dört tematik eksen etrafında yapılandırılmış olarak sunar ve analiz eder: (i) ticaret ve rekabet gücü etkileri, (ii) sektörel ve tedarik zinciri yeniden yapılandırması, (iii) yasal ve eşitlik boyutları ve (iv) firma düzeyinde adaptasyon ve yeşil inovasyon. Bölüm 4, ampirik bulguları makalenin temel sorusu olan yeşil güç ile gizli korumacılık arasındaki ilişkiye bağlayan eleştirel bir tartışma sunar ve özellikle kanıtların ortaya koyduğu asimetrik jeoekonomik mantıklara dikkat çeker. Bölüm 5, analizi AB'ye, ortak ülkelere ve çok taraflı kurumlara yönelik somut, gerçekçi ve uygulanabilir politika önerilerine dönüştürür. Bölüm 6, CBAM'ın iklim-ticaret yönetişiminin geleceği üzerindeki daha geniş etkilerini değerlendirerek ve daha fazla araştırma için yollar belirleyerek sona ermektedir.

1. KAVRAMSAL ÇERÇEVE: İKLİM, TİCARET VE JEOEKONOMİNİN KESİŞİM NOKTASINDA CBAM

1.1. İklim Dışsallığından Jeoekonomik Araçlara

CBAM'ın entelektüel temelleri standart çevre ekonomisine dayanmaktadır: Bir yargı bölgesi kendi iç emisyonlarını fiyatlandırırken, ticaret ortakları bunu yapmadığında, karbon yoğun üretim yurt dışına kayar – sözde "karbon kaçağı" sorunu – ve tek taraflı eylemin iklimsel faydası kısmen ortadan kalkar (Garganese, 2025; Bye vd., 2025). 2005'ten beri AB Emisyon Ticaret Sistemi (ETS) içinde uygulanan geleneksel çözüm, emisyon yoğun, ticarete açık (EITE) sektörlere emisyon izinlerinin ücretsiz tahsis edilmesidir. CBAM, ithalata eşdeğer bir ücret uygulayarak bu çıktı bazlı tahsisi değiştirmek ve böylece yerli ve yabancı üreticiler arasında fiyat simetrisini yeniden sağlamak üzere tasarlanmıştır (Bye vd., 2025; Sagone & Cellura, 2025). Dar bir bakış açısıyla, mekanizma bu nedenle sınırda işleyen ders kitaplarında yer alan tipik bir Pigou aracıdır. Ancak bu teknik çerçeve, daha derin bir dönüşümü

gizlemektedir. AB, karbon fiyatını ihraç ederek, dışsallığı içselleştirmekten daha fazlasını yapıyor: piyasa erişimini Avrupa standartlarıyla düzenleyici uyuma bağlıyor ve iklim politikasını dünya ticaret sisteminin yapısal bir özelliği olarak yeniden şekillendiriyor. Bu açıdan CBAM, şüphesiz jeoekonomiktir; iklimi de içeren ancak onun ötesine geçen stratejik hedefleri takip etmek için ekonomik karşılıklı bağımlılığı ve piyasa gücünü kullanır (Al-Sulaiti, 2026; Abel, 2026).

CBAM'ı tamamen çevresel bir araçtan ziyade jeoekonomik bir araç olarak ayıran üç özellik vardır. Birincisi, tasarımı AB üreticilerinin rekabet gücüne açık bir öncelik vermektedir: ücretsiz izinler 2034 yılına kadar kademeli olarak kaldırılacak, böylece Avrupa sanayisine uzun bir uyum penceresi tanınırken, yabancı ihracatçılar neredeyse anında tam fiyatla karşı karşıya kalacaktır (Lin & Zhao, 2026; Bye vd., 2025). İkincisi, başlangıçta kapsanan sektörler—demir ve çelik, çimento, alüminyum, gübreler, elektrik ve hidrojen—tam olarak AB'nin yüksek ithalat bağımlılığına ve önemli endüstriyel geri dönüş hedeflerine sahip olduğu sektörlerdir; bu da tesadüfi değil stratejik bir sektörel seçim olduğunu göstermektedir (Abel, 2026; Johnson vd., 2025). Üçüncüsü, gömülü emisyon muhasebesi çerçevesi, Avrupa'nın düzenleyici yetki alanı içindeki tesislerin kapsam-1 emisyonlarına öncelik verirken, doğrulanmış verileri olmayan ithalatlara yüksek varsayılan değerler atayarak, üçüncü ülke firmalarını raporlama ve üretimlerini AB standartlarına uygun hale getirmeye yapısal olarak teşvik etmektedir (Minten vd., 2025; Roppolo, 2026). Bu özelliklerin her biri teknik açıdan savunulabilir olsa da, birlikte ele alındığında rekabetçi sonuçları açısından iklim açısından nötr olmayan bir politika mimarisini ortaya koymaktadır.

1.2. CBAM ve İklim Kulübü Teorisi

İkinci bir analitik bakış açısı, iddialı devletlerden oluşan küçük grupların, piyasa erişimini iklim işbirliğine bağlayarak küresel iklim yönetiminin bedavacılık sorununu aşabileceğini savunan iklim kulübü teorisi tarafından sağlanmaktadır. Yue vd. (2025), bu çerçeveyi genişleterek, CBAM'ın fiilen AB liderliğindeki bir iklim kulübünü hayata geçirdiğini ve Birleşik Krallık, Kanada, Japonya ve giderek artan bir şekilde Amerika Birleşik Devletleri'nin tamamlayıcı mekanizmaları araştırdığını savunmaktadır. Çoklu kulüp birlikteliği senaryosunda, Çin'in GSYİH kayıpları tek kulüplü bir dünyaya göre daha büyüktür, ancak emisyon azaltımları da artmaktadır (Yue vd., 2025; Wang, E. C., vd., 2026). Bu nedenle iklim kulübü teorisi, AB'nin standartlarını başarılı bir şekilde uluslararasılaştırması durumunda CBAM'ın daha geniş bir "uluslararası karbonsuzlaştırma yarışını" tetikleyeceğini öngörmektedir (Johnson vd., 2025). Ancak aynı teori bir gerilimi de vurguluyor: Kulüpler tasarımları gereği dışlayıcıdır ve dışlanmanın refah maliyetleri, yeşil teknolojilere yatırım yapma yeteneği sınırlı olan gelişmekte olan ekonomileri en çok etkiler. Yeşil enerji/korumacılık tartışmasının dayandığı analitik nokta işte budur.

1.3. Asimetrik Uyumun Siyasi Ekonomisi

Siyasi ekonomi ve küresel değer zinciri analizinden yararlanan literatürün üçüncü bir kolu, CBAM'ı yeniden dağıtım mekanizması olarak ele almaktadır. Zhang ve Sovacool (2025), Küresel Güney ekonomilerinin yaşadığı "üçlü yük etkisi"ni belgelemektedir: uyum maliyetleri, kurumsal kapasite açıkları ve yerleşik sosyal eşitsizlikler, genel tarife etkisini daha da artırmaktadır. Brezilya, Güney Afrika, Hindistan ve Çin, uyum kapasiteleri açısından belirgin farklılıklar göstermekle birlikte, dördü de yapısal olarak benzer baskılarla karşı karşıyadır. Hermawan vd. (2026), Endonezya için, toplam GSYİH etkilerinin ihmal edilebilir olmasına rağmen, çelik ve alüminyum sektörlerinde sektörel bozulmanın belirgin olduğunu, işgücü talebinde düşüş ve zorunlu yeniden tahsisin yaşandığını göstermektedir. Sagone ve Cellura (2025), Akdeniz ekonomilerini inceleyerek, CBAM'ın tasarımının ortak ancak farklılaştırılmış sorumluluklar ve ilgili yetenekler (CBDR-RC) ilkesiyle çeliştiğini göstermektedir. Firma düzeyinde ise Kamal vd. (2025) yılındaki bir çalışma, Mısır ihracatçıları arasında yeşil sermaye yoğun yatırımların önündeki en büyük engelin yönetimsel isteksizlik değil, finansal kısıtlamalar olduğunu ortaya koymaktadır. Bu çalışmalar birlikte değerlendirildiğinde, AB'nin niyetleri çevre dostu olsa bile, CBAM'ın dağıtım ağının ülkeler arası bağlamda yapısal olarak geriye dönük olduğu sonucuna varılmaktadır.

1.4. Firma Düzeyi ve Tedarik Zinciri Mekanizmaları

Dördüncü ve hızla olgunlaşan bir çalışma alanı, CBAM'ın firma düzeyindeki kararları ve küresel tedarik zincirlerini nasıl yeniden şekillendirdiğini analiz etmektedir. Oyun teorisi ve tedarik zinciri modelleri—Ürkmez ve Kayis (2026), Li vd. (2026), Chang vd. (2026) ve Nagao vd. (2026)—CBAM'ın tedarikçi seçimini, çift kaynaklı tedarik kararlarını, doğrudan yabancı yatırım ile ihracat tercihlerini ve üretimin coğrafi dağılımını değiştirdiğini göstermektedir. Wang vd. (2025a), çift karbon politikaları altında, blok zinciri destekli yeniden üretim stratejilerinin Çinli güç bataryası ihracatçıları için rasyonel olarak cazip hale geldiğini göstermektedir. Lin ve Zhao (2026), bir sistem dinamikleri modeli kullanarak, özellikle izlenebilir doğrudan tedarikli yeşil elektriğe öncelik verilmesi yoluyla, yeşil elektrik ve karbon ticareti piyasaları arasındaki sinerjinin CBAM'a en uygun maliyetli yanıt olduğunu bulmuştur. Roppolo (2026), çarpıcı bir tanım uyumsuzluğu tespit etmektedir: ABD'nin §45Q vergi indirimi, gelişmiş petrol üretimini karbon yönetimi olarak ele alırken, AB metodolojileri bunu yapmayabilir ve bu da görünüşte uyumlu iki iklim rejimi arasında gizli ticaret engelleri yaratabilir. Bu firma ve zincir düzeyindeki analizler, CBAM'ın etkilerinin son derece heterojen kanallar aracılığıyla yayıldığını ve politika sonuçlarının derinden yol bağımlı olduğunu ortaya koymaktadır.

2. KANIT: TİCARET, SEKTÖRLER, HUKUK VE ADAPTASYON

2.1. Ticaret ve Rekabet Etkileri

Son literatürde en tutarlı ampirik bulgu, CBAM'ın karbon yoğun ekonomilerden AB'ye yapılan ihracatta ölçülebilir, sektöre özgü azalmalara yol açarken, ortak ülkeler üzerindeki toplam GSYİH etkilerinin mütevazı kaldığıdır. Wang, C. C., vd. (2026), iki aşamalı bir Armington Yapısı modeli kullanarak, ABD demir ve çelik endüstrisinin farklı senaryolar altında tek başına 176,7-256,1 milyon €'luk ihracat azalmasıyla karşı karşıya olduğunu, bunun da AB'ye yönelik ihracatının %8,7-12,6'sına denk geldiğini göstermektedir; dolaylı emisyonlar fiyatlandırıldığında çimento ihracatı %12,5'e kadar düşmektedir. Wang, E. C., vd. (2026), GTAP-E'yi kullanarak, CBAM'ın Çin'in AB'ye ihracatını %0,17 ve küresel olarak %0,19 oranında baskıladığını, yüksek karbonlu endüstrilerin en çok etkilendiğini, ulaşım ekipmanı gibi düşük karbonlu sektörlerin ise aslında genişlediğini -ihracat içi ikameyi gösterdiğini- tahmin etmektedir. Li vd. (2026), Karbon-Ekonomik Eşitsizlik Endeksi ile Küresel Çok Bölgeli Girdi-Çıktı (GMRIO) çerçevesini kullanarak, Hindistan, Rusya ve Türkiye'nin ihracat rekabet gücünde en keskin düşüşlerle karşı karşıya olduğunu; Çin için ise ihracat kayıplarının ilk aşamalarda 0,78 milyar €'dan CBAM genişledikçe 11,14 milyar €'ya yükseldiğini, ancak ETS genişlemesinin bu kayıpların %30-60'ını telafi edebileceğini bulmuştur.

Bu bulgular, korumacılık tartışmasına incelik katıyor. CBAM genel bir ticaret daralmasına yol açmıyor; aksine, ticaret akışlarının karbon yoğunluğu çizgileri boyunca yeniden yönlendirilmesini tetikliyor. Yue vd. (2025), Çin'in çimento ihracatının %30'unun 2034 yılına kadar AB dışı pazarlara kayabileceğini öngörüyor; Wang, C. C., vd. (2026) ise ABD endüstrileri için benzer modelleri belgeliyor. Yan vd. (2025), dinamik bir CGE modeli kullanarak, CBAM'ın uygulanmasının, özellikle serbest izinler kaldırıldıktan sonra, Çin'in GSYİH'sını ve yüksek enerji tüketen sektörel üretimini azalttığını doğruluyor. Bununla birlikte, Liou vd. (2025), teorik gerekçelerle CBAM'ın AB dışı ülkelerde yeşil yatırımı teşvik ettiğini, piyasa rekabetini dönüştürdüğünü ve küresel yeşil enerji gelişimini hızlandırdığını savunuyor; bu da kirli sektörlerdeki rekabet gücü kayıplarının kısmen temiz sektörlerdeki kazanımlarla telafi edildiğini gösteriyor. Dolayısıyla kanıtlar ne saf korumacılık anlatısını ne de saf iklim kulübü anlatısını desteklemekte, aksine rekabet avantajının düşük karbonlu üreticiler lehine yapısal olarak yeniden dağıtılmasını desteklemektedir.

2.2. Sektörel ve Tedarik Zinciri Aksaklıkları

Sektörel analizler, CBAM'ın etkisinin, tedarik zinciri üzerinde derin etkileri olan belirli sektörlerde yoğunlaştığını ortaya koymaktadır. Çelik sektörü bunun en tipik örneğidir. Lu vd. (2026), süreç düzeyinde muhasebe çerçevesini kullanarak, Çin çelik endüstrisi için 2050 yılına kadar senaryolar genelinde sertifika maliyetlerinin 0,29-12,3 milyar CNY arasında

olacağını tahmin etmekte ve AB ETS fiyatının birincil itici güç olarak ortaya çıktığını belirtmektedir. Doğrudan indirgenmiş demir (DRI) ve elektrik ark fırını (EAF) yöntemlerinin CBAM maruziyetini önemli ölçüde azalttığını ve çeliğin Çin'in ulusal karbon piyasasına dahil edilmesinin sertifika maliyetlerinin %11,4-18,8'ini telafi edebileceğini bulmaktadırlar. Johnson vd. (2025), Nature Communications'da yayınlanan bir çalışmada, yeşil hidrojen bazlı çelik üretiminin 2026 yılından itibaren Avrupa pazarında maliyet rekabetçiliğine ulaşacağını ve bunun enerji yoğun demir üretiminin yeniden konumlandırılması ve sıcak briketlenmiş demir ticareti için önemli sonuçlar doğuracağını göstermektedir. Crisci vd. (2026) yılındaki çalışma, gübre ticaretinde CBAM'ın maliyetinin (yıllık 4,04 milyar dolar) temel varsayımlar altında çevresel faydasını (2,58 milyar dolar) 1,46 milyar dolar aştığını göstermektedir; ancak duyarlılık analizi, karbonun sosyal maliyetinin artması durumunda maliyet-fayda oranının tersine döndüğünü göstermektedir.

Kurucu sektörlerin ötesinde, literatür giderek artan bir şekilde genişleme senaryolarını inceliyor. Minten vd. (2025), küresel olarak 4.470 kimyasal üretim tesisini değerlendirerek, mevcut CBAM çerçevesinin etilen ve polietilen için üretim emisyonlarının yalnızca %50-60'ını kapsadığını, önemli miktarda yukarı yönlü emisyonun fiyatlandırılmadığını ve piyasa teşviklerinin bozulma riskini taşıdığını bulmuştur. Kalpakchiev vd. (2025), Delphi tabanlı senaryo oluşturma yoluyla, CBAM'ın fosfor geri kazanımını içerecek şekilde yeniden çerçevelendirilebileceğini ve gübre tedarik zincirlerinde döngüsel ekonomi hedeflerini ilerletebileceğini önermektedir. Nagao vd. (2026), tamsayı programlama kullanarak CBAM altında küresel tedarik zinciri ağlarını modelleyerek, mekanizmanın çoğu durumda fabrika yer değiştirmelerini teşvik ettiğini ve toplam sera gazı emisyonlarını azalttığını, ancak daha yüksek toplam maliyetle olduğunu göstermektedir. Li vd. (2026), oyun kuramı modellemesi kullanarak, yüksek CBAM sertifika fiyatlarının AB çokuluslu firmalarını özellikle çimento ve alüminyumda ithalattan ziyade doğrudan yabancı yatırıma yönlendirdiğini, çelik sektöründe ise emisyon yoğunluğu düşük olduğunda ithalatın tercih edilmeye devam ettiğini göstermektedir. Wang vd. (2025a), ikili karbon politikaları altında faaliyet gösteren güç-batarya tedarik zincirleri için, blok zinciri destekli geri dönüşüm ve yeniden üretim stratejilerinin belirsiz karbon ticareti fiyatları altında faydayı maksimize ettiğini bulmuştur.

2.3. Hukuki, Kurumsal ve Eşitlik Boyutları

Hukuk alanındaki akademik çalışmalar, CBAM'ın Dünya Ticaret Örgütü kurallarıyla uyumluluğunun tartışmalı ancak savunulabilir olduğu konusunda hemfikir olmuştur. Garganese (2025), 2023/956 sayılı Yönetmeliğin anayasal ve idari hukuk temellerini inceleyerek, CBAM'ın aynı anda yerel çevre politikasının daha gevşek yabancı rejimler tarafından baltalanmasını önlemeyi ve küresel üreticileri daha yeşil uygulamalara yönlendirmeyi amaçladığını belirtmektedir. Al-Sulaiti (2026), Körfez hidrokarbon ihracatçı ekonomileri için CBAM'ın DTÖ'deki savunulabilirliğinin tartışmalı kaldığını ve etkili

katılımın "uyumluluğun ötesine geçerek proaktif kurum inşasına" geçmeyi gerektirdiğini savunmaktadır. Abel (2026), Şubat 2025 tarihli Temiz Sanayi Anlaşmasını analiz ederek, CBAM'ın tam olarak faaliyete geçmeden önce bile yeniden düzenlendiğini ve bunun çelik ve metal sektörü için hem ekonomik hem de hukuki sonuçlar doğurduğunu vurgulamaktadır. Roppolo (2026), ABD'nin §45Q vergi indirimleri ile (bu indirimler, petrol üretimini artırmayı giderek daha fazla nitelikli karbon yönetimi olarak kabul etmektedir) AB'nin karbon giderme standartları arasında ortaya çıkan bir politika uyumsuzluğunu tespit ederek, iklim değişikliğine uyumlu ortaklar arasında bile potansiyel ticaret sürtüşmelerine yol açabileceğini belirtmektedir.

Eşitlik konusunda kanıtlar açık ve nettir. Sagone ve Cellura (2025), 138 çalışmanın PRISMA tabanlı sistematik bir incelemesiyle, CBAM'ın evrensel uygulaması ile ortak ancak farklılaştırılmış sorumluluklar ilkesi arasında çarpıcı bir boşluk olduğunu belgelemektedir; literatürün yalnızca küçük bir kısmı Akdeniz ve MENA ekonomilerinde adil uygulama için farklılaştırma kriterleriyle doğrudan ilgilenmektedir. Zhang ve Sovacool (2025), CBAM'ın dış düzenleyici baskısının yerel kurumsal reformu ve endüstriyel yükseltmeyi tetikleyebileceği, ancak yalnızca asimetrik ticaret bağımlılığı koşullarında ve yalnızca tamamlayıcı destek mevcut olduğunda gerçekleşebileceği bir "baskı-fırsat paradoksu" kavramı geliştirmiştir. Brezilya, Güney Afrika, Hindistan ve Çin'e ilişkin vaka çalışmaları, oldukça farklı uyarlanma kapasitelerini göstermektedir. Kandoul ve Poulain (2025), CBAM'ın gelişen tasarımına ilişkin tamamlayıcı gözlemsel çalışmalar sunarken, Garganese (2025) somut sonuçlar beklenmeden önce orta ve uzun vadeli bir ufka ihtiyaç duyulduğunu vurgulamaktadır. Bu çalışmaların tümü birlikte ele alındığında, CBAM'ın jeoekonomik yüzünün en açık şekilde dağıtım mantığında görüldüğü argümanını desteklemektedir.

2.4. İşletme Düzeyinde Adaptasyon ve Yeşil İnovasyon

Firma düzeyinde, CBAM'ın yatırım, tedarik ve inovasyon kararlarını finansal kapasiteye, yönetimsel yönelime ve politika desteğine bağlı şekillerde yeniden şekillendirdiğine dair kanıtlar ortaya çıkmaktadır. Kamal vd. (2025), Mısır'dan firma düzeyinde anket verilerini enstrümantal değişken ve eğilim puanı eşleştirme teknikleriyle kullanarak, yeşil yönetim uygulamalarının hem kapsamlı hem de yoğun yeşil performans marjlarını önemli ölçüde artırdığını, finansal kısıtlamaların ise sermaye yoğun yeşil yatırımı engellediğini bulmuştur. Çelik, gübre ve çimento sektörlerindeki Mısır firmaları, hükümet desteği ve danışmanlık hizmetleri aracılığıyla CBAM izleme gerekliliklerine teknik olarak uyum sağlamış olsalar da, imtiyazlı uzun vadeli finansman ve ihracat pazarı çeşitlendirmesinin gerekliliğini vurgulamaktadırlar. Ürkmez ve Kayis (2026), oyun teorisine dayalı bölünmüş tedarik modeli kullanarak, CBAM ve ETS'nin tedarikçi seçimi ve yeşil yatırım teşviklerinde karmaşık karşılıklı bağımlılıklar yarattığını ve politika etkinliğinin, talep ve arz dinamiklerini hesaba katan "iyi tasarlanmış parametrelere" bağlı olduğunu göstermektedir. Chang vd. (2026) düşük

karbonlu düzenlemelere tabi bir ülkenin yerel bir karbon vergisi uygulaması gereken bir CBAM yoğunluk eşiğini tanımlamış ve optimal oranın CBAM yoğunluğuyla birlikte kademeli olarak arttığını belirtmiştir; bu bulgu, ticaret ortaklarında tamamlayıcı politikaların tasarımı açısından önemli sonuçlar doğurmaktadır.

Wang ve ark. (2025b) farklı bir açıdan bakarak, AB'nin gelişmekte olan ülkelere düşük karbonlu teknik yardım sağlamasının, olası misilleme önlemlerinden kaynaklanabilecek olumsuz sonuçları hafifletip hafifletemeyeceğini sorguluyorlar. GTAP tabanlı simülasyonları, hem gelişmiş hem de gelişmekte olan ekonomilerin misilleme eylemlerinin AB'ye zarar vereceğini, ancak gelişmekte olan ülkeler için hedefli teknoloji desteği ve tercihli karbon tarifelerinin darbeyi yumuşattığını doğruluyor. Bu, Zhang ve Sovacool (2025) ve Sagone ve Cellura (2025) tarafından sunulan eşitlik temelli argümanları tamamlayan, AB'nin kendi refahı için farklılaştırılmış muamelenin stratejik değerini açıkça gösteren az sayıdaki çalışmadan biridir. Paek ve Kim (2026), CBAM'ın bir haftalık fiyat penceresi tasarımından yaklaşık %4,36'lık bir "öngörülebilirlik avantajı" tespit ederek finansal mühendislik boyutunu ekliyorlar; bu da uyumlu firmaların yerel fiyat minimumlarında gezinmelerine olanak tanıyor ve AB Emisyon İzinleri fiyatlarının düştüğü dönemlerde politikanın çevresel hedefini aşındırabilecek bir arbitraj fırsatı yaratıyor. Toplu olarak, bu çalışmalar firma düzeyinde adaptasyonun gerçek ancak son derece dengesiz olduğunu ve CBAM'ın dönüştürücü potansiyelinin tamamlayıcı destek yapılarına önemli ölçüde bağlı olduğunu göstermektedir.

3. TARTIŞMA: YEŞİL ENERJİ Mİ YOKSA GİZLİ KORUMACILIK MI?

Yukarıda derlenen kanıtlar, makalenin temel sorusuna, kamuoyu tartışmasının her iki tarafının da tipik olarak izin verdiğinden daha ayrıntılı bir yanıt verilmesine olanak tanıyor. CBAM, ne Avrupa korumacılığının Truva atı ne de stratejik boyutu olmayan hayırsever bir iklim politikasıdır. Bunun yerine, ikili karakteri tasarımına yerleştirilmiş ve nihai dengesi - yeşil enerji veya gizli korumacılık- AB'nin gelir kullanımı, teknoloji transferi ve ortak katılımındaki tamamlayıcı seçimleriyle belirlenecek hibrit bir jeoekonomik araçtır. Bu yorumu destekleyen üç argüman çizgisi bulunmaktadır.

İlk olarak, çevresel etkinliğe ilişkin ampirik kanıtlar gerçekten olumlu ancak eksiktir. Çok sayıda CGE ve dinamik-CGE çalışması, CBAM'ın varsayımsal duruma göre karbon kaçağını azalttığını, ihracatçı ülkelerde yeşil yatırımları hızlandırdığını ve üçüncü ülkelerde yerel karbon fiyatlandırmasını teşvik ettiğini doğrulamaktadır (Bye vd., 2025; Yan vd., 2025; Liou vd., 2025; Wang, E. C., vd., 2026). Aynı zamanda, politikanın emisyon kapsamı düzensizdir: Minten vd. (2025), mevcut kurallar altında kimya sektörü emisyonlarının yalnızca %50-60'ının yakalanacağını belgelendirirken, Paek ve Kim (2026), sertifika fiyatlandırma penceresine yerleştirilmiş önemli bir arbitraj fırsatı tespit etmektedir. Bu nedenle mekanizmanın çevresel güvenilirliği, kimyasallara, dolaylı emisyonlara ve yukarı yönlü

hammaddelere doğru yinelemeli olarak genişlemesine ve 2034'ten sonra serbest izinlerin aşamalı olarak kaldırılmasıyla birlikte sıkı önlemlerin sürdürülmesine yönelik siyasi iradeye dayanmaktadır (Lin & Zhao, 2026). Bu genişletmeler olmadan, CBAM, Yeşil Mutabakat'ın vaat ettiği derin karbonsuzlaştırmayı sağlamadan sızıntı önlemeyi başaran bir politika haline gelme riski taşımaktadır.

İkinci olarak, tasarımın jeoekonomik mantığı açıkça ortadadır ancak mutlaka gayrimeşru değildir. Serbest izinlerin kademeli olarak kaldırılması, AB'nin endüstriyel geri dönüş hedefleriyle uyumlu EITE sektörlerine öncelik verilmesi ve bildirilmeyen ithalatlar için yüksek varsayılan değerlerin kullanılması, geçiş döneminde Avrupa rekabet gücünü koruyan bir politika mimarisine işaret etmektedir (Bye vd., 2025; Abel, 2026; Johnson vd., 2025). Bu, kendi başına gizli korumacılık değildir; DTÖ ayrımcı olmayan çevre önlemlerine izin vermektedir ve AB, gerekçesini kapsamlı bir şekilde belgelemiştir. Politikayı jeoekonomik açıdan yüklü kılan şey, üç özelliğin birleşimidir: Gelişmekte olan ekonomiler üzerindeki etkilerin asimetrisi (Zhang & Sovacool, 2025; Sagone & Cellura, 2025; Hermawan vd., 2026), gelir geri dönüşümü ve teknoloji transferi için yetersiz gelişmiş mekanizmalar (Wang vd., 2025b; Lu vd., 2026) ve ortak ancak farklılaştırılmış sorumluluklar ilkesine uyumla ilgili yasal belirsizlik (Al-Sulaiti, 2026; Sagone & Cellura, 2025). Bunlar teknik kusurlar değil; AB'nin göreceli pazarlık gücünü yansıtan politik-ekonomik tercihlerdir.

Üçüncüsü, CBAM'ın dağıtım sonuçları, korumacı yönünü polemik bir konu değil, ciddi bir analitik kategori olarak ele almayı haklı çıkarıyor. Ülkeler arası kanıtlar, Hindistan, Rusya, Türkiye ve Mısır'ın orantısız rekabet gücü kayıplarıyla karşı karşıya olduğunu (Li vd., 2026; Kamal vd., 2025), Endonezya ve Çin'in karbon yoğun sektörlerinin yapısal yeniden tahsis baskılarıyla karşılaştığını (Hermawan vd., 2026; Yan vd., 2025; Lu vd., 2026) ve Akdeniz ve Körfez ekonomilerinin ciddi yasal-politik gerilimlerle karşı karşıya olduğunu (Sagone & Cellura, 2025; Al-Sulaiti, 2026) göstermektedir. Daha da önemlisi, Mısır'daki firma düzeyindeki çalışmalar (Kamal vd., 2025), yeşil yatırımlar üzerindeki en büyük kısıtlamanın imtiyazlı uzun vadeli finansmana erişim olduğunu ortaya koymaktadır; bu kısıtlama CBAM tarafından şu anda ele alınmamaktadır. Zhang ve Sovacool'un (2025) belirlediği baskı-fırsat paradoksu gerçektir: dış düzenleyici baskı, uyum kapasitesiyle karşılaştığında faydalı reformları hızlandırabilir, ancak karşılaşmadığında eşitsizlikleri de pekiştirebilir. Bu nedenle, CBAM'ın yeşil enerjiye mi yoksa gizli korumacılığa mı yöneleceği, AB'nin mekanizmayı güvenilir bir dizi ek önlemle birleştirip birleştirmemesine bağlıdır.

Dördüncü bir gözlem, stratejik etkileşim etkileriyle ilgilidir. Yue vd. (2025), çok kulüplü bir arada yaşama durumunda CBAM'ın emisyon azaltımlarının arttığını ve ticaret kaymasının yoğunlaştığını göstermektedir; Wang vd. (2025b) ve Perdana vd. (2026), misillemenin her iki taraf için de refahı azalttığını ancak Çin ve diğer büyük ihracatçılar için siyasi olarak cazip olduğunu göstermektedir. Wang vd. (2025b), AB'nin gelişmekte olan ülkelere teknoloji

desteği ve tercihli muamele sunduğunda kendi refahının arttığına dair kritik kanıtlar sunarak, stratejik cömertliğin AB'nin aydınlanmış öz çıkarına uygun olduğunu öne sürmektedir. Roppolo'nun (2026) §45Q-CBAM uyumsuzluğuna ilişkin analizi, iklimle uyumlu ortaklar (ABD ve AB) arasında bile, tanımlama uyumsuzluğunun ticaret sürtüşmelerine yol açabileceğini göstermektedir. Bu stratejik etkileşim bulguları birlikte değerlendirildiğinde, AB'nin işbirliği önlemleri yoluyla CBAM'ın jeoekonomik avantajlarını yumuşatmak için hem etik hem de kendi çıkarlarına dayalı nedenleri olduğu anlaşılıyor.

Özetle, yeşil enerji ile gizli korumacılık ikilemi, CBAM'ın gerçekliğini yansıtmak için fazla ikili bir yaklaşımdır. Bu mekanizma, gerçek bir iklim amacına, gerçek koruyucu etkilere ve önemli dağıtım sonuçlarına sahip jeoekonomik bir araçtır. Uzun vadeli meşruiyeti, söylemsel güvenceye değil, AB'nin politikanın yarattığı asimetrileri ele alan tamamlayıcı önlemleri (ortak ülkelerin karbonsuzlaştırılması için gelir geri dönüşümü, yabancı karbon fiyatlarının karşılıklı tanınması, teknoloji transferi ve prosedürel dahil etme) uygulamasına bağlıdır. Bu tür önlemler olmadan, CBAM ortaklar tarafından giderek yeşil kılıflı korumacılık olarak algılanacaktır; bu önlemlerle birlikte, daha adil bir küresel iklim rejiminin temelini oluşturabilir.

4. POLİTİKA ÖNERİLERİ

Bu bölüm, analitik bulguları Avrupa Birliği'ne, ticaret ortaklarına ve çok taraflı iklim-ticaret mimarisine yönelik somut, gerçekçi ve uygulanabilir önerilere dönüştürmektedir. Her öneri, önceki bölümlerde sunulan kanıtlara doğrudan dayanmakta ve iklim hedeflerini ticaret eşitliğiyle uzlaştırmayı amaçlamaktadır.

4.1. Avrupa Birliği İçin Öneriler

(1) İş Ortaklarının Karbonsuzlaştırılması İçin Bir CBAM Gelir Geri Dönüşüm Tesisi Kurun.

CBAM gelirlerinin öngörülebilir bir payı (başlangıçta %25, 2030 yılına kadar %50'ye yükselecek şekilde), düşük ve orta gelirli ortak ülkelerde endüstriyel karbonsuzlaştırmayı finanse eden özel bir tesise ayrılmalıdır; bu tesiste imtiyazlı uzun vadeli krediler, karma finansman araçları ve izleme, raporlama ve doğrulama (MRV) sistemleri için hedefli hibeler önceliklendirilmelidir. Lu vd. (2026) ve Kamal vd. (2025)'ten elde edilen kanıtlar, finansal kısıtlamaların karbon yoğun ekonomilerdeki firmalar için bağlayıcı bir engel olduğunu göstermektedir; bu kısıtlamaları geniş ölçekte ele almak, CBAM baskısını gerçek emisyon azaltımlarına dönüştürmenin en etkili yoludur. Tesis, siyasallaştırılmış koşullardan kaçınmak için çok taraflı kalkınma bankalarıyla birlikte yönetilmelidir.

(2) Kimyasal Sektörde Dolaylı Emisyonlar ve Hammadde Tedarik Zincirine Yönelik CBAM Uygulamasının Genişletilmesini Hızlandırın.

Minten ve ark. (2025), mevcut sektörel kapsamın kimya sektörü emisyonlarının yalnızca %50-60'ını kapsadığını göstermektedir; genişleme olmadan, CBAM piyasa teşviklerini bozma ve politikayı çevresel olarak savunmasız bırakma riski taşımaktadır. AB, kimyasalların (özellikle etilen, polietilen ve rafineri ürünleri), çelik ve alüminyumdaki dolaylı emisyonların ve Kalpakchiev ve ark. (2025)'e dayanarak fosfor geri kazanımı gibi döngüsel ekonomi yeniden çerçevelemeleri için pilot mekanizmaların dahil edilmesi için 2027 yılına kadar bağlayıcı bir yol haritası yayınlamalıdır.

(3) Öngörülebilirlik Arbitraj Açığını Kapatın.

Paek ve Kim (2026), bir haftalık fiyat aralığından kaynaklanan ortalama %4,36'lık bir öngörülebilirlik avantajı tespit etmiştir. AB, mevcut fiyat aralığını, AB Emisyon İzinleri fiyatlarının üstel ağırlıklı hareketli ortalamasıyla değiştirmeyi düşünmeli ve böylece kısa vadeli arbitraj fırsatlarını ortadan kaldırırken idari kolaylığı korumalıdır. Bu değişiklik teknik olarak küçük olsa da çevresel açıdan önemli sonuçlar doğuracaktır.

(4) Yabancı Karbon Fiyatlandırma Şemaları İçin Karşılıklı Tanıma Anlaşmaları Geliştirin.

AB, ETS eşdeğeri şemalar için öncülük edilen metodolojiyi temel alarak, Çin'in ulusal ETS'si, Güney Afrika karbon vergisi ve gelişmekte olan Latin Amerika ve Güneydoğu Asya şemaları da dahil olmak üzere, güvenilir yerel karbon fiyatlandırma mekanizmalarına sahip ticaret ortakları için basitleştirilmiş bir tanıma yolu oluşturmalıdır. Tanıma, yabancı fiyat kapsamına giren ithalatlarda CBAM sertifikası yükümlülüklerini azaltmalı veya ortadan kaldırmalıdır. Bu, Zhang ve Sovacool (2025), Sagone ve Cellura (2025) ve Al-Sulaiti (2026) tarafından dile getirilen eşitlik endişelerini doğrudan ele alacaktır.

(5) CBAM Karbon Giderme Tanımlarını Başlıca Ortaklarla Uyumlu Hale Getirin.

Roppolo (2026) tarafından tespit edilen §45Q–CBAM uyumsuzluğu, ikili ve çok taraflı diyalog yoluyla çözülebilir. AB, iklimle uyumlu ortaklar arasında istenmeyen ticaret engellerini önlemek için, ABD, İngiltere, Kanada ve Japonya ile birlikte, karbon yakalama, kullanım ve depolama için ortak bir teknik sınıflandırma geliştirmek üzere bir çalışma grubu oluşturmalıdır; bu sınıflandırma, petrol üretimini artırma ve mühendislik yoluyla karbon uzaklaştırma yöntemlerinin de üzerinde anlaşmaya varılmasını içermelidir.

4.2. Ortak Ülkeler İçin Tavsiyeler

(6) Yurtiçi Karbon Fiyatlandırmasını Güçlendirin ve Stratejik Olarak Genişletin.

Çin, Hindistan ve Endonezya'dan elde edilen kanıtlar (Lu vd., 2026; Li vd., 2026; Yan vd., 2025; Hermawan vd., 2026), yerel karbon fiyatlandırmasının, Çin örneğinde ihracat kayıplarının %30-60'ına kadarını telafi eden, karbon yoğun sektörlerin yerel ETS veya karbon vergisi sistemlerine dahil edilmesini hızlandırmalı ve elde edilen gelirleri yeşil sanayi dönüşümüne ayırmalıdır. Chang vd. (2026), karbon yoğun sektörlerin yerel karbon vergisi oranlarının, karbon yoğun sektörlerin yoğunluğu arttıkça kademeli olarak artırılmasının analitik gerekçesini sunmaktadır.

(7) Hassas Sektörlerde Hedef Odaklı Yeşil Sanayi Politikası İzleyin.

Ülkeye özgü kanıtlar (Hermawan vd., 2026; Kamal vd., 2025; Lu vd., 2026; Lin & Zhao, 2026), yeşil sanayi politikasının -yeşil hidrojen sübvansiyonları, karbon yoğun süreçlerin elektrifikasyonu ve DRI-EAF çelik üretim hatlarına yönelik hedefli destek- yatay sübvansiyonlardan daha etkili olduğunu göstermektedir.Ortak hükümetler, uyum kapasitesinin en yüksek olduğu ve CBAM maruziyetinin yoğunlaştığı sektörlere öncelik vermeli ve yapısal yeniden tahsisi kolaylaştıran işgücü piyasası politikalarıyla desteklemelidir.

(8) AB ile Yapıcı Bir Şekilde İşbirliği Yaparken İhracat Pazarlarını Çeşitlendirmek.

Kamal vd. (2025)'deki nitel kanıtlar, firmaların AB yoğunlaşma riskinin farkında olduğunu vurgulamaktadır; Yue vd. (2025) ve Wang, C. C., vd. (2026), çimento ihracatının %30'unun 2034 yılına kadar AB dışı pazarlara kayabileceğini göstermektedir. Ortak ülkeler, Wang vd. (2025b) ve Perdana vd. (2026)'nın her iki taraf için de refahı azaltıcı olduğunu gösterdiği misilleme önlemleri yerine, ihracat pazarlarının çeşitlendirilmesi (ASEAN, Körfez ve Afrika içi ticarete doğru) ve AB ile teknoloji işbirliği, yerel karbon fiyatlandırmasının tanınması ve teknik yardım konularında yapıcı bir şekilde etkileşimde bulunma gibi paralel stratejiler izlemelidir.

4.3. Çok Taraflı İklim-Ticaret Mimarisine İlişkin Öneriler

(9) Karbon Sınır Tedbirleri konusunda DTÖ-UNFCCC Koordineli Çalışma Grubu Başlatın.

Garganese (2025), Al-Sulaiti (2026) ve Abel'in (2026) hukuki analizlerine dayanarak, WTO ve UNFCCC sekreterlikleri, şeffaflık standartları, uyuşmazlık çözüm prosedürleri ve eşitlik güvenceleri de dahil olmak üzere karbon sınır önlemleri için ortak ilkeler geliştirmek üzere ortak bir teknik çalışma grubu oluşturmalıdır. Bu, ABD, İngiltere, Kanada, Japonya ve

Avustralya'nın kendi yaklaşımlarını geliştirmesiyle uyumsuz mekanizmaların parçalı bir şekilde yayılmasını önlemeye yardımcı olacaktır (Yue vd., 2025).

(10) CBDR Uyumlu Bir Farklılaştırma Mekanizmasını İşler Hale Getirin.

Sagone ve Cellura (2025), farklılaştırma kriterleri konusunda açık bir literatür boşluğu olduğunu belgeliyor. Muhtemelen UNFCCC himayesinde çok taraflı bir mekanizma, kişi başına gelir, tarihsel emisyonlar ve uyum kapasitesine dayalı olarak kademeli CBAM maruziyet seviyeleri geliştirmeli ve buna karşılık gelen indirimler, geçiş dönemleri ve teknoloji transferi hükümleri içermelidir. Bu, ortak ancak farklılaştırılmış sorumlulukların soyut ilkesini operasyonel politikaya dönüştürecek ve CBAM'ın mevcut biçimine yönelik en ciddi yasal ve etik itirazları ele alacaktır.

Bir araya getirildiğinde, bu on öneri birbirini destekleyici ve aşamalı olarak uygulanabilir niteliktedir. Hiçbiri CBAM'ın temelden yeniden tasarlanmasını gerektirmez; hepsi mevcut yasal ve kurumsal temeller üzerine kuruludur. Amaçları, CBAM'ı tek taraflı jeoekonomik bir araçtan, daha adil, etkili ve meşru bir küresel iklim-ticaret rejiminin temel taşı haline dönüştürmektir.

5. SONUÇ

Bu çalışma, Avrupa Birliği'nin Karbon Sınır Ayarlama Mekanizmasını (CBAM) Avrupa Yeşil Mutabakatı'nın jeoekonomik yüzü olarak incelemiş ve bunun "yeşil güç" mü yoksa "gizli korumacılık" mı oluşturduğunu sorgulamıştır. 2025-2026 yıllarında yayınlanan en güncel ampirik ve teorik çalışmalardan yararlanan analiz, ikiliğin çok keskin olduğunu göstermiştir. CBAM, karbon kaçağını azaltmada ve ihracatçı ekonomilerde yeşil yatırımı katalize etmede gerçekten etkilidir, ancak aynı zamanda rekabet avantajını Avrupa üreticileri lehine yeniden dağıtmakta ve sınırlı uyum kapasitesine sahip gelişmekte olan ülkelere asimetrik maliyetler yüklemektedir. Mekanizma, uzun vadeli meşruiyeti AB'nin bundan sonra ne yapacağına, özellikle de CBAM'ı gelir geri dönüşümü, karşılıklı tanıma ve teknoloji transferi gibi güvenilir önlemlerle tamamlayıp tamamlamayacağına bağlı olacak hibrit bir jeoekonomik araçtır.

Üç geniş kapsamlı sonuç ortaya çıkıyor. Birincisi, iklim-ticaret ilişkisi artık geçici bir tartışma değil, küresel ekonomik yönetişimin yapısal bir özelliğidir; akademisyenler ve politika yapıcılar, çevre ekonomisi, ticaret hukuku ve uluslararası siyasi ekonomi gibi dar disiplin alanlarının ötesine geçen entegre analitik çerçeveler geliştirmelidir. İkincisi, asimetrik uyumun siyasi ekonomisi sürekli dikkat gerektiriyor: CBAM'ın dağıtımcı sonuçları tesadüfi değil, kurucu niteliktedir ve çok taraflı işbirliğinin politikasını giderek daha fazla şekillendirecektir. Üçüncüsü, tamamlayıcı önlemlerin tasarımı -AB'nin CBAM ile birlikte ne

yapacağı- politikanın erdemli bir küresel karbonsuzlaştırma yarışına mı yol açacağını yoksa dünya ekonomisini rekabet eden iklim kulüplerine mi böleceğini belirleyecektir.

Bu analizden yola çıkarak daha fazla araştırma için çeşitli yollar ortaya çıkmaktadır. Özellikle Sahra Altı Afrika, Güney Asya ve Orta Asya'daki ek ekonomilerde, burada incelenen Mısır, Çin ve Endonezya kanıtlarını tamamlamak için firma düzeyinde çalışmalara ihtiyaç duyulmaktadır. CBAM ile diğer yeni ortaya çıkan karbon sınır önlemleri (özellikle İngiltere, Kanada ve Avustralya'da) arasındaki etkileşime ilişkin karşılaştırmalı hukuk çalışmaları genişletilmeyi hak etmektedir. Teknoloji transferi geri bildirim döngülerini içeren dinamik CGE çalışmaları, Bölüm 5'te önerilen politika karışımlarının refah etkilerini nicelleştirmeye yardımcı olacaktır. Son olarak, ücretsiz izinlerin aşamalı olarak kaldırıldığı 2026-2034 geçiş aşamasının boylamsal analizi, son literatürde ileri sürülen teorik tahminleri ampirik olarak test etmek için elzem olacaktır. Yeşil Mutabakat'ın jeoekonomik yüzü ancak önümüzdeki on yılda tam olarak görünür hale gelecektir; bunu dikkatlice izlemek, siyasi ekonomistler, ticaret avukatları ve iklim bilimcileri için en önemli görevlerden biridir.

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DİJİTAL DÖNÜŞÜM: KÜRESEL EĞİLİMLER VE SİYASAL SONUÇLAR

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Özet

Dijital dönüşüm, yirmi birinci yüzyılın ekonomik, toplumsal ve siyasal yapıları yeniden şekillendiren en güçlü küresel dinamiklerinden biri olarak öne çıkmaktadır. Bilgi ve iletişim teknolojilerindeki hızlı gelişmeler; üretim süreçlerinden kamu yönetimine, uluslararası ticaretten siyasal katılım mekanizmalarına kadar geniş bir alanda köklü değişimlere yol açmaktadır. Dijital altyapıların yaygınlaşması, veri odaklı ekonomik modellerin gelişmesi ve yapay zekâ temelli karar alma süreçlerinin kurumsallaşması, yalnızca ekonomik rekabet koşullarını dönüştürmektedir. Bu bildiri, dijital dönüşümün küresel ölçekte ortaya çıkardığı temel eğilimleri ve bunların siyasal sonuçlarını analiz etmeyi amaçlamaktadır. Çalışmada öncelikle dijital ekonominin yükselişiyle birlikte platform kapitalizminin küresel ölçekte güç kazanması, ekonomik yoğunlaşmanın artması ve veri temelli sermaye birikim modellerinin yaygınlaşması incelenmektedir. Özellikle küresel teknoloji şirketlerinin ekonomik kapasitesinin birçok devletin mali gücünü aşan bir seviyeye ulaşması, ulus-devletlerin düzenleyici yetkilerini sınamakta ve ekonomik egemenlik tartışmalarını yeniden gündeme getirmektedir. Bu süreç, klasik piyasa rekabeti anlayışının dönüşmesine ve dijital alanın yeni bir jeoekonomik rekabet sahası hâline gelmesine neden olmaktadır. Bildiri ayrıca dijital dönüşümün siyasal yönetim süreçleri üzerindeki etkilerini ele almaktadır. Dijital devlet uygulamaları, kamu hizmetlerinin daha hızlı, verimli ve erişilebilir biçimde sunulmasını mümkün kılarken; büyük veri temelli yönetim anlayışı siyasal karar alma süreçlerini daha ölçülebilir ve merkeziyetçi hâle getirmektedir. Sonuç olarak, bu çalışma, dijital dönüşümün küresel eğilimlerinin yalnızca ekonomik modernleşme ve teknolojik ilerleme perspektifinden okunamayacağını savunmaktadır. Bu nedenle dijital dönüşümün siyasal sonuçlarını anlamak, yalnızca teknoloji politikalarını değil, aynı zamanda küresel yönetişim, demokratik meşruiyet ve egemenlik tartışmalarını birlikte ele almayı gerektirmektedir. Bildiri, bu çerçevede dijital çağın siyasal yapılar üzerindeki etkilerini eleştirel bir perspektifle değerlendirerek literatüre kavramsal katkı sunmayı hedeflemektedir.

Anahtar Kelimeler: Küreselleşme, Siyasal Sistem, Dönüşüm, Dijitalleşme

DIGITAL TRANSFORMATION: GLOBAL TRENDS AND POLITICAL CONSEQUENCES

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Abstract

Digital transformation stands out as one of the most powerful global dynamics reshaping the economic, social, and political structures of the twenty-first century. Rapid advancements in information and communication technologies are leading to profound changes across a wide range of areas, from production processes to public administration, international trade, and mechanisms of political participation. The widespread adoption of digital infrastructures, the development of data-driven economic models, and the institutionalization of AI-based decision-making processes are transforming not only the conditions of economic competition but also the overall economic landscape. This paper aims to analyze the fundamental trends arising from global digital transformation and their political consequences. The study primarily examines the rise of the digital economy, the growing strength of platform capitalism globally, the increasing economic concentration, and the proliferation of data-driven models of capital accumulation. In particular, the fact that the economic capacity of global technology companies has reached levels exceeding the financial power of many states is challenging nation-states' regulatory powers and bringing economic sovereignty debates back to the forefront. This process is transforming the classical understanding of market competition and the digital realm into a new geo-economic arena of competition. The paper also addresses the impacts of digital transformation on political governance processes. While digital government applications enable the delivery of public services more quickly, efficiently, and accessibly, a big data-based governance approach makes political decision-making processes more measurable and centralized. Consequently, this study argues that global trends in digital transformation cannot be understood solely in terms of economic modernization and technological progress. Therefore, understanding the political consequences of digital transformation requires considering not only technology policies but also discussions on global governance, democratic legitimacy, and sovereignty. Within this framework, the paper aims to contribute conceptually to the literature by critically evaluating the effects of the digital age on political structures.

Keywords: Globalization, Political System, Transformation, Digitalization

GİRİŞ

Yirmi birinci yüzyılın en belirleyici gelişmelerinden biri dijital teknolojilerin ekonomik ve toplumsal yaşamın merkezine yerleşmesidir. İnternet teknolojilerinin yaygınlaşmasıyla başlayan süreç, yapay zekâ, büyük veri analitiği, blokzincir ve nesnelerin interneti gibi yeni teknolojilerin gelişimiyle daha karmaşık bir dönüşüm sürecine evrilmiştir. Günümüzde dijitalleşme yalnızca teknik bir yenilik olarak değil, ekonomik üretim biçimlerini, toplumsal ilişkileri ve siyasal yönetim süreçlerini dönüştüren kapsamlı bir paradigma değişimi olarak değerlendirilmektedir.

Dijital dönüşümün etkileri özellikle küresel ekonomi üzerinde belirgin biçimde görülmektedir. Dijital platformlar aracılığıyla faaliyet gösteren şirketlerin piyasa değerleri birçok devletin ekonomik kapasitesini aşarken, veri yeni ekonomik düzenin en stratejik kaynağı hâline gelmiştir. Bu durum yalnızca ekonomik rekabet koşullarını değiştirmemekte, aynı zamanda devletlerin düzenleyici kapasiteleri üzerinde de önemli etkiler yaratmaktadır.

Bu çalışma, dijital dönüşümün küresel ölçekte ortaya çıkardığı ekonomik ve siyasal eğilimleri incelemekte ve söz konusu dönüşümün siyasal sistemler üzerindeki etkilerini değerlendirmektedir.

1. DİJİTAL DÖNÜŞÜM VE DİJİTAL EKONOMİNİN YÜKSELİŞİ

Dijital ekonomi, ekonomik faaliyetlerin önemli ölçüde dijital teknolojiler üzerinden yürütüldüğü yeni bir ekonomik düzeni ifade etmektedir. Geleneksel üretim faktörleri olan emek, sermaye ve doğal kaynaklara ek olarak veri, ekonomik değer yaratımının temel unsurlarından biri hâline gelmiştir (Schwab, 2016).

Dördüncü Sanayi Devrimi olarak da tanımlanan bu süreçte üretim sistemleri dijital teknolojilerle bütünleşmekte ve ekonomik faaliyetlerin önemli bir bölümü çevrimiçi platformlar üzerinden gerçekleştirilmektedir. Bu dönüşümün temel özelliklerinden biri ekonomik faaliyetlerin fiziksel mekândan bağımsızlaşmasıdır. E-ticaret, dijital finans ve çevrimiçi hizmet platformları küresel ekonomik etkileşimleri hızlandırmaktadır.

Dijital ekonominin gelişimi aynı zamanda ekonomik verimlilikte artış sağlamaktadır. Yapay zekâ destekli sistemler, üretim maliyetlerini azaltırken karar alma süreçlerini hızlandırmaktadır. Bununla birlikte dijitalleşmenin ekonomik faydaları ülkeler arasında eşit biçimde dağılmamaktadır. Gelişmiş ülkeler dijital altyapı yatırımları sayesinde dönüşümden daha fazla yararlanırken, gelişmekte olan ülkeler dijital uçurum nedeniyle çeşitli dezavantajlarla karşı karşıya kalmaktadır (Castells, 2010).

2. PLATFORM KAPİTALİZMİ VE VERİ TEMELLİ SERMAYE BİRİKİMİ

Dijital dönüşümün en önemli sonuçlarından biri platform kapitalizminin ortaya çıkmasıdır. Platform kapitalizmi, ekonomik faaliyetlerin dijital platformlar aracılığıyla organize edildiği yeni bir sermaye birikim modelini ifade etmektedir (Srnicek, 2017).

Bu modelde platformlar yalnızca hizmet sunan araçlar değil, aynı zamanda veri toplama ve işleme mekanizmalarıdır. Kullanıcı davranışlarından elde edilen veriler ekonomik değere dönüştürülmekte ve şirketlerin rekabet avantajı elde etmelerinde önemli rol oynamaktadır. Böylece veri, yeni dönemin stratejik sermaye unsuru hâline gelmektedir.

Platform ekonomisinin yükselişi ekonomik yoğunlaşmayı da beraberinde getirmiştir. Küresel ölçekte faaliyet gösteren teknoloji şirketleri piyasalarda güçlü tekelleşme eğilimleri göstermektedir. Ağ etkileri nedeniyle büyük platformlar daha fazla kullanıcı çekmekte ve bu durum piyasa giriş engellerini artırmaktadır. Sonuç olarak ekonomik güç belirli şirketlerin elinde yoğunlaşmaktadır.

Bu süreç klasik piyasa ekonomisi anlayışını da dönüştürmektedir. Geleneksel sanayi kapitalizminde üretim araçlarının kontrolü belirleyici iken, dijital kapitalizmde veri ve algoritmalar ekonomik gücün temel kaynakları hâline gelmektedir.

3. DİJİTALLEŞME VE DEVLETİN DÖNÜŞÜMÜ

Dijital dönüşüm devletlerin işleyiş biçimlerini de önemli ölçüde değiştirmektedir. Kamu yönetiminde dijital teknolojilerin kullanılmasıyla birlikte e-devlet uygulamaları yaygınlaşmış ve kamu hizmetlerinin sunumunda önemli değişiklikler meydana gelmiştir.

Dijital devlet uygulamaları vatandaşların kamu hizmetlerine erişimini kolaylaştırmakta, bürokratik maliyetleri azaltmakta ve hizmet sunumunu hızlandırmaktadır. Vergi işlemleri, sağlık hizmetleri, sosyal güvenlik uygulamaları ve eğitim hizmetleri giderek daha fazla dijital platformlar üzerinden yürütülmektedir.

Ancak dijitalleşmenin kamu yönetimine sağladığı avantajların yanında çeşitli riskleri de bulunmaktadır. Büyük veri kullanımının yaygınlaşması, devletlerin vatandaşlar üzerinde daha kapsamlı gözetim mekanizmaları geliştirmesine imkân tanımaktadır. Özellikle yapay zekâ destekli izleme sistemleri bireysel özgürlükler ve mahremiyet hakları açısından önemli tartışmaları beraberinde getirmektedir (Zuboff, 2019).

4. DİJİTAL YÖNETİŞİM VE DEMOKRATİK SÜREÇLER

Dijital teknolojiler siyasal katılım biçimlerini de dönüştürmektedir. Sosyal medya platformları ve dijital iletişim araçları vatandaşların siyasal süreçlere daha hızlı katılmalarını mümkün kılmaktadır. Bu durum demokratik katılımın genişlemesi açısından önemli fırsatlar sunmaktadır. Özellikle seçim kampanyaları, kamuoyu oluşturma süreçleri ve siyasal iletişim

faaliyetleri dijital platformlar üzerinden yürütülmektedir. Siyasal aktörler seçmen davranışlarını analiz etmek amacıyla büyük veri teknolojilerinden yararlanmakta ve hedef odaklı iletişim stratejileri geliştirmektedir.

Bununla birlikte dijitalleşmenin demokrasi üzerindeki etkileri her zaman olumlu değildir. Yanlış bilginin hızlı yayılması, algoritmik manipülasyonlar ve dijital propaganda faaliyetleri demokratik süreçleri olumsuz etkileyebilmektedir. Sosyal medya platformlarının kamuoyu üzerindeki etkisi demokratik meşruiyet ve hesap verebilirlik tartışmalarını yeniden gündeme taşımaktadır (Benkler, Faris, & Roberts, 2018).

Ayrıca algoritmaların karar alma süreçlerinde artan rolü, siyasal kararların şeffaflığı konusunda yeni sorunlar ortaya çıkarmaktadır. Karar süreçlerinin teknik sistemlere devredilmesi demokratik denetim mekanizmalarının etkinliğini azaltabilmektedir.

5. DİJİTAL EGEMENLİK VE KÜRESEL GÜÇ MÜCADELESİ

Dijital dönüşüm aynı zamanda yeni bir jeoekonomik rekabet alanı yaratmaktadır. Veri merkezleri, yapay zekâ teknolojileri ve yarı iletken üretimi küresel güç mücadelesinin stratejik unsurları hâline gelmiştir.

Özellikle Amerika Birleşik Devletleri ve Çin arasında yaşanan teknoloji rekabeti dijital egemenlik kavramının önemini artırmıştır. Devletler dijital altyapılar üzerindeki kontrolü ulusal güvenliğin bir parçası olarak değerlendirmeye başlamıştır.

Bu gelişmeler dijital alanın yalnızca ekonomik değil aynı zamanda siyasal ve stratejik bir alan olduğunu göstermektedir. Dijital egemenlik tartışmaları veri yönetimi, siber güvenlik ve ulusal düzenleme kapasitesi gibi konuları uluslararası siyasetin merkezine taşımaktadır.

6. SONUÇ

Dijital dönüşüm, çağdaş dünyanın ekonomik ve siyasal yapılarında kapsamlı değişimlere yol açmaktadır. Dijital ekonomi, platform kapitalizmi ve veri temelli sermaye birikimi süreçleri küresel ekonomik düzeni yeniden şekillendirirken, devletlerin işleyişi ve demokratik süreçler de bu dönüşümden etkilenmektedir.

Çalışma göstermektedir ki dijitalleşme yalnızca teknolojik ilerleme veya ekonomik verimlilik açısından değerlendirilemez. Dijital dönüşüm aynı zamanda egemenlik, demokratik meşruiyet, siyasal katılım ve yönetişim gibi temel siyasal kavramları yeniden tanımlamaktadır. Bu nedenle dijital çağın anlaşılması, teknoloji politikalarının ötesine geçerek siyasal ekonomi ve küresel yönetişim perspektifleriyle ele alınmasını gerektirmektedir.

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DİJİTALLEŞMENİN SİYASAL EKONOMİSİ: DEVLET, PİYASA VE DÖNÜŞEN İKTİDAR İLİŞKİLERİ

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Özet

Dijitalleşme, çağdaş siyasal ve ekonomik yapıları dönüştüren en temel dinamiklerden biri olarak devlet, piyasa ve iktidar ilişkilerini yeniden şekillendirmektedir. Özellikle bilgi ve iletişim teknolojilerindeki hızlı gelişim, ekonomik üretim süreçlerinden kamu yönetimine, siyasal karar alma mekanizmalarından küresel sermaye hareketlerine kadar geniş bir alanda yapısal dönüşümlere yol açmaktadır. Bu dönüşüm yalnızca teknik bir yenilenme süreci olarak görülmemektedir. Aynı zamanda iktidarın üretim, dağıtım ve denetim biçimlerini yeniden tanımlayan çok boyutlu bir siyasal süreç ortaya çıkarmaktadır. Dijitalleşmenin ortaya çıkardığı yeni ekonomik ilişkilerin, devletin düzenleyici kapasitesini farklılaştırırken piyasa aktörlerinin siyasal süreçler üzerindeki etkisini arttırdığı düşünülmektedir. Veri temelli yönetim anlayışı klasik egemenlik ve otorite kavramlarının yeniden tartışılmasını zorunlu kılmaktadır. Bu bildiri, dijitalleşmenin siyasal ekonomi üzerindeki etkilerini devlet, piyasa ve iktidar ekseninde incelemeyi amaçlamaktadır. Çalışmada, dijital kapitalizm yaklaşımı çerçevesinde platform ekonomilerinin yükselişi, büyük veri temelli ekonomik birikim analiz edilmektedir. Özellikle dijital platformların ekonomik kaynakların dağılımında belirleyici aktörler hâline gelmesi, klasik piyasa rekabeti anlayışını dönüştürmekte ve devletlerin düzenleyici rolünü yeniden yapılandırmaktadır. Bu bağlamda dijitalleşme, bir yandan ekonomik verimlilik ve yönetsel etkinlik üretirken diğer yandan demokratik denetim sorunlarını derinleştirebilmektedir. Sonuç olarak çalışma, dijitalleşmenin ekonomik ve siyasal yapılar üzerindeki etkilerinin salt teknolojik determinizm çerçevesinde değerlendirilemeyeceğini savunmaktadır. Dijital dönüşüm, mevcut güç ilişkilerini yeniden üreten ya da dönüştüren bir siyasal mücadele alanı olarak değerlendirilmelidir. Bu bağlamda bildiri, dijitalleşmenin ortaya çıkardığı yeni iktidar ilişkilerini eleştirel bir siyasal ekonomi perspektifiyle değerlendirerek literatüre katkı sunmayı hedeflemektedir.

Anahtar Kelimeler: Dijitalleşme, Dönüşüm, Siyasal İktidar, Güç İlişkileri

THE POLITICAL ECONOMY OF DIGITALIZATION: STATE, MARKET, AND TRANSFORMING POWER RELATIONS

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Abstract

Digitalization, as one of the most fundamental dynamics transforming contemporary political and economic structures, is reshaping state, market, and power relations. In particular, rapid developments in information and communication technologies are leading to structural transformations across a wide range of areas, from economic production processes to public administration, from political decision-making mechanisms to global capital movements. This transformation is not seen merely as a technical renewal process. It also creates a multi-dimensional political process that redefines the forms of production, distribution, and control of power. It is believed that the new economic relations created by digitalization differentiate the state's regulatory capacity while increasing the influence of market actors on political processes. The data-based governance approach necessitates a re-examination of the classical concepts of sovereignty and authority. This paper examines the effects of digitalization on the political economy in the context of the state, the market, and power. The study analyzes the rise of platform economies and big data-based economic accumulation within the framework of the digital capitalism approach. The increasing influence of digital platforms as decisive actors in the allocation of economic resources is transforming the classical understanding of market competition and restructuring the regulatory role of states. In this context, while digitalization generates economic efficiency and managerial effectiveness, it can also deepen problems of democratic oversight. Consequently, this study argues that the effects of digitalization on economic and political structures cannot be evaluated solely within the framework of technological determinism. Digital transformation should be considered as a political arena of struggle that reproduces or transforms existing power relations. In this context, the paper aims to contribute to the literature by evaluating the new power relations created by digitalization from a critical political economy perspective.

Keywords: Digitalization, Transformation, Political Power, Power Relations.

GİRİŞ

Son otuz yılda yaşanan teknolojik gelişmeler, ekonomik ve siyasal sistemlerde önemli değişimlere yol açmıştır. Özellikle internet teknolojilerinin yaygınlaşması, mobil iletişim araçlarının gelişmesi ve veri işleme kapasitesindeki artış, dijitalleşmenin (Castells, 2010; Schwab, 2016) hemen her alanına nüfuz etmesini sağlamıştır. Günümüzde dijitalleşme yalnızca teknik bir yenilik olarak değil, ekonomik üretim süreçlerini, kamu yönetimini ve siyasal karar alma mekanizmalarını dönüştüren yapısal bir süreç olarak değerlendirilmektedir.

Dijital teknolojilerin yaygınlaşmasıyla birlikte devletlerin yönetsel kapasitesi artarken, küresel ölçekte faaliyet gösteren teknoloji şirketleri de ekonomik ve siyasal süreçlerde belirleyici aktörler hâline gelmiştir. Bu durum, geleneksel devlet-piyasa ilişkilerinin yeniden tanımlanmasını gerekli kılmaktadır. Özellikle veri üretimi ve veri kontrolü, ekonomik gücün (Zuboff, 2019; Srnicek, 2017) olarak ortaya çıkmaktadır.

Bu çalışma, dijitalleşmenin siyasal ekonomi üzerindeki etkilerini incelemeyi amaçlamaktadır. Bu kapsamda öncelikle dijitalleşme ve siyasal ekonomi ilişkisi teorik açıdan ele alınmakta, ardından dijital kapitalizmin yükselişi, platform ekonomilerinin etkileri ve devletin dönüşen rolü değerlendirilmektedir.

1. DİJİTALLEŞME VE SİYASAL EKONOMİ İLİŞKİSİ

Siyasal ekonomi, ekonomik süreçler ile siyasal kurumlar arasındaki (Fuchs, 2014) inceleyen disiplinlerarası bir çalışma alanıdır. Klasik siyasal ekonomi yaklaşımında devlet ve piyasa arasındaki ilişkiler ekonomik kaynakların dağılımı açısından değerlendirilirken, günümüzde dijitalleşme bu ilişkinin yeni boyutlar kazanmasına neden olmaktadır.

Dijital teknolojiler ekonomik faaliyetlerin gerçekleştirilme biçimlerini önemli ölçüde değiştirmiştir. Üretim süreçlerinin otomasyonu, elektronik ticaretin yaygınlaşması ve veri odaklı iş modellerinin gelişmesi ekonomik yapının (Castells, 2010) kazanmasını sağlamıştır. Bunun sonucunda ekonomik değer üretiminde fiziksel sermayenin yanı sıra veri, algoritma ve dijital ağlar da belirleyici unsurlar hâline gelmiştir.

Siyasal ekonomi açısından değerlendirildiğinde dijitalleşme, yalnızca ekonomik üretim ilişkilerini dönüştürmekle kalmamakta, aynı zamanda siyasal iktidarın uygulanma biçimlerini de etkilemektedir. Kamu kurumlarının dijitalleşmesiyle birlikte devletler vatandaşlar hakkında daha fazla veri toplayabilmekte ve karar alma süreçlerini veri temelli yönetim anlayışı çerçevesinde şekillendirebilmektedir. Böylece dijitalleşme, ekonomik ve siyasal güç ilişkilerinin (Zuboff, 2019) katkı sağlamaktadır.

2. DİJİTAL KAPİTALİZMİN YÜKSELİŞİ

Dijitalleşmenin siyasal ekonomi üzerindeki etkilerini açıklamak için son yıllarda geliştirilen önemli kavramlardan biri (Srnicek, 2017; Fuchs, 2014). Dijital kapitalizm, ekonomik değer üretiminin giderek veri temelli süreçlere dayanması ve dijital platformların sermaye birikiminde merkezi bir konuma yerleşmesi olarak tanımlanmaktadır.

Nick Srnicek'e göre platformlar, kullanıcılar tarafından üretilen verileri ekonomik değere dönüştüren yeni nesil (Srnicek, 2017). Google, Amazon, Meta ve Microsoft gibi küresel teknoloji şirketleri, veri toplama ve işleme kapasiteleri sayesinde piyasa üzerinde önemli bir hâkimiyet kurmaktadır. Bu şirketlerin sahip oldukları ekonomik güç, bazı durumlarda birçok devletin ekonomik kapasitesini aşabilecek düzeye ulaşmaktadır.

Dijital kapitalizm aynı zamanda yeni eşitsizlik biçimlerini de beraberinde getirmektedir. Veriye erişim imkânı bulunan büyük şirketler ile diğer ekonomik aktörler arasında oluşan güç farkı piyasa rekabetini etkilemektedir. Ağ etkileri nedeniyle büyük platformların piyasadaki konumlarını koruması kolaylaşırken yeni girişimlerin rekabet gücü sınırlanabilmektedir.

Bu süreç, klasik rekabet teorilerinin yeniden değerlendirilmesini gerekli kılmaktadır. Geleneksel piyasalarda fiyat mekanizması belirleyici olurken dijital piyasalarda veri kontrolü ve algoritmik yönetim daha önemli hâle gelmektedir. Böylece ekonomik gücün kaynakları da dönüşmektedir.

3. DEVLETİN DÖNÜŞEN ROLÜ

Dijitalleşme süreci devletin işlevlerinde de önemli değişikliklere neden olmaktadır. Bir taraftan devletler dijital teknolojiler sayesinde hizmet sunumunda etkinlik kazanmakta, diğer taraftan dijital ekonomiyi düzenleme konusunda (OECD, 2020) karşılaşmaktadır.

Elektronik devlet uygulamaları kamu hizmetlerinin daha hızlı ve düşük maliyetle sunulmasını sağlamaktadır. Vergi yönetimi, sosyal yardım sistemleri ve kamu harcamalarının izlenmesi gibi alanlarda dijital teknolojiler yönetsel kapasiteyi artırmaktadır. Bununla birlikte devletlerin dijital platformlar üzerindeki düzenleyici yetkileri giderek daha fazla tartışma konusu olmaktadır.

Özellikle küresel teknoloji şirketlerinin ulusal sınırları aşan faaliyetleri, devletlerin düzenleme kapasitesini zorlamaktadır. Veri güvenliği, kişisel verilerin korunması, dijital vergilendirme ve rekabet hukuku gibi alanlarda yeni düzenlemelere ihtiyaç duyulmaktadır. Avrupa Birliği'nin son yıllarda geliştirdiği Dijital Hizmetler Yasası ve Dijital Piyasalar Yasası (European Commission, 2022a, 2022b) bu eğilimin önemli örnekleri arasında yer almaktadır.

Dolayısıyla dijitalleşme devletin ortadan kalkmasına değil, yeni koşullara uyum sağlayan farklı bir devlet modelinin ortaya çıkmasına işaret etmektedir. Devletler hem dijital dönüşümün aktörü hem de düzenleyicisi olarak süreçte merkezi roller üstlenmektedir.

4. DİJİTALLEŞME VE İKTİDAR İLİŞKİLERİNİN YENİDEN YAPILANMASI

Dijitalleşmenin en önemli sonuçlarından biri iktidar ilişkilerinin yeniden yapılandırılmasıdır. Geleneksel siyasal sistemlerde iktidar büyük ölçüde devlet kurumları aracılığıyla kullanılırken dijital çağda özel sektör aktörleri de önemli ölçüde güç kazanmıştır.

Büyük veri analitiği, yapay zekâ uygulamaları ve algoritmik karar alma mekanizmaları bireylerin davranışlarını yönlendirme kapasitesine sahiptir. Sosyal medya platformları kamuoyu oluşumunda etkili olmakta, seçim kampanyalarından toplumsal hareketlere kadar birçok siyasal süreç üzerinde belirleyici roller üstlenebilmektedir.

Bu durum demokratik denetim açısından yeni sorunlar doğurmaktadır. Algoritmaların nasıl çalıştığının bilinmemesi, karar alma süreçlerinde şeffaflık eksikliği ve veri tekelleşmesi gibi sorunlar demokratik hesap verebilirliği (Couldry & Mejias, 2019; Zuboff, 2019) zayıflatabilmektedir. Ayrıca dijital gözetim araçlarının yaygınlaşması bireysel özgürlükler açısından da önemli tartışmalara neden olmaktadır. Bu nedenle dijitalleşmenin yalnızca ekonomik verimlilik perspektifiyle değerlendirilmesi yeterli değildir. Sürecin aynı zamanda siyasal güç ilişkileri ve demokratik yönetim ilkeleri üzerindeki etkileri de dikkate alınmalıdır.

5. SONUÇ

Dijitalleşme, çağdaş siyasal ve ekonomik sistemleri dönüştüren temel güçlerden biri olarak ortaya çıkmaktadır. Veri temelli üretim süreçleri, platform ekonomilerinin yükselişi ve dijital yönetim uygulamaları devlet, piyasa ve iktidar ilişkilerini yeniden şekillendirmektedir. Bu süreçte ekonomik gücün önemli bir kısmı dijital platformlar etrafında yoğunlaşırken devletler de yeni düzenleyici mekanizmalar geliştirmeye çalışmaktadır.

Çalışma sonucunda dijitalleşmenin yalnızca teknolojik bir ilerleme olarak değerlendirilmesinin yetersiz olduğu görülmektedir. Dijital dönüşüm aynı zamanda ekonomik kaynakların dağılımını, siyasal otoritenin kullanımını ve toplumsal güç ilişkilerini etkileyen kapsamlı bir siyasal süreçtir. Bu nedenle dijitalleşmenin etkileri eleştirel siyasal ekonomi perspektifinden analiz edilmelidir (Castells, 2010; Zuboff, 2019).

Gelecekte yapay zekâ teknolojilerinin gelişmesi, veri ekonomisinin genişlemesi ve platformların küresel etkisinin artmasıyla birlikte devlet-piyasa ilişkilerinin daha da dönüşeceği öngörülmektedir. Bu dönüşümün demokratik değerler, ekonomik adalet ve toplumsal eşitlik açısından yaratacağı sonuçlar siyasal ekonomi literatürünün temel araştırma alanlarından biri olmaya devam edecektir.

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ÇAĞDAŞ YÖNETİM YAKLAŞIMLARI EKSENİNDE KADIN LİDERLİĞİ: DÖNÜŞÜMCÜ LİDERLİK ROLÜ VE KAPSAYICI YÖNETİŞİM BAĞLAMINDA BİR DEĞERLENDİRME

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Özet

Bugünün hızla değişen iş dünyasında ve endüstriyel ekosistemlerde geleneksel liderlik modelleri artık yeterli olmamaktadır. Bu dinamik durum, modern örgütleri insan odaklı çağdaş liderlik kuramlarına yöneltmiştir. Bu kuramlar arasında yer alan "Dönüşümcü Liderlik", çalışanlara ortak bir vizyon katma, empati kurma ve kapsayıcı bir ortam yaratma yönüyle öne çıkmaktadır. Güncel araştırmalar, kadın liderlerin toplumsal cinsiyet rolleri ve ilişkisel yaklaşımları nedeniyle bu çağdaş liderlik tarzını benimsemeye daha yatkın olduğunu göstermektedir. Bu çalışmanın temel amacı, dönüşümcü liderlik yaklaşımı ile kadın liderliği arasındaki bağları kapsayıcı yönetişim ve toplumsal etkiler çerçevesinde incelemektir. Araştırma literatür taraması şeklinde gerçekleştirilmiş olup, kadın yöneticilerin kriz yönetimi, motivasyon süreçleri ve adil dönüşüm adımlarında sergiledikleri dönüşümcü liderlik pratiklerini ele alan akademik çalışmalar incelenmiştir. Elde edilen bulgular, kadın liderlerin esnek ve empatik yönetim yaklaşımlarının kriz anlarında örgütsel bağlılığı güçlendirdiğini ortaya koymaktadır. Ayrıca, kapsayıcı yönetim pratiklerinin çalışan motivasyonunu artırarak kurumsal başarıyı ve sürdürülebilirliği doğrudan pozitif etkilediği belirlenmiştir. Yapılan değerlendirmeler sonucunda, kadın liderlerin katılımcı yönetim yaklaşımlarının kurumsal başarıyı ve toplumsal kapsayıcılığı pozitif yönde etkilediği tartışılmaktadır. Bu araştırmanın, çağdaş liderlik kuramları ve toplumsal cinsiyet odağında yapılacak gelecek uygulamalı çalışmalara katkı sağlaması beklenmektedir.

Anahtar Kelimeler: Çağdaş Liderlik, Dönüşümcü Liderlik, Kadın Liderliği, Kapsayıcı Yönetişim, Toplumsal Etkiler

GİRİŞ

Ekonomik çalkantılar, hızlı teknolojik gelişmeler ve krizlerin günlük hayatın bir parçası haline gelmesi modern iş dünyasını derinden etkilemektedir. Bugünün kurum ve şirketleri, artık sadece emir-komuta zincirine ve katı hiyerarşik kurallara dayanan eski yönetim kalıplarıyla varlıklarını sürdürememektedir (Northouse, 2018). Eski yönetim tarzları gücü tek bir merkezde toplamayı ve çalışanları sıkı denetim altında tutmayı esas alırken; yeni dönem esnekliği, hızı ve insan odaklı bir yaklaşımı zorunlu kılmaktadır. Tam olarak bu noktada geleneksel modellerin yetersiz kalması, yönetim literatüründe "Çağdaş Liderlik Kuramları" şeklinde adlandırılan yeni yaklaşımların önünü açmıştır. Modern örgüt yapılarında artık çalışanların sadece fiziksel güçlerinden değil, fikirlerinden ve yaratıcılıklarından da yararlanmak bir zorunluluk haline gelmiştir. Bu durum lider ile çalışan arasındaki ilişkinin boyutunu da kökten değiştirmiştir.

Yeni nesil çağdaş yaklaşımlar arasında kurumsal düzeyde en çok benimsenen ve üzerine en çok araştırma yapılan model "Dönüşümcü Liderlik" tarzıdır (Bass, 1985). Bu liderlik biçimi, çalışanların motivasyonunu ve geleceğe yönelik bakış açılarını yukarıya taşıyarak kurumsal bir bağ kurmayı amaçlar. Baskı unsurlarından uzak, karşılıklı saygı, yüksek iletişim ve empati üzerine odaklanır. Dönüşümcü bir lider, kurumun hedefleri ile çalışanların kişisel amaçlarını ortak bir paydada buluşturabilme yeteneğine sahiptir. Bu sayede çalışanlar sadece kendilerine verilen görevleri yerine getirmekle kalmaz, kurumun geleceği için kendi istekleriyle daha fazla çaba sarf etme eğilimi gösterirler.

Bununla birlikte, modern yönetim süreçlerinde "kapsayıcılık" ve "fırsat eşitliği" ilkeleri artık sadece bir sosyal sorumluluk projesi değil, kurumsal bir gerekliliktir. Kapsayıcı yaklaşım, kadınların yönetim kademelerinde adil şekilde temsil edilmesini ve karar alma mekanizmalarında aktif rol almasını gerektirir. Toplumsal cinsiyet rolleri çerçevesinde yapılan birçok çalışma, kadınların toplumsal yapıdaki rolleri ve gelişmiş iletişim yetenekleri sayesinde dönüşümcü yönetim biçimlerine erkek meslektaşlarına göre daha yüksek bir yatkınlık gösterebildiğine işaret etmektedir (Eagly ve Carli, 2003). Kadın yöneticilerin dinleme, empati kurma ve çatışmaları büyümeden çözme konusundaki doğal eğilimleri, onları modern iş dünyasının aradığı esnek lider profiline yaklaştırmaktadır.

Bu ön kabullerden ve güncel kurumsal ihtiyaçlardan hareketle yürütülen bu araştırmanın temel amacı; çağdaş yönetim modelleri çerçevesinde dönüşümcü liderlik kuramı ile kadın liderliği arasındaki ilişkileri teorik bir temelde ele almak ve kadın yöneticilerin sergiledikleri uygulamaların kurumsal verimliliğe ve çalışan bağlılığına olan katkılarını ortaya koymaktır. Bu doğrultuda çalışma, kadın liderlerin ilişkisel ve dönüşümcü pratiklerinin kurumsal mekanizmalardaki yerini kavramsallaştırarak, yönetim literatüründe toplumsal cinsiyet odaklı teorik tartışmalara güncel bir perspektif kazandırmayı amaçlamaktadır.

1. KAVRAMSAL ÇERÇEVE VE LİTERATÜR TARAMASI

1.1. Liderlik Modellerinin Tarihsel Gelişimi

Yönetim biliminin geçmişine bakıldığında liderlik kavramı, ilk başlarda sadece doğuştan gelen bireysel yetenekler, zeka, karizma veya fiziksel özelliklerle tanımlanmıştır. "Özellikler Teorisi" olarak bilinen bu dönemden sonra, liderin somut olarak ne yaptığına ve çalışanlarına karşı nasıl davrandığına odaklanan "Davranışsal Liderlik Teorileri" geliştirilmiştir (Yukl, 2013). Zaman ilerledikçe, tek bir doğru liderlik tarzının olmadığı, en iyi yöntemin içinde bulunulan durumun şartlarına göre değiştiğini savunan "Durumsallık Yaklaşımları" literatüre egemen olmuştur.

Ancak 1980'li yıllardan sonra hız kazanan küresel rekabet ortamı ve internet çağının başlaması, bu eski ve mekanik yaklaşımları yetersiz kılmıştır. Fabrika odaklı eski iş dünyasından bilgi ve hizmet odaklı yeni iş dünyasına geçiş, liderlik anlayışını da dönüştürmüştür. Çağdaş liderlik kuramları, liderliği tek taraflı bir yönetim veya emir verme sürecinden çıkarıp; çalışanları destekleyen, onları yetkilendiren, fikirlerini önemseyen ve tamamen şeffaflığa dayanan karşılıklı bir süreç haline getirmiştir.

1.2. Dönüşümcü Liderlik Modeli ve Boyutları

Dönüşümcü liderlik, örgütlerde inovasyon, kalıcı gelişim ve yüksek motivasyon sağlamayı hedefleyen modern bir yönetim anlayışıdır. Sadece mevcut düzeni korumaya çalışan geleneksel liderlerin aksine, dönüşümcü liderler kurumlarda bir vizyon değişimi yaratmayı hedeflerler. Bu yaklaşım literatürde dört temel boyuttan güç alır (Bass ve Avolio, 1994):

1. Örnek Teşkil Etme (Karizma): Lider, sergilediği dürüstlük, iş ahlakı ve kurumsal duruşla çalışanlar için bir rol model olur. Çalışanlar lidere güvendiği için onun vizyonunu daha kolay benimserler.
2. Gelecek Vizyonu Aşılama (İlham Verme): Lider, kurumun yarınlarına dair motive edici, heyecan verici ve net bir hedef paylaşır. Takım ruhunu canlı tutarak herkesin aynı amaca inanmasını sağlar.
3. Yenilikçiliği Destekleme (Entelektüel Teşvik): Personelin eski sorunlara yeni ve yaratıcı çözümler üretmesini sürekli teşvik eder. Hata yapmanın bir öğrenme süreci olduğunu kabul ettirerek yenilikçi fikirlerin önünü açar.
4. Bireysel Değer Verme: Her çalışanın kişisel gelişim isteklerini, yeteneklerini ve ihtiyaçlarını ayrı ayrı dikkate alır. Onlara sadece bir iş gücü olarak değil, birer birey olarak yaklaşarak mentorluk ve koçluk yapar.

1.3. Toplumsal Cinsiyet Rolleri ve Yönetim Tercihleri

Toplumsal normlara ve yetiştirilme tarzlarına göre, erkek yöneticilerden genellikle daha sonuç odaklı, sert, rekabetçi, mesafeli ve bağımsız adımlar atması beklenmektedir. Buna karşın kadın yöneticilerden daha paylaşımcı, empatik, diyaloga açık ve iş birliğini önemseyen davranışlar sergilemesi beklenir (Eagly ve Wood, 2012). Bu beklentiler iş hayatındaki yönetim tarzlarına da doğrudan yansımaktadır.

Geleneksel yönetim modelleri geçmişte daha çok sert, otoriter ve mesafeli niteliklerle bağdaştırılmış, bu yüzden yönetim kademeleri uzun süre erkek egemen bir yapıda kalmıştır. Ancak modern iş dünyasının aradığı esneklik, iyi iletişim ve ekip çalışması gibi çağdaş yönetim nitelikleri, kadınların toplumsal olarak geliştirdikleri bu yapıcı özelliklerle birebir örtüşmektedir. Kadın liderlik yaklaşımı; ortaklaşa karar alma, yetkiyi çalışanlarla paylaşma ve dikey hiyerarşiler yerine yatay, açık iletişim kanalları oluşturma adımlarıyla dikkat çekmektedir (Rosener, 1990). Bu durum, kadın liderlerin modern kurumsal ihtiyaçlarla çok net bir uyum sergilediğini ortaya koymaktadır.

2. YÖNTEM

Bu çalışma, çağdaş yönetim yaklaşımları ile kadın liderliği arasındaki ilişkileri ele almak amacıyla yapılan teorik bir çalışmadır. Araştırma literatür taraması şeklinde gerçekleştirilmiş olup, kadın yöneticilerin kriz yönetimi, motivasyon süreçleri ve adil dönüşüm adımlarında sergiledikleri dönüşümcü liderlik pratiklerini ele alan akademik çalışmalar incelenmiştir. Çalışma kapsamında herhangi bir anket, mülakat veya saha uygulaması yapılmamış; tamamen mevcut yazılı literatürün taranması esas alınmıştır.

Söz konusu kaynaklar incelenirken, çalışmanın amacına doğrudan hizmet eden, kadın yöneticilerin sergiledikleri yönetim tarzlarını ve bu tarzların çalışanlar üzerindeki etkilerini ele alan çalışmalar öncelikli olarak seçilmiştir. Son aşamada ise, kadın liderlerin katılımcı ve esnek yönetim yaklaşımlarının kurumsal başarıya, iş gücü motivasyonuna ve toplumsal kapsayıcılığına olan yansımaları, taranan bu literatürdeki bulgular ışığında bütüncül bir bakış açısıyla yorumlanmıştır.

3. BULGULAR VE TARTIŞMA

3.1. Kadın Yöneticiler ve Dönüşümcü Yönetim Eğilimi

Yazındaki araştırmalar, kadın yöneticilerin dönüşümcü liderlik davranışlarıyla sıklıkla ilişkilendirildiğini göstermektedir. Yapılan bazı geniş ölçekli çalışmalarda, kadın liderlerin çalışan odaklılık, yenilikçiliği destekleme ve vizyon paylaşımı gibi alanlarda öne çıkabildiği belirtilmektedir (Eagly ve ark., 2003). Bu durum, kadın yöneticilerin katılımcı bir yönetim tarzı benimseyerek çalışan motivasyonunu gözetme eğiliminde oldukları şeklinde

yorumlanmaktadır. Kadın liderler, çalışanlarının sadece iş performanslarıyla değil, kişisel gelişim süreçleriyle de yakından ilgilenmekte ve karar alma süreçlerine astlarını dahil ederek kurum içinde adil ve şeffaf bir çalışma ortamı yaratmaktadırlar.

3.2. Zorlu Dönemlerde Kadın Liderlerin Örgütsel Bağlılığa Etkisi

Kriz süreçleri, şirketlerde ve kurumlarda belirsizliğin, stresin ve çalışan kaygısının en üst noktaya tırmandığı zorlu dönemlerdir. İlgili yazındaki araştırmalar incelendiğinde, kriz anlarında kadın liderlerin esnek, sakin ve empatik yaklaşımlarının, personelin kuruma olan bağlılığını (örgütsel bağlılık) güçlendirmede çok önemli bir rol oynadığı görülmektedir (Post ve ark., 2011). Zor zamanlarda çalışanlar katı kurallardan, cezalandırıcı yaklaşımlardan ve baskıdan ziyade; kendilerini güvende hissettirecek şeffaf bir iletişim, anlaşılma duygusu ve manevi destek aramaktadır. Kadın yöneticiler, destekleyici ve yapıcı yönleri sayesinde kriz ortamlarında iş gücünün moralini yükselterek kurum içi istikrara katkı sağlamaktadır.

3.3. Kurumsal Değişim Süreçlerinde Personel Motivasyonu

Modern iş dünyasının en temel ve kaçınılmaz gündem maddelerinden biri teknolojik adaptasyon, dijitalleşme ve sürdürülebilirlik adımlarıdır. Bu köklü değişimler, personelin yıllardır alıştığı günlük iş yapış biçimlerini sarsmakta ve kurumsal bir direnç doğurmaktadır. Çalışanlar yeni sistemlere uyum sağlarken kendilerini yetersiz hissedebilirler. Literatürdeki çalışmalar, kapsayıcı yönetim anlayışına sahip kadın liderlerin, bu geçiş süreçlerinde çalışan motivasyonunu yukarı taşıdığını doğrulamaktadır (Cook ve Glass, 2014). Kadın yöneticiler, değişim süreçlerini yukarıdan aşağıya emirlerle dayatmak yerine karşılıklı diyalogla, eğitimleri destekleyerek ve personeli yüreklendirerek yürütmektedir. Bu katılımcı yaklaşım sayesinde çalışanların yeniliklere uyum sağlama hızı ve kurumsal motivasyonu çok daha yüksek olmaktadır.

3.4. Katılımcı Yönetim ve Kurumsal Sürdürülebilirlik

Kapsayıcı yönetim anlayışı, bir kurumdaki tüm personelin fikirlerinin dinlenmesini ve çeşitliliğin korunmasını amaçlar. Yönetim basamaklarında kadın temsilinin ve kadın yönetici oranının artması, kurumsal sürdürülebilirlik ve sosyal sorumluluk hedefleri ile doğrudan pozitif bir paralellik göstermektedir (Bear ve ark., 2010). Kadın liderler, karar alma mekanizmalarına sadece finansal kârlılık çıktılarını değil; etik değerleri, çalışan haklarını ve çevreye duyarlılık unsurlarını da eklemektedir. Katılımcı yönetim uygulamaları, kurumsal başarıyı sadece kısa vadeli kazanç elde etmek olarak görmeyip, kurumu geleceğe taşıyacak uzun vadeli ve saygın bir kurumsal duruş olarak temellendirmektedir.

4. SONUÇ VE ÖNERİLER

4.1. Genel Değerlendirme

Bu araştırmada, çağdaş yönetim modelleri ve dönüşümcü liderlik kuramı ekseninde kadın liderliğinin kurumsal dinamikler üzerindeki etkileri teorik boyutta analiz edilmiştir. Elde edilen tüm yazınsal veriler ve literatür bulguları açıkça göstermektedir ki; modern iş ortamının getirdiği belirsizlikler ve hızlı değişimler, kadın liderlik özelliklerinin (empati, iyi iletişim, iş birliği, esneklik ve kapsayıcılık) kurumsal başarı için lüks değil, temel birer ihtiyaç haline gelmesine zemin hazırlamıştır. Kadın liderler, dönüşümcü liderlik anlayışını başarıyla hayata geçirerek personelin kurumsal aidiyetini artırmakta, kriz anlarında bağlılığı korumakta ve çalışma isteğini yüksek tutmaktadır. Dolayısıyla yönetimde kadın temsilinin artması sadece bir eşitlik meselesi değil, kurumların geleceği için stratejik bir gerekliliktir.

4.2. Öneriler

- Kurumsal Düzeyde Uygulama Önerileri: Şirketler, kamu kurumları ve sivil toplum kuruluşları, kadın çalışanların üst yönetim basamaklarına yükselmesini zorlaştıran görünmez engelleri (cam tavan sendromu) kaldırmak adına şeffaf, adil ve liyakate dayalı yükselme politikaları uygulamalıdır. Kurum içinde kadın çalışanlara yönelik mentorluk ve liderlik eğitim programları desteklenmelidir.
- Akademik Düzeyde Araştırma Önerileri: Bu araştırma teorik bir literatür taramasıyla sınırlandırılmıştır. Bu çalışma, çağdaş liderlik kuramları ile kadın yöneticilerin yaklaşımları arasındaki güçlü bağı teorik düzeyde ele almıştır. Gelecek çalışmalarda bu teorik çerçevenin saha araştırmaları ve somut verilerle desteklenmesi, literatürün zenginleşmesi açısından önem arz etmektedir. İleride yapılacak çalışmalarda, çağdaş liderlik modelleri ile kadın liderliği arasındaki bu güçlü bağlar, farklı sektörlerde (örneğin eğitim, sağlık, bankacılık veya teknoloji sektörlerinde) yürütülecek uygulamalı (anket, mülakat veya karma yöntemler) saha araştırmalarıyla ampirik olarak test edilmelidir.

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ADİL GEÇİŞ Mİ, SOSYAL MALİYET Mİ? AB YEŞİL DÖNÜŞÜMÜNÜN GÖRÜNMEYEN YÜZÜ

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Özet

Avrupa Birliği'nin Yeşil Mutabakatı, dünyanın en iddialı karbonsuzlaşma programıdır; ancak kamusal anlatısı ezici biçimde emisyonlar, teknoloji ve büyüme üzerinden kurulurken, Uyum maliyetlerini üstlenen kesim, çoğunlukla görünmez bir konumda kalmaktadır. Bu bildiri bilinçli olarak kutuplaştırıcı bir soru sormaktadır: AB yeşil dönüşümü gerçekten bir "adil geçiş" midir, yoksa sosyal maliyetlerin halihazırda kırılgan olan işçilere, bölgelere ve hanelere yıkılması mıdır? Çalışma, sosyal etki ve sürdürülebilirlik dönüşümleri üzerine yapılmış güncel (2023–2026) otuz hakemli çalışmaya dayanarak, yeni ampirik veri üretmek yerine İddia temelli bir literatür incelemesi ve tartışma geliştirir. Dört adımda ilerler. İlk olarak, yeşil dönüşümün sosyal risklerinin —temiz enerji teknolojilerinde kullanılan malzemelerden karbon yoğun endüstrilerin kapanışına kadar— çevresel ve ekonomik çıktılara kıyasla sistematik biçimde eksik ölçüldüğünü gösterir. İkinci olarak, bu ölçüm boşluğunun nötr olmadığını savunur: ölçülmeyen yönetilmez; dolayısıyla fiyatlandırılmayan sosyal maliyetler enerji yoksulluğu, bölgesel çöküş, yerinden edilme ve usul dışı dışlama olarak birikir. Üçüncü olarak, bu maliyetleri görünür kılmak için gereken değerlendirme araçlarının—sosyal etki değerlendirmesi, sosyal yaşam döngüsü değerlendirmesi ve eşitlik odaklı değerlendirme—halihazırda mevcut olduğunu ancak tutarsız biçimde uygulandığını ve nadiren bağlayıcı AB politikalarına gömülü olduğunu gösterir. Dördüncü olarak, bu bulguları zorunlu dağılımsal etki değerlendirmesi, koşullu geçiş finansmanı ve kurumsallaştırılmış katılım üzerine kurulu somut, gerçekçi politika önerilerine çevirir. Temel iddia şudur: yeşil dönüşümde adalet, bir finansman sorunu olmadan önce bir bilgi ve hesap verebilirlik sorunudur; sosyal maliyetler ölçülmedikçe, atfedilmedikçe ve Sorgulanabilir hale dönüştürülmedikçe "adil geçiş" önlemeyi vaat ettiği eşitsizlikleri meşrulaştıran bir slogan olarak kalma riski taşır. Dönüşümün görünmeyen yüzünü görünür kılmak, bu nedenle onu adil biçimde yönetmenin önkoşuludur. Çalışma, Avrupa Yeşil Mutabakatı'nın yalnızca teknik bir program değil, bölgeler, sınıflar ve kuşaklar arasında derin bir yeniden dağıtım süreci olduğunu vurgular ve sosyal maliyetin ölçülmesini bu sürecin meşruiyetinin temel koşulu olarak konumlandırır.

Anahtar Kelimeler: Adil Geçiş, Avrupa Yeşil Mutabakatı, Sosyal Etki Değerlendirmesi, Sosyal Maliyet, Enerji Yoksulluğu, Dağılımsal Adalet

JUST TRANSITION OR SOCIAL COST? THE INVISIBLE FACE OF THE EU GREEN TRANSITION

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Abstract

The European Union's Green Deal is the world's most ambitious decarbonization program; However, while public discourse is largely shaped around emissions, technology, and growth, the segment of society bearing the cost of adaptation remains largely invisible. This article deliberately poses a polarizing question: Is the EU's green transition truly a "just transition," or is it the shifting of social costs onto workers, regions, and households that are already vulnerable? Drawing on thirty recent (2023–2026) peer-reviewed studies on labor, social impact, and sustainability transitions, this study develops a claim-based literature review and discussion rather than generating new empirical data. It proceeds in four steps. First, the social risks of the green transition used in clean energy technologies from raw materials to the phasing out of carbon-intensive industries systematically, compared to the environmental and economic consequences indicates that it was measured incorrectly. Second, he argues that this measurement gap is not neutral: What is not measured cannot be managed; consequently, unaccounted-for social costs accumulate in the form of energy poverty, regional decline, displacement, and unfair exclusion. Third, the assessment tools needed to make these costs visible—social impact assessment, social life cycle assessment, and equity-focused assessment— shows that it currently exists but is implemented inconsistently and is rarely embedded in binding EU policies. Fourth, these findings, along with the mandatory distributional impact assessment, translates into concrete, realistic policy recommendations based on conditional transition financing and institutionalized participation. The central argument is this: in the green transition, justice is a matter of information and accountability before it is a matter of financing; unless social costs are measured, attributed, and made transparent, the "just transition" risks remaining nothing more than a slogan that legitimizes the very inequalities it claims to prevent. Making the hidden aspects of transformation visible is, therefore, a prerequisite for managing it fairly. The study emphasizes that the European Green Deal is not merely a technical program but a profound process of redistribution across regions, social classes, and generations, and positions the measurement of social costs as a fundamental condition for the legitimacy of this process.

Keywords: Just Transition, European Green Deal, Social İmpact Assessment, Social Costs, Energy Poverty, Distributive Justice

GİRİŞ

Avrupa Yeşil Mutabakatı, Avrupa Birliği'ni 2050 itibarıyla iklim nötr olmaya zorunlu kılmakta ve enerji sistemlerini, sanayiyi, ulaşımı, tarımı ve finansı tek bir karbonsuzlaşma buyruğu etrafında yeniden örgütlemektedir. Bir uygarlık projesi olarak iklim krizinin ölçeğiyle meşrulaştırılır ve çevresel mantığı ikna edicidir: toplumlar, iki yüzyıldır modern refahı ayakta tutan fosil yakıtlardan hızla uzaklaşmak zorundadır (Beckfield & Evrard, 2023). Bu nedenle karbonsuzlaşma, pek çok politikadan biri değil, Avrupa yaşamının maddi temelinin yapısal bir dönüşümüdür; evlerin nasıl ısıtıldığına, malların nasıl üretildiğine ve işçilerin nasıl geçindiğine dokunur (Lazaroiu et al., 2024). Tam da erişim alanı bu denli bütünsel olduğu için, dönüşüm yalnızca teknik ya da ekonomik bir girişim değil, riskleri, maliyetleri ve fırsatları bölgeler, sınıflar ve kuşaklar arasında yeniden dağıtan derinden sosyal bir girişimdir. Bu yeniden dağıtımı doğru yapmanın önemini abartmak zordur: tüm iklim gündeminin meşruiyeti ve nihayetinde uygulanabilirliği, yurttaşların bunu adil olarak deneyimleyip deneyimlemediğine bağlıdır.

Ne var ki dönüşümün baskın çerçevelemesi asimetriktir. Kamusal tartışma, kurumsal raporlama ve hatta akademik değerlendirme çevresel ölçütleri—önlenen CO_2 tonu, kurulan yenilenebilir kapasite, sağlanan verimlilik—ve yeşil istihdam ile yatırım gibi ekonomik ölçütleri önceliklendirirken, sosyal boyut artık bir kategori olarak ele alınır; retöriksel olarak anılır ama nadiren ölçülür (Bianchi et al., 2025; Zimek & Baumgartner, 2024). Bu asimetrinin sonuçları vardır. Bir sistemdeki iyileşmenin daha büyük toplumsal sisteme otomatik olarak yarar sağlayacağı varsayıldığında, yükler ortadan kaldırılmak yerine sessizce kaydırılır (Zimek & Baumgartner, 2024). Böylece dönüşümün görünmeyen bir yüzü ortaya çıkar: yönetilen çöküşle karşı karşıya kalan kömür bölgeleri, yükselen enerji ve yenileme maliyetlerine maruz kalan düşük gelirli haneler ve temiz teknolojilerin tedarik zincirleri boyunca çıkarma ile altyapı etkilerini soğuran topluluklar (Rahimpour et al., 2024; Enríquez-de-Salamanca, 2024). Bu bildiriyi harekete geçiren gerilim, aynı süreçlerin iki okuması arasındadır: resmi "adil geçiş" vaadi ile sosyal maliyetin en az taşıyabilecek olanlara büyük ölçekli aktarılmasının ampirik olasılığı.

Bu arka plana karşı net bir araştırma boşluğu belirir. Sosyal etkileri görünür kılmaya yönelik metodolojik araç takımı—sosyal etki değerlendirmesi (SED) ve sosyal yaşam döngüsü değerlendirmesi (S-YDD)—olgun ve genişleyen bir alanı oluşturur (Farías et al., 2026; Vardaro et al., 2026; Lehmann et al., 2025); paralel bir literatür de eşitliğin böyle her değerlendirmenin örgütleyici ilkesi olması gerektiğinde ısrar eder (Parsons & Mottee, 2023; Dawson & Suich, 2025). Buna karşın çarpıcı biçimde, özellikle yeşil dönüşümün sosyal riskleri doğa bilimleri literatüründe bile "yeterince araştırılmamış" olarak kalır (Rahimpour et al., 2024) ve aşım koşulları altında iklim eyleminin insani ve sosyal sonuçları "büyük ölçüde bilinmiyor" olarak nitelenir (Kruczkiewicz et al., 2025). Daha geniş anlamda sosyal

etki araştırması, standartlaştırılmış ve karşılaştırılabilir ölçüm açısından hâlâ "emeklemeye çalışan" bir alan olarak tanımlanır (Rundle-Thiele et al., 2024). Dolayısıyla boşluk araçların yokluğu değil, onları en önemli olduğu yerde uygulamadaki başarısızlıktır: AB karbonsuzlaşma politikasının ürettiği sosyal maliyetleri sistematik biçimde ölçen, atfeden ve yöneten tutarlı, bağlayıcı bir mekanizma yoktur.

Bu boşluğu kapatmadan bırakmanın maliyeti ne soyut ne de ertelenmiştir. Ölçülmeyen yönetilmez ve fiyatlandırılmayan sosyal maliyetler ortadan kalkmaz; enerji yoksulluğu, bölgesel ekonomik çöküş, yerinden edilme ve kamu güveninin aşınması olarak yeniden belirir (Zahedi & Aslani, 2023; Nhlengethwa & Chitakira, 2024). Değerlendirmenin zayıf olduğu yerde etkiler mekânda ve nüfusta eşitsiz dağılır ve en az sese sahip gruplarda yoğunlaşır (Jones et al., 2023; Kirishima & Sasaki, 2025). Finansal piyasalarda aynı kör nokta, "yeşil" sermayenin açıklanmamış önemli sosyal zararları olan projelere tahsis edilmesine olanak tanır; böylece güvenilir göstergeler yokluğunda yeşil aklama (greenwashing) palazlanır (Popescu et al., 2024). Ölçülmeyen her zarar aynı zamanda siyasi bir yükümlülüktür: iklim politikasına yönelik tepki, tam da seçkinlerin hedef koyup sıradan insanların bedel ödediği algısıyla beslenir. Sosyal maliyeti görünür kılmamak bu nedenle yalnızca adaletsizlik üretmez; dönüşümün kendi kalıcılığını da tehlikeye atar.

Bu bildiri söz konusu boşluğu ele alır. Araştırma sorusu doğrudandır: AB yeşil dönüşümü bir adil geçiş midir, yoksa sosyal maliyetin yeniden dağıtımı mıdır—ve aradaki farkı anlamak ne gerektirir? Amaç, yeni ampirik tahminler üretmek değil, dönüşümün hangi kavramsal ve yönetişimsel koşullar altında adil olarak adlandırılabileceğini netleştirmek için güncel (2023–2026) otuz çalışmanın argümantatif bir sentezini kurmaktır. Temel sav şudur: yeşil dönüşümde adalet, ilk planda bir finansman sorunundan çok bir bilgi ve hesap verebilirlik sorunudur; sosyal maliyeti ölçme araçları vardır (Vardaro et al., 2026; Joanpere et al., 2025; Desmoitier et al., 2023), ancak bu maliyetler ölçülmedikçe, kararlara atfedilmedikçe ve etkilenen insanlarca itiraz edilebilir kılınmadıkça, "adil geçiş" uygulanabilir bir standarttan çok meşrulaştırıcı bir slogan işlevi görür. Bunu izleyen temel bulgu şudur: ölçüm–yönetişim boşluğunu kapatmak, herhangi bir adil olma iddiası için—sübvansiyonlar veya tazminatlardan mantıksal olarak önce gelen—önkoşuldur.

Bildiri kavramsal ve Avrupa odaklıdır; ancak incelediği sosyal etki yöntemleri ve dinamikleri AB ile sınırlı olmadığı için küresel kanıtlardan da yararlanır (Leitão et al., 2025; Wan et al., 2024; Moreno-Silva et al., 2025). Herhangi bir tek ulusal programı ayrıntılı değerlendirmez ve karbonsuzlaşmanın gerekliliğini de tartışmaz; eleştirisi yeşil gündeme içseldir ve onu güçlendirmeyi amaçlar. Geri kalan bölümler şöyle ilerler. Sonraki bölüm, sosyal maliyetlerin dönüşümde nerede ortaya çıktığına ve neden görünmez kaldığına dair katmanlı bir tablo kurarak kavramsal savı geliştirir. Tartışma bölümü ise bu iddiaları derlenen kanıtlar karşısında temellendirir ve sınar, karşı savları tartar. Sondan önceki bölüm somut, gerçekçi ve

uygulanabilir politika önerileri sunar; sonuç ise temel savı ve bunun Avrupa iklim yönetişimi açısından imalarını yeniden ortaya koyar.

1. YEŞİL DÖNÜŞÜMÜN SOSYAL AYAK İZİ: KAVRAMSAL BİR GELİŞTİRME

Dönüşümün görünmeyen yüzünü net görmek için, sosyal maliyetlerin aslında nerede ortaya çıktığını ayrıştırmak yararlıdır. Bunlar tek bir olgu değil, karbonsuzlaşmanın tüm yaşam döngüsüne yayılmış katmanlı bir etkiler kümesidir—temiz teknolojilerin malzeme ve tedarik zincirlerinde yukarı akışta, karbon yoğun faaliyetlerin kapanışı ve yeniden yapılandırılmasında orta akışta ve yeni altyapı ile tüketim maliyetlerinin hanelere aktarılmasında aşağı akışta. Bu katmanları birlikte okumak, salt betimleyici değil argümantatif bir anlatının gerektirdiği şeydir.

İlk katman yukarı akıştır. Temiz enerji ekonomisi malzeme yoğundur ve bağımlı olduğu metal ve minerallerin çıkarılması ile işlenmesi, kendi sosyal risklerini taşır; Rahimpour ve diğerleri (2024) bu risklerin teknolojilerin iklim faydalarına kıyasla sistematik biçimde az incelendiğini gösterir. Yeşil enerji malzemelerine bağlı sosyal etki göstergeleri üzerine analizleri keşkin bir sav ortaya koyar: bir teknoloji kullanım noktasında çevresel açıdan erdemli olabilirken, zincirinin başka bir yerinde emek, sağlık ve topluluk zararlarını içine gömebilir. Yaşam döngüsü düşüncesi bu yer değiştirmeyi açığa çıkarır. Endüstriyel patikaların—örneğin metanolün polipropilene dönüştürülmesinin—sosyal yaşam döngüsü değerlendirmesi, çevresel ve sosyal performansın birlikte hareket etmesi gerekmediğini ve ayrı ayrı değerlendirilmesi gerektiğini gösterir (Vardaro et al., 2026). Aynı mantık negatif emisyon stratejilerine de uygular: yüzlerce çalışma üzerinden incelendiğinde, karbon tutma ve ağaçlandırma, azaltım sağlarken arazi kullanımı ve geçim kaynakları üzerinde istenmeyen yerel etkiler dayatabilir (Enríquez-de-Salamanca, 2024). Nedensel açıdan finans bile yukarı akışta yer alır; çünkü yatırım fonları sermayeyi bu faaliyetlere yönlendirir ve mevcut göstergelerin yakalayamadığı önemli sosyal ve çevresel etkilerden bizzat "sorumludur" (Popescu et al., 2024).

İkinci katman orta akıştır: karbon yoğun endüstrilerin ve onlara bağlı işçiler ile bölgelerin yönetilen çöküşü. Bu, "adil geçiş"in klasik zeminidir ve sosyolojinin fosil yakıtlar ile modernliğin iç içeliğine yönelik uzun ilgisi tam burada analitik olarak merkezi hale gelir. Beckfield ve Evrard (2023), arz yanlı karbonsuzlaşmanın—fosil kaynakları bilinçli biçimde yakılmadan bırakmanın—istihdam, topluluk kimliği ve bölgesel ekonomiler üzerinde, talep yanlı önlemlerden türü bakımından farklı belirgin sosyal etkiler ürettiğini savunur. Benzer büyük müdahalelerden çıkan ders ayıkıtıcıdır: barajlar üzerine literatür, yerinden edilen ve bağımlı topluluklar üzerindeki sosyal etkilerin kalkınma hedefleri peşinde tarihsel olarak ihmal edildiğini, eşitlik ve katılımın sonradan düşünülen şeyler olarak ele alındığını gösterir

(Nhlengethwa & Chitakira, 2024). Yeşil dönüşüm bu örüntüyü kıtasal ölçekte yinelerse, karbonsuzlaşma aynı asimetrik fedakarlık dağılımını yeni bir bayrak altında üretebilir.

Üçüncü katman, geçiş maliyetlerinin hanelere ve gündelik hareketliliğe ulaştığı aşağı akıştır. Karbonsuzlaşma; yenileme, elektrifikasyon ve akıllı ev teknolojileri aracılığıyla eve uzanır; bunların faydaları gerçek ancak eşitsiz biçimde erişilebilirdir ve kimin katılımı karşılayabileceği ve kimin daha yüksek maliyet ödeyerek geride bırakılacağı konusunda dağılımsal sorular doğurur (Lazaroiu et al., 2024). Hizmet coğrafyaları da önemlidir: toplu taşıma gibi ağlar rasıyonelleştirme ya da modernleştirme adına geri çekildiğinde, sosyal etki alternatifi olmayanlarda yoğunlaşır ve mekânsal bir risk örüntüsü olarak haritalanabilir (Kirishima & Sasaki, 2025). Dönüşümü desteklemek için inşa edilen altyapı da muaf değildir; iklimle baskılanan su sistemlerini yönetmek için giderek daha fazla devreye alınan tuzdan arındırma, proje ve bölge ölçeklerinde keskin biçimde değişen olumsuz sosyal etkiler taşır (Moreno-Silva et al., 2025). Üç katman boyunca tek bir yapısal özellik yinelenir: faydalar yaygın ve kutlanan, maliyetler ise yoğun, yerel ve yeterince raporlanmayan niteliktedir.

Bu maliyetler neden görünmez kalır? Yanıt tesadüfi değil, metodolojik ve kurumsaldır. Sosyal etkileri görme kapasitesi vardır. Sosyal etki değerlendirmesi, açık eşitlik hedefleri olan bir disipline olgunlaşmıştır (Parsons & Mottee, 2023) ve politikaların sosyal etkilerini, gezegensel sınırlarla asgari sosyal temelleri birleştiren “mutlak sınırlar” karşısında—güvenli ve adil işletim alanı—değerlendiren yöntemler artık mevcuttur (Desmoitier et al., 2023). Yeni değerlendirme modelleri bunu daha da ileri taşır: diyalojik çerçeveler etkilenen paydaşları kurumsal etki değerlendirmesine doğrudan dahil eder (Joanpere et al., 2025) ve rafine S-YDD yaklaşımları, yaşamları etkilenenlerin temsil edilebilirliğini artırmak için etki alt kategorilerini hiyerarşikleştirir (Lehmann et al., 2025). Öyleyse sorun sosyal maliyetin bilinemez olması değildir. Sorun, bu araçların seçici, gönüllü ve tutarsız biçimde uygulanmasıdır—korumada ve proje değerlendirmesinde güçlü, baş anlatı iklim politikasında çok daha zayıf (Dawson & Suich, 2025; Wan et al., 2024).

İşte savın düğüm noktası budur. Bir dönüşüm aynı anda çevresel açıdan ilerici ve sosyal açıdan gerici olabilir ve simetrik ölçüm olmadan ikisi kolayca birbirine karıştırılır. Sistemik sürdürülebilirlik değerlendirmesi, bir alt sistemi en iyilemenin—etkiler sınırlar boyunca izlenmedikçe—yük kaydırma yoluyla daha büyük sistemi bozabileceği konusunda uyarır (Zimek & Baumgartner, 2024). Ne var ki yeşil ekonominin kurumları böyle bir izleme üzerine kurulu değildir. Piyasalar açıklanan çevresel performansı ödüllendirirken sosyal zararlar fiyatlandırılmadan kalır (Popescu et al., 2024); kurumsal etki, bir firmanın çıkışının yol açacağı refah kaybı olarak titizlikle tanımlandığında bile dar ekonomik terimlerle kavramsallaştırılır (Allcott et al., 2026); ve sürdürülebilirliğin sosyal boyutu hem pratikte hem teoride en az gelişmiş boyut olarak yinelenir (Bianchi et al., 2025; Rundle-Thiele et al., 2024).

Dönüşümün görünmeyen yüzü bu nedenle doğal bir olgu değil, bir yönetişim seçimidir—ve tersine çevrilebilir.

2. TARTIŞMA

Yukarıdaki kavramsal anlatı, kanıtlar ve makul itirazlar karşısında sınanmayı hak eden üç iddiaya dayanır. Birinci iddia, sosyal maliyetlerin çevresel ve ekonomik çıktılara kıyasla sistematik biçimde eksik ölçüldüğüdür. İkincisi, bu asimetrinin nötr olmadığı, aksine etkin biçimde dağılımsal olduğu, yükleri kırılgan gruplara kaydırdığıdır. Üçüncüsü, çözümün esasen kurumsal olduğudur: mevcut araçlar, zorunlu ve katılımcı kılındığında görünmeyeni görünür kılabilir. Bunları sırasıyla ele almak, savı yalnızca ileri sürmek yerine temellendirmeyi sağlar.

Birinci iddia konusunda, bağımsız literatürlerin yakınsaması dikkat çekicidir. Yeşil enerji malzemeleri (Rahimpour et al., 2024), iklim aşımı (Kruczkiewicz et al., 2025), dijital tarım araçları (Bianchi et al., 2025) ve pazarlama eksenli sosyal etki (Rundle-Thiele et al., 2024) üzerine çalışan araştırmacılar, çok farklı başlangıç noktalarından aynı teşhise varır: sosyal boyut hem veri hem yöntem açısından çevresel ve ekonomik boyutun çok gerisindedir. Bu, tek bir alt alanın yakınması değil, sürdürülebilirlik değerlendirmesinin yapısal bir özelliğidir. İddianın en güçlü biçimi şudur: asimetri teşvik mimarisine gömülüdür—çevresel ölçütler standartlaştırılmış ve giderek düzenlenmişken sosyal ölçütler gönüllü, parçalı ve karşılaştırılması zor kalır (Popescu et al., 2024; Zimek & Baumgartner, 2024). Makul bir itiraz, sosyal etkilerin doğası gereği CO_2 tonundan daha zor nicelendiğidir. Bu kısmen doğrudur ancak boşluğu tam açıklayamaz; çünkü sağlam sosyal değerlendirme yöntemleri ispatlanmış biçimde mevcuttur (Farías et al., 2026; Lehmann et al., 2025; Joanpere et al., 2025). Güçlük bu nedenle fizibiliteden en az o kadar irade ve yetkiyle ilgilidir.

İkinci iddia konusunda, asimetrinin dağılımsal sonuçlar doğurduğuna dair kanıt bağlamlar boyunca tutarlıdır. Sosyal etkilerin mekânsal olarak haritalandığı yerlerde, bunlar eşitsiz düşer, belirli yerlerde ve nüfuslarda yoğunlaşır (Jones et al., 2023) ve hizmetlerin geri çekilmesi öngörülebilir biçimde ikamesi olmayanlara zarar verir (Kirishima & Sasaki, 2025). Büyük müdahalelerin tarihsel kaydı, sosyal değerlendirmeyi ihmal etmenin nötr sonuçlar değil, yerinden edilen ve bağımlı olanları güvenilir biçimde dezavantajlı kılan sonuçlar doğurduğunu gösterir (Nhlengethwa & Chitakira, 2024). Politika düzeyindeki modelleme bunu makro ölçekte pekiştirir: iklim politikalarının hesaplanabilir genel denge analizi, çevresel önlemlerin gruplar arasında türdeş faydalardan çok heterojen ekonomik ve sosyal etkiler ürettiğini bulur (Zahedi & Aslani, 2023). Dağılımsal okuma böylece spekülatif değildir. Bir kuşkucu, dönüşümün aynı zamanda faydalar da yarattığını—örneğin yeşil girişimcilik ve yerel ekonomik canlanma—ileri sürebilir (Prokopenko et al., 2024). Bu doğru ve önemlidir; ancak iddiayı çürütmez, keskinleştirir. Faydalar ve maliyetler aynı anda

gerçektir ve yönetişim sorusu, bunların adil dağıtılıp dağıtılmadığıdır—ki ikisi de ölçülmedikçe bu bilinemez.

Üçüncü iddia konusunda, çözümün teknik değil kurumsal olduğu savı en önemli olanıdır. Derlenen çalışmalar, hazır ancak yeterince devreye alınmamış bir araç takımı olduğunu gösterir. Eşitlik odaklı SED, etkilenen toplulukların haklarını ve katılımını öne çıkarabilir (Parsons & Mottee, 2023; Dawson & Suich, 2025); mutlak sınır yöntemleri politikaları birleşik ekolojik ve sosyal eşikler karşısında sınayabilir (Desmoitier et al., 2023); yaşam döngüsü yaklaşımları sosyal maliyeti tedarik zincirleri boyunca izleyebilir (Vardaro et al., 2026; Enríquez-de-Salamanca, 2024); ve diyalojik ve hiyerarşikleştirilmiş modeller paydaş sesini süsleyici değil merkezi kılabilir (Joanpere et al., 2025; Lehmann et al., 2025). Gelişmekte olan dijital kapasiteler bile aynı yönü işaret eder: kırılgan ve kaynak yoksunu nüfuslara yönelmiş yapay zekâ yaklaşımları sosyal etkiyi ölçekte izlemenin maliyetini düşürebilir (Tambe et al., 2025) ve Avrupa'daki haritalama çalışmaları sosyal fayda için tasarlanmış teknoloji çözümlerini halihazırda kataloglar (Leitão et al., 2025). Eksik olan yetenek değil, yükümlülüktür. Sektörel pratik örüntüyü doğrular: ulaşım planlaması sosyal sürdürülebilirliği hâlâ yetersiz kurumsallaşmış olarak ele alır (Wan et al., 2024) ve hizmetleşmiş, döngüsel endüstriyel modeller bile sosyal etkilerini çevresel olanlardan ayrı görünür kılmak için açık çerçevelere ihtiyaç duyar (Beducci et al., 2025).

İki daha geniş ima izler. İlk olarak, "sosyal" ile "ekonomik" maliyet arasındaki sınırın kendisi bir yönetişim ürünüdür. Kurumsal sosyal etki, bir firmanın çıkışının yol açtığı refah kaybı olarak tanımlandığında (Allcott et al., 2026), karbon yoğun bir tesisin kapanması yalnızca bir iklim defterindeki satır değil, ölçülebilir bir sosyal maliyet olarak açığa çıkar—yeter ki birinin onu ölçmesi gereksin. İkinci olarak, örgütsel biçim önemlidir: sosyal işletmeler ve kooperatifler, geleneksel firmaların dışsallaştırdığı sosyal hedefleri içselleştirdikleri için tam da sistemik değişimin taşıyıcısı olabilir (Longoni et al., 2024; Pavlis, 2026). Bu, adil bir geçişin yalnızca zararı sınırlamakla değil, sosyal değeri görünür ve hesap verebilir kılan aktörleri ve araçları bilinçli olarak güçlendirmekle ilgili olduğunu düşündürür. Bununla birlikte sosyal etki değerlendirmesi disiplininin kendisi de bir ritüele dönüşmekten kaçınmalıdır; güvenilirliği, bir uyum egzersizi olmaktan çok eşitlikçi, katılımcı ve sonuç doğurucu olmasına bağlıdır (Parsons & Mottee, 2023; Udir et al., 2025).

Birlikte ele alındığında, bu üç iddia bildirinin temel tezini destekler. Sosyal maliyeti tanımlama, atfetme ve itiraz edilebilir kılma araçları vardır; bu maliyetleri gizleyen asimetri teşviklere ve yetkilere gömülü bir seçimdir; ve asimetriyi yerinde bırakmanın sonuçları dağılımsal ve siyaseten aşındırıcıdır. "Adil geçiş" retörik düzeyinde doğrulanamaz. Bu, karbonsuzlaşmanın sosyal ayak izinin—karbon ayak izinin halihazırda olduğu kadar—görünür, karşılaştırılabilir ve bağlayıcı kılınmasını gerektiren ampirik ve kurumsal bir iddiadır.

3. POLİTİKA ÖNERİLERİ

Eğer temel sorun iyi niyet eksikliği değil bir ölçüm–yönetişim boşluğuysa, en yararlı öneriler sosyal maliyeti mevcut Avrupa kurumları içinde görünür, atfedilebilir ve itiraz edilebilir kılanlardır. Aşağıdaki öneriler bilinçli olarak artımsaldır ve halihazırda kullanılan araçlar üzerine kurulur; böylece özlemci değil gerçekçi ve uygulanabilirdir.

1. Büyük iklim politikaları ve fonlanan projeler için dağılımsal ve sosyal etki değerlendirmesini zorunlu kılın. Çevresel etki değerlendirmesi nasıl gerekli ise, AB de büyük karbonsuzlaşma önlemlerini benimsemeden önce—kimin kazandığını, kimin kaybettiğini ve ne kadar olduğunu belirleyen—standartlaştırılmış bir sosyal ve dağılımsal etki değerlendirmesini, halihazırda mevcut olan ve ekolojik ile sosyal eşikleri birleştiren yöntemleri kullanarak gerekli kılmalıdır (Desmoitier et al., 2023; Parsons & Mottee, 2023; Wan et al., 2024).
2. Ürün, firma ve fon düzeyinde standartlaştırılmış, karşılaştırılabilir sosyal göstergeler benimseyin. Hazır kullanılabilir, politikayla ilişkili sosyal yaşam döngüsü göstergeleri üzerine inşa ederek, düzenleyiciler ortak bir sosyal ölçüt kümesinin çevresel raporlamayla birlikte açıklanmasını zorunlu kılmalı, böylece sürdürülebilir finansta sosyal yeşil aklamanın kapısını kapatmalıdır (Popescu et al., 2024; Rahimpour et al., 2024; Lehmann et al., 2025).
3. Geçiş finansmanını doğrulanmış sosyal sonuçlara koşullu kılın. Kamu desteği—Adil Geçiş Fonu türü araçlar dahil—dilimleri yalnızca girdilere değil, denetlenmiş sosyal sonuçlara (işinde tutulan veya yeniden beceri kazandırılan işçiler, dizginlenmiş enerji maliyeti yükü) karşı serbest bırakmalı; böylece para ölçülen adaleti izlemelidir (Beckfield & Evrard, 2023; Zahedi & Aslani, 2023).
4. Etkilenen toplulukların değerlendirme ve tasarıma katılımını kurumsallaştırın. Diyalojik ve eşitlik odaklı değerlendirme usul dışı bir hak olarak gömülmeli; işçilere, düşük gelirli hanelere ve etkilenen bölgelere yaşamlarını yeniden şekillendiren kararlarda resmi bir ses verilmelidir (Joanpere et al., 2025; Dawson & Suich, 2025; Nhlengethwa & Chitakira, 2024).
5. Dönüşümün aşağı akış kenarındaki haneleri koruyun. Yenileme, elektrifikasyon ve hareketlilik programları, kırılgan gruplar için açık karşılanabilirlik güvenceleri ve hizmet sürekliliği garantileriyle, aksi takdirde geride bırakılacak olanların mekânsal haritalanmasından beslenerek tasarlanmalıdır (Lazaroiu et al., 2024; Kirishima & Sasaki, 2025; Moreno-Silva et al., 2025).
6. Sosyal ekonomi aktörlerini teslimat ajanları olarak güçlendirin. Sosyal hedefleri içselleştiren sosyal işletmelere ve kooperatiflere geçiş finansmanı ve satın almada öncelikli erişim verilmeli, böylece yeşil yatırım yerel olarak hesap verebilir sosyal

değere yönlendirilmelidir (Longoni et al., 2024; Pavlis, 2026; Prokopenko et al., 2024).

7. Ortak izleme altyapısı ve kapasite oluşturun. AB, açık veriye ve uygun olduğunda kırılgan nüfuslara yönelik yapay zekâ destekli izlemeye yatırım yapmalı ve mevcut sosyal odaklı teknoloji çözümlerini haritalamalı; böylece sosyal etki izleme istisnai değil rutin ve düşük maliyetli hale gelmelidir (Tambe et al., 2025; Leitão et al., 2025; Bianchi et al., 2025).

Bu önlemlerin hiçbiri karbonsuzlaşmayı yavaşlatmaz; her biri onun sosyal sonuçlarını okunabilir ve yönetilebilir kılar. Birlikte, "adil geçiş"i bir vaatten, Avrupa iklim politikasının hesap verebilir kılınabileceği bir standarda dönüştürürler.

4. SONUÇ

Bu bildiri, AB yeşil dönüşümünün bir adil geçiş mi yoksa sosyal maliyetin yeniden dağıtımı mı olduğunu ve ikisini birbirinden ayırt etmenin ne gerektirdiğini sormak üzere yola çıktı. Savunduğu yanıt, sorunun retörik düzeyinde çözülemeyeceğidir; çünkü dönüşümün görünmeyen bir yüzü vardır: temiz teknoloji tedarik zincirlerinde yukarı akışta, karbon yoğun endüstrilerin çöküşünde orta akışta ve karbonsuzlaşmanın hane ve hareketlilik yüklerinde aşağı akışta ortaya çıkan sosyal maliyetler, çevresel ve ekonomik çıktılara kıyasla sistematik biçimde eksik ölçülür. Bu görünmezlik kaçınılmaz değildir. Çevresel açıklamayı standartlaştıran ve ödüllendiren, sosyal maliyeti ise gönüllü, parçalı ve fiyatlandırılmamış bırakan bir teşvik mimarisinin ürünüdür.

Temel katkı, yeşil dönüşümde adaleti, her şeyden önce bir finansman sorunundan çok bir bilgi ve hesap verebilirlik sorunu olarak yeniden çerçevelemektir. Sosyal maliyeti görünür kılacak metodolojik araçlar—sosyal etki değerlendirmesi, sosyal yaşam döngüsü değerlendirmesi, mutlak sınır ve diyalojik modeller—halihazırda mevcuttur ve hızla ilerlemektedir; eksik olan, karbonsuzlaşma kararlarının gerçekte verildiği yerde onları uygulama yükümlülüğüdür. Sosyal maliyetler ölçülmedikçe, belirli kararlara atfedilmedikçe ve onları taşıyan insanlarca itiraz edilebilir kılınmadıkça, "adil geçiş" önlemeyi vaat ettiği eşitsizlikleri gizleyen meşrulaştırıcı bir slogan olarak işleme riski taşır.

Avrupa iklim yönetişimi açısından ima bu nedenle hem mütevazı hem zorludur. Mütevazıdır, çünkü gereken araçlar AB'nin halihazırda kullandığı uygulamaların artımsal uzantılarıdır. Zorludur, çünkü karbonsuzlaşmanın sosyal ayak izini karbon ayak izi kadar görünür, karşılaştırılabilir ve bağlayıcı kılmak yalnızca kaynakları değil hesap verebilirliği de yeniden dağıtır. Gerçekten adil bir geçiş, maliyetleri görülebilen, adı konabilen ve itiraz edilebilen bir geçiştir. Görünmeyeni görünür kılmak, iklim politikasına bir ek değil; o politikayı adil yapmanın ve kalıcı olmasını sağlamanın önkoşuludur.

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MACROECONOMIC IMPLICATIONS OF DIGITALIZATION & CIRCULAR ECONOMY

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Abstract

The aim of this study is to analyse the macroeconomic implications of digitalisation and the circular economy on the basis of panel data analysis. While the broadening of the digital transformation and the growing importance of sustainable economic practices for economic development have received increased attention in recent years, little work has examined the joint effects of these developments on macroeconomic performance. A panel data set consisting of cross-section and time-series observations of the selected Western Balkan countries on the period 2010-2022. The dependent variable is economic growth (as reflected in GDP growth) and digitalisation is proxied by internet usage and the circular economy is captured through a sustainability-related indicator. Among the control variables, trade openness and foreign direct investment (FDI) are considered.

The empirical analysis is carried out with the help of panel data technique, where the Random Effects model is adopted because of the Hausman test. The findings show positive and statistically significant impact of trade openness and FDI on economic growth which shows that external integration and FDI inflows are important for economic growth. The macroeconomic benefits of digitalisation are still not fully realised in the selected economies, as indicated by the weak and statistically insignificant effect. The relationship between the circular economy proxy and growth is positive and significant on the other hand, suggesting that sustainable practices can positively affect the economy.

Keywords: Digitalization, Circular Economy, Economic Growth, Trade Openness, Foreign Direct Investment (FDI), Sustainability, Western Balkans

NAVIGATING TWIN TRANSITION PRESSURES: AI AND SUSTAINABLE PRODUCTION IN THE POLISH FILM SECTOR

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Abstract

The European twin transition, the concurrent digital and green transformation of industrial ecosystems, has become a central concern of EU policy, yet empirical research has concentrated on manufacturing, energy, and mobility sectors, leaving creative industries largely unexplored. This study examines how the twin transition unfolds in the Polish film industry, where producers simultaneously confront the disruption of generative artificial intelligence and virtual production, and the pressure of sustainable production protocols introduced by streaming platforms and European environmental regulations. The study addresses two research questions: (1) how Polish film producers adopt, contest, and integrate generative AI and virtual production technologies in long-cycle film projects; and (2) which sustainable production practices and ESG mechanisms are being implemented in Polish film projects. The methodology comprises eleven structured interviews with film producers selected through purposive sampling from the membership directory of the Krajowa Izba Producentów Audiowizualnych (KIPA), and analysed through two-stage grounded coding in ATLAS.ti, moving from first-order codes to a set of second-order categories. The findings demonstrate that producers in development and physical production embrace digital tools as creative and economic enablers, while specialists in post-production frame the same technologies as threats to professional employment and craft knowledge. On the green dimension, sustainable production practices diffuse predominantly through international streaming platforms operating in Poland, with the first sustainable production serving as a pioneering case that institutionalizes new roles such as the eco-coordinator. The study contributes to twin transition research by extending its empirical scope to project-based creative industries and demonstrates that digital and green transformations in this sector should be analysed as interconnected dynamics shaping the future of European creative production.

Keywords: Twin Transition, AI Adoption, Sustainable Production, Polish Film Industry, EU Policy

INTRODUCTION

The European twin transition, the simultaneous and interconnected pursuit of digital and green transformation of industrial ecosystems, has become a defining concept of European Union policy since the launch of the European Green Deal in 2019 (European Commission, 2019). The Joint Research Centre of the European Commission has framed twin transitions as a coordinated effort in which digital technologies are mobilised to advance environmental objectives, while the green agenda shapes the direction of digital innovation (Muench et al., 2022). The 2022 Strategic Foresight Report further consolidated this framing by identifying a set of priority areas for governing the twin transitions, ranging from supply-chain resilience to social cohesion and the adaptation of education systems (European Commission, 2022). Yet, as critical scholarship has begun to argue, the relationship between digital and green transformations is not automatically synergistic; digital technologies can reinforce environmental objectives but may also intensify resource consumption and amplify social inequalities (Kovacic et al., 2024).

Empirical research on the twin transition has so far concentrated on capital-intensive sectors such as manufacturing, energy, agriculture, and mobility, where digital and environmental pressures translate directly into measurable shifts in productivity, emissions, and value chains (Muench et al., 2022; European Commission, 2022). Comparatively little attention has been devoted to creative industries, despite the fact that the cultural sector is increasingly exposed to similar dynamics: the rapid uptake of generative artificial intelligence and virtual production technologies on the digital side, and the diffusion of sustainable production protocols and environmental, social and governance (ESG) standards on the green side. The film industry is a revealing case here, because it combines high carbon intensity in physical production, strong exposure to platform-driven digital transformation (Brodherson, Wrubel and Vickers, 2025), and a project-based organisational logic that complicates the implementation of long-term transition agendas (Sydow, Lindkvist and DeFillippi, 2004).

The Polish film industry is a well-suited setting for studying these dynamics. It is a project-based ecosystem in which most productions involve international co-financing, depend on state funding through the Polish Film Institute, and increasingly rely on international streaming platforms that introduce their own contractual standards and quality expectations. At the same time, the sector operates within a relatively fragmented institutional environment, with limited formal regulation specifically addressing either digital adoption or environmental sustainability of film production. This combination of high external pressure and low domestic institutionalisation makes the Polish case suitable for examining how twin transition pressures translate into concrete production practices.

Polish film producers are currently confronted with two distinct but interconnected pressures. On the digital side, they engage with generative AI tools for screenwriting, deep-fake reconstruction of actors, virtual production using LED-volume environments, and AI-assisted research that increasingly substitutes traditional production roles. On the green side, they face protocols of sustainable production introduced primarily by international streaming platforms, alignment with the EU climate-neutrality target, and the institutionalisation of new functions such as the eco-coordinator. These pressures are not equally distributed across the value chain: producers operating in development and physical production frequently frame digital tools as creative and economic enablers, while specialists involved in post-production express concerns about professional displacement and the erosion of craft knowledge.

Building on this empirical situation, the study addresses two research questions. First, how do Polish film producers adopt, contest, and integrate generative AI and virtual production technologies in long-cycle film projects? Second, which sustainable production practices and ESG mechanisms are being implemented in Polish film projects? Together, the two questions allow for an examination of the digital and green dimensions of the twin transition as they are concretely enacted within a single creative sector.

1. THEORETICAL FRAMEWORK

1.1. AI Adoption and Virtual Production In Creative Industries

The digital dimension of the twin transition in film production is shaped by two related but distinct technological developments: generative artificial intelligence and virtual production. Generative AI tools, among them large language models for screenwriting, text-to-video systems and deep-fake reconstruction, have moved from experimental applications to integrated workflow elements (Brodherson, Wrubel and Vickers, 2025). Virtual production, particularly the use of LED-volume environments combined with real-time game-engine rendering, has reshaped pre-visualisation, scenography, and physical-set construction in major productions.

These technologies illustrate Christensen's (1997) classic analysis of disruptive innovation. They initially appear as cost-reducing substitutes for established workflows, but progressively reshape the entire value chain by altering the relative position of incumbent professionals. Brynjolfsson and McAfee (2017) extend this analysis by emphasising that the contemporary digital economy is structured around the interplay of machines, platforms, and crowds, in which automation, platform intermediation, and distributed creative labour reorganise both production and value distribution. In cultural industries, this dynamic is particularly pronounced because creative labour is often project-based, freelance, and reliant on reputation networks rather than on formal employment relations.

Industry analyses suggest that generative AI is reshaping film and television workflows unevenly across functional domains. Recent industry research argues that AI could transform every stage of the creative production process from script to screen, but that adoption proceeds at different speeds and with different implications for pre-production, physical production, and post-production (Brodherson, Wrubel and Vickers, 2025). Pre-production benefits from accelerated storyboarding and previsualisation, while post-production faces both efficiency gains and significant labour-displacement pressures. These uneven dynamics raise the question of how individual producers, operating in specific national contexts, adopt or contest these technologies in practice.

1.2. Sustainable Production and ESG Diffusion In Film

The green dimension of the twin transition in film production is driven primarily by several factors: the recognition that film production is a carbon-intensive industry, the institutionalisation of corporate ESG reporting by major streaming platforms, and the alignment of European climate policy with the carbon-neutrality objective. Empirical evidence suggests that the physical production of streamed audiovisual content generates significant greenhouse gas emissions, with electricity-intensive activities such as on-site generators, lighting, and transport accounting for the largest share of the footprint. In response, leading streaming platforms have introduced sustainable production protocols, including clean mobile power, electric vehicle fleets, and the appointment of eco-coordinators on selected productions.

These corporate ESG commitments diffuse into national production ecosystems through a combination of contractual requirements, training programmes, and the gradual emergence of new professional roles. In several European markets, the eco-coordinator function has been formalised as a distinct production role responsible for measuring emissions, implementing waste-reduction protocols, and coordinating with crew on environmental practices. The diffusion of these practices into the Polish film industry is at an early stage, as the function is not yet embedded in formal production hierarchies and the relevant infrastructure, including ecological generators and accredited environmental consultants, remains scarce.

Beyond carbon reduction, sustainable production practices increasingly include a social sustainability dimension that overlaps with the European concept of just transition. This encompasses the introduction of intimacy coordinators, anti-harassment procedures, and equality protocols designed to protect crew members during physically and psychologically demanding production processes. The combination of environmental and social sustainability elements complicates the implementation of green transition objectives, as it requires simultaneous changes in technical infrastructure, contractual standards, and organisational culture on set.

2. METHOD

2.1. Research Design and Sampling

The study employs a qualitative interpretive research design grounded in the constructivist tradition of grounded theory (Charmaz, 2014; Strauss and Corbin, 1998). The design was selected to capture the situated meanings and practices through which film producers enact twin transition pressures, rather than to test pre-specified hypotheses about adoption rates or compliance levels. Participants were selected through purposive sampling using the membership directory of the Krajowa Izba Producentów Audiowizualnych (KIPA), the principal professional association representing audiovisual producers in Poland. This sampling frame ensured that all participants were active, professionally recognised producers operating within the established institutional structure of the Polish film industry. The criterion-based selection enabled access to experienced practitioners with substantial project portfolios across both domestic and international productions. Table 1 presents an overview of the eleven participants, with pseudonymous codes (P01–P11) used throughout the paper to preserve confidentiality.

Table 1. Overview of Interview Participants

Code	Professional role	Industry domain	Professional focus
P01	Line Producer	Poland	Author cinema, academic research
P02	Producer	Poland	Independent film, AI-enabled production
P03	Producer	Poland	Author cinema, international workshops
P04	Producer	Poland	International co-productions
P05	Producer	Poland	Cinema-art, festival films
P06	Producer	Poland	Co-productions, virtual production, AI
P07	Line Producer	Poland	International co-productions
P08	Line Producer	Poland	Sustainable production
P09	Executive Producer	Poland	International co-productions
P10	Producer	Poland	Author cinema, international development
P11	Producer	Poland	Post-production, industry advocacy

Source: Own elaboration.

2.2. Data Collection

Data collection comprised eleven semi-structured in-depth interviews conducted between July 2024 and May 2025. All participants were experienced producers with substantial professional backgrounds in domestic and international projects, ensuring sufficient depth of practical knowledge regarding twin transition pressures. The interviews were recorded with

informed consent and transcribed verbatim. The interview protocol (Table 2) was designed to elicit accounts of digital technology adoption and contestation, sustainable production practices, knowledge transfer mechanisms, and broader institutional dynamics shaping the Polish film industry. Each interview was conducted in Polish, with quotations subsequently translated into English for analytical purposes while preserving the original meaning.

Table 2. Interview Protocol

No	Interview question
1	How do you build trust-based relationships with collaborators in the early development phase of a film project?
2	How is professional reputation built, maintained, and lost in the Polish film industry?
3	How did you learn your profession — who were your mentors, what role did formal education play?
4	How do you support the development of younger crew members or junior collaborators?
5	How are technological changes (AI, virtual production, post-production tools) affecting your work and the way knowledge is shared?
6	What sustainable production practices and ESG mechanisms are being implemented in your projects?
7	What practices help you sustain a long-cycle film project under conditions of uncertainty?

Source: Own elaboration.

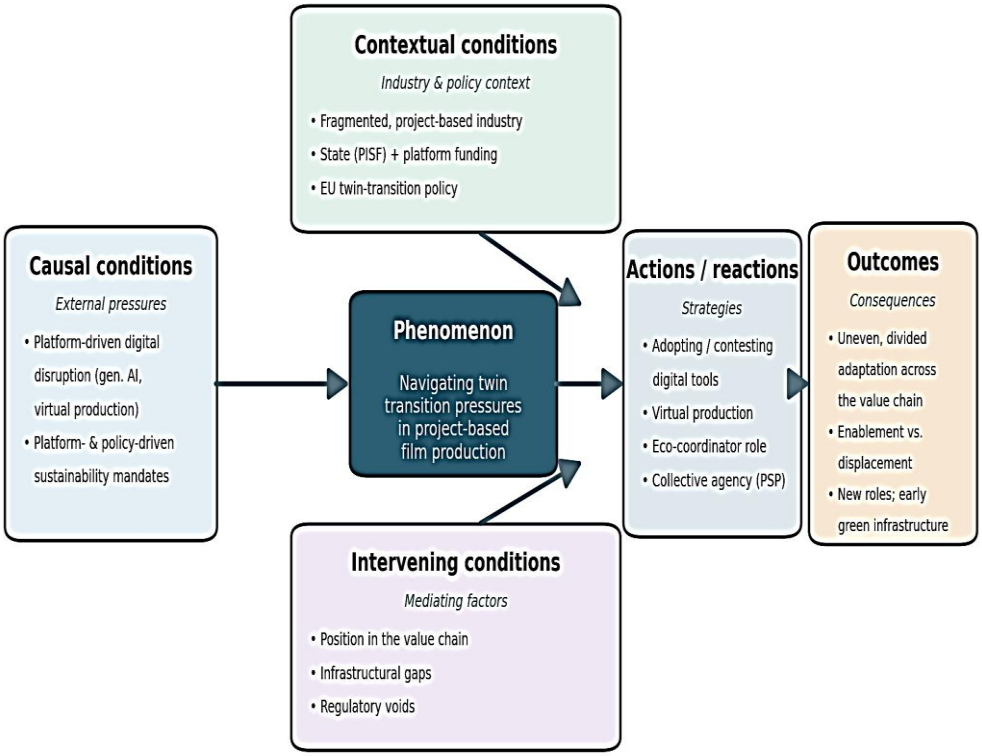
2.3. Data Analysis With ATLAS.ti

Data analysis followed a two-stage grounded coding procedure consistent with constructivist grounded theory (Charmaz, 2014; Strauss and Corbin, 1998), carried out in the computer-assisted qualitative data analysis software ATLAS.ti, which stored the material and kept the coding auditable while the interpretive work remained with the researcher (Friese, 2019; Friese, Soratto and Pires, 2018). The transcripts were imported as separate documents and assigned to document groups reflecting professional role and position in the value chain, so that coded material could later be compared across subgroups. In the first stage, the transcripts were open-coded line by line, with gerund-based codes attached to meaning-bearing segments to preserve the action orientation of the accounts; new codes were created from the data and existing ones reapplied from the Code Manager.

In the second stage, these initial codes were consolidated through axial coding: related codes were grouped into higher-order categories using code groups, each defined in its comment field, producing the second-order categories reported in Table 3. The ATLAS.ti network function was then used to relate codes and categories through named links, while the Code-Document Table and the query tool were used to examine how categories were distributed

across the document groups and to locate negative and divergent cases. Trustworthiness was supported through verbatim quotation, attention to negative cases, and reflexive memo-writing throughout the process. Read together, the categories can be organised into a paradigm model in the Straussian sense (Strauss and Corbin, 1998), which guided the interpretation of the findings.

Figure 1. Paradigm Model of The Twin Transition In The Polish Film Industry



Source: Own Elaboration

3. FINDINGS

The findings are presented in two parts. The first (Sections 3.1–3.5) concerns the digital dimension, and the second (Sections 3.6–3.8) the green dimension. Table 3 gives an overview of the second-order categories and the participants whose accounts contributed to each.

Table 3. Second-Order Categories From Axial Coding

RQ	ID	Second-order category	Participants
RQ1	**TT-D1**	AI adoption as economic optimisation	P02, P03, P06, P11
RQ1	**TT-D2**	AI contestation and anticipated labour displacement	P02, P06, P11
RQ1	**TT-D3**	Virtual production diffusion and infrastructural maturity	P03, P06, P11
RQ1	**TT-D4**	Platform economy and creative authority restructuring	P02–P09
RQ1	**TT-D5**	Post-production sectoral fragility under twin pressures	P07, P09, P10, P11
RQ2	**TT-G1**	Pioneering sustainable production under platform mandates	P08
RQ2	**TT-G2**	Eco-coordinator role institutionalisation	P08
RQ2	**TT-G3**	Operational decarbonisation practices	P03, P08
RQ2	**TT-G4**	Just transition and social sustainability practices	P03, P08
RQ2	**TT-G5**	Regulatory voids and infrastructural gaps	P03, P06, P08
RQ2	**TT-G6**	Crew resistance and social friction in green transition	P08

Source: Own elaboration based on axial coding.

3.1. AI Adoption as Economic Optimisation

Producers in development and physical production engage with generative AI primarily through an economic-optimisation lens, framing the technology as a means to compress production budgets, accelerate workflows, and substitute specialised labour where appropriate. One producer working on co-productions described an ongoing project in which AI integration substantially reduces overall production costs:

> *"I am currently researching a project that costs far more without AI than with it, because we do not have to build elaborate historical scenography. A large part of the costs disappears."* ***(P06)***

In this account, AI integration is treated as a concrete production-economics decision that reshapes the project's budget envelope. Similar instances were reported in independent film projects, where deep-fake reconstruction was used to portray a single character across multiple time perspectives, replacing the casting of additional actors and accelerating the post-production timeline:

> *"They scanned masks and facial expressions and fed it into the model. Not long ago it would have been impossible. Today they are doing it, and it works."* ***(P02)***

Beyond deep-fake applications, AI is also integrated into earlier phases of production work. Producers reported using large language models for screenwriting support and for generating preliminary text-to-video content directly from mobile applications, a workflow that did not exist until recently. These adoption patterns are driven less by formal industry-level policy

than by individual producers experimenting with available tools and gradually integrating them into established workflows as the cost-benefit ratio becomes favourable.

3.2. AI Contestation and Anticipated Labour Displacement

Alongside the economic-optimisation framing, several participants articulated explicit critiques of AI adoption, particularly when the technology is presented exclusively as a cost-reduction tool. The same producer who reported the cost-reduction case described above framed the broader digital revolution in markedly more cautious terms:

> *"I think AI and this whole digital revolution we are witnessing is what they call a game changer — but unfortunately in a bad sense. If we are only going to look at cutting costs and applying it everywhere, the social consequences will be far-reaching."* ***(P06)***

Contestation was voiced most forcefully by participants working primarily in post-production, who framed the same technologies as a threat to professional employment and to the integrity of established craft knowledge:

> *"AI is the first technology that will not give us as many jobs in compensation. Every previous technology did. With AI, part of the workforce will simply self-eliminate, and the rest will have to find a new place — which is far from guaranteed."* ***(P11)***

This account also includes a sharp critique of the democratisation discourse surrounding generative AI. The same participant observed that the easier access to AI tools brings people without professional film backgrounds into production work, which may dilute craft standards rather than expand the talent pool. These producers do not reject AI as such; their concern is how its benefits and risks are distributed across the value chain. Producers in development and physical production capture most of the savings, while post-production specialists bear the displacement risk. This uneven distribution emerged as one of the most consistent findings across the digital dimension of the study.

3.3. Virtual Production Diffusion and Infrastructural Maturity

Virtual production using LED-volume environments is gradually entering the Polish film industry, although its diffusion is constrained by infrastructural limitations and professional uncertainty. Virtual production studios have recently begun operating in Poland, and producers are beginning to use them as substitutes for international location shoots:

> *"There are virtual studios in Poland now. We are at the stage of testing whether to do a single scene that requires Monaco using virtual production in Warsaw, on LED walls, instead of flying the whole crew abroad."* ***(P06)***

One of the largest recent domestic productions is among the first to deploy virtual production techniques. Several smaller productions are also experimenting with the technology for single-scene international locations that would otherwise require disproportionate logistical effort. Producers note, however, that the technology is only now reaching the visual quality threshold required for cinema-grade work:

> *"I have the feeling that this technology has really caught up visually only recently. Earlier you could see the pixels. Now, with the right setup, it works."* ***(P06)***

Resistance to virtual production was reported among cinematographers and some producers who do not yet trust the technology, particularly its capacity to deliver consistent results across long production days. Concerns were also raised about the economic non-sustainability of rapid LED-hardware refresh cycles: post-production professionals observed that nobody can afford to replace LED walls so frequently, which constrains the long-term viability of virtual production infrastructure in a relatively small national market.

3.4. Platform Economy and Creative Authority Restructuring

International streaming platforms have become central financiers of Polish audiovisual production in recent years. Their entry restructures the producer role itself: under platform original-content arrangements, the platform acquires the intellectual property and reframes the lead Polish producer as an executive producer commissioned to deliver the work:

> *"[The platform] says: we are buying the rights to this text, we are giving you money to deliver this work, plus your fee. So in fact you are doing this work for us. You are an executive producer."* ***(P09)***

Several participants reported that platform-funded productions require trading creative ownership for financing certainty. One producer described accepting a fully platform-financed feature in exchange for surrendering all rights to the resulting film. Distinctions also emerge between platform licence deals, in which the producer retains substantial autonomy, and platform original productions, in which final creative decisions rest with the platform. These structural shifts coexist with a continued role for the Polish Film Institute (PISF) as a co-financier for art-house and independent productions, generating a layered system in which producers must navigate multiple financing logics simultaneously.

3.5. Post-Production Sectoral Fragility Under Twin Pressures

Post-production emerged in the interviews as the segment of the Polish film value chain most exposed to combined pressures of platform price-setting, AI substitution, and inadequate domestic funding. National support for post-production is structurally limited to a small

annual budget for the entire Polish post-production sector, with a low ceiling per project. Practitioners describe this funding level as merely symbolic:

> *"The first instrument we have is what PISF created because we, through PSP — our Polish post-production association — fought for it. It is a tiny amount for all of Poland, with a very low cap per project. These are ridiculous sums."* ***(P11)***

Margin compression is exacerbated by inflation. Several participants reported that DI (digital intermediate) costs for feature films have remained flat in nominal terms in recent years, despite substantial cumulative inflation over the same period. As a result, post-production houses have begun to cut infrastructure maintenance contracts and to refuse capital investment in new technologies whose pay-back horizon is too long. The mobilisation of collective agency through the Polish post-production association (PSP) represents the principal response to these pressures, but its bargaining power remains limited by the fragmentation of the sector. Several producers also reported offshoring post-production to Belgium and other tax-incentive jurisdictions, further reducing demand for domestic post-production capacity.

3.6. Sustainable Production Pioneering and Eco-Coordinator Institutionalisation

The green dimension of the twin transition in the Polish film industry is currently concentrated in a small number of pioneering productions, with the first platform-commissioned feature in Poland to integrate sustainable production protocols serving as a pioneering case. The line producer responsible for this production described its emergence as a combination of personal initiative, alignment with the platform's global ESG mission, and a dedicated additional budget secured from the platform:

> *"The project we are doing now we are making for a streaming platform as the first with sustainable ecological production. So waste, but also carbon footprint. There is no separate transport for the director or the operator — we travel with the crew, always on route. Actors travel between cities by train."* ***(P08)***

Within this production, the eco-coordinator role was formally institutionalised for the first time in a Polish platform-commissioned production. The eco-coordinator is responsible for measuring the carbon footprint using a dedicated carbon-footprint calculator, identifying generators as the largest carbon source on set, and coordinating practical waste-reduction measures including dietary interventions on the catering line. Although the function is well established in the Western European market, notably in Germany and France, it is not yet formally embedded in the Polish production hierarchy:

> *"This is the first eco-coordinator on a platform original production in Poland. The platform has very few eco-coordinators for the whole of Europe, and none was dedicated to Poland because there had not been any productions yet."* ***(P08)***

The participant also reported attending industry sustainability-training workshops which have trained a growing number of Polish crew members, suggesting that an early professional infrastructure is forming around sustainable production even before formal regulatory anchoring is in place.

3.7. Operational Decarbonisation and Just Transition Practices

Concrete decarbonisation practices reported by participants span energy, transport, and material flows on set. The principal source of emissions identified is on-set electricity generation: traditional diesel generators dominate the Polish equipment market, and ecological alternatives are virtually unavailable domestically. Reduced reliance on single-use packaging, elimination of unnecessary printing, and restrictions on diesel vehicles in city centres during shoots were reported as standard practices in productions where sustainability is prioritised.

These environmental practices are complemented by a social sustainability dimension, particularly the introduction of intimacy coordinators on set as a standard practice for scenes involving physical intimacy:

> *"We are paying more attention to psychological comfort too. There are procedures so that nobody feels their boundaries are being crossed. Intimacy coordinators are now common practice — they help plan scenes that involve undressing so that the people involved feel secure and that the rest of the crew can do its work."* ***(P03)***

Equality protocols extend beyond intimacy coordination to encompass flat crew hierarchies on transport, anti-mobbing reporting procedures, and explicit clauses negotiated with platforms ensuring that sustainability practices cannot compromise artistic quality. These practices articulate the social sustainability dimension of the green transition and connect the green agenda with concerns about labour conditions in the Polish creative sector.

3.8. Regulatory Voids, Infrastructural Gaps, and Crew Resistance

The diffusion of sustainable production practices in Poland operates within a regulatory void. No legal framework specifically addresses the environmental impact of film production, and the only relevant national-level document is a non-binding guide issued by KIPA. Some film grants are linked to documentation of sustainable practices, but compliance is not contractually enforced. Infrastructural gaps further constrain implementation:

> *"We did a small research project on ecological generators. It turned out the nearest ones are abroad — in Poland they are practically unavailable. The generators we use are standard. I know that in the West there is increasing pressure on this."* ***(P03)***

Crew resistance also emerged as a recurrent theme in implementation accounts. The eco-coordinator on the first platform-commissioned sustainable production reported encountering crew members who do not believe in climate change, declining enthusiasm for dietary interventions such as vegetarian Thursdays, and persistent perceptions of the eco-coordinator as an enforcer of unwelcome rules. These dynamics illustrate that the green transition in creative production is contested not only at the structural level but also in everyday on-set practice, and that its consolidation depends on the gradual cultivation of professional cultures that accept environmental considerations as legitimate constraints on creative work.

4. CONCLUSION, DISCUSSION AND SUGGESTIONS

This study examined how the twin transition unfolds in the Polish film industry through an analysis of eleven semi-structured interviews with audiovisual producers selected from the KIPA membership directory and analysed through two-stage grounded coding in ATLAS.ti. On the digital dimension, the findings demonstrate that Polish film producers respond to generative AI and virtual production along divided pathways: producers operating in development and physical production embrace these tools as creative and economic enablers, while specialists involved in post-production contest them as threats to professional employment and craft knowledge. On the green dimension, the findings show that sustainable production practices and ESG mechanisms are being implemented predominantly through international streaming platforms operating in Poland rather than through formal domestic regulation. The first platform-commissioned sustainable production in Poland acts as a pioneering case, institutionalising new professional roles such as the eco-coordinator and creating an early infrastructure for green transition diffusion. The study contributes to twin transition research by extending its empirical scope to project-based creative industries and by demonstrating that digital and green transformations in this sector should be analysed as interconnected dynamics, with adaptation operating unevenly across functional specialisations within a single value chain.

The study has several limitations. The sample of eleven interviews, while theoretically saturated, was drawn entirely from the KIPA membership and therefore underrepresents independent producers operating outside the formal institutional structure. The findings are situated in the Polish context and may not generalise directly to film industries operating under different funding regimes or labour regulations. Future research could compare the Polish case with other Central European film industries or with mature creative ecosystems such as the United Kingdom, France, or Germany, where the eco-coordinator role and AI-enabled virtual production are already more institutionalised. Longitudinal designs could trace how the twin transition reshapes production practices across the multi-year cycle of a typical film project, while comparative work across functional specialisations within the producing role

could deepen understanding of how digital and green adaptation varies between development, physical production, and post-production.

For practitioners and policy-makers, the findings suggest several directions of intervention. First, producers can strengthen the readiness of Polish productions for twin transition pressures by investing in early-stage planning of AI integration and sustainability protocols, and by developing internal evaluation procedures that involve both creative and technical specialisations. Second, the Polish Film Institute and the Krajowa Izba Producentów Audiowizualnych could play a stronger institutional role by formalising the eco-coordinator function, by linking national funding more explicitly to verifiable sustainability documentation, and by supporting professional sustainability-training programmes for crew. Third, European policy-makers should recognise that twin transition outcomes in creative industries depend on distributed developmental infrastructures, including international training programmes, professional associations and sector-specific funding mechanisms, rather than on top-down regulation alone. Treating digital and green transformations as interconnected dynamics, rather than as separate policy tracks, is essential for ensuring that creative industries can contribute meaningfully to the European twin transition agenda.

Ethics declaration

All participants provided informed consent prior to the interviews. Pseudonymous codes (P01–P11) were assigned to protect confidentiality. The study followed standard ethical guidelines for qualitative research with adult professionals.

AI declaration

AI tools were not used for this article.

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GREEN WORDS, GREY DEEDS? SYMBOLIC VERSUS SUBSTANTIVE ESG DISCLOSURE AND GREENWASHING IN TÜPRAŞ'S 2021 SUSTAINABILITY REPORT: A MAXQDA CONTENT ANALYSIS

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Abstract

The gap between informing stakeholders and managing how they perceive the firm is the main question in the greenwashing literature, and corporate sustainability reporting is all about this. Most of the methodological approaches to the study of that gap are quantitative, and the close qualitative analysis of how a single report constructs claims is less developed. This paper explores the less noisy strand of the literature by reading one report in detail. The case concerns Tüpraş, the largest oil refiner in Turkey, which is a long-term sustainability reporter and has announced its Strategic Transition Plan and a long-horizon decarbonisation commitment in the year. The research question is: how are the symbolic and substantive aspects of ESG disclosures experienced and interpreted in the 2021 sustainability report of the firm? The study is based on legitimacy theory and the distinction between symbolic and substantive aspects of legitimacy, and greenwashing is operationalised using the TerraChoice typology and the selective-disclosure literature. The method is qualitative content analysis, following the tradition of Mayring and Schreier, and was analysed in the software MAXQDA, using a layered coding frame that spans the ESG topics, disclosure types, and rhetorical patterns. The analysis reveals that symbolic and substantive content are not equally balanced in the report, that the symbolic content is focused at the strategic core, at the point where the firm's legitimacy is most vulnerable, and that vagueness is the most prevalent rhetorical pattern. The study provides a close textual case that adds to a literature dominated by aggregate measures and provides a baseline for a longitudinal extension.

Keywords: Greenwashing, ESG Disclosure, Legitimacy Theory, Sustainability Reporting, Content Analysis

INTRODUCTION

Sustainability reporting has emerged as the primary public indicator of the actions that big industrial companies plan to take to manage their environmental footprint. This type of report establishes goals, outlines programs and provides statistics that regulators, investors and the general public use to evaluate corporate intent. However, the same reports also engage in legitimacy work. They tell a story the firm wants to be believed, and that story can be away from what the firm is actually doing. What is said and what is done is what the greenwashing literature refers to (Delmas & Burbano, 2011; Lyon & Maxwell, 2011; TerraChoice, 2010) and is a central question for ESG research. That gap is studied primarily by quantitative methodological tools. The most prevalent methods are disclosure indices, automated sentiment scoring, and close qualitative analysis of the development of claims in a single report, with the latter being less advanced (Crossley et al., 2021; Manes-Rossi & Nicolò, 2022). This study tackles the quieter side of the literature by reading one report in detail and asking what it does at the level of the individual passage.

The case is Tüpraş. The company has 4 refineries with a total annual capacity of 30 million tonnes, owns 75 per cent of the refining capacity in Turkey, and provides 53 per cent of the Turkish petroleum products market (Tüpraş, 2021). It is Turkey's biggest industrial company and has been a long-term sustainability reporter, reporting practices predating the broader Turkish requirement for mandatory reporting. In November 2021, the firm announced a Strategic Transition Plan, in which it pledged to achieve a 27 per cent reduction in its emissions on the 2017 baseline by 2030 and carbon neutrality by 2050 (Tüpraş, 2021). The pledge year is what makes 2021 a helpful year to study. Such a long-term commitment calls on stakeholders to assess the firm's performance against a goal it has not yet reached, and the report issued in that year is the first formal report on the firm's performance in relation to the target it has just embarked on. From the perspective of the legitimacy theory, the pledge increases the pressure on the firm to communicate its environmental performance in a certain manner (Cho & Patten, 2007; Suchman, 1995). This report is now an account and a piece of communication, and the balance that it achieves between these two is the empirical question that this study addresses.

The contribution is influenced by three gaps in the current literature, first on the method. The majority of greenwashing research is conducted with large samples and aggregated measures, which only reflect the quantity and intensity of greenwashing, but not the building of a single greenwashing claim (Marquis et al., 2016). Close textual reading of a single report can recover that construction. Second, on setting. ESG and greenwashing research is largely based on empirical evidence from North American and European companies, with reporting practices in emerging markets receiving less attention. Turkey has a developing sustainability reporting regime and has a large fossil-fuel sector, making it an underexamined site. Third, in the sector.

The oil refining sector is facing intense pressure for change, and its disclosure is consequential, but close qualitative analysis of the reports of the oil refining sector is relatively uncommon. Tüpraş is at the intersection of these three considerations, which is why the report for 2021 is not a narrow one but an instructive one.

The study combines two lines of theory to read the report. It is derived from legitimacy theory, which posits that disclosure can be used to help shape perceptions as well as to inform (Deegan, 2002; Suchman, 1995). From the symbolic and substantive distinction, it takes an analytical axis along which any single claim can be placed (Ashforth & Gibbs, 1990; Crossley et al., 2021). The greenwashing typology created by TerraChoice (2010), combined with the rhetorical patterns identified by strategic-disclosure accounts of Lyon and Maxwell (2011) and Marquis et al. (2016), provides the rhetorical patterns that tend to signal the symbolic end of that axis. These tools help to define the question of the study, which is as follows.

How are the symbolic and substantive dimensions of ESG disclosures experienced and interpreted in Tüpraş's sustainability report published in 2021?

The qualitative content analysis in the tradition of Mayring (2014) and Schreier (2012) is used to answer the question, and the coding frame is structured by topic, disclosure type and rhetorical pattern, using the software environment MAXQDA. The methodological approach of that tradition is followed by not converting coded segments into counts or percentages. Themes are reported as qualitative relative weights. Numerical evidence only comes into the analysis when it is taken from the firm's own reported data, which is used as field evidence, not as coding output.

The paper is organised as follows. Section 2 outlines the literature and theoretical background, including the symbolic and substantive distinction in the context of legitimacy theory and the greenwashing literature. The methodology is explained in Section 3, which covers the coding frame, the application of MAXQDA and the principles on which findings are presented. The results are presented in Section 4, and the implications for the symbolic-and-substantive literature, the location of symbolic work in a corporate sustainability report and the boundaries of the concept are discussed in Section 5. The contribution is summarised, and the longitudinal extension of the present study is identified at the end of section 6.

1. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

1.1. ESG Disclosure and The Management of Legitimacy

The legitimacy theory is based on the premise that an organisation's ability to function depends on the society's acceptance of its actions (Deegan, 2002; Suchman, 1995). According to Suchman (1995), legitimacy is a generalised perception that an entity's actions are appropriate in a socially constructed system of norms and values, and he distinguishes three

bases of legitimacy: pragmatic, moral, and cognitive. He also separates the processes of obtaining, sustaining and restoring legitimacy, and he mentions disclosure as one of the tools managers resort to when they feel they are in danger of being perceived as improper. Cho and Patten (2007) give empirical support to this reading. They discover that companies in industries that have environmental sensitivity, and those with poorer environmental records, tend to disclose more environmental information, consistent with the idea that disclosure can be a legitimating device, not a neutral representation of performance. Sustainability and ESG reporting thus have a dual nature. It can educate stakeholders, and it can control the perception of the firm by the stakeholders.

This literature has been divided into two paths to legitimacy. Ashforth and Gibbs (1990) talk about substantive management (changing the actual practice and output of the organisation) and symbolic management (changing the way the practice and output are presented without changing the practice). They also determine a hazard. When a claim is made, it is important that there is visible effort to appear legitimate; otherwise, it can come across as 'over-protesting' and reduce the credibility of the claim. Crossley et al. (2021) use this combination in the context of corporate sustainability. They demonstrate through interviews with companies that social and environmental practices are typically a mix of symbolic and substantive aspects rather than having a single type. For the present study, the distinction is useful because it is analytical. It provides a framework for determining, for any given section of a sustainability report, whether it documents a real change in behaviour or primarily serves to shape the perception.

1.2. Greenwashing as Selective and Symbolic Communication

Greenwashing names the gap between environmental talk and environmental action. It is defined by Delmas and Burbano (2011) as the practice of deceiving stakeholders regarding the environmental impact of a company or the environmental advantages of its products, and they outline the motivation for it at the market, organisational and individual levels. Their account identifies the worst greenwashing among companies with poor environmental performance and positive environmental communication. Two patterns can be found throughout the broader literature. The first is selective disclosure. Lyon and Maxwell (2011) propose a model of greenwash that is a strategic disclosure of positive environmental information, withholding unfavourable information, which is more likely to be attractive when the firm has a low chance of being audited. Marquis et al. (2016) note the same selectivity in practice in a large international sample. The more harmful companies report their emission less fully, and the more external scrutiny, the less this behaviour. The second is symbolic communication. Much corporate environmentalism is symbolic, and involves the creation of signals like commitments, reports, and eco-labels that may or may not reflect

actual improvement, and that these signals remain because the audience accepts them, argues Bowen (2014).

The seven sins of greenwashing, among others, are vagueness, hidden trade-off, irrelevance, the lesser of two evils, worshipping false labels, no proof and fibbing, as identified by the survey of product claims conducted by TerraChoice (2010). The typology was developed for product marketing, but the categories also appear in corporate reports, such as a general statement with no metric of support, or a particular positive value being highlighted against a larger and unmentioned value. The present study uses this typology, in combination with the symbolic and substantive distinction, as a coding vocabulary for the report text.

1.3. Symbolic and Substantive Disclosure in Environmentally Sensitive and Emerging Market Settings

The symbolic versus substantive question has been explored most frequently in large samples and with scoring techniques, and has been explored less frequently in close reading of a single report. Manes-Rossi and Nicolò (2022) examine the reporting of EU energy companies on SDGs in the energy sector. They discover that many references are still symbolic and that companies tend to focus on the targets that are appropriate to them, but not much is provided to support their performance against these targets. They found that symbolic reporting is widespread in the high-emitting industry to which oil refining belongs. The present study leaves room for three features of the existing evidence. The first one is about the method. The qualitative interpretation of the construction of a single claim is less advanced than the quantitative indices or automated text scoring for greenwashing and symbolic reporting. The second is about the setting. The bulk of the evidence is from North American and European companies, and there is less research on reporting in emerging markets. The third relates to the sector. Fossil-fuel refining is under intense pressure for change, but has received little detailed textual focus. Instructive case studies are not the same as narrow case studies, and Turkey's biggest refiner, Tüpraş, is a long-standing sustainability reporter; hence, a single report in 2021 can serve as an instructive case study rather than just a narrow one. A close reading also yields something that the indices cannot, because it can reveal the internal structure of a claim and any internal tensions between one claim and another on the same page.

1.4. Theoretical Framework For The Present Study

The study brings together the two strands stated above. Legitimacy theory supplies the motive. A refiner that makes a long-horizon decarbonisation commitment is subjecting itself to scrutiny by its stakeholders, thereby increasing the stakes associated with the manner in which the refinery tells its environmental story (Deegan, 2002; Suchman, 1995). The symbolic versus substantive distinction provides the analytical axis. Each disclosure can be interpreted

as leaning toward substantive content (quantified, baselined or independently assured claims) or symbolic content (aspiration, forward-looking language without a baseline, selective emphasis, description of process without a reported outcome), as did Ashforth and Gibbs (1990), and their sustainability application by Crossley et al. (2021). The greenwashing typology of TerraChoice (2010), in conjunction with the accounts of selective disclosure of Lyon and Maxwell (2011) and Marquis et al. (2016), provides the rhetorical patterns that are typically associated with the symbolic conclusion of that axis. These tools collectively form the basis of the study's question: How are the symbolic and substantive aspects of ESG disclosure perceived and understood in Tüpraş's sustainability report in 2021? The framework considers the report as a text that is to be interpreted, rather than scored, as the balance of presenting performance and managing perception is considered on a passage-by-passage basis.

2. METHODOLOGY

2.1. Research Design

The study is based on the qualitative content analysis method proposed by Mayring (2014) and Schreier (2012). This method reads a text body systematically against a coding frame, but with the focus on meaning, distinguishing it from word counting. The choice is appropriate to the research question, which is about the symbolic and substantive aspects of ESG disclosure as they are experienced and interpreted in a single report, not about the frequency of a disclosure. The categories were inductively derived from theory and from existing reporting frameworks and were then further elaborated inductively as distinctions were proposed in the report that were not included in the initial framework (Mayring, 2014). The reading was done in an iterative fashion; the frame and the material were mutually informing.

2.2. Case Selection and Corpus

The design was a single instrumental case, selected for its insights into the phenomenon, not for its statistical representativeness (Yin, 2018). Tüpraş was chosen for three reasons. It is the largest oil refiner in Turkey, and its environmental performance is significant in a developing environment, which has received less study than in North America and Europe. It has a long history of sustainability reporting, providing a developed text to read. In 2021, it also made a long-term decarbonisation commitment, adding to the legitimacy stakes and making that year a good starting point. The corpus is a 129-page Sustainability Report in 2021 (Tüpraş, 2021). The analysis is constructed as a communicative artefact, considering the narrative text, the targets and the framing around the reported figures.

2.3. Coding Frame

The coding frame is structured in layers, with each layer being applied to the same passages, thus allowing multiple coding layers for the same passages. The first layer captures the ESG Topic. The categories have been deductively identified from existing sustainability reporting frameworks, particularly the GRI Standards and the GRI 11 Oil and Gas Sector Standard, and sector-specific environmental categories are based on SASB and the TCFD recommendations. The second layer is for disclosure type on the symbolic to substantive continuum. Substantive codes are used where claims are quantified, baselined, or independently assured and symbolic codes are used where claims are aspirational, forward-looking language without a baseline, selective emphasis, and to describe process without a reported outcome, based on Suchman (1995), Ashforth and Gibbs (1990), and the sustainability application by Crossley et al. (2021). The third layer focuses on the greenwashing patterns and is based on the typology of TerraChoice (2010) and the selective disclosure accounts of Lyon and Maxwell (2011) and Marquis et al. (2016). A fourth, milestone layer tags passages that establish the 2021 position as a baseline for the planned longitudinal extension and is not analysed in the present paper. The codes are followed by a definition, a coding rule, and an anchor example, as recommended in Schreier (2012).

2.4. Coding Procedure and Software

The report, the coding frame and the coded segments are stored in one project in MAXQDA and can be retrieved across layers. The report was read through, and each relevant passage was given codes from the relevant layers. Coded segments were arranged and exported using a spreadsheet, providing an ordered list of the content that was coded behind each category. Since intersections are recorded at the sub-code level and no intersections are returned at the parent level, co-occurrence between codes was examined at the leaf code level using the Code Relations Browser. The Code Matrix Browser was read in the same fashion to determine which topics are related to which disclosure types.

2.5. Trustworthiness and The Presentation of Evidence

The credibility is based on the discipline of the coding frame. Each category is explicitly defined, accompanied by a coding rule and an anchor example, and a coding decision can thus be traced and questioned, rather than taken on faith (Mayring, 2014; Schreier, 2012). An audit trail is composed of the corpus, the frame, and the coded segments. The study was carried out as a single-coder pilot to ensure consistency of the frame and repetition of the material, and it considers interpretation as situated and not neutral, consistent with the interpretive approach of the method. There is one additional decision that will affect the reporting of results. The analysis does not convert the coding judgements into counts or percentages, as this would be an assumption of the method and a claim of its precision, following the tradition of Mayring

and Schreier. Findings are presented in qualitative terms with descriptors such as dominant, prominent or heavily concentrated to provide relative emphasis. Numbers are only used where they are reported by the firm, for example, in the statements of emissions, targets and investments, which are treated as field evidence rather than as coded.

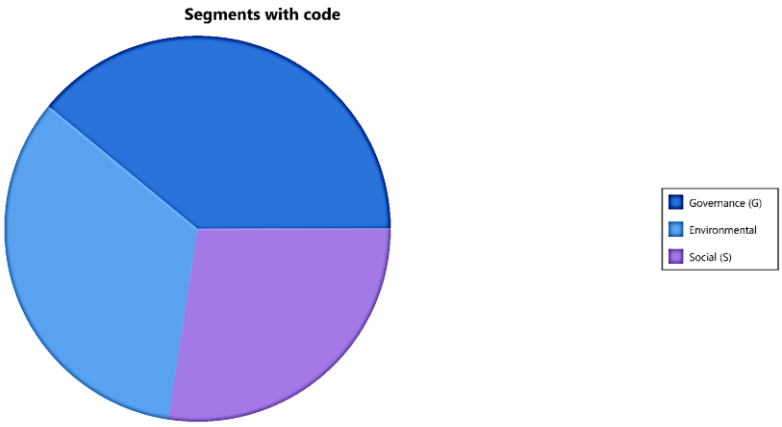
3. FINDINGS

This section reports how ESG disclosure is constructed in Tüpraş's 2021 Sustainability Report, read through the symbolic and substantive distinction set out earlier. Following the methodology, the analysis is presented in qualitative terms. The figures are drawn from MAXQDA outputs and function as visual maps of relative emphasis.

3.1. Where The Report Concentrates Its Attention

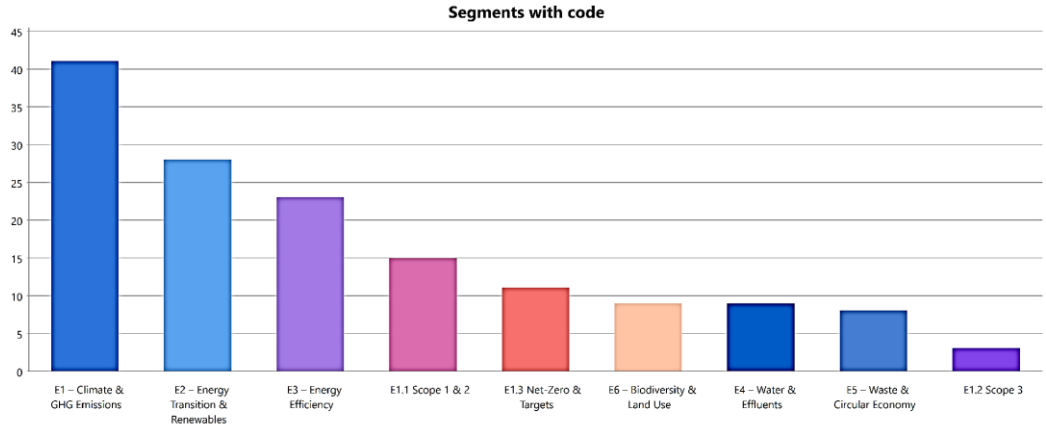
The distribution across the three ESG dimensions, taken at the parent level, shows that the report's coverage is split fairly evenly between the three categories, with governance carrying slightly more coded material than environmental, and social standing as the smallest of the three. The pattern is visible in Figure 1.

Figure 1. ESG Topic Coverage at The Parent Level (MAXQDA, Segments With Code)



Within the environmental domain, the emphasis is uneven. Climate and greenhouse gas emissions, energy transition and renewables, and energy efficiency carry the bulk of the coverage, while biodiversity and land use, water and effluents, environmental compliance, and waste and circular economy receive lighter and similar treatment. Inside the climate sub-themes, Scope 1 and Scope 2 emissions hold a clear position, the net-zero target is given steady attention, and Scope 3 is the thinnest of the three by a wide margin. The shape of this internal distribution appears in Figure 2.

Figure 2. Environmental Sub-Theme Coverage (MAXQDA, Segments With Code)

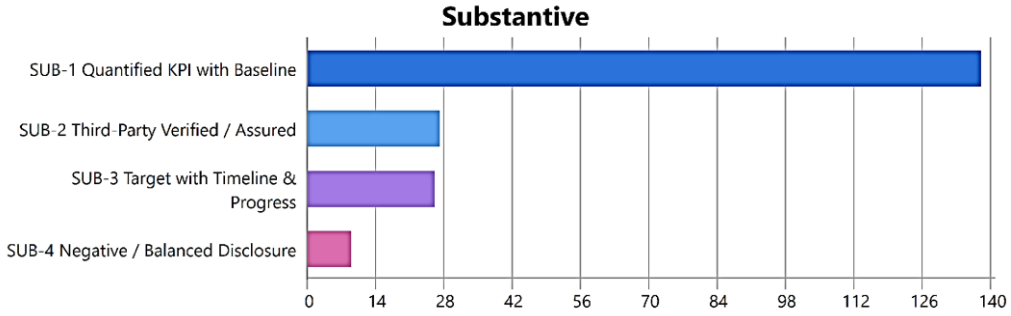


The social and governance dimensions show different concentrations. Within social, diversity, equity, inclusion and human rights, and employee development and training, dominate the coverage, while community and social investment, supply chain sustainability, occupational health and workforce safety, and customer and product responsibility are present but lighter. Within governance, regulatory compliance with reporting standards is the most heavily covered theme, followed by risk management and board structure and ethics, with audit, assurance and verification, stakeholder engagement and materiality, and ESG governance and executive pay treated more briefly. Two observations follow. The first is that the most heavily covered single topic across the entire report is regulatory compliance with frameworks such as the Turkish Sustainability Reporting Standards, GRI, and TCFD, which is the architectural feature of the disclosure rather than its environmental content. The second is that the climate sub-themes carry the report's substantive headline ambition, while the rest of the document is built around routine reporting on operations.

3.2. The Dominance of Substantive Disclosure

Read as a whole, the report is substantive in form. Quantified indicators with prior-year baselines are by far the most common single mode of disclosure, exceeding all symbolic disclosure types combined. Third-party verified or assured indicators, and the pairing of targets with timelines and progress are also present in comparable measure, while balanced disclosure that reports negative outcomes alongside positive ones is the smallest of the substantive sub-codes. The distribution is shown in Figure 3.

Figure 3. Substantive Disclosure Types (MAXQDA, Segments With Code)

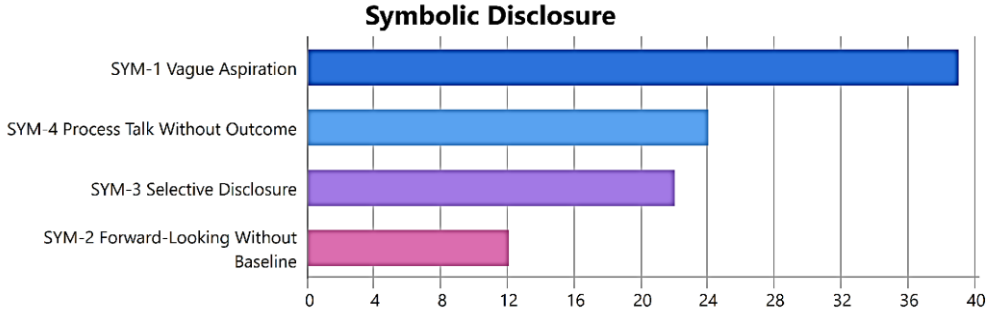


The substantive content does not spread evenly across the report. It concentrates on operational topics where what the firm can readily demonstrate is reported in a measurable form. Diversity and human rights, energy efficiency, board structure and ethics, employee development and training, regulatory compliance, and risk management carry the densest substantive coverage. The net-zero target itself is substantive in structure, since it pairs a 2017 baseline with a dated 2030 target, an architecture that supports verification over time. A reader moving through the operational and target sections meets data-rich text that supports the firm's claim to transparency.

3.3. Where Symbolic Content Concentrates

Symbolic disclosure is real but concentrated. Within the symbolic category, vague aspiration is the leading sub-code, followed by process talk without outcome, selective disclosure, and forward-looking statements without a baseline. The distribution is shown in Figure 4.

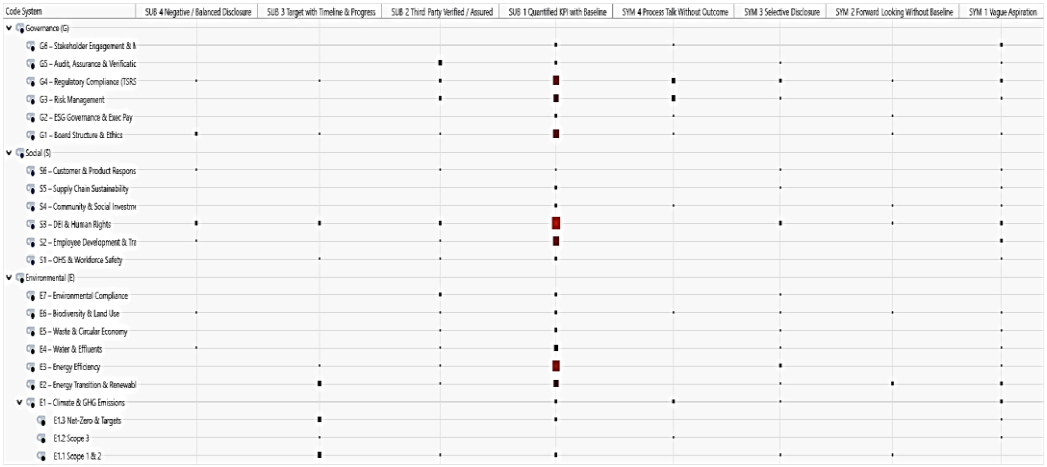
Figure 4. Symbolic Disclosure Types (MAXQDA, Segments With Code)



The location of these symbolic markers is where the analytical interest lies. Reading the disclosure-type codes against the topic codes through the Code Relations Browser shows

where the two registers concentrate. Substantive quantification clusters most densely at diversity and human rights, energy efficiency, regulatory compliance, board structure and ethics, employee development and training, and risk management. Symbolic content clusters at a different set of points. Forward-looking statements without a baseline concentrate on energy transition and renewables. Process talk without outcome concentrates on regulatory compliance and risk management, where the firm describes governance procedures without reporting their results. Vague aspiration is the most widely scattered symbolic code, surfacing at stakeholder engagement and materiality, energy transition, the climate parent, and employee development. Selective disclosure concentrates on diversity and human rights and at energy efficiency, where favourable indicators are highlighted while comparable indicators receive lighter treatment. The intersections are visible in Figure 5.

Figure 5. Code Relations Browser Matrix Of ESG Topic Categories By Symbolic And Substantive Disclosure Type. Cell Symbol Size Reflects The Relative Density Of Co-Coded Segments

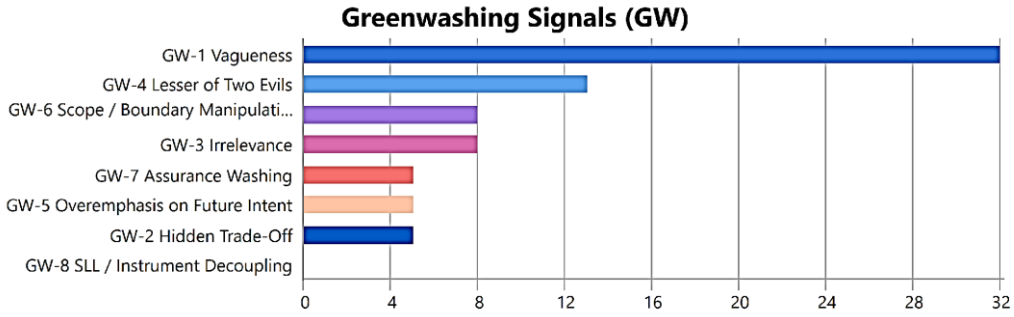


Energy transition and renewables are the topic where the two registers most visibly interleave. It carries one of the report's heaviest concentrations of forward-looking language without a baseline, alongside one of its heaviest concentrations of target-with-timeline disclosure. The strategic ambition sits beside the substantive architecture meant to support it. In the Sustainability Priorities section, for example, the report states that Tüpraş "aims to increase its investments in Sustainable Aviation Fuel, Zero-Carbon Electricity and Green Hydrogen projects and initiatives to 70% by 2035" (Tüpraş, 2021, p. 24). The target is forward-looking and gives no corresponding share of these investments in 2021, which is the feature that places it toward the symbolic end of the axis.

3.4. Vagueness As The Leading Rhetorical Pattern

Among the rhetorical greenwashing patterns, vagueness is dominant. It is the most heavily applied greenwashing code by a wide margin, and it sits well ahead of the lesser-of-two-evils framing that follows. Scope and boundary manipulation and the irrelevance pattern occupy the middle tier. Assurance washing, the overemphasis on future intent, and hidden trade-offs are present but lighter. The sustainability-linked instrument decoupling code shows no application in the 2021 report, which is consistent with the firm having no sustainability-linked loan in that year. The distribution is shown in Figure 6.

Figure 6. Greenwashing Rhetorical Pattern Coverage (MAXQDA, Segments With Code)



The dominance of vagueness alongside the dominance of quantified indicators is the point that matters. The firm reports many numbers and still relies on broad claims without a supporting metric, where its position is least secure. The pattern is closer to selective and strategic communication than to crude misstatement. The Emission Management narrative offers a representative example, stating that "the current best practices and the highest standards are applied for the minimisation of emissions stemming from operations" (Tüpraş, 2021, p. 48). The claim carries no named practice and no benchmark against which the standards could be tested, which is the feature that marks it as vague within the coding frame.

3.5. The Pledge-Data Paradox

The sharpest tension in the report sits between its central pledge and its own contemporaneous figures. In the same report that foregrounds the 27 per cent reduction target against the 2017 baseline, the firm's own reported figures show Scope 1 emissions rising from 5,724,407 tonnes of CO_2e in 2020 to 5,875,393 tonnes of CO_2e in 2021, an increase of 150,986 tonnes in the pledge year itself (Tüpraş, 2021, p. 47). The energy-efficiency projects highlighted as evidence of near-term progress achieved a reduction of 106,700 tonnes of CO_2, which corresponds to roughly 1.8 per cent of the 2021 Scope 1 figure (Tüpraş, 2021, p. 47).

The gap is not the ordinary distance between a long-term pledge and a future result, which cannot yet be known. It is the distance between the framing of forward progress and the firm's record for the very year in which the pledge was made. This is the point at which symbolic framing and substantive record diverge most clearly.

3.6. The Assurance Contradiction On Page 47

A second tension takes the form of a direct internal contradiction on a single page. On page 47, the body text states that audits conducted under ISO 14064-1, together with certification by accredited bodies and independent third parties, "have confirmed its Scope 1 and Scope 2 greenhouse gas emissions" (Tüpraş, 2021, p. 47). The Scope 1 and Scope 2 emissions table directly below carries an asterisk attached to the 2021 figures, and the footnote to that asterisk states that the "ISO14064 Data verification process has yet to be completed" (Tüpraş, 2021, p. 47).

The two statements cannot both hold. The body text claims an assurance that the footnote shows the firm had not yet obtained the very numbers being reported. Within the coding frame, this passage is the clearest instance of assurance washing, and its presence on a single page makes the gap between claim and basis unusually easy to see.

3.7. Reading The Symbolic and Substantive Balance

Three observations answer the research question. First, the report is substantive in form across most of its operational coverage, where quantified indicators with prior-year baselines carry the disclosure. Second, the symbolic content is not dominant overall but is concentrated at specific points, principally at the energy transition narrative, where forward-looking language sits beside the substantive architecture of the headline target, and across the report's broad environmental and stakeholder claims, which carry the leading rhetorical pattern of vagueness. Third, at two specific points, the pledge-data paradox and the contradiction on page 47, the symbolic framing diverges from the firm's own substantive record. The symbolic and substantive dimensions are therefore not separate channels in this report. They are interleaved within the same passages, and the report's legitimacy work depends on the symbolic dimension carrying weight that the substantive record does not yet support at the points where the firm's position is most exposed.

4. DISCUSSION

4.1. An Uneven Distribution of Symbolic and Substantive Disclosure

The analysis addresses the research question by demonstrating that the symbolic and substantive dimensions do not constitute separate registers in the report but are unevenly spread over the topics of the report. The report is overall substantial in form. It is most often

disclosed through quantified indicators with prior-year baselines and is found in abundance in operational areas like employee training, diversity and human rights, risk management, and energy efficiency. The reader who travels through these sections encounters a rich description of data, which bolsters the firm's claim to transparency (Deegan, 2002). This makes it difficult to simply interpret the report as greenwashing because a lot of it is quantifiable and can be verified.

The symbolic markers do not spread evenly. They are collected at the heart of the report, where the climate ambition is stated. There, the language of vague aspiration and forward-looking language without a baseline is much of the disclosure, alongside the substantive architecture of the timelined target itself. The report is thus informative about the usual functioning and symbolic about the most important commitment. This fits with Ashforth and Gibbs (1990) distinction between substantive management (what an organisation can easily show) and symbolic management (what it contests and/or is uncertain about). In this report, the measurable is quantified, and the contested is narrated.

4.2. Symbolic Work Concentrates Where Legitimacy Is Most Exposed

The placement of the symbolic disclosure is itself meaningful. According to the legitimacy theory, firms reveal the most when their performance is the most vulnerable to scrutiny (Cho & Patten, 2007; Suchman, 1995). The decarbonisation pledge is the firm's most closely watched commitment, and it is here that the report shifts from numbers to aspiration. The energy transition theme is most clearly evident in this interleaving because it features substantive targets as well as forward-looking statements without a baseline to benchmark progress. The net-zero headline is tangible in its form, combining a target with a time horizon, but its story is based on intention and not on the record of the year.

This is where the pledge-data paradox gains its force. It isn't that the company hides numbers, since it has many to report on. It's because the real building of the target is next to a symbolic interpretation of progress, and the actual emissions made by the firm during the pledge year went in the other direction. The shift is similar to the tendency of the greenwashing literature to focus on the future intent, which is considered a separate pattern (Delmas & Burbano, 2011; TerraChoice, 2010). The carbon account boundary is an example of that. The biggest portion of emissions for a refiner comes downstream in the use of sold products, but the Scope 3 category is the thinnest of the climate sub-themes in the report. The framing of the account in the more favourable scopes is the scope and boundary manipulation pattern identified in the analysis, and it parallels the selective emphasis that Manes-Rossi and Nicolò (2022) find within European energy companies.

4.3. Vagueness And The Limits Of A Greenwashing Verdict

Vagueness is the most prominent of the rhetorical patterns. The broad environmental claims that have no accompanying metric are the most common greenwashing signal, consistent with the vagueness as the cheapest and most readily available move accounts (Lyon & Maxwell, 2011; TerraChoice, 2010). What the case brings is the coexistence of vagueness with the heavy quantification. The firm can report many numbers, and still have a lot of vague or forward-looking statements where it is weakest. This selectivity in quality and substance in the routine and vagueness at the core is more akin to the strategic disclosure model proposed by Lyon and Maxwell (2011) and identified by Marquis et al. (2016) than to the mere misstatement. An absolute greenwashing would be missing this structure. The report is more readable as a balanced mix, with a strategic story that the year's performance doesn't yet substantiate but is managed by the reporting.

4.4. Contribution And Limitations

Two contributions follow. The case demonstrates that the symbolic and the substantive are not the property of a report as a whole, but a distribution, and that the symbolic work is concentrated in the areas of highest scrutiny. This makes the disclosure-as-legitimation argument more nuanced because it doesn't rely on the assumption of symbolic content, but instead identifies it. In terms of method, the close reading reveals that concentration, as it is done in an index-based or automated way which aggregates across a document, is not designed to reveal it (Crossley et al., 2021). The lesson for a reader of such reports is that the density of numbers is not a good indicator of substance because the numbers and the symbolic claims may be in different places in the same report. The study is limited by the design. It is only one report from one company in one year, interpreted by one analyst, and therefore only applicable to this case and not to the sector. The limits also establish the direction of the planned extension, which will follow to see if the symbolic core becomes more limited as assurance becomes more robust, Scope 3 disclosure becomes more sophisticated, and regulatory requirements evolve in the future reports of the firm.

5. CONCLUSION

This study aimed to examine Tüpraş's 2021 Sustainability Report in detail in order to understand the symbolic and substantive dimensions of the report on the passage level. The analysis offers three related responses to the question. First, the symbolic and the substantive are not properties of the report as a whole, but are unevenly distributed within it. The report is substantive in form in its operational sections, with quantified indicators with baselines providing most of the disclosure, and leans symbolic at the energy transition narrative, where forward-looking language and vagueness sit beside the substantive architecture of the headline target. Second, the symbolic work concentrates precisely where the firm's legitimacy

is most exposed. The decarbonisation pledge is the most closely examined pledge in the report, and where the aspiration, forward-looking language, and selective emphasis sit beside the substantive architecture of the headline target rather than displacing it. Third, at specific points, the symbolic framing diverges from the firm's own substantive record. The climate narrative borrows credibility that the firm's own reported figures contradict in one case, and that the report's own footnote disclaims in the other.

The contribution is twofold. In theory, the case highlights the symbolic-and-substantive approach to corporate sustainability disclosure, demonstrating that these are not alternative registers of the disclosure, but rather layers within the disclosure, and that the symbolic work situates itself where the scrutiny of stakeholders is greatest. This gives the legitimacy-as-disclosure argument specificity, as it is not assumed but discovered. With this method, the close reading uncovers a pattern that aggregate measures are not able to capture. The density of numbers in a report is not a good indicator of the substantive nature of the report, as substantive quantification and symbolic framing can appear in different sections of the same report. That distinction became visible in the course of qualitative content analysis in the sense of Mayring and Schreier, which was carried out with the help of MAXQDA.

The study is limited and has been designed as such. It reads one report, from one firm, in one year, through one analyst's interpretation, and it doesn't give coding counts. Its claims are not applicable to the refining sector or to Turkish reporting in general, but rather to this case. Consistency is provided in the single-coder pilot by an explicit coding frame, anchor examples, and multiple passes over the material; a future study would benefit from second coder verification and comparison to a peer refiner.

These limits also set the agenda. This analysis is intended to be a baseline for a longitudinal extension. There are three milestones in the later reporting cycle that can be used to test the symbolic core identified here. The 2022 transition to integrated reporting adds a new architecture for the framework and a new external assurance provider; the 2023 reporting year adds Scope 3 disclosures and assured key indicators, and the 2024 reporting year features the Turkish Sustainability Reporting Standards and a sustainability-linked loan on the firm's account. The empirical question the extension will address is whether the symbolic concentration that is seen at the 2021 climate core narrows as these milestones are reached. The close reading recommends that readers of corporate sustainability reports, such as regulators, analysts and researchers, benefit from looking at the point where the numbers get thin and at the point where they get thick. The legitimacy work that is most important is not usually conducted in the area of highest data density. It is done where the data give way to language.

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DIGITAL ESG COMMUNICATIONS AS DUAL-TRANSITION INFRASTRUCTURE: A COMPARATIVE ANALYSIS OF RUSSIAN AND TURKISH RETAIL AND PLATFORM-BASED COMMERCE COMPANIES

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Abstract

The paper examines how digital channels, platform interfaces, data, and public disclosure are changing the ESG communications (environmental, social, and governance) of retail and platform companies in Russia and Turkey. The study is based on a qualitative comparative case analysis and a documentary analysis of open corporate materials for the reporting year 2024, available in 2025-2026. The Turkish block includes Trendyol, Hepsiburada, and Migros, while the Russian block includes X5 Group, Magnit, Sber, and Yandex. Companies are considered not as a statistically representative sample, but as information-rich cases that allow comparing different models of digital transparency. An analysis of public corporate materials shows that in Turkish cases, ESG communication is more often built around platform visibility, consumer interface, and relationships with sellers, while Russian cases are more strongly related to reporting, corporate governance, ecosystem services, and institutional accountability. In both cases, digitalization does not guarantee the reliability of the ESG disclosure. Disclosure is characterized by the greatest analytical credibility, in which digital visibility is combined with verifiable data, transparency of supply chains and managerial responsibility.

Keywords: ESG Communications, Digital Transformation, Dual Transition, Platform Economy, Sustainable Development, International Trade, Russia, Turkey

INTRODUCTION

The dual transition combining digital transformation and sustainable development (European Commission, 2020) is changing not only the technological basis of business, but also the ways of corporate disclosure. For companies operating in retail, e-commerce, and platform-based commerce, sustainability is becoming less and less confined to a separate non-financial report. It is becoming part of digital infrastructure, websites, applications, marketplaces, investor relations, client services, supplier communications, and public ESG sections. Therefore, the research focus is shifting from the very fact of reporting on sustainable development to the quality of the link between communication, data, management decisions and verifiable practices.

In this paper, the concept of dual transition is used not as a normative policy program (as it is in the context of the EU), but as an analytical framework for describing parallel and interrelated processes of digitalization and the integration of sustainability into business models. In this interpretation, it is applicable to any economy, including Russia and Turkey, where companies are simultaneously developing digital infrastructure and constructing ESG communications, albeit in different regulatory and institutional settings. In the literature, digital transformation is seen as a change in ways of creating value and organizational logic, rather than as a simple technology introduction (Vial, 2019; Verhoef et al., 2021). As Orlikowski (2000) warns, the organizational effect of digital solutions is determined not by the tools themselves, but by how they are integrated into practices, rules, and management structures. Technological reductionism here would be analytically untenable. A similar shift is taking place in ESG disclosure. Non-financial information is increasingly being evaluated through its usefulness to investors, regulators, and other stakeholders, rather than just through its image effect. IFRS S1 relates the disclosure of sustainability information to its importance to users of financial statements who make decisions about the provision of company resources (IFRS Foundation, 2023). This makes ESG communication part of a broader corporate accountability framework. However, a review of studies on mandatory non-financial reporting shows that regulatory pressures alone do not guarantee meaningful disclosure, with the nature of incentives, quality of standards, and management controls playing a key role (Christensen et al., 2021).

This problem is becoming noticeable in international trade. Digital orders, cross-border data flows, platform intermediaries, and supply chains transform sustainability communication into an element of market coordination. The Handbook on Measuring Digital Trade defines digital trading through transactions carried out through digital ordering and/or digital delivery (International Monetary Fund et al., 2023). UNCTAD (2021) and the World Bank (2021) further emphasize that the value of data depends on trust, access rules, and institutional safeguards. Digital ESG communications in trade, therefore, are not limited to publishing a

report. They are involved in building trust between companies, suppliers, consumers, investors, and regulators.

Previous studies have analyzed digital transformation (Vial, 2019; Verhoef et al., 2021), ESG reporting (Christensen et al., 2021), and supply chain transparency (Gardner et al., 2019) primarily as separate phenomena. Less attention is paid to how digital tools are changing the communication of sustainable development in different institutional environments. Comparing Russia and Turkey allows us to consider this problem not as a matter of universal "digital maturity", but as a difference in corporate transparency models. E-commerce, retail networks, and digital ecosystems are developing in both countries, but the regulatory environment, international engagement, government role, and ESG disclosure structure differ.

The object of the research is ESG communications of retail and platform-based commerce companies in Russia and Turkey. The subject is ways of digital disclosure of ESG information through reports, platform interfaces, data, supply chains and governance mechanisms. The purpose of the study is to identify how digital channels, platform interfaces, data, and disclosure practices are transforming ESG communications between Russian and Turkish retail and platform companies in a dual transition environment. Research question: How are digital tools changing the ESG communications of companies in Russia and Turkey, and what are the institutional differences between these models? The analytical assumption of the study is that digital ESG communication looks more convincing when digital channels are linked to verifiable data, management structures, and transparent supply chains. Documentary analysis does not allow us to prove causality, but it does allow us to assess the public credibility of disclosure using four analytical dimensions.

To achieve this aim, the study addresses five research objectives, each corresponding to a specific section of the article: to conceptualize digital ESG communications within the framework of the dual transition logic, to identify the analytical dimensions on which case comparisons are based, to systematically analyze the public materials of selected companies on these dimensions, to compare the Russian and Turkish models of digital ESG communications, to identify the factors that cause differences in the credibility and verifiability of digital ESG disclosure in different institutional contexts. The structure of the article corresponds to the sequence of tasks: theoretical conceptualization, methodology, empirical context, case analysis and comparative discussion with conclusions. Corporate documents (annual and non-financial reports, ESG sections of websites, investor relations materials) are considered not as a neutral mirror of practices, but as managed forms of self-disclosure through which companies construct a public image of their own sustainability.

1. THEORETICAL FRAMEWORK: DIGITAL ESG COMMUNICATIONS AND DUAL TRANSITION

Within this study, digital ESG communications are understood as a system of public disclosure and interaction, where information about sustainable development is transmitted through reports, websites, applications, platforms, data, interfaces and management procedures. This definition makes it possible to separate the digital form of the report from the actual digital transformation of communication. Posting a PDF file on a website does not change the disclosure architecture yet. The change begins when ESG information is included in customer services, work with suppliers, investor relations, data chains and feedback mechanisms.

Unlike the traditional model, where sustainability information was concentrated in periodic reports, the digital environment distributes it across multiple points of contact, product cards, logistics interfaces, investor pages, and supplier data. This increases the likelihood of an external comparison, but does not automatically make the message reliable. The stakeholder gets the opportunity to compare ESG statements with other sources only when the data exists in a verifiable form.

Research on CSR and sustainability communication shows that responsibility communication is not limited to one-way transmission of a message. Morsing and Schultz (2006) distinguish between informational, responsive, and engaging CSR communication strategies. Although this typology was created in the pre-digital era, it retains analytical value provided that the specifics of digital channels and the asymmetry of data between the platform and stakeholders are taken into account. Du et al. (2010) link the effectiveness of communication with the content of the message, the channel, the characteristics of the audience and the trust in the source. In the digital environment, these factors are becoming more sensitive, as the same ESG thesis is perceived differently in the annual report, in the consumer application and in the marketplace interface, as each channel sets its own level of detail and expectations of evidence.

The relationship between digitalization and sustainability is often described through the category of digital sustainability. Guandalini (2022) shows that digital technologies can support the sustainable transformation of organizations, but by themselves they do not solve the issue of reliability of disclosure. Data, AI, analytics, and traceability become important only if the disclosed indicators, their verification procedures, and responsibility for interpreting and relating the results to management decisions are clearly defined. This is of great importance for ESG communications, since the digital form of a message can enhance both transparency and selectivity of disclosure, a risk that is conceptualized in the literature as greenwashing and its digital variant (Lyon & Maxwell, 2011; Seele & Gatti, 2017).

The role of artificial intelligence and data analytics in ESG communication goes beyond technological support. Jarrahi (2018) suggests considering human-AI interaction as a mutual complement, rather than as a complete substitute for managerial judgment. Raisch and Krakowski (2021) show that automation and enhanced human capabilities in organizations are intertwined and create new managerial strains. For ESG communications, this means that AI can help collect, compare, and visualize data, but it does not remove responsibility for selecting metrics, interpreting results, and publicly explaining limitations. If a company refers to AI as a sustainability tool, it should show not only a technological fact, but also a management procedure. What data is used, who verifies the conclusions, and how errors or selective disclosure are prevented (Shrestha et al., 2019). In the analyzed cases, AI is mentioned in the context of Sber and Yandex as a component of the digital ecosystem, but no specific descriptions of the management procedure for verifying AI findings were found in the public ESG materials of these companies, which in itself is an analytical observation in the framework of this study.

International trade adds a dimension of supply chains to this framework. Gereffi et al. (2005) consider global value chains as coordination systems where standards, information distribution, and control are important. Gardner et al. (2019) clarify that transparency supports sustainable management only if the information disclosed is relevant to decision-making and is associated with the possibility of influencing practice. Therefore, digital ESG communications of retailers and platforms should connect the digital surface visible to the consumer with the less obvious infrastructure of procurement, logistics, suppliers, standards and corporate control.

Further analysis is built around four dimensions: formalized disclosure, platform visibility, transparency of data and supply chains, as well as governance and management responsibility. The first dimension includes annual reports, ESG sections, investor documents, and disclosure standards. The second applies to websites, applications, marketplaces, and digital interfaces, where sustainability becomes part of the interaction with the consumer or supplier. The third is related to traceability, logistics, data analytics, and information supply chains. The fourth, governance and management responsibility, covers internal policies, the allocation of responsibility for the ESG agenda, control mechanisms, and the verifiability of decisions. These dimensions are analytically separated, but they often overlap in corporate practice.

This framework intentionally excludes two simplifications: the identification of digitalization with transparency (a digital channel can both speed up external verification and enhance marketing packaging) and the perception of ESG as a purely reporting procedure, divorced from operational practices and market interactions. For trading and platform companies, sustainability becomes compelling when reporting, interface, product data, logistics, and governance explain each other rather than existing in different communication spaces.

2. RESEARCH METHODOLOGY AND CASE SELECTION

The study is based on qualitative comparative case analysis and documentary analysis. This design was chosen because the main task is not to build an ESG maturity rating or quantify the effectiveness of communications, but to identify how companies form different models of digital transparency. The logic of structured focused comparison assumes that each case is analyzed through the same set of questions, which makes the comparison consistent and at the same time preserves attention to contextual differences (George & Bennett, 2005; Yin, 2018).

Documentary analysis is used as the main method of working with empirical material. Bowen (2009) considers it as a systematic procedure for studying and interpreting documents. The subject is publicly presented ESG communications, not internal management motives. Corporate documents, websites, and interfaces are analyzed as manageable forms of self-representation. Therefore, careful attribution is used in the work, for example, the company "indicates", "reports" or "presents" when it comes to data from its own sources, and theses on effectiveness are not formulated without independent confirmation.

The cases are chosen analytically, not statistically. The Turkish block includes Trendyol, Hepsiburada and Migros, the Russian X5 Group, Magnit, Sber and Yandex. This set covers platform companies, e-commerce, large network retail, and digital ecosystems relevant to commerce, data, client interfaces, and public ESG disclosure. It does not represent the entire business of Russia and Turkey, but it allows us to compare information-rich cases in which digital infrastructure and ESG communication overlap most clearly. This logic corresponds to the argument of Flyvbjerg (2006) about the value of deeply studied cases for understanding complex social phenomena. The selection criteria were: the availability of a public ESG disclosure for the reporting year 2024, published and available for analysis in the period from May 2025 to May 2026, the importance of digital channels in the company's operational and communication model, coverage of at least two types of business models (platform and network retail) in each country, the availability of documents for independent analysis without access restrictions. The inclusion of four Russian cases, unlike the three Turkish ones, is due to the need to cover both network retail (X5 Group, Magnit) and two fundamentally different types of digital ecosystems (Sber as a financial and infrastructural actor influencing trade through payments and business lending; Yandex as a technological aggregator of services), without which the Russian model ESG communications would be described incompletely. Sber is considered solely as an infrastructural contextual case, because it is not a retailer or marketplace and is not included either in a direct comparison with trading companies or in the final conclusions about the retail model. His analysis allows us to capture the specifics of the Russian ecosystem logic of ESG, which otherwise would not have been described. The

empirical analysis of the Yandex case is based solely on the materials of the Yandex ICPAO, the documents of Yandex N.V. are used only to contextualize corporate restructuring.

Table 1 sets uniform analysis criteria for all seven cases and reduces the risk of arbitrary comparison.

Table 1. Criteria For The Analysis of Digital ESG Communications

Dimension	**Indicators**	**Main Sources**	**Analytical question**
Formalized disclosure	Reports, ESG sections, standards, materiality, KPIs	Annual and ESG reports, investor relations	Does the company structure the ESG as a form of accountability or as a set of statements?
Platform visibility	Websites, applications, marketplaces, product cards, user services	Official websites, applications, and public pages	Is sustainability becoming a part of digital interaction with the consumer or the seller?
Data and supply chains	Traceability, logistics, suppliers, audit, quality, packaging, data	Reports, supplier pages, logistics materials	Is it possible to link ESG statements with verifiable data and control procedures?
Governance and risks	responsible bodies, policy makers, risk management, data security, AI	Corporate governance, policies, reports	Is it clear who is responsible for the content of the disclosure and the consequences of the decisions?

The analysis procedure. Each case was analyzed in four dimensions (Table 1). For each dimension, indicators were recorded based on open documents (annual reports, ESG sections of websites, investor materials, and sections on supply chains): formulations, data, references to standards, and the degree of detail. The data was entered into the working matrix of the case. The comparison is carried out in two stages. First, companies are considered within the national context, so as not to transfer external criteria without taking into account the institutional environment. Then a cross-country comparison is carried out according to the four criteria in Table 1. This procedure allows to maintain the same analytical grid and at the same time avoid mechanical comparisons of companies operating in different regulatory and market conditions.

Four questions were tested on each case. First, how the company formalizes the ESG disclosure. Through a report, standard, strategy, materials analysis, or individual statements. Secondly, where exactly does sustainability become visible in the digital environment, on a website, in an application, in a marketplace, in an investor section, or in communication with suppliers. Third, is there a connection between the ESG message and data from the supply chain, logistics, quality, packaging, or digital security? Fourth, does the company show who is responsible for the content of the disclosure and how it relates to management decisions? Such questions ensure the rigor of the comparison and reduce the risk of descriptive retelling of corporate materials.

The analytical assumption test is based on comparing the presence or absence of features across four dimensions in each case, which corresponds to the logic of qualitative assumption testing in comparative case studies (George & Bennett, 2005). The analysis period is limited to materials related to the reporting year 2024 and published or made available for analysis in 2025-2026. This allows to compare companies over a short time horizon and not mix different stages of reporting. At the same time, individual regulatory documents of 2025 are used only to clarify the institutional context, since they affect the trajectory of disclosure in the coming reporting periods. This approach keeps the research relevant, but does not turn it into monitoring all current market changes.

3. THE EMPIRICAL CONTEXT OF RUSSIA AND TURKEY

The empirical context is formed at the intersection of the growth of digital commerce, the institutionalization of ESG disclosure and the strengthening of the role of platform infrastructures. Russia and Turkey demonstrate the development of e-commerce and digital services, but differ in the regulatory environment, international inclusion and the logic of corporate transparency. Therefore, the comparison is not based on a "better—worse" scale. It is aimed at identifying different models of digital ESG communication.

In Turkey, digital commerce has become a significant element of the national trade infrastructure. According to the Turkish Ministry of Commerce, the volume of e-commerce in 2024 exceeded 3 trillion Turkish liras, an increase of 61.7% compared to the previous year, and the number of transactions reached 5.91 billion (Republic of Turkiye Ministry of Trade, 2025). ESG communication in Turkish trade, therefore, takes place primarily in the space of user and platform interfaces.

Turkey's regulatory framework is increasingly converging with the international architecture of sustainability reporting. The Turkish Public Oversight, Accounting and Auditing Standards Authority has published TSRS 1 and TSRS 2 (Turkish Sustainability Reporting Standards) standards related to general financial disclosure requirements on sustainability and climate disclosures, respectively (Kamu Gözetimi, Muhasebe ve Denetim Standartları Kurumu

[KGK], n.d.). The profile of the IFRS Foundation indicates that Turkey has included the ISSB (International Sustainability Standards Board) standards in the Turkish Sustainability Reporting Standards, mandatory from January 1, 2024 for organizations that meet the established criteria (public companies and financial institutions of a certain scale) (IFRS Foundation, 2025). This strengthens reporting discipline and links ESG communications with the expectations of financial stakeholders.

This creates double pressure for Turkish companies, as the rapid growth of digital commerce requires explaining sustainability in market and user language, while convergence with ISSB/TSRS strengthens reporting discipline and makes ESG communication more important for investors and regulators. Therefore, in Turkish cases, it is important to evaluate not only the presence of an ESG page or report, but also how the company combines consumer visibility with formalized disclosure.

Russian digital commerce is characterized by a high role of internal platforms and marketplaces. According to the Association of Online Commerce Companies (an industry organization that publishes data based on membership reports), the volume of online commerce in Russia in 2024 increased by 41% and reached almost 9 trillion rubles, of which 97% accounted for purchases in Russian online stores and domestic marketplaces, and the cross-border segment was about 3% (Association of Internet Trade Companies, 2025). This structure points to a localized digital trading infrastructure and the increased role of national platform ecosystems.

The Russian ESG disclosure system is developing differently. The recommendations of the Bank of Russia form guidelines for public companies, issuers, and financial organizations, but they do not create a completely similar ISSB-based mandatory reporting regime for a wide range of companies and do not provide for administrative responsibility for ignoring recommendations (Bank of Russia, 2023). At the same time, the Russian system is gradually becoming more complex. The Bank of Russia has published an XBRL taxonomy for disclosure of information in the field of sustainable development by issuers of securities of the first and second levels of listing, its application is planned voluntarily from 2026 for 2025 and mandatory from 2027 for 2026 (Bank of Russia, 2025). This means that the Russian model cannot be described solely as a recommendation model. It is moving towards a more digitalized and formalized disclosure, although its institutional logic differs from TSRS/ISSB.

For Russian companies, this means a different configuration of requirements. What comes to the fore is not so much direct adherence to a single international standard, but rather the ability to independently link sustainability with corporate strategy, risk management, digital services, and regulatory expectations. Kuzmin et al. (2025) report problems related to uneven coverage and limited public access to ESG disclosures of Russian companies. Therefore, Russian cases

require careful interpretation, because a well-developed digital infrastructure by itself does not provide external comparability of ESG data and does not make sustainability understandable to the mass consumer.

It is necessary to take into account the environmental cost of digitalization itself. UNCTAD (2024) highlights that the digital economy creates its own resource and environmental challenges related to infrastructure, devices, energy and water. Digital tools in ESG communication cannot be perceived as a neutral solution. Companies must explain not only the sustainability of goods and supply chains, but also the sustainability of their own digital infrastructure.

4. TURKISH CASES: PLATFORM VISIBILITY AND FORMALIZING DISCLOSURE

The Turkish cases show a model in which ESG communication increasingly combines reporting with platform and consumer visibility. Sustainability is represented not only in the corporate document, but also through the user's digital experience, relationships with sellers, logistics, product labeling, and trust in the platform. Corporate statements require critical interpretation. High platform visibility does not eliminate the issue of calculation methods and external verification. This remark applies to all seven cases and is not specifically repeated further.

4.1. Trendyol

Trendyol is the most pronounced example of platform-ecosystem logic. In the Sustainability Report 2024, the company indicates that the report covers Trendyol Marketplace, Trendyol Express, Trendyol Go, Dolap, Trendyol Digital Products and Financial Services for the period from January 1 to December 31, 2024 and was prepared in accordance with the standards of the GRI (Global Reporting Initiative) 2021, with reference to the UN Sustainable Development Goals and SASB (Sustainability Accounting Standards Board) (Trendyol Group, 2025). The fundamental difference between this case is that ESG communication is not built around a single report document, but covers different elements of the digital ecosystem: marketplace, logistics, second-hand platform, international sales and tools for sellers.

The company describes the scale of this ecosystem through over 40 million customers, over 250,000 business partners, over 45 million products, and an international presence (Trendyol Group, 2025, p. 12). These indicators do not prove the quality of ESG practices, but they show the scale of the audience, to which sustainability should be explained not only in the language of reporting. Dolap is especially significant. Trendyol connects this second-hand platform with the circular economy and reports that in 2024, more than 16 million goods were recycled

through it, and the company estimated the prevented emissions at 307 thousand. tons of CO_2e (Trendyol Group, 2025, p. 43). The calculation parameters in the analyzed report are not detailed (methodology, basic assumptions, categorization), and in the academic context, the figure cannot be considered as a verified indicator. The calculation of prevented emissions is presented as a final corporate assessment, rather than as a reproducible independent methodology. In comparison with industry methods for calculating the effect of repeated consumption using Consequential Life Cycle Assessment and primary transactional data (Vaayu & Vinted, 2023 — an unpre-reviewed corporate analytical report, used here solely as an illustration of industry methodology), the Trendyol report does not disclose enough parameters for independent comparison. This does not make the assessment obviously erroneous, but it significantly limits its evidentiary value. Without a transparent and reproducible calculation methodology, Dolap's environmental impact remains a corporate statement rather than a verifiable fact available for independent verification.

Trendyol's international trade dimension is reflected in the fact that sustainability is communicated through an ecosystem that includes sellers, logistics, and cross-border channels. This is essential for a platform company, since it does not produce all goods on its own, but manages access conditions, category visibility, rules for sellers, and part of the logistics infrastructure. Therefore, the quality of ESG communication is determined not only by how convincingly the platform formulates its own goals, but also by whether it is able to show real mechanisms of influence on partners. This is a key risk, because the wider the network of sellers and suppliers, the more difficult it is to prove that the declared principles of sustainability are translated into real operational relationships, rather than remaining in the perimeter of a corporate document.

4.2. Hepsiburada

Hepsiburada forms a similar but more reporting-oriented model. In the 2024 Sustainability Report Summary, the company indicates that the report has been prepared in accordance with GRI 2021 and covers the period from January 1 to December 31, 2024 (Hepsiburada, 2025). The platform specifics are manifested in the fact that a significant part of sales is generated through the marketplace model, that is, sustainability affects not only its own operations, but also the network of sellers, logistics, customer experience and trust in the digital environment. The “Always by Your Side” strategy divides ESG communication into three areas: Standing by the Planet, Standing by the Ecosystem, and Standing by Trust. The latter area is particularly important for digital commerce, as it includes data privacy, responsible marketing, digitalization, innovation, and ethical business conduct.

Hepsiburada’s disclosure refers to the principle of double materiality (an approach that simultaneously takes into account the company's impact on the environment and society and

the impact of ESG risks on its financial position). The company announces an update to materials analysis through surveys, interviews with stakeholders and desk-based research, as well as an assessment of 23 topics. This indicates a transition to a more modern sustainability reporting language. By itself, the presence of double materiality does not guarantee the depth of disclosure. Credibility is determined by the transparency of the methodology, the quality of the data, and the relationship of the analysis results to specific management decisions. In this case, ESG communication is most analytically convincing where trust in the platform is based on data protection, marketing ethics, and digital governance. At the same time, open materials do not contain independent evidence of the level of data protection (for example, ISO 27001 certificates or external audit results), which limits the evidentiary value of this disclosure block.

For Hepsiburada, digital trust is becoming part of the ESG agenda because the marketplace model depends on the quality of rules, data, and relationships between the platform, sellers, and buyers. If the platform is talking about sustainable logistics, entrepreneur support, or responsible marketing, these topics cannot be separated from the governance of the digital environment. Therefore, the Trust block in this case has not an auxiliary, but an analytically central importance. He shows that in e-commerce, the social and managerial components of ESG include data security, correctness of platform processes, and transparency of marketing practices.

4.3. Migros

Migros differs from the two platform cases in that it connects traditional retail with digital services and integrated reporting. In the 2024 Integrated Annual Report and Sustainability Materials, the company links ESG to climate, water, sustainable agriculture, food waste prevention, supplier engagement, and digitalization of customer services (Migros Ticaret A.Ş., 2025). The Migros communication model is less marketplace-oriented, but it is important for the research topic. The retailer shows that ESG in trade arises at the intersection of procurement, product quality, logistics, customer data, suppliers, and operational efficiency. The main analytical flaw of this case is not the lack of topics, but the weakness of their evidence. A wide range of initiatives is convincing only when the key KPIs show the calculation base, dynamics, responsibility of departments and the relationship with management decisions.

In the case of Migros, digital ESG communication depends less on a single marketplace interface and is more closely linked to the retail operating chain. For the food and everyday consumer segment, the origin of products, work with farmers and suppliers, waste management, water and climate risks, the quality of goods and the availability of information for the customer are important. Therefore, the analysis of this case should not be limited to

listing initiatives. Further evidence-based disclosure would be enhanced by a single comparative set of indicators on water, waste, climate, and suppliers over several years. It would allow us to see not only the availability of programs, but also the pace of change in practices.

The Turkish block demonstrates a model where ESG seeks to move from a report to a digital interface and consumer interaction. Its advantage is visibility and connection to the market, while its weakness is the risk of fragmentation. If sustainable products, second-hand mechanisms, digital trust, and reporting standards are not coupled with verifiable data and governance, communication remains visually compelling, but not necessarily evidence-based.

5. RUSSIAN CASES: ECOSYSTEM LOGIC AND GUIDED DISCLOSURE

The Russian cases show a different configuration. Here, digital ESG communications are more often associated with corporate strategies, reporting, management structures, ecosystem services, information security, and responsible financing. Consumer visibility is present, but it is usually not the only center of communication. The logic of institutional accountability and managed disclosure is more visible.

5.1. X5 Group

X5 Group presents the case of a large retailer, where ESG communication is related to the scale of daily trade, suppliers, logistics and digital channels of interaction with consumers. The 2024 Annual Report and the company's ESG materials allow us to consider sustainability as part of the corporate strategy and operating system (X5 Group, 2025). Unlike platform companies, where ESG can be embedded in the marketplace interface, X5 has more important links between reporting, sustainability programs, product quality, supply infrastructure, customer services, and social initiatives. The strength of the case is in scale and institutionalization, the risk is that ESG messages often remain in the reporting loop and do not reach the consumer at the time of purchase.

X5 needs not only a public ESG strategy, but also the ability to translate it into the operational language of a large retail chain. The retailer works with everyday purchases, suppliers, logistics, assortment, loyalty programs, and digital channels. Therefore, its ESG communication must meet two different expectations. The investor and the regulator need a disclosure structure, goals, and governance, and the consumer needs a clear link between sustainability, product, quality, price, accessibility, and social initiatives. X5 Group's analyzed public materials include the annual report 2024 (sections on corporate responsibility and sustainable development, about 80 pages), the ESG section of the website, and materials for investors. A search for the keywords "application", "mobile", "loyalty", "interface", "consumer" did not reveal a description of the mechanisms linking corporate ESG reporting

with consumer digital channels. This is a limitation of the present analysis, and not a definitive conclusion about the absence of such mechanisms.

5.2. Magnit

Magnit demonstrates a similar retail logic, but with an emphasis on managing ESG processes and technologizing operations. In the materials of the Annual Report 2024 on Sustainable Development, the company describes the corporate governance of the ESG agenda, non-financial reporting, stakeholder engagement and operational initiatives (Magnit, 2025). It is not the very existence of environmental or social programs that is analytically significant, but how exactly digital retail solutions, including analytics, automation, customer services, store technologization and logistics, are supported by measurable ESG indicators. Such a connection requires careful proof. The presence of "smart" technologies in a store or logistics is not an ESG result in itself, because technological modernization without measuring ESG effects can be a form of greenwashing, creating the appearance of sustainable practices without their meaningful confirmation (Lyon & Maxwell, 2011; Seele & Gatti, 2017).

The Magnit case is indicative for assessing the risk of technological displacement, a situation where digital modernization is presented as ESG progress without evidence of its impact on specific environmental or social indicators. In retail, it's easy to present digitalization as proof of progress. Store automation, demand analytics, digital services, and logistics solutions can indeed increase efficiency, but this is a necessary but insufficient condition for ESG analysis. Convincing evidence can only be provided by showing the specific impact of a technological solution on waste, energy consumption, safety, product quality, or interaction with suppliers.

5.3. Sber

Sber is included in the Russian block not as a retailer, but as a digital and financial ecosystem that influences trade, payments, data, entrepreneurs and responsible financing. Sber’s case expands the understanding of digital ESG communications, because sustainability here is manifested not only through consumer interfaces, but also through financial products, ESG risks, AI, data security, and business infrastructure. Sber's open materials on annual reporting, responsible financing, and ESG show that sustainability communication can be built around managerial and financial trust, rather than around a product card or marketplace (Sberbank, 2025).

At the same time, the inclusion of Sber requires a methodological caveat, since it is not comparable to retailers as a trading company, but is comparable as an infrastructural participant in the digital economy. In the context of international and platform-based commerce, the financial ecosystem affects payments, business lending, customer ESG risks, data, security, and access to digital services. Therefore, the Sber case is not used for a direct

"shop versus bank" comparison, but to identify the Russian ecosystem logic of ESG communication, where sustainability is increasingly explained through financial products, risk management and technological infrastructure.

5.4. Yandex

Yandex presents a digital ecosystem case where sustainability is linked to multiple services, data, mobility, delivery, product quality, information security, and human capital. Yandex's public materials emphasize the link between the sustainability agenda and areas close to the business strategy, including information security, human capital development, and service quality (Yandex, n.d.). In the platform economy, ESG communication fundamentally goes beyond environmental priorities. It covers algorithmic management, user security, digital accessibility, service quality, and ecosystem responsibility to market participants. After corporate restructuring, the perimeter of the sources requires precise designation. The restructuring was completed in July 2024. The empirical analysis is based solely on the materials of the Yandex ICPAO for 2024-2025, whereas the documents of Yandex NV are used only to explain changes in the corporate perimeter (Yandex, n.d.; Yandex NV, 2024).

In the Yandex case, the problem of the boundaries of ESG communication in the digital ecosystem is very noticeable. When a company integrates search, transportation, delivery, education, cloud solutions, and user data services, sustainability is no longer limited to environmental initiatives. It includes security, availability of services, quality of algorithmic solutions, work with partners, and the impact of digital infrastructure on the urban and commercial environment. Therefore, Yandex communication requires stricter evidence. A broad ecosystem enhances the potential effect, but at the same time increases the requirements for data transparency, responsibility for platform solutions, and a clear definition of the disclosure perimeter.

In the analyzed Russian cases, a stronger link to management, reporting, and ecosystem infrastructure was identified. Its advantage is the ability to link ESG with corporate policies, risk management, data, and responsibility, and its limitation is less consumer "readability." Sustainability may remain in the annual report or corporate policy and be worse translated into the language of simple digital interaction with the buyer, small supplier or seller of the platform.

6. COMPARATIVE DISCUSSION

The comparison shows that the difference between the Russian and Turkish cases is not along the line of "presence or absence of ESG", but along the center of communication. In Turkish companies, this center is more often located closer to the platform, the market and the consumer. In Russian cases, it is more often shifted to corporate governance, reporting,

ecosystem solutions, and institutional accountability. Both models are incomplete if they develop in isolation. The Turkish model demonstrates strong consumer visibility, but is vulnerable in terms of reproducibility of calculations and transparency of partner networks. The Russian model is stable at the level of management structures and reporting, however, this accountability in the analyzed materials was rarely translated into an accessible digital language of interaction with a consumer or a small supplier.

Table 2 systematizes the key parameters of each case by four analytical dimensions

Table 2. Comparative Case Matrix

Case	Type	ESG communication channel	Strength	The main risk
Trendyol	Platform	Report + marketplace + logistics + second-hand	ESG's connection to the digital ecosystem and consumer choice	Company estimates require independent verification
Hepsiburada	Platform	GRI report + trust/data/privacy + marketplace	ESG's Connection to digital trust and double materiality	Formal reporting language may outpace evidence base
Migros	Retail	Integrated Report + Suppliers + customer services	ESG's relationship to procurement, quality, and operations	A wide range of initiatives needs to be more tightly coupled with KPIs
X5 Group	Retail	Annual Report + ESG Strategy + Digital Services	Institutionalization of ESG in a large trading system	Consumer visibility may be weaker than reporting logic
Magnit	Retail	Reporting + ESG management + digitalization of operational processes	The relationship of sustainability with operational management	Digital solutions are not always confirmed as an ESG result.
Sber	The financial ecosystem	Responsible financing + data + AI + governance	ESG's connection to financial trust and market infrastructure	The risk of mixing ESG communication and technology demonstration
Yandex	The digital ecosystem	Reporting + service interfaces + data security	Extending ESG to digital environment quality issues	Uncertainty of the perimeter of sources after corporate restructuring

Note to Table 2. The matrix captures the interpretation of public disclosure in four dimensions based on open corporate sources for 2024-2025, it is not an ESG maturity rating.

From this comparison, it follows that the Russian model does not need to abandon the reporting logic, but rather translate it into the language of trading and digital experience. For a consumer or small supplier, accountability becomes important when it manifests itself in clear operating rules, service interfaces, data quality, operational security, and accessible communication.

For international trade, the distinction plays a big role, as cross-border platforms and retailers simultaneously operate in multiple regulatory environments with different ESG disclosure requirements. Retailers and platforms are located between manufacturers, suppliers, logistics operators, consumers, investors, and regulators. Their ESG communication performs not only a reputational, but also a coordinating function, as it sets expectations for suppliers, explains to consumers the origin and characteristics of the product, signals to investors about the risk management system and demonstrates to regulators the willingness to be accountable.

The main comparative conclusion is that digital ESG communications form a more convincing infrastructure for public disclosure in a dual-transition environment when four elements are combined: public communication, verifiable data, platform or service architecture, and management responsibility. In the analyzed Turkish cases, ESG became visible primarily through platform interfaces and consumer channels. In the analyzed Russian cases, ESG was more often integrated into governance structures and ecosystem infrastructure.

The comparative result should not be interpreted as an assessment of the superiority of one country over another. Both models are analytically consistent in their context, but each has structural gaps. Turkish companies are showing a more pronounced shift in ESG towards interfaces and market visibility, but this visibility needs to be methodically verified. Russian companies are demonstrating more managerially structured disclosure, but it needs to be better translated into the language of user experience. In other words, the difference is not in the level of development, but in which part of the transparency infrastructure each model makes central. In one case, it is a market and a platform, in the other, governance and reporting. The analysis captures the system limitations of each of the models in an isolated form. Thus, Turkey is vulnerable in terms of verifiable data and reproducibility of calculation methods, while Russia is vulnerable in terms of consumer readability of disclosure. This difference is partly explained by institutional pressures. The mandatory TSRS/ISSB logic in Turkey creates an incentive for formalized disclosure aimed at financial stakeholders and consumers, while the advisory nature of the Central Bank framework in Russia allows maintaining a predominantly managerial reporting orientation. For companies operating in cross-border trade relations, a model combining platform visibility with verifiable evidence is more functional.

7. CONCLUSION

The analysis shows that digital ESG communications in retail and platform trade should be considered as an independent element of a dual transition. They are not limited to the publication of a report and are not a simple consequence of digitalization. Their quality depends on how a company relates sustainability to data, interfaces, supply chains, corporate governance, and the expectations of specific stakeholders.

Answering the research question about how digital tools are changing the ESG communications of companies in Russia and Turkey and what institutional differences are emerging, we can say that digital tools are transforming ESG communication in two fundamentally different directions due to the institutional environment. In Turkish cases, they primarily enhance the platform and consumer visibility of sustainability, while in Russian cases they help integrate it into corporate reporting, risk management, and ecosystem infrastructure. The institutional difference that defines this asymmetry is, first of all, the different regulatory regime for ESG disclosure - the mandatory TSRS/ISSB in Turkey versus the advisory CB framework in Russia. Digital tools do not create a single model of ESG communication. In the analyzed materials, no cases were found where platform visibility would be accompanied by a full disclosure of the methodology for calculating key ESG indicators. Platform integration often outstrips methodological transparency (Trendyol, Hepsiburada), while advanced corporate reporting is not always translated into a digital interface accessible to consumers (X5 Group, Magnit).

The analytical assumption is partially confirmed. It has been confirmed that the presence of digital channels without sufficient evidence base reduces the credibility of disclosure. This was most clearly demonstrated in the cases of Trendyol (calculation of prevented emissions without reproducible methodology) and Magnit (technological modernization without demonstrable ESG outcomes). It was not confirmed, due to the limited sample size, that developed governance structures always compensate for the lack of consumer visibility. The Sber case does not allow us to draw such a conclusion, since it is fundamentally different in nature from retail companies. This indicates the contextual dependence of the assumption and the need to test it on an expanded and methodologically homogeneous sample. Based on an analysis of public corporate materials, it can be assumed that for companies involved in trading and platform relationships, a more convincing disclosure model requires a unified system where reporting, digital interfaces, product and logistics data, supplier engagement, and corporate governance explain each other.

The theoretical contribution of the research is the conceptualization of digital ESG communications as a multidimensional infrastructure in which digital transformation, sustainability reporting, platform economics and international trade intersect.

Methodologically, the work shows the applicability of a structured comparative case analysis to assess corporate ESG disclosure in conditions of limited public access to verified data. In practical terms, the results show that expanding the number of digital channels alone does not increase the credibility of ESG disclosure. A more consistent model is one in which platform visibility and verifiable evidence are seen as complementary rather than competing strategies.

8. LIMITATIONS OF THE STUDY AND DIRECTIONS OF FURTHER WORK

The limitation of the research is related to the use of open corporate sources. They make it possible to analyze public communication, but they do not provide a complete picture of internal processes, the independent effectiveness of initiatives and the actual fulfillment of stated goals. An additional limitation concerns the perimeter of Yandex after the corporate restructuring. Materials from various legal contours are used only to the extent that they allow us to correctly describe the public architecture of ESG communication. The limitation to the 2024–2025 period does not allow the study to trace changes in the ESG communication of individual companies over time. The geographical coverage of Russia and Turkey is determined by the logic of a dual transition and the contrast of institutional contexts, but the conclusions do not apply to other markets without separate verification. The analysis is based solely on documentary sources and does not include independent stakeholder validation, user surveys, or data on the actual behavioral effects of ESG communication. Promising areas for further research include: comparing reported CO_2 emissions with independent monitoring data, analyzing user interfaces for patterns that obscure unsustainable products, interviewing stakeholders to verify compliance of public disclosure with internal practices, and comparative analysis of regulatory requirements in different jurisdictions. Special attention should be paid to the assessment of how the gap between the mandatory TSRS/ISSB logic in Turkey and the advisory approach of the Central Bank of Russia is being transformed as domestic requirements become stricter (in particular, the introduction of mandatory XBRL reporting from 2027).

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THE EVOLUTION OF GREENWASHING RESEARCH (2012–2026): A COMPREHENSIVE BIBLIOMETRIC MAPPING AND FUTURE AGENDA

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Abstract

Despite the growing prominence of greenwashing in corporate sustainability, the literature remains highly fragmented. This study aims to comprehensively map the intellectual, conceptual, and social structures of core greenwashing research during its maturity phase (2012–2026). Employing a bibliometric approach guided by the PRISMA framework, a total of 935 core documents were retrieved from the Scopus database using a strict title-based search strategy, with data subsequently analyzed and visualized using the R-tool Biblioshiny. The descriptive analysis reveals an exponential trajectory in publication growth, driven heavily by recent global sustainability mandates. Furthermore, the social structure analysis indicates a profound geographic decentralization, with China emerging as the undisputed central hub for academic partnerships, effectively dismantling historical Western-centric dominance. The thematic evolution highlights a significant conceptual paradigm shift: while early research predominantly focused on deceptive marketing, communication, and consumer skepticism, contemporary literature is heavily anchored in systemic macro-level issues such as corporate governance, ESG (Environmental, Social, and Governance) disclosures, and institutional accountability. By leveraging thematic mapping, this study outlines a robust future research agenda, urging scholars to investigate critical emerging avenues including stringent regulatory policies, carbon disclosures, corporate profitability, and the intersection of artificial intelligence with environmental claims. Ultimately, this paper provides a comprehensive roadmap for researchers, practitioners, and policymakers navigating the complex and highly regulated landscape of greenwashing.

Keywords: Greenwashing, Bibliometric, Bibliometric Mapping

INTRODUCTION

Over the past decade, global demands for corporate sustainability have radically transformed the landscape of corporate social responsibility. Companies currently face immense institutional pressure from investors, policymakers, and civil society to integrate environmental considerations into their core operations (Mahoney et al., 2013). Paradoxically, this mounting pressure has triggered an escalation in asymmetric information dissemination, wherein business entities exaggerate or falsify their environmental performance—a manipulative phenomenon widely recognized as greenwashing (Marquis et al., 2016). Conceptually, greenwashing operates within the blind spot between poor environmental performance and excessive corporate communication (Delmas & Burbano, 2011). This practice intentionally exploits information gaps to suppress consumer skepticism and artificially inflate positive stakeholder perceptions (Nyilasy et al., 2014). Consequently, these unsubstantiated environmental claims not only severely damage brand reputation and credibility but also obstruct the broader macroeconomic transition toward genuine sustainability (Seele & Gatti, 2017).

In tandem with dynamic market regulations, the conceptualization and operationalization of greenwashing have undergone a significant thematic evolution. In its early phases, academic discourse was predominantly driven by marketing literature, which scrutinized deceptive green advertising and its detrimental effects on consumer purchase intentions (Testa et al., 2018). However, spurred by recent global mandates for carbon transparency and corporate sustainability reporting, the issue has transformed into a far more complex, systemic threat within the domain of corporate governance (Berrone et al., 2017; Du, 2015). Contemporary greenwashing practices have mutated, subtly infiltrating Environmental, Social, and Governance (ESG) disclosures and green financial markets (Yu et al., 2020). This paradigm shift—from a peripheral advertising concern to a critical crisis of financial and regulatory integrity—has been met by the global academic community with an exponential surge in empirical publications. This massive proliferation indicates that greenwashing research has firmly entered its maturity phase, thereby necessitating a comprehensive structural and thematic evaluation.

Although the volume of greenwashing research has expanded rapidly over the past decade, the current literature remains highly fragmented across multiple disciplines and theoretical perspectives. Previous literature reviews have attempted to synthesize this phenomenon; however, they predominantly focused on narrow, context-specific scopes such as the impact of greenwashing on advertising and consumer behavior (Schmuck et al., 2018) or were conducted prior to the recent global explosion of ESG mandates (Yu et al., 2020). Furthermore, many existing reviews rely on subjective qualitative assessments that struggle to capture the macro-level dynamics of thousands of publications. Consequently, a

comprehensive, macro-level understanding of how the intellectual and thematic structures of core greenwashing literature have evolved during its maturity phase (2012–2026) remains largely absent.

To bridge this critical research gap, this study aims to comprehensively map the evolution of core greenwashing literature during its maturity phase. Leveraging a bibliometric approach a highly robust method for evaluating large volumes of scientific data and uncovering underlying intellectual networks (Donthu et al., 2021) this study extracted and analyzed 935 core articles using a strict title-based search strategy. The data were processed using the R-tool Biblioshiny, an advanced open-source interface specifically designed for rigorous science mapping and thematic evaluation (Aria & Cuccurullo, 2017). This methodology allows for a meticulous, quantitative exploration of performance trends, social collaboration networks, and conceptual evolution, thereby overcoming the subjective biases often found in traditional systematic reviews (Zupic & Čater, 2015; Paul et al., 2021).

The primary contribution of this paper lies in providing a robust, data-driven conceptual roadmap for future academic inquiries. By identifying late-stage emerging themes, particularly the intersection of greenwashing with public policy, carbon disclosures, and corporate profitability, this study outlines a critical future research agenda. Ultimately, the thematic maps and historical trajectories presented in this paper are expected to serve as a strategic compass for scholars, practitioners, and policymakers navigating the complex, highly regulated landscape of corporate environmental claims in the forthcoming decade.

1. METHODOLOGY

1.1. Research Design and Data Source

This study employs a science mapping approach based on bibliometric analysis to explore the intellectual, social, and conceptual structures of greenwashing literature. Bibliometric analysis was selected for its capability to quantitatively and objectively evaluate large volumes of scientific data, thereby minimizing the subjective biases often associated with traditional systematic literature reviews (Donthu et al., 2021; Zupic & Čater, 2015). All secondary data used in this research were extracted from the Scopus database, chosen for its comprehensive coverage of social science literature and its rigorous peer-review quality control mechanisms.

1.2. Search Strategy

The data extraction process was conducted in May 2026 using a highly specific search strategy. To ensure that greenwashing is the central focus of the analyzed articles—rather than a supplementary keyword in the abstract or background—the search query was strictly confined to the Article Title. The Boolean search string applied in the database was as follows:

TITLE ("greenwashing" OR "green washing" OR "green-washing" OR "deceptive green claims" OR "environmental washing")

1.3. Inclusion, Exclusion, and PRISMA Protocol

To filter out irrelevant literature and maintain data integrity, this study adopted the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol guidelines (Page et al., 2021). The raw data obtained from the initial search were screened using the following restrictive criteria:

- Time Span: Limited to the period from January 2012 to May 2026, specifically to capture the maturity phase and the modern regulatory expansion of greenwashing literature.
- Document Type: Restricted exclusively to empirical Research Articles. Conference proceedings, book chapters, and editorials were excluded to ensure the highest standard of peer-reviewed data.
- Language: Confined to documents published in English to prevent linguistic bias during the co-word and thematic network analyses.
- Subject Area: Focused strictly on disciplines relevant to corporate governance, namely Business, Management and Accounting, Economics, Econometrics and Finance, and Social Sciences. Literature from pure sciences and engineering was excluded.

After applying the complete inclusion and exclusion filtering process, the final dataset yielded exactly 935 core documents.

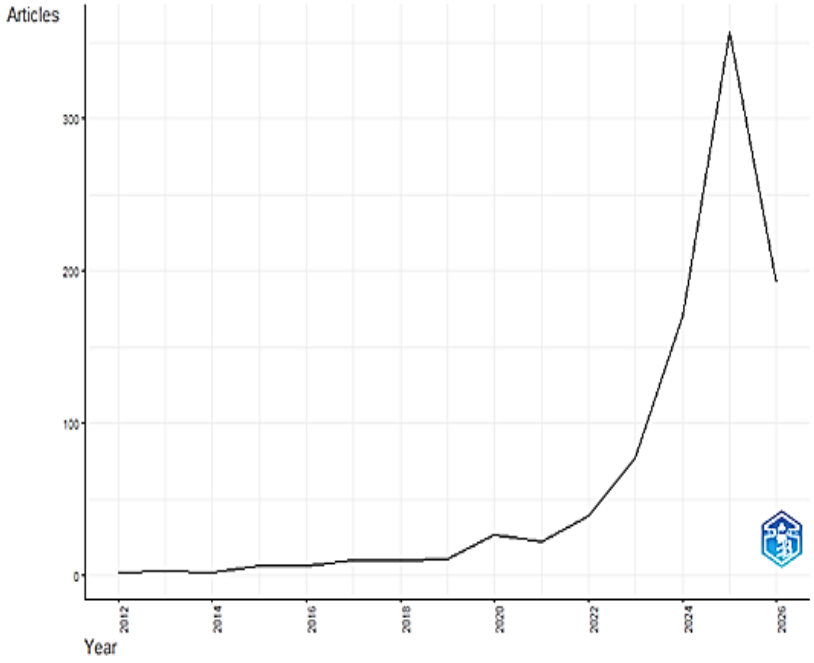
1.4. Data Analysis Tool

The final dataset of 935 documents was exported in a CSV format and subsequently analyzed using RStudio with the bibliometrix package (Aria & Cuccurullo, 2017). The Biblioshiny web interface was utilized to visualize three primary bibliometric dimensions: (1) Performance metrics, to evaluate annual scientific production and author impact; (2) Social structure, through country collaboration networks to identify global research alliances; and (3) Conceptual structure, utilizing thematic evolution and thematic maps to formulate a robust future research agenda.

2. RESULTS AND DISCUSSIONS

2.1. Bibliometric Performance Analysis

Figure 1. Annual Scientific Production



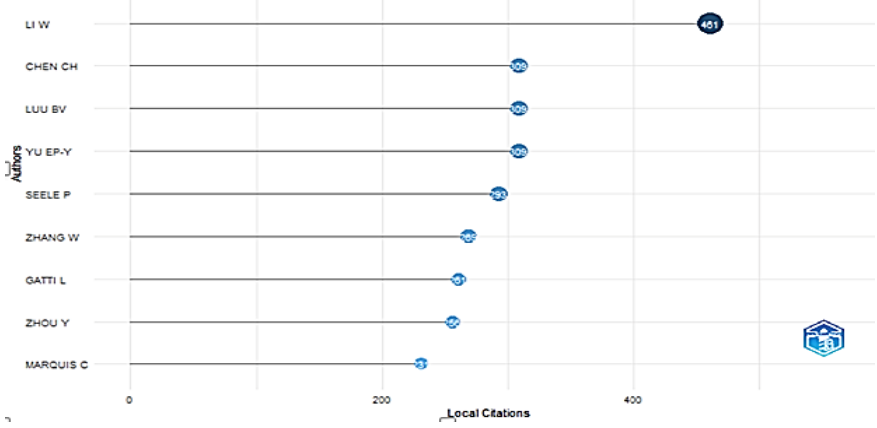
Annual Scientific Production Trends The trajectory of greenwashing research from 2012 to 2026 demonstrates an exponential growth pattern, signaling the maturation of the academic field. In the early phase (2012–2019), publication volume remained marginal, consistently hovering under 15 articles per year. A noticeable inflection point occurred in 2020 with 27 articles, setting the stage for a massive structural surge. The literature experienced a definitive boom between 2023 and 2025, escalating from 77 articles in 2023 to an unprecedented peak of 357 articles in 2025. The data for 2026 already records 192 publications, indicating sustained momentum. This dramatic spike aligns with the global regulatory tsunami, as stricter compliance mandates compel academia to investigate greenwashing phenomena intensely.

Figure 2. Most Relevant Sources



Most Relevant Sources The dispersion of publications across academic journals highlights a distinct conceptual pivot toward sustainability and financial governance. Sustainability (Switzerland) emerges as the most prolific outlet with 76 articles. Crucially, the prominent position of Finance Research Letters (47 articles) and Business Strategy and the Environment (38 articles) corroborates the paradigm shift of greenwashing research from a traditional marketing lens to hard-data financial and corporate governance investigations. Other key contributors include Corporate Social Responsibility and Environmental Management (32 articles) and Journal of Cleaner Production (28 articles).

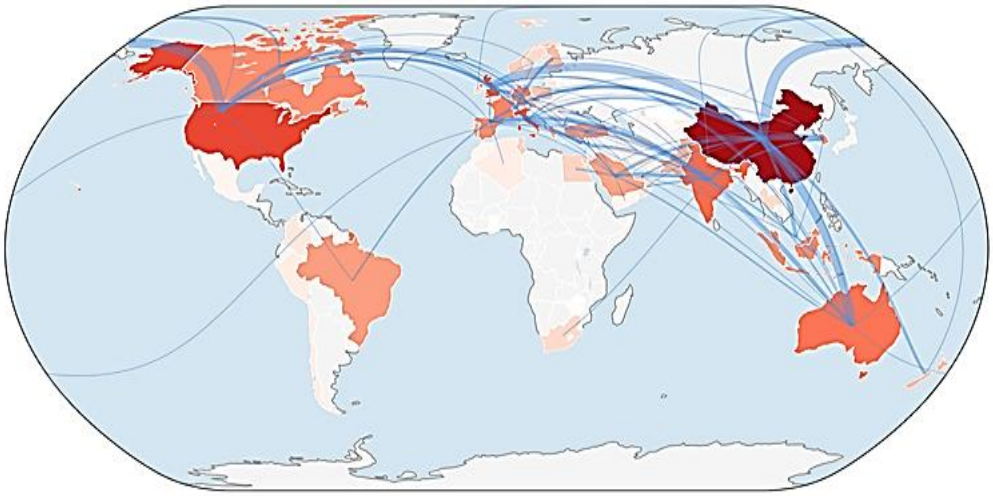
Figure 3. Most Influential Authors



Most Influential Authors: The local citation metrics reveal the most impactful voices within this specific dataset. Li W. leads the network with 461 citations. Other highly influential scholars include Chen C.H., Luu B.V., and Yu E.P-Y., each garnering 309 citations. The prominence of these authors underscores the shifting epicenter of greenwashing discourse toward Asian contexts.

2.2. Social Structure and Global Collaboration Analysis

Figure 4. Global Collaboration Analysis



Country Collaboration Network: The global collaboration network illustrates a profound geographic decentralization, effectively dismantling the historical Western-centric dominance in greenwashing research. China stands as the undisputed central hub for international academic partnerships. The strongest collaborative ties exist between China and major Western nations, prominently the USA (24 collaborative instances), the United Kingdom (19 instances), and Australia (18 instances). Regional partnerships are also robust, highlighted by China's strong collaborations with Hong Kong (13 instances) and South Korea (11 instances).

Beyond China, other emerging economies demonstrate active engagement in the global discourse. India showcases notable collaborative links, particularly with Australia and France, with 6 instances each. Meanwhile, the USA maintains a strong localized partnership with Canada, recording 10 collaborative instances. Ultimately, the network structure confirms that the focal point of greenwashing research has decisively transitioned to emerging markets, reflecting the global realities of industrial growth and the urgent need for regulatory transparency in these regions.

2.3. Trend Topics and Thematic Evolution

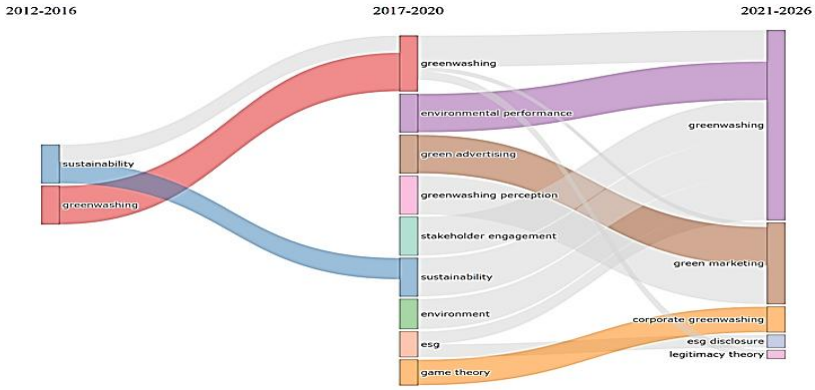
Table 1. Trend Topics and Thematic Evolution

Term	Frequency	Year (Q1)	Year (Median)	Year (Q3)
environmental communication	8	2020	2022	2025
greenwashing perception	6	2020	2022	2023
green advertising	13	2020	2023	2024
theoretical study	11	2022	2023	2026
csr	10	2021	2023	2025
stakeholder	28	2023	2024	2025
climate change	26	2024	2024	2025
consumption behavior	26	2023	2024	2025
greenwashing	640	2024	2025	2025
sustainability	146	2023	2025	2025
china	115	2024	2025	2025
carbon	10	2025	2026	2026
profitability	6	2024	2026	2026
public policy	6	2025	2026	2026

An analysis of the literature's trend topics reveals a clear maturation in the study of greenwashing, shifting from consumer perception to broader systemic issues. Based on the median year of topic occurrence, the research trajectory can be outlined as follows:

- Initial Focus on Communication (2022–2023): Early literature predominantly centered on the marketing elements of greenwashing. Themes such as "environmental communication" and "greenwashing perception" peaked in 2022. This was followed by "green advertising," "theoretical study," and "csr" (corporate social responsibility) reaching their median frequency in 2023.
- Broadening Scope to Stakeholders (2024): As the discourse matured, academic attention pivoted toward external pressures and systemic impacts. By 2024, keywords including "stakeholder," "climate change," and "consumption behavior" dominated the academic landscape.
- Core Consolidation (2025): The overarching concepts of "greenwashing" (with an overwhelming frequency of 640 occurrences) and "sustainability" (146 occurrences) reached their median peak in 2025. This cemented these terms as the absolute focal points of contemporary research.

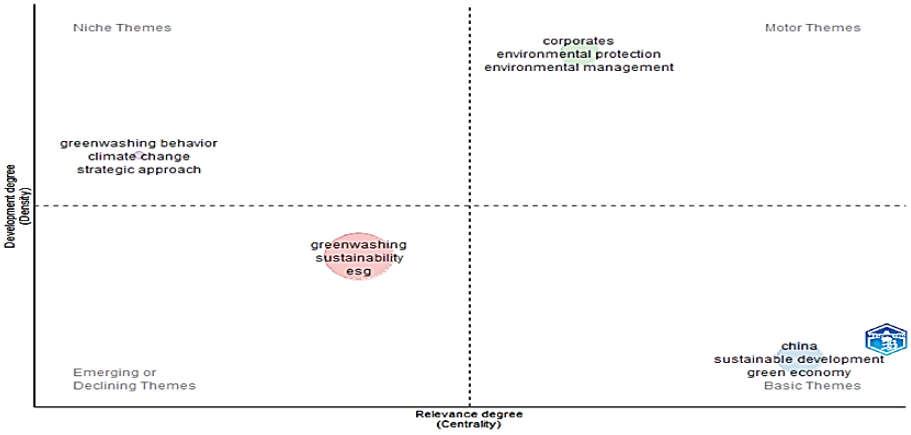
Figure 5. The Thematic Evolution



The thematic evolution further illustrates this paradigm shift across distinct chronological research periods. Historically, from 2012 to 2016, the foundational pillars of the field were broadly defined as "sustainability" and "greenwashing". During the 2017–2020 phase, the literature began branching into operational specifics, introducing terms like "environmental performance," "esg," and "game theory". In the most recent period spanning 2021 to 2026, these concepts evolved into highly structured, governance-oriented themes such as "esg disclosure," "corporate greenwashing," and "legitimacy theory". This reflects a definitive transition from merely examining corporate messaging to rigorously scrutinizing institutional accountability and regulatory compliance.

2.4. Thematic Map and Conceptual Clustering

Figure 6. The Thematic Map



The thematic map provides a spatial representation of the conceptual structure within the greenwashing domain, categorized by centrality and density. Centrality measures the relevance of the theme to the entire research field, while density indicates the internal strength and development of the theme. The analysis identifies four primary clusters driving the literature:

- Greenwashing: Functioning as the central node of the literature, this cluster contains the highest concentration of high-frequency keywords. It acts as a massive umbrella encompassing "sustainability," "esg," "corporate social responsibility," "marketing," and "corporate governance". This cluster represents the core transversal theme that connects marketing practices with corporate operations.
- China: Emerging as a highly central theme with a Centrality Rank of 4, this cluster signifies a massive geographic focus in recent literature. It highlights how the research epicenter is extensively addressing the rapidly developing regulatory and corporate environments in emerging Asian markets.
- Corporates: Demonstrating both high centrality (Centrality Rank: 3) and the highest density (Density Rank: 4), this cluster acts as a well-developed motor theme. It indicates that studies focusing directly on corporate entities, their operational behaviors, and financial impacts are internally mature and highly relevant to the overall academic discourse.
- Greenwashing Behavior: While possessing a lower centrality rank of 1, this cluster shows strong internal development with a Density Rank of 3. This suggests a specialized, highly developed niche within the literature dedicated to understanding the specific mechanics, psychological drivers, and nuanced behavioral patterns associated with deceptive environmental claims.

3. CONCLUSION AND FUTURE RESEARCH AGENDA

The comprehensive bibliometric mapping of greenwashing research from 2012 to 2026 highlights a dynamic and rapidly maturing academic field. Based on the structural and conceptual analysis, several key conclusions can be drawn:

- Exponential Growth and Maturation: The volume of greenwashing literature has experienced an exponential growth trajectory, driven heavily by global sustainability mandates. The field transitioned from marginal publication volumes prior to 2019 to an unprecedented peak in 2025, signaling its firm entry into a maturity phase.
- Thematic Paradigm Shift: The conceptual structure of greenwashing has undergone a radical transformation. In its early phases, the discourse was dominated by marketing perspectives, focusing primarily on deceptive green advertising, environmental communication, and consumer skepticism. Currently, contemporary

research has pivoted toward systemic macro-level issues, becoming heavily anchored in corporate governance, green finance, institutional accountability, and Environmental, Social, and Governance (ESG) reporting.

- Geographic Decentralization: The global collaboration network reveals a definitive end to historical Western-centric dominance within this field. China has established itself as the undisputed central hub for international academic partnerships, maintaining robust ties with the USA, the UK, and Australia. The research epicenter has decisively shifted toward emerging economies, reflecting the urgent global demand for regulatory transparency alongside industrial growth in these regions.

The identification of late-stage emerging themes and conceptual clusters provides a robust, data-driven roadmap for future academic inquiries. To navigate the increasingly complex and highly regulated landscape of corporate environmental claims, future scholarship must move beyond studies of consumer intention and focus on the following critical avenues:

- Stringent Regulatory Impacts and Public Policy: Future research must rigorously examine how modern dynamic market regulations and public policies are reshaping corporate sustainability. Scholars are urged to investigate the efficacy of global mandates and regulatory scrutiny on corporate behaviors.
- Carbon Disclosures and Corporate Profitability: With a definitive shift toward hard-data financial investigations, upcoming studies should focus on the intersection of verifiable carbon disclosures and corporate profitability. Research must address how greenwashing infiltrates green financial markets and impacts broader economic transitions.
- Technological Intersections: As greenwashing practices become more sophisticated, there is a crucial need to investigate the intersection of artificial intelligence with corporate environmental claims.
- Systemic Risk within ESG: Researchers should continue to explore how unsubstantiated environmental claims threaten financial integrity, specifically focusing on the subtleties of ESG disclosures and the legitimacy of corporate accountability structures.

Ultimately, this mapping of historical trajectories and modern thematic developments is designed to serve as a strategic compass for practitioners, policymakers, and scholars in the forthcoming decade.

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STRATEGY OF DIGITAL TRANSFORMATION AND INTELLIGENT ASSET MANAGEMENT IN THE OIL AND GAS INDUSTRY

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Abstract

This paper investigates the mechanisms for adapting extractive corporations to the new realities of the global energy market through the implementation of high-tech management models. It substantiates the transition from legacy asset operation methods to a data-driven approach, which significantly minimizes resource losses and optimizes capital expenditures. The author emphasizes the integrated combination of sensor networks, deep learning algorithms, and cloud computing to enhance the reliability and service life of production facilities. The study describes the practical value of utilizing intelligent systems in hydrocarbon exploration, production, and transportation, ensuring operational stability even under conditions of high price volatility. A special role is assigned to the protection of strategic infrastructure against cyber threats and sabotage through the deployment of integrated security systems and autonomous surveillance tools. Furthermore, the prospects for process greening through precision modelling and emission control are examined, contributing to the strengthening of companies' ESG profiles. The research also highlights the necessity of reforming corporate education to train a new generation of specialists capable of managing the cognitive systems of the future. The proposed strategic vectors facilitate the enhancement of the oil and gas sector's competitiveness amidst a changing technological landscape and the transition toward full facility autonomy.

Keywords: Digital Transformation, Oil And Gas İndustry, Asset Management, Development Strategy

DIGITAL TRANSFORMATION, GLOBAL VALUE CHAIN INTEGRATION AND LABOUR MARKET OUTCOMES IN AFRICA UNDER THE TWIN TRANSITION

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Abstract

Structural challenges in African labour markets persist, including high informality, low wages, skills mismatch, and limited productive employment. These challenges are increasingly compounded by rapid digital transformation and uneven integration into global value chains (GVCs) within the context of the twin transition. This study therefore examines the effect of digital transformation and GVC integration on labour market outcomes in Africa under the twin transition framework. The analysis is based on an unbalanced panel of 45 African countries over the period 1990–2024. To address potential endogeneity, reverse causality, and simultaneity bias associated with digitalization, GVC participation, and labour market outcomes, the study employs the Generalized Method of Moments (GMM) estimator. Robustness checks are conducted using the Common Correlated Effects Mean Group (CCEMG) estimator and quantile regression to ensure stability of results across different points of the labour market distribution. The findings indicate that the combined effect of digitalization and green industrialization produces stronger positive impacts on labour market outcomes compared to either digital or green transformation alone. Results further show that backward GVC participation yields greater employment benefits than forward participation, suggesting stronger gains from integration into downstream production activities. The interaction effect of the twin transition is positive and statistically significant, indicating complementarity between digital and green transformations. However, notable heterogeneity exists across income groups, sub-regions, and institutional quality levels. The study concludes that integrated twin transition policies promoting digital infrastructure, renewable energy, green manufacturing, skills development, and strengthened institutions under the AfCFTA framework are essential for improving inclusive and resilient labour market outcomes in Africa.

Keywords: Digital Transformation, Global Value Chain Integration, Labour Market Outcomes, Twin Transition, African

FINANCING THE FUTURE: GREEN INVESTMENT AND AFRICA'S TRANSITION TO A LOW-CARBON ECONOMY

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Abstract

Africa is facing a dual challenge of energy poverty and climate vulnerability, with more than 600 million people in the continent still without access to electricity, and where Africa is disproportionately affected by climate change impacts, despite contributing less than 4% to the global carbon emissions. This study investigates the impact of green investment on the transition of Africa towards a low carbon economy using a total of 37 African countries for the period 2000–2024. The Method of Moments Quantile Regression (MMQR) was used to capture the heterogeneous effects of green investment in the full distribution of low-carbon transition outcomes, while the Cross-Sectionally Augmented Autoregressive Distributed Lag (CS-ARDL) was used to establish long-run relationship without neglecting the cross-sectional dependence of data across countries. The results show that green investment is found to have a significant effect on Africa's low-carbon transition, resulting in reduced carbon emissions, enhanced the use of renewable energy, and improved energy efficiency across all quantiles in the distribution, with the effects being stronger in the upper quantiles, suggesting that the impact of green investment flows is stronger among countries already in a high end of the low-carbon transition; further, the long-run estimates show that the relationship between green investment and low-carbon transition is stable, with institutional quality, financial development, and trade openness being important mediating paths that amplify the green investment-climate nexus. The study calls for increased green investment flows, enhanced capacity of the African financial and institutional systems, as well as the use of the Green Climate Fund and the African Continental Free Trade Area (AfCFTA) as effective tools to kick-start an inclusive, resilient and sustainable low carbon transition in Africa.

Keywords: Green Investment, Low Carbon Economy, Renewable Energy, Carbon Emissions

JEL Classification: Q54, Q56, G38, G11, G18

DIGITAL FINANCIAL INCLUSION AND MONETARY POLICY EFFECTIVENESS FOR NATION BUILDING IN DEVELOPING ECONOMIES

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Abstract

The effectiveness of monetary policy in developing economies is often constrained by weak financial systems, limited financial inclusion, and large informal sectors, all of which hinder sustainable nation-building. However, the rapid expansion of digital financial technologies particularly fin-tech has introduced new opportunities to strengthen financial systems and enhance Nation Building. Despite these developments, limited empirical evidence exists on how digital financial inclusion influences the effectiveness of monetary policy in promoting macroeconomic stability and supporting nation-building objectives. This study examines the role of digital financial inclusion in shaping monetary policy effectiveness and Nation Building across developing economies over the period 2010–2024. Using secondary data from the World Bank, Global Findex, and IMF databases, the study adopts a dynamic panel data approach. A two-step System Generalized Method of Moments (System GMM) estimator is employed to address endogeneity, reverse causality, and country-specific heterogeneity. Inflation and economic growth are used as outcome variables, while monetary policy stance is proxies by policy interest rates. Digital financial inclusion is measured through mobile money usage and digital financial access indicators, with an interaction term included to capture its moderating effect. The study found out that digital financial inclusion strengthens monetary policy transmission, enhances financial inclusion, and improves macroeconomic stability key pillars of effective nation-building. The finding also recommends that policy-relevant insights on aligning digital financial development with monetary policy frameworks fostered inclusive growth and sustainable development.

Keywords: Monetary Policy, Digital Financial Inclusion, System GMM, Fin-tech, Developing Economies, Macroeconomic Stability

EXTENDED PRODUCER RESPONSIBILITY FOR ELECTRONIC WASTE MANAGEMENT: A COMPARATIVE ANALYSIS OF REGULATORY FRAMEWORKS AND IMPLEMENTATION IN NIGERIA, INDIA, AND THE UNITED KINGDOM

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Abstract

The rapid acceleration of global digitization has triggered an exponential surge in electronic waste (e-waste), presenting a critical threat to planetary health and material circularity. Mitigating this crisis requires robust Extended Producer Responsibility (EPR) frameworks capable of steering industrial supply chains toward a closed-loop paradigm. However, global waste tracking is severely fragmented by a widening digital divide in environmental enforcement. This paper presents a qualitative comparative analysis tracking the evolutionary spectrum of EPR governance across three distinct socio-economic terrains, the United Kingdom, India, and Nigeria. Anchored in the Circular Economy Paradigm and Public Enforcement Theory, this study evaluates how varying degrees of digital integration alter compliance efficiency and structural resilience. The analysis reveals a distinct evolutionary trajectory. While mature systems like the United Kingdom utilize advanced digital storefront liability to regulate global retail loop leaks, developing nations like Nigeria remain constrained by high-friction, inspection-heavy, manual policing models. These analog enforcement mechanisms consistently fracture when confronting dominant, cash-based informal scrap economies. Conversely, India's deployment of a centralized, market-driven Digital EPR Credit Portal demonstrates how automated data architecture can systematically formalize unorganized value chains by turning verified mass-balance processing data into a digital asset class. Ultimately, the paper synthesizes these cross-jurisdictional dynamics to construct an evolutionary blueprint for developing economies. We outline actionable policy mechanisms including cloud-based EPR credit tokenization, custom-to-portal database bridging, and statutory e-commerce platform accountability. By demonstrating how automated, traceable digital assets can eliminate manual regulatory bottlenecks, this study provides a pragmatic framework for operationalizing the Twin Transition, fostering resilient industrial ecosystems, and securing transnational circular governance.

Keywords: Extended Producer Responsibility (EPR), Electronic Waste (E-Waste), Waste Management, Environmental Policy, Circular Economy, Nigeria, India, United Kingdom

INTRODUCTION

Modern society is bound to an unprecedented, escalating electronic dependency. Rapid global digitization accelerated by hyper connected telecommunications architectures, cloud computing networks, and artificial intelligence infrastructure continues to drive exponential growth in the volume of Electrical and Electronic Equipment (EEE) manufactured, purchased, and discarded worldwide (Abalu & Oke, 2024; Baldé et al., 2025). While this high-velocity consumption cycle generates substantial corporate revenue and sustains international connectivity, it leaves an hazardous, complex material byproduct, electronic waste (e-waste). This distinct post-consumer refuse stream spans obsolete cellular devices, unserviceable server arrays, discarded computing hardware, and outdated heavy domestic appliances. Structurally, these objects are characterized by a highly volatile material duality. They house a concentrated mixture of hazardous compounds and toxic heavy metals such as lead, cadmium, hexavalent chromium, and mercury positioned directly adjacent to concentrated, highly valuable reserves of rare precious metals and transition elements like gold, copper, silver, and palladium (Parajuly et al., 2019).

Absent systematic, scientifically validated end-of-life (EOL) management, environmental discharge triggers multi-layered ecological breakdowns. Toxic heavy metals migrate rapidly into regional topsoil layers, percolating downward to contaminate underlying drinking water tables and systematically bioaccumulating within localized agricultural food chains (Needhidasan et al., 2014). Furthermore, within under regulated jurisdictions, informal scrap handlers frequently subject plastic-coated copper cables and laminated circuit boards to open air combustion to isolate raw metallic yields. This crude thermal extraction releases dense plumes of halogenated flame retardants and carcinogenic dibenzo-p-dioxins directly into the localized atmosphere, inflicting severe epidemiological shocks on adjacent populations. Concurrently, a systemic failure to recover and re-integrate these secondary raw materials forces manufacturing networks to satisfy resource shortfalls through aggressive primary mining operations. This extractive reliance causes widespread habitat destruction, deepens geopolitical instabilities over rare earth elements, and actively sabotages international sustainable development targets (Manomaivibool, 2009).

Environmental economists and policy architects address this structural linear market failure through Extended Producer Responsibility (EPR). Originally formulated by Thomas Lindhqvist in 1992, EPR alters the foundational logic of industrial manufacturing by shifting the financial and physical post-consumer burdens away from municipal public tax bases and placing them directly onto the producing brands. By internalizing estimated downstream collection, logistics, and eco-friendly detoxification costs directly into the upfront wholesale pricing structure of hardware, EPR attempts to exploit market mechanisms to incentivize eco-design. The underlying policy objective is to compel electronic brands to eliminate non-

recyclable hazardous compounds at the conception stage and engineer highly modular, easily repairable electronics suited for seamless integration into closed-loop recycling networks (Lifset et al., 2013).

When viewed through the lens of the "Twin Transition", the strategic pairing of green circular economy objectives with advanced digital transformation tools, EPR ceases to be a mere waste management checklist. It becomes the foundational framework for building resilient industrial ecosystems. Historically, environmental enforcement has been constrained by an analog paradigm of high friction physical auditing, which is structurally incapable of policing highly fragmented, globalized e-commerce supply chains. Bridging this gap requires a fundamental shift toward automated, traceable, and cloud-based circular governance. By utilizing next generation digital monitoring systems, environmental regulatory agencies can track mass balance material trajectories across cross-border value chains, rendering data falsification impossible and ensuring corporate accountability across a product's entire lifecycle.

This study executes a qualitative comparative analysis mapping how EPR legal architectures operate across three distinct socio-economic landscapes: Nigeria, India, and the United Kingdom. These jurisdictions feature stark disparities in infrastructure, administrative funding, and operational oversight, representing distinct phases along the digital and circular spectrum. The United Kingdom maintains a highly mature, heavily institutionalized formal compliance ecosystem. Its structural collection and treatment networks align with European circular economy principles and undergo regular legislative modernizations most notably via the WEEE updates of 2025 to establish absolute online marketplace platform liability and eliminate free-riding by international digital storefronts (Turner et al., 2016). India, an expanding industrial power, works aggressively to organize a sprawling, decentralized informal recycling workforce. It accomplishes this not through punitive prohibition, but by deploying a unique, market-driven digital asset exchange system that converts verified physical recycling metrics into tradable Digital EPR Certificates via a centralized state portal (Dwivedy & Mittal, 2013). Nigeria on the other hand, represents a developing economy operating as a primary global destination for near-end-of-life second-hand Western electronics. It struggles under severe enforcement deficits, constrained personnel budgets, and a dominant, unintegrated informal sector that processes over 90% of inbound streams through untraceable cash networks (Nnorom & Osibanjo, 2008).

This paper analyzes how these disparate enforcement methodologies interface with localized marketplace realities to isolate the specific systemic failure points within transnational waste-tracking systems. By critiquing the operational realities of these three diverse economic tiers, this inquiry yields an evolutionary governance blueprint. Ultimately, it maps out actionable policy mechanisms designed to guide developing jurisdictions away from slow, manual

inspection models toward automated, high-yield digital circularity, thereby securing localized public health while fostering a resilient global industrial ecosystem.

1. THE CIRCULAR ECONOMY PARADIGM AND PUBLIC ENFORCEMENT THEORY

This paper's theoretical scaffolding is constructed upon the deliberate convergence of two distinct intellectual domains, the Circular Economy Paradigm (Geissdoerfer et al., 2017) and Public Enforcement Theory (Polinsky & Shavell, 2000). The circular economy model directly refutes the traditional, path-dependent "take-make-waste" linear industrial configuration. It substitutes this open-ended extraction model with an intentional regenerative loop designed to minimize virgin resource draw, systemic material leakage, and carbon-heavy emissions. This is achieved by systematically slowing down product lifecycles through reuse, closing supply loops via advanced recycling, and narrowing material inputs through precise eco-design. Within this self-sustaining paradigm, EPR acts as the primary regulatory engine. Shifting post-consumer waste management away from an externalized, taxpayer funded public municipal service and transforming it into a non-negotiable corporate liability which compels manufacturers to internalize lifecycle mechanics (Tojo, 2004). When corporate boards face direct accountability for their physical products across their entire operational and post-utility existence, environmental compliance shifts from a superficial corporate social responsibility metric into a core determinant of structural financial risk.

However, Public Enforcement Theory highlights the operational friction that occurs when these conceptual green loops clash with real-world market incentives. According to Polinsky and Shavell (2000), corporate compliance is fundamentally a function of the probability of detection multiplied by the severity of the legal penalty. If the economic gain from evading a regulation outweighs the expected penalty, rational market actors will default to non-compliance. Empirical literature detailing transnational electronic waste movements exposes how this rational evasion manifests across asymmetrical international corridors. Defective, fractured, or unserviceable hardware frequently migrates from heavily monitored Global North jurisdictions to vulnerable Global South destinations. This transboundary flow is routinely obscured under the deliberate mislabeling of shipments as humanitarian electronics donations or functional, second-hand consumer merchandise (Ogungbuyi et al., 2012). While highly industrialized nations frequently exhibit robust domestic collection and recycling rates on paper through formal Producer Compliance Schemes (PCS), stringent regional processing costs and rigid toxic waste handling standards create an economic paradox. These strict domestic environmental limits can inadvertently incentivize waste brokers to illegally export hazardous volumes to less regulated spaces, particularly if national border verification regimes remain reliant on slow, manual inspections (Lepawsky, 2015).

In emerging and developing economies lacking formal trade or institutional integration with the Global North, academic literature focuses heavily on the informal sector. Critical fieldwork assessments of massive, self-organized electronic waste hubs most notably the Alaba International Market in Lagos, Nigeria and the Seelampur district in New Delhi, India confirm that unorganized scrap dealer syndicates routinely intercept between 80% and 90% of domestic electronic waste streams (Osibanjo & Nnorom, 2007; Chatterjee & Kumar, 2009). These highly fragmented, informal networks dominate localized waste value chains because they deploy fluid, cash-in-hand transactions, maintain vast door-to-door aggregation workforces, and execute hyper flexible, low-cost extraction methods. However, researchers point out that the localized human and ecological toll associated with these informal operations completely erases any short-term economic efficiencies. The systemic reliance on manual acid stripping and open air cable burning triggers chronic heavy metal poisoning, exposes child labor workforces to neurotoxins, and causes irreversible ecosystem degradation, presenting a profound systemic threat to localized public health and industrial resilience (Sinha et al., 2016).

Lately, academic discourse highlights a widening “digital divide” in environmental enforcement. Legacy environmental protection agencies remain structurally constrained by an outdated command-and-control enforcement paradigm that relies on manual oversight, analog paper trails, and random, physical border checks (Xanthos & Walker, 2017). Next-generation environmental compliance theory argues that these high friction, inspection-heavy approaches fail entirely when tasked with monitoring highly fragmented, fast moving, and globalized electronic retail supply chains. To close these administrative gaps, contemporary literature advocates for smart regulation designs that move away from monolithic state policing. As championed by Gunningham and Sinclair (2017), smart regulation deploys a flexible, pluralistic mix of regulatory instruments, third-party commercial levers, and automated technologies to achieve compliance. This theoretical intersection underpins the “Twin Transition,” wherein green circular economy initiatives are directly enabled by digital transformation tools. To operationalize smart circular governance, contemporary literature advocates for technological innovations, including blockchain-enabled material tracking, digital environmental certificates, and strict statutory legal liability for e-commerce platforms (Wang et al., 2022). The paper addresses a critical gap in this body of knowledge by evaluating how different levels of digital integration within EPR legal frameworks alter compliance and processing efficiency across various economic tiers.

2. CASE STUDIES

2.1. The United Kingdom: Formalized Governance and Statutory Modernization

The United Kingdom operates a highly institutionalized, structurally mature regulatory apparatus for electronic waste management. Originally derived from European Union directives, this legal architecture was seamlessly integrated into domestic law via the Waste Electrical and Electronic Equipment (WEEE) Regulations 2013 (Department for Environment, Food and Rural Affairs [Defra], 2013). This statute established a rigorous taxonomic system that categorizes electronic assets into clear commercial streams, binding producers to strict life-cycle rules. Under these statutory limits, any manufacturer, re-brander, or importer introducing more than 5 tonnes of Electrical and Electronic Equipment (EEE) onto the UK market during a calendar year faces an absolute legal mandate to join a state-approved Producer Compliance Scheme (PCS). The PCS acts as a specialized collective proxy, absorbing the logistical, operational, and financial liabilities of its member brands. By pooling corporate capital, these compliance schemes directly fund the systematic collection, transport, and environmentally sound breakdown of consumer tech (Environment Agency [EA], 2020).

At the apex, overarching policy direction is dictated by the Department for Environment, Food and Rural Affairs (Defra). However, the day-to-day enforcement grid is decentralized across regional environmental enforcement units to optimize local compliance. The Environment Agency (EA) polices corporate compliance across England; Natural Resources Wales handles Welsh territories; the Scottish Environment Protection Agency (SEPA) covers Scottish jurisdictions; and the Northern Ireland Environment Agency manages its respective province. To handle the complex realities of modern digital distribution, the state separated product safety and digital retail surveillance from physical environmental policing. The tracking of digital storefronts and cross-border e-commerce compliance falls under the jurisdiction of the Office for Product Safety and Standards (OPSS).

Downstream waste logistics rely on a vast grid of Designated Collection Facilities (DCFs) administered primarily by municipal authorities via civic amenity sites and retail take-back networks. Recovered materials bypass public streams and move exclusively to Approved Authorized Treatment Facilities (AATFs). These plants operate under strict statutory mandates requiring the deployment of Best Available Treatment, Recovery, and Recycling Techniques (BATRRT) (Defra, 2013). To counteract modern purchasing shifts, online retail evasion, and evolving processing demands, the state updated its regulatory parameters via the Waste Electrical and Electronic Equipment (Amendment) Regulations 2025. These interventions systematically target the "free-riding" vulnerabilities exploited by international dropshippers on digital platforms (Defra, 2025).

Indicatively, the 2025 statutory revisions codify clear online marketplace accountability. E-commerce platforms must now register as the legal producer for any unrepresented third-party vendors utilizing their services, compelling these storefronts to internalize end-of-life processing overheads. Furthermore, the amendments widen physical drop-off avenues. Major commercial retailers are legally obligated to provide complimentary, unconditional in-store and delivery-linked take-back mechanisms for small consumer electronics, deflecting consumer volume away from strained municipal infrastructure.

2.2. India: The Digital Credit Framework and Evolving Formalization

India's regulatory trajectory illustrates a rapid shift from manual compliance checklists to an automated, market-driven environmental ecosystem. E-waste management is anchored in the E-Waste (Management) Rules 2022, enacted under the foundational Environment (Protection) Act 1986. This statutory shift abandoned the fragmented 2016 framework, replacing decentralized physical collection targets with a centralized, fully digitalized, and legally binding EPR credit exchange system (Ministry of Environment, Forest and Climate Change [MoEFCC], 2022). At the apex, the Central Pollution Control Board (CPCB) orchestrates national enforcement, operating in tandem with regional State Pollution Control Boards (SPCBs) and local Union Territory committees. The CPCB owns and administers a unified EPR Portal, which serves as the digital architecture powering the national compliance network. Under this framework, every manufacturer, importer, dismantler, and recycler must maintain an active, verified profile on this central interface.

The state imposes escalating recycling targets on producers, pinning quotas directly to historical sales records and estimated product lifespans. Crucially, the policy eliminates physical collection mandates for producers. Licensed recycling facilities upload raw mass-balance data regarding processed tonnage directly to the CPCB portal. The application immediately converts these physical metrics into Digital EPR Credits, calculating token values based on end-material categories and resource purity (Central Pollution Control Board [CPCB], 2022). To satisfy annual statutory quotas, electronics manufacturers must log onto the portal and acquire these digital certificates directly from certified recyclers.

The state tightened this architecture through the E-Waste (Management) Amendment Rules 2025, which introduced end-to-end material tracking algorithms to eliminate fraudulent credit generation (CPCB, 2025). The software detects phantom credits where a facility attempts to monetize certificates for electronic volume it never physically handled by automated cross-checking of facility electricity consumption patterns and chemical refining logs against declared recycling outputs. Despite this advanced digital framework, India faces systemic friction from its vast informal recycling sector. Millions of unorganized scrap dealers continue to process substantial e-waste volumes via hazardous, backyard chemical extraction (Verma

et al., 2016). The digital portal seeks to address this by positioning licensed recyclers as primary aggregators; these plants utilize the portal's financial incentives to purchase raw e-waste from informal networks, absorbing them into a traceable, visible supply chain.

2.3. Nigeria: The Inspection-Heavy Model and Institutional Bottlenecks

Nigeria's electronic waste strategy is anchored in the National Environmental Standards and Regulations Enforcement Agency (NESREA) Act 2007, which establishes the agency as the primary environmental watchdog. Technical execution falls under the National Environmental (Electrical/Electronic Sector) Regulations, S.I. No. 23 of 2011. Historically, Nigeria led the African continent by launching a formal operational guide for EPR, creating the E-Waste Relief Foundation (ERF) and the E-Waste Producer Responsibility Organisation Nigeria (EPRON) to orchestrate corporate compliance and capitalize formal processing centers (NESREA, 2011). Despite this progressive policy framing, Nigeria's operational framework remains tied to an analog regulatory paradigm centered on physical inspection and direct policing. NESREA field officers execute manual audits of commercial warehouses, examine inbound shipping containers at maritime ports, and conduct on-site sweeps at electronic retail malls to penalize unregistered importers. This hands-on enforcement methodology faces severe structural and financial impediments:

- The Scale of the Informal Sector: Up to 90% of inbound electronic waste bypasses formal governance completely, routed directly into sprawling, decentralized commercial clusters such as the Alaba International Market or Computer Village in Lagos (Ogbuifor, 2023). Informal scrap syndicates deploy fluid cash transactions and rapid mobile communications networks to acquire old tech directly from residential doors, effectively starving formal processing channels of raw feedstocks (Amachree, 2021).
- Infrastructural Deficits: The formal sector lacks capital-intensive, industrial-scale automated sorting and advanced hydrometallurgical chemical refining plants. Formal recycling facilities struggle to maintain solvency because they cannot match the high scrap buy-back prices offered by informal dealers, who externalize environmental costs by avoiding safety gear or pollution controls (Innocent & Ndubuisi, 2022).
- Enforcement Constraints: NESREA operates under severe personnel shortages, restricted budgetary allocations, and complex jurisdictional friction at ocean shipping terminals. Substantial volumes of broken electronics enter national territory mislabeled as functional, second-hand merchandise, completely overwhelming manual port inspectors (Okoye & Odoh, 2023).

3. COMPARATIVE ANALYSIS AND SYNTHESIS

3.1. Comparative Matrix of EPR Frameworks

The structural variations across the three analyzed jurisdictions are synthesized in Table 1.

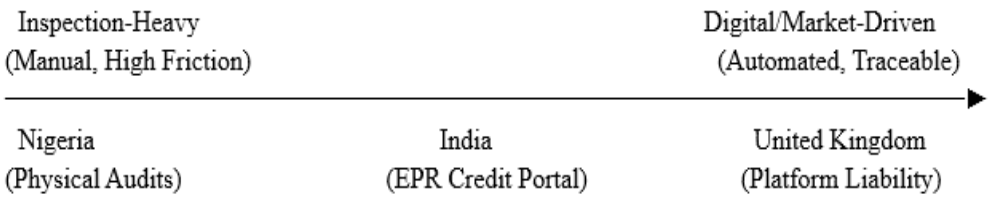
Table 1. Cross-Jurisdictional Structural and Operational Matrix

Analytical Pillar	Nigeria	India	The United Kingdom
Primary Legislation	NESREA Act 2007; National Environmental Sector Regulations 2011	E-Waste Rules 2022 (as updated by the 2025 Amendments)	WEEE Regulations 2013 (as amended by the WEEE Regulations 2025)
Primary Regulatory Agency	NESREA & EPRON (PRO)	Central Pollution Control Board (CPCB) & regional SPCBs	Defra, Environment Agency (EA), and OPSS
Compliance System	Collective Producer Responsibility Organisation (EPRON)	Centralized Digital EPR Certificate Trading Platform	Collective Producer Compliance Schemes (PCS) with target allocations
Marketplace Liability	No explicit statutory liability framework for online storefronts	Platform registration required with tracking via the portal	Full platform liability assigned to online marketplaces for third parties
Informal Sector Status	Dominant (>90% market share); highly fragmented and unintegrated	Dominant but systematically integrated via digital credit values	Negligible; formalized municipal and retail collection systems
Enforcement Mechanism	Manual facility audits, physical container tracking, and port policing	Automated data cross-checking and portal asset tracking	Data auditing, retail inspection, and marketplace platform policing

3.2. The Regulatory and Digital Divide

The comparative assessment exposes a profound digital divide in environmental enforcement across global jurisdictions. The United Kingdom leverages cross agency database synchronization and strict digital storefront liability mandates. This architectural layout allows inspectors to police global retail networks entirely via remote desktop tracking, shifting the administrative surveillance burden onto major e-commerce platforms and removing the need for incessant physical facility audits. India presents a market-driven alternative. By engineering its national EPR Portal, the Indian state converted regulatory compliance into a

fluid digital asset class (EPR Credits). This system channels competitive corporate funding straight to licensed recyclers through automated software algorithms.



In sharp contrast, Nigeria remains constrained by a low velocity, high friction manual inspection model. Relying on physical site visits and visual port audits creates severe security gaps when facing a massive informal cash economy. Without automated database cross-checking and scalable digital tracking tools, manual inspectors cannot monitor the thousands of informal collectors, repairmen, and scrap dealers moving goods through open-air markets. This institutional mismatch hinders Nigeria's Producer Responsibility Organisation (EPRON). Formal recycling facilities are financially outmatched by the quick, untraceable cash networks of the informal sector.

4. POLICY RECOMMENDATIONS FOR DEVELOPING ECONOMIES

4.1. Transition to a Digital EPR Credit Architecture

Developing nations must overhaul traditional electrical sector regulations. Rather than issuing manual compliance certificates, environmental protection agencies should deploy a centralized, cloud-based EPR registration and trading portal modeled on India's CPCB architecture. Under this mechanism, authorized recyclers receive unique, traceable digital tokens for every metric tonne of verified e-waste processed via sound environmental methods. Producers then buy these tokens through an open marketplace to fulfill their legal quotas, moving the regulatory focus from high-friction, physical site visits to automated digital auditing.

4.2. Implementation of Integrated Data Portals Matching Customs Flows

To eliminate structural reporting blind spots, developing jurisdictions should forge a direct link between maritime customs tracking systems and environmental compliance engines. Integrating seaport manifest registries with environmental databases ensures that when an electronic shipment enters a country, the importer's end-of-life recycling quota scales automatically in real time. This automated tracking removes data manipulation opportunities and isolates illegal e-waste dumping under the guise of second-hand charity.

4.3. Statutory Accountability for Online Marketplaces

National environmental codes require immediate amendments to close free-riding loopholes exploited by unlisted foreign manufacturers. Mirroring the UK's WEEE 2025 updates, local laws must assign full legal and financial lifecycle liability to the digital e-commerce platforms hosting the sales. Making online marketplaces legally responsible for the end-of-life processing of third-party goods sold through their applications builds a protective regulatory wall that insulates domestic recycling infrastructure.

4.4. Inclusive Formalization of the Informal Economy

State enforcement bodies must abandon punitive, command-and-control strategies that criminalize informal scrap collectors, as this invariably drives the unorganized workforce further underground. Instead, policy must leverage digital portal valuations to link informal networks directly to the formal supply chain. Registered informal cooperatives should be designated as official raw material collection nodes. By routing gathered components to licensed, automated treatment plants, these cooperatives earn a digital financial premium funded directly by producer compliance fees. This mechanism secures a safer, stabilized income for informal workers while systematically redirecting hazardous chemical processing toward safe, technologically equipped facilities.

5. CONCLUSION

Effective electronic waste management requires regulatory frameworks that match the operational reality of the markets they govern. A comparative analysis of Nigeria, India, and the United Kingdom reveals that traditional, inspection heavy compliance models struggle to manage highly informal, decentralized electronics supply chains. While the United Kingdom uses advanced platform liability and European circular frameworks to manage its formal circular economy, India utilizes an innovative digital credit portal to formalize its massive processing sector. Nigeria's reliance on physical inspection creates institutional friction that limits its overall effectiveness.

To build resilient circular economies, developing nations must bridge this regulatory digital divide. Transitioning to automated, portal-tracked digital credit trading, embedding customs tracking integration, and establishing clear online marketplace responsibility can lower administrative costs and turn environmental compliance into a self-sustaining financial model. Implementing these reforms can help developing countries transition from hazardous, unorganized urban mining toward structured, safe, and digitally traceable resource recovery systems. This evolution supports global circular economy integration while protecting localized public health and ecosystem stability.

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FROM GREEN ENERGY TO GREY ZONES: CRITICAL MINERALS, SUSTAINABILITY DILEMMAS AND CONFLICT DYNAMICS IN AFRICA

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Abstract

The accelerating global shift toward green energy and digital technologies has significantly increased demand for critical minerals such as cobalt, lithium, and gold—many of which are concentrated in Africa. While this "twin transition" is often framed as a pathway to sustainability, its implications for environmental degradation and conflict dynamics in resource-rich yet fragile contexts remain insufficiently explored. This paper investigates how the integration of African mineral economies into global supply chains reshapes local security environments, focusing on the interaction between environmental stress, governance challenges, and conflict.

The study adopts a comparative case study approach, examining the Democratic Republic of Congo (DRC) and Ghana. In the DRC, cobalt and coltan extraction—frequently located in conflict-affected and weakly governed regions—has been linked to armed group financing, ecological degradation, and severe human insecurity. In contrast, Ghana's gold sector, particularly informal "galamsey" mining, demonstrates how environmental damage such as deforestation and water pollution can erode livelihoods, intensify local grievances, and generate new forms of social tension, even in relatively more stable political contexts. The comparison highlights how variations in state capacity, regulatory frameworks, and patterns of global market integration shape the relationship between resource extraction and conflict.

Theoretically, the paper is grounded in a Neo-Gramscian International Political Economy framework, complemented by environmental security perspectives. It argues that the global green transition operates within structures of unequal exchange that externalize environmental and social costs to the Global South. In this context, Africa is positioned as a peripheral supplier of raw materials, bearing disproportionate ecological and security burdens while capturing limited value. This dynamic is conceptualized as a "green resource curse," whereby sustainability transitions in the Global North inadvertently exacerbate environmental degradation and conflict risks in resource-producing regions.

Methodologically, the paper employs qualitative analysis based on secondary data, policy reports, and conflict datasets, supported by process tracing to identify causal mechanisms.

The paper contributes by linking critical mineral supply chains with conflict dynamics through the lens of environmental degradation, advancing the concept of the "green resource curse," and critically reassessing dominant sustainability narratives by emphasizing their uneven global impacts.

Keywords: Critical Minerals, Green Resource Curse, Environmental Degradation, Conflict Dynamics, Global Supply Chains

INTRODUCTION

The rapid expansion of green energy technologies and digital industries has led to an unprecedented increase in global demand for critical minerals such as cobalt, lithium, and gold, many of which are concentrated in Africa. Although this twin transition is widely promoted as a cornerstone of sustainable development, far less attention has been paid to its environmental and security consequences in resource-rich but institutionally fragile countries. This paper examines how the growing integration of African mineral economies into global supply chains is reshaping local conflict dynamics by exploring the links between environmental degradation, governance challenges, and insecurity.

This paper compares two contrasting cases: the Democratic Republic of Congo (DRC) and Ghana. In the DRC, the extraction of cobalt and coltan is largely concentrated in regions affected by weak governance and protracted conflict, where mineral revenues have long fueled armed groups while accelerating environmental destruction and human insecurity. Ghana presents a different, though equally revealing, picture. The expansion of informal gold mining (galamsey) has contributed to widespread deforestation, water pollution, and the loss of agricultural livelihoods, generating local grievances and new forms of social tension despite the country's comparatively stable political environment. Comparing these two cases demonstrates how differences in state capacity, regulatory effectiveness, and integration into global mineral markets influence the relationship between resource extraction and conflict.

The research argues that the global green transition continues to operate within unequal structures of production and exchange that shift many of its environmental and social costs onto the Global South. As a result, African countries remain positioned primarily as suppliers of raw materials while capturing only a limited share of the economic benefits and bearing a disproportionate share of the ecological and security burdens. This paper conceptualizes this contradiction as a green resource curse, whereby sustainability-driven transitions in the Global North unintentionally deepen environmental degradation and increase conflict risks in mineral-producing regions.

Methodologically, the study relies on qualitative comparative analysis based on secondary literature, policy documents, and conflict datasets. Process tracing is employed to identify the mechanisms through which critical mineral extraction contributes to environmental degradation and, in turn, shapes patterns of conflict. By bringing together the literature on critical minerals, environmental security, and global supply chains, the paper offers a new perspective on the relationship between sustainability transitions and conflict. It also develops the concept of the green resource curse as a framework for understanding how the benefits of the global energy transition are distributed unevenly, often at significant environmental and security costs for resource-producing countries.

1. CONCEPTUALIZING THE GREEN RESOURCE CURSE

The concept of the "resource curse," which has held a central place in the international political economy and development literature for many years, argues that natural resource wealth does not automatically strengthen economic development, democratization, and institutional capacity; on the contrary, under certain conditions, it can lead to negative consequences in these areas. It is argued that countries possessing strategic natural resources such as hydrocarbons, gold, and diamonds fail to achieve the expected economic prosperity and institutional development; instead, they are drawn into structures that are vulnerable to external exploitation, fragile, and produce chronic political and economic instability due to asymmetric dependency mechanisms established with more developed actors within global power relations (Esu, 2017).

However, the global green transition that has taken place over time has caused significant changes within the scope of the "resource curse" concept. To analyze these changes, it is first necessary to clarify the concept of the global green transition, which has been frequently mentioned in the literature and reports of international organizations recently. The global green transition can be defined as the process of transformation from economic models based on fossil fuels such as oil, natural gas, and coal to economic models that utilize clean, sustainable, and renewable energy models. The main goal of the global green transition is to widespread the use of renewable energy to reduce carbon emissions in the fight against climate change. Furthermore, this process aims to create a sustainable economic development model by ensuring energy security. Thus, it is intended to minimize environmental damage by using natural resources more efficiently. While trying to achieve these goals with the global green transition, certain policies are intended to be utilized. These policies include net-zero emission targets, support for renewable energy investments, the creation of carbon taxes and emission trading systems, the widespread adoption of circular economy and recycling practices, electric vehicles and clean transportation policies, and green economy and sustainable investment mechanisms (United Nations Environment Programme, 2024).

Therefore, in the green transition process, technologies that will enable the shift away from fossil fuels towards energy systems with lower carbon emissions, such as electric vehicles, solar panels, energy storage systems, grids, and wind turbines, largely highlight the dependence on critical minerals, and especially rare earth elements. The rare earth elements mentioned here consist of 17 metallic elements in the periodic table and are quite important in the production of technological products due to their high magnetic properties. On the other hand, critical minerals consist of metals and minerals such as cobalt, nickel, lithium, copper, and graphite, which are technologically and economically important. The relationship between these groups can be defined as follows: rare earth elements are a subset of the critical minerals group (Kamran et al., 2023).

It can be said that the global green transformation process is managed by the Global North countries, which have completed their industrial development and are mostly developed nations. In this new system, the North countries, with their superiority in capital, markets, and technology, are essentially weaving a new asymmetrical network of relationships, similar to the colonial era, with African, Latin American, and Asian countries from which they obtain raw materials such as the aforementioned rare earth elements and critical minerals. While the North countries are positioned as the central countries in the system, the raw material supplier countries in the Global South, especially African countries, are placed in a peripheral position. Although the peripheral countries assume all ecological and security risks in this new transformation process, they have a very low share of the market. This situation has been referred to as the "green resource curse" in the literature in recent years. On the other hand, as competition among developed states increases, investments in the southern countries, especially in Africa, from which raw materials are supplied, are intensified, along with militarization and armament. The competitive environment, reinforced by existing structural problems, brings proxy conflicts to the forefront, threatening both local security and disrupting the supply chain, thus affecting the global system. This situation is conceptualized as the "green security dilemma."

2. CRITICAL MINERALS AND AFRICA'S STRATEGIC IMPORTANCE: THE CASES OF THE DEMOCRATIC REPUBLIC OF CONGO AND GHANA

The ongoing global green transition has elevated the strategic importance of critical minerals, placing them at the heart of contemporary debates on energy security, geopolitical competition, and technological leadership. Rich in resources such as lithium, cobalt, manganese, copper, platinum, and gold, African countries have consequently become indispensable to global supply chains and increasingly central to the geopolitical competition surrounding access to these strategic minerals.

African states, together with the African Union and other regional organizations, seek to leverage the local processing and value addition of critical minerals as a pathway to sustainable economic development within the context of the global green transition. However, the benefits of this transformation have so far accrued primarily to multinational corporations and major global and regional actors, while many resource-rich African countries continue to bear the costs in the form of environmental degradation, governance challenges, and increasingly complex security threats driven by competition over critical mineral resources. Against this backdrop, this section examines the Democratic Republic of the Congo (DRC) and Ghana—two resource-rich countries that have become emblematic of the emerging "green resource curse"—to explore how the growing global demand for critical minerals has reshaped local environmental, security, and governance dynamics.

2.1. Mineral Resources, Geostrategic Competition, and the Cycle of Violence in the Democratic Republic of Congo

The Democratic Republic of Congo (DRC) stands out as one of the most important raw material exporters in the global green transition due to its critical mineral resources. According to the USGS Mineral Commodity Summary 2026 data, the DRC alone accounted for approximately three-quarters of global cobalt production in 2025. Of the 310,000 metric tons of global production, approximately 230,000 metric tons came from the DRC; the country's reserves of approximately 8.5 million tons account for 71 percent of the global total. When these two figures are considered together, the picture that emerges is extremely striking: the DRC is the de facto architect of the global supply chain when it comes to cobalt, both in current production and in future supply potential (U.S. Geological Survey, 2026). Besides cobalt, the DRC is also a notable producer of copper, gold, and tantalum.

China can be considered the most prominent player in the mining sector of the DRC. Over the past two decades, numerous Chinese energy companies have made significant investments in areas containing important cobalt and copper deposits, primarily in the cities of Lualaba and Katanga. Therefore, it is estimated that approximately 70% of the DRC's cobalt production is carried out by Chinese companies (IEA, 2024). On the other hand, the US, which is in fierce global competition with China, also wants to have influence over the DRC's natural resources. Furthermore, as part of the global green transition, other Western countries want to reduce their dependence on China for critical mineral supplies. Therefore, the DRC has become one of the regions where the global competition between the US and China has been felt most intensely in recent years.

Due to its abundant critical mineral resources, the Democratic Republic of the Congo (DRC) is not only a focal point of global geopolitical competition but also the site of numerous armed conflicts involving both rebel groups and extremist organizations seeking to control mining areas. In the eastern part of the country, long-standing conflicts have intensified as various armed actors compete for control of these resource-rich regions. Among them, the March 23 Movement (M23) has emerged as one of the most significant threats to regional security. Composed primarily of members of the Tutsi ethnic group and, according to United Nations reports, receiving military and financial support from Rwanda, the movement has expanded its influence in the mineral-rich provinces of North and South Kivu. Originally established in 2012, M23 re-emerged in 2021 and has since intensified its military operations, consolidating control over several strategic areas. Although the movement presents itself as a political actor, it has become closely associated with proxy warfare and the political economy of mineral extraction. As M23 has expanded its territorial control, it has not only seized mining sites but has also contributed to a severe humanitarian crisis across eastern DRC (CFR, 2026). According to United Nations estimates, between 900 and 2,000 civilians had been killed in

and around Goma by early 2025, while hundreds of thousands were forced to flee their homes. By the end of 2025, the number of internally displaced people in the DRC was estimated to have reached approximately 21 million (IOM, 2025). However, M23 is not the only armed actor fueling insecurity in the DRC. Other armed groups—including the Allied Democratic Forces (ADF), the Cooperative for the Development of the Congo (CODECO), the Democratic Forces for the Liberation of Rwanda (FDLR), and the Wazalendo militias—are also engaged in violent competition for control of mining areas and access to mineral revenues. Their activities continue to undermine state authority, exacerbate insecurity, and contribute to the protracted conflict that has characterized eastern DRC for decades.

The struggle for control over the DRC's mineral deposits has national, regional, and international dimensions. Beyond the competition between the aforementioned entities, the disagreements between the DRC and Rwanda are not solely limited to border disputes. The problems between the two countries are also related to the Hutus who fled to eastern Congo after the Rwandan genocide in 1994, which gained international attention. Rwanda views this Hutu-influenced region as a threat and seeks to take countermeasures, while the DRC interprets these efforts as a struggle for control of mineral-rich areas. These disagreements between the two countries have become a highly complex security issue, exacerbated by the use of entities like M23 as proxies (Global Centre for the Responsibility to Protect, 2026). Tensions in the region escalated when the M23 movement gained control of the Goma and Bukavu areas, rich in cobalt and gold mines, in 2025. According to reports from international organizations such as the UN, the M23 movement, which has increased its power through the revenues from these mines, is also illegally transferring some of these revenues to Rwanda. Following these developments, which heightened tensions between Rwanda and the DRC, the Donald Trump administration in the US initiated mediation efforts in the region. This was because the Trump administration aimed both to effectively control the rich mining areas and to encircle China, its most important international rival (Tilsley, 2026). This mediation effort by the US, undertaken with the aim of securing mining concessions, failed as conflicts intensified again in South Kivu immediately after an agreement was signed between the actors (ISS, 2026).

Despite possessing one of the world's richest reserves of critical minerals, the Democratic Republic of Congo (DRC) faces significant challenges in translating this wealth of natural resources into economic development and social well-being. This situation is a prime example of the "green resource curse," a concept that argues that natural resources do not always support development but can, under certain conditions, deepen economic and political vulnerabilities. According to the resource curse literature, in countries with weak institutional capacity, natural resource revenues can fuel problems such as corruption, poor governance, political instability, and armed conflict, creating serious obstacles to sustainable development

(Ross, 2015). In the DRC, the fact that a significant portion of high-value minerals such as cobalt, coltan, and gold are located in the conflict-ridden eastern regions allows armed groups to finance their activities with income from these resources. On the other hand, the insufficient establishment of state authority in these regions makes it difficult to effectively monitor mining activities, while also perpetuating chronic problems such as child labor, informal production, smuggling, and human rights violations. Therefore, the DRC example clearly demonstrates that although critical minerals hold strategic value for the global green transition, unless supported by strong institutions and effective governance mechanisms, natural resource wealth can deepen security problems and social vulnerabilities rather than generate economic prosperity (World Bank, 2024).

2.2. Gold Wealth, Galamsey, and the Environmental Security Crisis in Ghana

Ghana, a long-time producer of gold in Africa, relies primarily on gold exports for its income (Pulse Ghana, 2026). However, the scale of the gold sector has not brought Ghana the desired peace and prosperity. Gold trading in the country is largely driven by illegal and unregulated activities known as galamsey. The term galamsey, derived from the phrase "gather them and sell," refers to small-scale, unregulated, and illegal gold trading. Factors contributing to the rise of galamsey in Ghana include insufficient employment, corruption and weak governance, individuals' desire for quick and easy income, and rising global gold prices. According to reports published by SWISSAID, a Swiss organization, approximately 229 tons of gold, worth about €10 billion, were illegally smuggled out of Ghana between 2019 and 2023 (The Fourth Estate, 2025).

Illegal galamsey activities in Ghana cause more than just economic losses. Uncontrolled and illegal gold mining operations are causing widespread deforestation and serious water pollution in and around gold mines. Many people, most of whom earn their living from nature-related sectors such as agriculture, livestock farming, and fishing, are losing their sources of income due to the environmental problems caused by galamsey activities. This is because large quantities of mercury and cyanide are used in illegal gold mining. These harmful substances, released into rivers and waterways, pollute groundwater and fertile agricultural lands, causing significant damage to the natural ecosystem. The pollution of water resources due to gold mining activities poses a threat of the near depletion of potable water sources in Ghana. Furthermore, deforestation to create mining areas leads to the endangerment of many species and increases environmental degradation such as soil erosion (World Bank, 2023).

In Ghana, illegal gold mining, known as "galamsey," has become a serious governance problem, not only due to the environmental damage it causes, but also because of its multifaceted impacts that simultaneously undermine state authority, security, and social stability. The struggle to control the country's rich gold reserves pits different interest groups

against each other in the same area, turning mining regions into increasingly competitive and conflict-ridden zones. In this environment, violent incidents frequently occur between licensed mining companies and illegal galamsey groups over site control, production, and land use. Security forces' operations often fail to provide a lasting solution and, on the contrary, in some areas deepen security risks, paving the way for questioning the authority of the state (Hilson & Maconachie, 2020). The problem is exacerbated by the fact that galamsey activities have become intertwined with informal economic networks and political patronage relationships over time. Research reveals that in some mining regions, informal relationships based on mutual benefit have developed between illegal mining groups and local political elites, traditional authorities, security officials, and various intermediaries. This network prevents the fair and efficient management of natural resources, weakens the rule of law, and makes corruption almost a part of the system. As a result, income from gold becomes a tool that consolidates the economic and political power of a narrow interest group, rather than benefiting society as a whole (Crawford et al., 2016).

This erosion in resource management also undermines trust between the state and its citizens. The state's inability to prevent illegal mining, or the association of some public officials with these activities, leads to a serious loss of confidence in the legitimacy of public institutions. As a result, while public belief in the state's ability to manage natural resources for the public good weakens, tensions escalate among local communities over resource sharing, land use, and the unequal distribution of environmental damage. Deepening economic inequalities, loss of livelihoods, and suffering caused by environmental degradation, particularly in rural areas directly affected by mining, fuel social polarization and can even escalate into local violence and conflicts (Aidoo, 2016; Hilson, 2002). In conclusion, the Ghanaian example clearly demonstrates that when natural resource wealth is not supported by strong governance mechanisms, it can transform from an environmental problem into a multi-dimensional crisis directly threatening security, political legitimacy, and social stability.

2.3. Different Pathways of Conflict Under the Curse of Resources: A Comparative Assessment of the Democratic Republic of Congo and Ghana

The green resource curse is essentially a key hypothesis highlighting the relationship between natural resource abundance and instability and conflict within a country. However, it is insufficient to explain how this indirect resource curse can lead to different outcomes in countries with abundant natural resources. Indeed, as seen in the examples of the DRC and Ghana described above, while similar situations are observed in the natural resource reserves and their exploitation in both countries, different security problems exist. In each country, natural resources are not used fairly for the benefit of the citizens. However, the abundance of resources creates very different security threats within the framework of different dynamics, including institutional differentiation, global markets, and influential actors (Ross,

2015). The institutional differentiation mentioned here is related to the state capacity of the countries. For example, in the DRC, the state has not developed an effective management mechanism in the region where mining is concentrated. Following the 1994 Rwandan genocide, regional tensions, ethnic tensions, and armed conflicts emerged in this region, creating an advantageous atmosphere for illegal organizations to control the mining areas. On the other hand, in Ghana, the state is effectively more influential, but deep-seated corruption among the political elite and members of the security forces is eroding institutional capacity, paving the way for galamsey activities in the mines (Le Billon 2001).

Another difference observed in the cases of the DRC and Ghana lies in the nature of the conflicts. In the DRC, an ethnically based geopolitical conflict rooted in the 1994 Rwandan genocide is combined with competition for natural resources, while the conflict stemming from galamsey activities in Ghana is more environmentally and socio-economically based. On the other hand, the relationship between natural resources and the global market structure in these two countries can also be seen as a differentiating factor in the conflict environment. The critical minerals in the DRC are of great importance for critical areas such as the energy transition within the scope of the global green transition, advanced technology sectors, and the defense industry. These minerals cause competition to intensify in the DRC not only among various groups within the country but also among regional actors such as neighboring countries and global actors such as the US and China. The gold sector in Ghana, however, creates a much more complex and multi-actor network of relationships. Gold extracted illegally and uncontrollably through galamsey activities in Ghana is transported to international markets through illegal channels. This smuggling network deepens corruption and malpractice in the country, giving rise to social polarization and local tensions (Nebe, 2025).

3. CRITICAL MINERALS, US-CHINA COMPETITION, AND AFRICA'S STRATEGIC POSITION

The global green transformation, which has come to the forefront in recent years, has led to the spread of advanced technology sectors and digitalization, and an increased need for critical minerals. This rapidly increasing demand has made critical minerals one of the most important elements of geostrategic competition in the international order. In this process, countries in Africa rich in critical minerals have not only become raw material suppliers exporting critical minerals, but also areas where global actors such as the US and China compete fiercely. Countries rich in critical minerals, particularly in the DRC (Dutch Republic of Africa), such as Angola, Zambia, and Namibia, have been heavily affected by the competition between China and the US (Church & Crawford, 2020). However, the competition mentioned here is not limited to the economic sphere. In recent years, competition between the two actors has

been observed in various areas, especially technological superiority, the defense industry, and control of the global supply chain (Institut français des relations internationales, 2019).

During the period in question, China became Africa's largest trading partner. Parallel to this, it gained a significant advantage in the competition for critical minerals in Africa. China is often able to convert payments for infrastructure projects in Africa's critical mineral-rich countries into mining concessions. This trading model has allowed China to control the supply of raw materials in Africa and has had a significant impact on the energy and transportation infrastructure of the region's countries (Brautigam, 2020).

This increasing influence of China over critical minerals in Africa is causing concern for the US and European countries. In recent years, influenced by the developing competitive relationship between them, the US has been trying to develop policies aimed at reducing its dependence on Beijing for supplies. Therefore, it has undertaken mediation efforts to increase its influence in the DRC, which ranks among the top countries in the world in terms of mineral resources, and on the other hand, as seen in the Lobito Corridor example, it is trying to develop new logistics routes against China in Africa (Carrai, 2025).

In conclusion, the US–China rivalry over critical minerals has elevated Africa to an increasingly strategic position within the global system. However, whether this competition can be translated into sustainable development for African countries depends not merely on the scale of foreign investment but also on the ability to build strong institutions, generate greater local value addition, ensure transparent governance, and successfully implement regional industrialization strategies. Without these foundations, critical minerals may become more than just strategic resources shaping the winners of the global energy transition; they may also fuel a new cycle of resource curses in Africa, reinforcing patterns of external dependency, accelerating environmental degradation, and intensifying geopolitical competition.

4. CONCLUSION

The global green transformation and the rapid advancement of digitalization have brought critical minerals to the forefront internationally, highlighting them as one of the most strategic elements of the international order and global economic structure. The increasing prevalence of electric vehicles, battery technologies, clean energy systems, and the developing defense industry have placed the rich natural resources of African countries—such as cobalt, lithium, magnesium, copper, and gold—at the heart of geopolitical competition. However, this growing demand for critical minerals has not brought the expected development and stability to these resource-rich African countries; on the contrary, it has led to various security problems in areas where state-building processes are incomplete and corruption is widespread. In this context, the concept of the "green resource curse," evoking environmental

degradation, social and ethnic conflicts, and political chaos, has frequently been used to explain new policies of exploitation and domination over African countries in the context of critical minerals.

The DRC and Ghana, examined in this study, have similar economic potential and expectations in terms of their natural resources, yet they have come to the international forefront due to different security problems. In the Democratic Republic of Congo (DRC), critical minerals have become one of the main sources of funding for armed groups in the eastern regions where state authority is weak or has effectively disappeared. Revenues obtained from controlling mining sites enable these organizations to acquire manpower, arm themselves, and maintain operational continuity; thus, natural resources become a structural component of the war economy, which forms the material infrastructure of the conflict. Indeed, in the case of the DRC, natural resources function not merely as an object of struggle, but as a strategic tool that ensures the reproduction of the conflict.

The dynamic in Ghana, however, follows a qualitatively different course. Illegal gold mining, known as "Galamsey," instead of directly generating an armed internal conflict, leads to accelerated environmental destruction, the spread of informal economic activities, the consolidation of corruption and political patronage networks, and the erosion of institutional effectiveness in public institutions. This process weakens the state's capacity for natural resource management, erodes public trust in the rule of law, and increases the visibility of social tensions and local violence, particularly in mining areas.

A comparative analysis of the two countries reveals that natural resource wealth is not, in itself, an independent variable generating conflict or instability; rather, the security environment, institutional framework, and political economy in which these resources are managed are the primary factors determining the nature of the outcome. In this context, state capacity, quality of governance, the legacy of historical conflict, and the way in which the country is integrated into global value chains emerge as key explanatory variables determining whether natural resource wealth will evolve into armed conflict or an environmental and governance crisis.

In conclusion, this study demonstrates that the issue of critical minerals in Africa cannot be considered solely as an economic resource management problem. The continent's strategic minerals are situated at the intersection of numerous interconnected dynamics, including security, environment, development, and great power competition. The examples of the Democratic Republic of Congo and Ghana show that natural resource wealth does not produce the same results in every country, but creates similar vulnerabilities, albeit in different forms, in the absence of strong and accountable institutions.

In this context, it is insufficient to measure the success of the green transition solely by reducing carbon emissions or spreading clean energy technologies. It is also necessary to ensure that the economic value derived from critical minerals is fairly distributed to producing countries, that environmental damage is limited, and that natural resource revenues are managed in a way that supports inclusive development. Otherwise, while the green economy discourse represents a new environmental transformation, it may revert to a structure that reproduces the extractive relationships of the past in economic and political terms. Therefore, for the energy transition to be truly sustainable, it depends not only on moving away from fossil fuels, but also on implementing a new approach to natural resource governance that prioritizes fairness, transparency, and local development.

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ARTIFICIAL INTELLIGENCE GOVERNANCE AND THE CIRCULAR DIGITAL ECONOMY IN AFRICA: LEGAL AND POLICY PERSPECTIVES UNDER THE AFRICAN UNION AI STRATEGY

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Abstract

The African Union's emerging approach to artificial intelligence (AI) governance reflects a recognition that AI will play a central role in Africa's digital transformation, economic integration, and sustainable development agenda. At the same time, African economies face increasing pressure to adopt circular economy models to address resource scarcity, ecological degradation, electronic waste, and structural inequalities in digital markets. This paper examines the intersection of artificial intelligence, law, the digital economy, and the circular economy through the lens of the African Union's AI policy framework and broader continental development strategies, including Agenda 2063 and the African Continental Free Trade Area (AfCFTA).The paper argues that AI has the potential to accelerate Africa's transition toward a circular digital economy by enabling smarter resource management, sustainable agriculture, predictive maintenance, waste reduction, financial inclusion, and more efficient cross-border trade systems. AI technologies can support data-driven environmental governance and foster innovation ecosystems across emerging African digital markets. However, the rapid deployment of AI also raises serious legal and regulatory concerns regarding data governance, digital sovereignty, algorithmic bias, unequal access to technology, labour displacement, cybersecurity, and the concentration of digital power among global technology actors. Using a doctrinal legal and policy methodology, the study analyses the African Union's evolving AI governance principles alongside relevant regional instruments on digital trade, data protection, sustainability, and innovation policy. The paper also evaluates how African legal systems can balance technological innovation with environmental sustainability, human rights protections, and inclusive economic development. Particular attention is given to the challenge of regulating AI in contexts marked by uneven digital infrastructure, fragmented regulatory systems, and dependency on externally developed technologies. The paper concludes that Africa's AI governance framework presents an opportunity to develop a uniquely African model of responsible and sustainable digital transformation. It proposes a "circular AI governance" approach grounded in digital sovereignty, regional cooperation, sustainability-by-design, ethical AI principles, and inclusive economic participation. Such a framework could strengthen Africa's position within the global digital economy while advancing environmentally sustainable and socially equitable development across the continent.

Keywords: Artificial Intelligence, Circular Economy, Digital Governance, African Union, Sustainable Development

BEYOND TECHNOLOGY ADOPTION: GOVERNING THE TWIN TRANSITION FOR CIRCULAR AND RESILIENT INDUSTRIAL ECOSYSTEMS

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Abstract

The twin transition has become a central concern for economies that must digitalize while reducing material waste, carbon intensity, and supply-chain vulnerability. Yet much of the current debate still treats digitalization as if the mere adoption of artificial intelligence, Internet of Things, blockchain, cloud platforms, or analytics will automatically deliver circular and resilient industrial outcomes. This qualitative conceptual article argues that the twin transition is not primarily a technology-adoption problem; it is a governance problem. Drawing on a thematic synthesis of recent international journal literature published between 2021 and 2025, supported by selected secondary indicators on circularity, e-waste, clean-energy investment, and digital-intensity gaps, the article develops an ecosystem-based framework for governing digitalization, circular economy practices, and industrial resilience together. The findings identify five governance themes: making material flows visible and accountable; translating circularity into business-model change; treating resilience as adaptive capacity; coordinating data, standards, incentives, and trust across actors; and preventing the twin transition from reproducing a capability divide between large firms and SMEs. The article contributes by shifting attention from digital tools as isolated enablers to governance arrangements that determine whether digital capability becomes circular value and resilient industrial performance.

Keywords: Twin Transition, Digitalization, Circular Economy, Industrial Resilience, Industrial Ecosystems, Governance, Qualitative Study

INTRODUCTION

The theme of governing the twin transition is timely because industries are being asked to move in two directions at once. They must become more digital, data-driven, and connected, while also becoming less wasteful, less carbon-intensive, and less dependent on virgin materials. In policy language, these movements are often placed side by side: digital transformation and green transformation. In business reality, however, they are not automatically aligned. A firm can install sensors, dashboards, enterprise platforms, and artificial intelligence while still operating with a linear logic of extraction, production, consumption, and disposal. A company can also introduce recycling programs or resource-efficiency initiatives without having the data infrastructure needed to trace materials, measure product use, coordinate reverse logistics, or redesign a business model. The twin transition, therefore, is not simply a matter of purchasing digital technologies or announcing circular-economy ambitions. It is a question of how industrial actors are governed, connected, incentivized, and enabled to change the way value is created and circulated.

Recent empirical signals show why this issue cannot be postponed. The global circularity rate remains low, and recent reporting suggests that global circularity has moved in the wrong direction, falling from 9.1 percent in 2018 to 7.2 percent in 2023. At the same time, the digital economy has a growing material footprint. The Global E-waste Monitor reports that 62 million tonnes of e-waste were generated in 2022, while only 22.3 percent was documented as formally collected and recycled. These numbers make the paradox visible: the technologies used to support sustainability may also generate new streams of waste, new demand for critical minerals, and new pressure on energy systems. The European Union, often viewed as a leading region in circular-economy policy, recorded a circular material use rate of 11.8 percent in 2023. This is progress, but it also means that most material input still comes from non-circular sources. In parallel, the digital transition is uneven. Eurostat reported that 58 percent of EU SMEs reached at least a basic level of digital intensity in 2023, compared with 91 percent of large enterprises. The transition is therefore not only ecological and technological; it is also organizational and distributive.

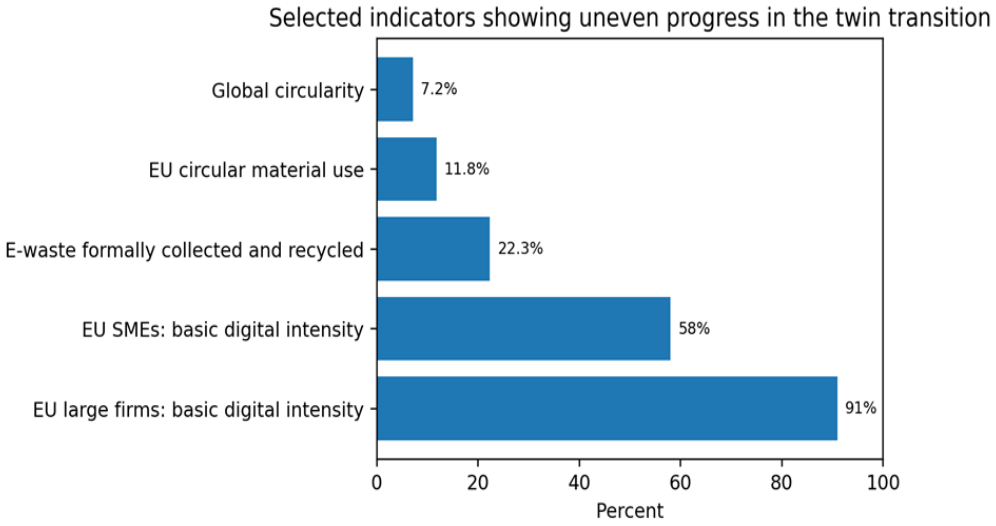
Table 1. Selected Indicators Behind The Twin-Transition Governance Challenge

Phenomenon	Recent indicator	Governance meaning
Weak global circularity	Global circularity rate: 7.2% in 2023; down from 9.1% in 2018	Circularity discourse is growing faster than material-loop closure.
Digital waste pressure	62 Mt of e-waste generated in 2022; 22.3% formally collected and recycled	Digital transformation needs circular design and end-of-life governance.
EU circularity gap	EU circular material use rate: 11.8% in 2023	Even advanced policy regions remain far from circular material systems.

Phenomenon	Recent indicator	Governance meaning
SME digital divide	58% of EU SMEs reached basic digital intensity in 2023; large firms reached 91%	The twin transition can widen capability inequality without support mechanisms.
Clean-energy investment	Global energy investment expected to exceed USD 3 trillion in 2024; about USD 2 trillion for clean energy	Capital is moving, but ecosystem governance is needed to translate investment into resilience.

Data Sources: Circularity Gap Report 2024; Global E-waste Monitor 2024; Eurostat circular material use and digital intensity releases; IEA World Energy Investment 2024.

Figure 1. Uneven Progress Across Circularity, Digitalization, And Energy-Transition Indicators



Note: Percentages are not a single composite index; they are displayed together to illustrate the uneven landscape in which twin-transition governance takes place.

The investment landscape adds another layer to the problem. The International Energy Agency estimated that global energy investment would exceed USD 3 trillion in 2024, with around USD 2 trillion directed to clean-energy technologies and infrastructure. This shift indicates that capital is moving toward decarbonization. Yet investment in infrastructure does not automatically produce circularity inside firms or resilience across industrial ecosystems. Circular strategies such as repair, reuse, remanufacturing, product-service systems, and closed-loop logistics require cooperation among manufacturers, suppliers, customers, recyclers, digital-service providers, regulators, and financial institutions. These actors rarely

share the same incentives, time horizons, data standards, or risk exposure. The governance challenge is to make the transition operational across the ecosystem rather than leaving it as a strategic slogan at the firm level.

The literature increasingly recognizes this complexity. Tabares, Parida, and Chirumalla (2025) define twin transition as mutually reinforcing digital and green transformations, but they also emphasize that firms struggle to align sustainability goals with digital innovation in a structured way. Siedschlag, Mohan, and Yan (2024) provide firm-level evidence that digitalization and environmental sustainability measures can go together, while also showing that adoption is uneven across firm groups, sectors, and regions. Chauhan, Parida, and Dhir (2022) show that technologies such as big data, artificial intelligence, blockchain, and the Internet of Things can support circular-economy initiatives, but their review also points to barriers and fragmented implementation. Neri et al. (2023) specifically highlight that industrial SMEs face both a digital divide and a circular divide, making it difficult for them to exploit Industry 4.0 technologies for circular-economy practices. These studies are important because they move beyond technological optimism, but the governance dimension remains insufficiently integrated.

This article responds to that gap. Its novelty lies in arguing that digitalization should not be studied only as an enabler of circular economy, and circular economy should not be studied only as an environmental strategy. Both must be understood as mutually dependent transitions that become effective only when governed at the level of industrial ecosystems. Governance here refers to the formal and informal arrangements through which actors coordinate data access, standards, investments, skills, responsibilities, risks, and value distribution. The article therefore asks: how can the twin transition be governed so that digitalization supports circularity and circularity strengthens industrial resilience? The answer developed in this paper is qualitative and conceptual: resilient industrial ecosystems emerge when digital tools make material flows visible, circular strategies redesign value creation, and governance mechanisms align actors who otherwise have little reason to cooperate.

1. LITERATURE REVIEW AND RESEARCH NOVELTY

The concept of twin transition has gained attention because it captures a practical tension in contemporary development. Digital technologies are expected to accelerate environmental transformation, but digitalization also consumes energy, materials, and managerial attention. Tabares et al. (2025) describe twin transition as parallel and mutually reinforcing digital and green transitions that can produce sustainable competitiveness. Their framework is useful because it avoids treating digital and green agendas as independent projects. However, their own research agenda also implies that firms still need clearer guidance on the organizational practices and success factors required to implement the transition. In this article, that concern

is extended from the firm to the industrial ecosystem. The ecosystem view is necessary because many circular practices cannot be implemented by one firm alone. A manufacturer can design a product for repair, but repairability depends on parts availability, consumer practices, service networks, regulations, and information flows.

Digitalization is often framed as a solution because it can reduce information asymmetry. Sensors can monitor product conditions. Digital twins can simulate resource use. Blockchain can improve traceability. Artificial intelligence can identify maintenance needs, predict demand, or optimize production. Cloud systems and data platforms can connect actors across supply chains. Liu et al. (2022) classify digital functions that support circular-economy strategies, including monitoring, tracking, optimization, prediction, and automation. Piedra-Munoz et al. (2025) further argue that the relationship between digital technologies and circular economy should be broadened beyond the familiar Industry 4.0 toolkit, because digital technologies can support narrowing, slowing, closing, and regenerating material loops. These contributions are valuable, but they also show that technology is only the visible part of a deeper organizational process. Data must be trusted, shared, interpreted, and acted upon.

Circular economy literature has also moved from simple recycling narratives to more systemic interpretations. Trevisan et al. (2022) describe circular ecosystems as networks of autonomous but interdependent actors that jointly create a circular value proposition. This definition is essential for understanding why governance matters. Circularity requires the redesign of products, processes, logistics, procurement, contracts, and consumer relationships. It also changes the meaning of economic value. In a linear model, value is often captured at the point of sale. In a circular model, value can be created through extended product life, reuse, repair services, remanufacturing, data-based maintenance, residual-value recovery, and reduced exposure to resource shocks. Schoggl, Stumpf, and Baumgartner (2024) provide empirical evidence that interorganizational collaboration has a strong effect on circular-economy practices, while digital technologies mainly support collaboration rather than replace it. This finding is central to the argument of the present article: digitalization does not govern the transition by itself; it can strengthen governance when embedded in collaborative arrangements.

Table 2. Main Literature Streams And The Remaining Governance Gap

Stream	Key recent contribution	Remaining gap addressed in this article
Twin transition	Twin transition is framed as mutually reinforcing digital and green transformation that can support sustainable competitiveness (Tabares et al., 2025).	How this alignment is governed beyond the individual firm remains underdeveloped.

Stream	Key recent contribution	Remaining gap addressed in this article
Digitalization and circular economy	Digital tools can monitor, trace, optimize, predict, and automate circular practices (Liu et al., 2022; Piedra-Munoz et al., 2025).	Technology functions need to be connected to accountability, standards, and shared action.
Industrial SMEs	SMEs face digital and circular divides that constrain implementation (Neri et al., 2023).	The twin transition requires inclusive governance, not only lead-firm transformation.
Circular ecosystems	Circular value is co-created by interdependent actors across ecosystems (Trevisan et al., 2022).	Ecosystem coordination must be linked to resilience outcomes.
Supply-chain resilience	Digital technologies improve visibility, memory, and responsiveness (Alvarenga et al., 2023; Modgil et al., 2022).	Resilience should be defined as adaptive circular capacity, not simply fast recovery.

Industrial resilience is the third element in the framework. In many policy documents, resilience is used broadly to mean the capacity to survive disruption. In industrial ecosystems, resilience should be understood more specifically as the capacity to absorb shocks, adapt routines, recover functionality, and transform structures when old arrangements are no longer viable. Supply-chain studies show that digital technologies can enhance visibility, memory, and responsiveness (Alvarenga et al., 2023; Modgil et al., 2022). Patidar et al. (2023) similarly emphasize the role of Industry 4.0 technologies in supply-chain visibility and sustainability. Yet resilience is not only about speed. A supply chain that recovers quickly but continues to depend on fragile, wasteful, or extractive flows remains vulnerable. Circularity can strengthen resilience by reducing dependence on virgin materials, creating secondary-resource markets, diversifying supply sources, and extending the productive life of assets. Digitalization can strengthen this process by making circular flows measurable and governable.

Several studies indicate the risk of a capability divide. Siedschlag et al. (2024) show that larger firms and firms employing ICT specialists are more likely to adopt environmental sustainability measures connected to digital technologies. Neri et al. (2023) argue that industrial SMEs face both digital and circular divides, because they often lack financial resources, managerial capabilities, and technical knowledge. Trevisan, Acerbi, Dukovska-Popovska, Terzi, and Sassanelli (2024) add that the twin transition requires new professional skills, combining digital, resilience, and specialized technical competences. This matters for governance because an ecosystem cannot become resilient if only the lead firms are digitally capable. In many sectors, SMEs provide components, services, logistics, repair, and local adaptation. If they are excluded from digital platforms or circular standards, the transition may become fragmented, unfair, and operationally weak.

The literature therefore points to an important research gap. We know increasingly well that digital technologies can support circular practices; we know that circular strategies can

contribute to sustainability; and we know that resilience requires visibility and flexibility. What remains less developed is an integrated explanation of how governance connects these three agendas. This article addresses that gap by developing a qualitative governance framework. Rather than asking which technology should be adopted, it asks what kinds of coordination make digital technologies useful for circular and resilient outcomes.

2. METHODOLOGY

This article uses a qualitative conceptual design based on an integrative literature review and thematic synthesis. The objective is not to test a statistical relationship, but to develop a governance-based explanation of the twin transition by interpreting patterns across recent scholarship. A qualitative approach is appropriate because the twin transition involves meanings, institutional arrangements, strategic tensions, and coordination problems that are difficult to capture through indicators alone. The method follows a logic of analytical synthesis: the literature is read not only for findings, but also for concepts, assumptions, contradictions, and gaps.

The review focused on international peer-reviewed journal articles published between 2021 and 2025. The selection emphasized journals in sustainability, operations management, technology forecasting, supply-chain management, and business strategy. Keywords included twin transition, digital transformation, circular economy, circular ecosystem, industrial resilience, digital technologies, supply-chain resilience, Industry 4.0, circular business models, and governance. Twenty core references were selected because they directly connect at least two of the three domains: digitalization, circular economy, and resilience. To strengthen the introduction, the article also uses selected secondary indicators from reputable public sources, including the Circularity Gap Report, the Global E-waste Monitor, Eurostat, and the International Energy Agency. These indicators are not treated as the main empirical data; they are used to clarify the phenomenon and justify the research problem.

The analysis proceeded in three stages. First, each article was read to identify its main contribution, level of analysis, and implied governance problem. Second, recurring ideas were coded into provisional categories, such as data visibility, circular business models, collaboration, digital divide, skills, resilience, and policy coordination. Third, these categories were interpreted into five higher-order themes that structure the findings. The resulting framework is conceptual, but it is grounded in recent literature and supported by publicly available transition indicators.

Table 3. Qualitative Analytical Protocol

Stage	Analytical activity	Output
1. Literature identification	Selection of 20 recent peer-reviewed journal articles published in 2021-2025.	Core literature corpus.
2. Open coding	Extraction of recurring concepts related to digitalization, circularity, resilience, and governance.	Initial codes such as visibility, collaboration, skills, standards, trust, and digital divide.
3. Axial synthesis	Connection of codes into higher-level themes across the literature.	Five governance themes.
4. Conceptual integration	Interpretation of how themes interact at the industrial ecosystem level.	Governance-based framework for circular-resilient twin transition.

3. FINDINGS AND DISCUSSION

The thematic synthesis generated five findings. They are presented as interpretive themes because the objective of this article is to explain the governance logic of the twin transition rather than to rank technologies or test causal effects. Together, the themes show why industrial ecosystems need to move beyond technology adoption and toward coordinated circular-resilient transformation.

3.1. From Digital Visibility To Circular Accountability

Digital technologies are useful for the circular economy because they make flows visible. Without information about where materials come from, how products are used, when components fail, and where waste goes, circularity remains largely aspirational. Digital tools can create visibility through product passports, sensors, connected machines, enterprise systems, data analytics, blockchain ledgers, and digital twins. However, visibility does not automatically become accountability. A company may collect data without changing procurement, product design, or end-of-life responsibility. The governance question is therefore: who is responsible for acting on the data? This question is rarely technical. It concerns contracts, regulatory obligations, reporting norms, and shared metrics across the ecosystem. If a supplier knows the material composition of a component but that information is not shared with repairers, recyclers, or customers, the digital record has limited circular value. Governance turns visibility into obligation, coordination, and learning.

3.2. Circular Economy As Business-Model And Ecosystem Redesign

Circularity changes the way firms define value. In a linear model, the firm sells a product and externalizes many end-of-life consequences. In a circular model, value is extended through repair, reuse, remanufacturing, upgrading, product-service systems, and secondary-material recovery. This shift requires more than operational improvement. It demands new revenue

models, new relationships with users, and new roles for actors that are often ignored in conventional supply-chain maps. For example, a repair network may become as strategically important as a distributor. A recycler may become a knowledge partner. A digital platform provider may influence the flow of circular information. Studies on circular ecosystems and interorganizational collaboration show that these transformations depend on relational capability, not just technology. Digital tools can support a circular business model, but the model has to be deliberately designed and governed.

3.3. Resilience Beyond Speed And Recovery

Industrial resilience is often discussed after disruptions, such as pandemics, wars, extreme weather, logistics bottlenecks, or energy-price shocks. The immediate concern is usually recovery: how quickly can production restart, how fast can a supplier be replaced, or how much inventory is available? These questions are necessary, but they are insufficient. A resilient ecosystem is not only one that returns to the previous state; it is one that can learn and transform when the previous state is part of the problem. Circular economy strengthens resilience by reducing dependence on single-use resources, creating local recovery loops, increasing material flexibility, and lowering exposure to volatile virgin-resource markets. Digitalization strengthens resilience when it provides early warning, traceability, coordination, and scenario analysis. The twin transition therefore reframes resilience as adaptive circular capacity, not merely crisis response.

3.4. Governance As The Missing Layer Of The Twin Transition

The central finding of this article is that governance is the missing layer between technology adoption and transition outcomes. Many firms can adopt digital tools, and many can introduce selected circular practices. The harder task is to make these initiatives coherent across an industrial ecosystem. Governance includes standards for data interoperability, rules on data ownership, trust mechanisms for sharing commercially sensitive information, incentives for suppliers, skills programs for workers, financing for SMEs, procurement criteria, and policy frameworks that reward long-term circular value. Governance is also needed to prevent rebound effects, where efficiency gains reduce costs and stimulate more consumption. A digitally optimized linear system may be faster, but not necessarily more sustainable. The twin transition becomes meaningful only when digitalization is directed toward circular performance and resilience objectives.

3.5. The Capability Divide And The Justice Of Transition

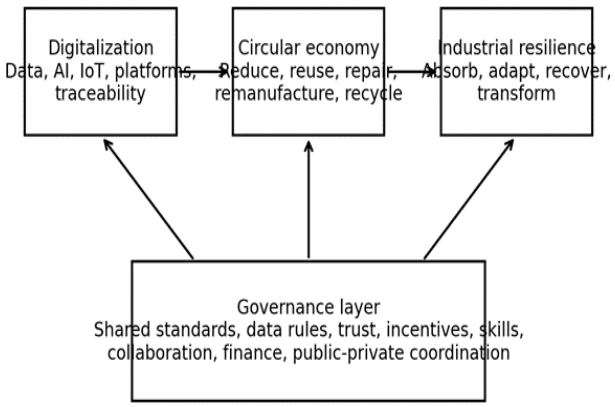
The twin transition can create winners and losers if governance is weak. Large firms may have the capital, specialists, and strategic visibility to invest in digital-circular capabilities. SMEs may face high costs, limited knowledge, incompatible platforms, and uncertain returns.

Workers may be expected to use new systems without receiving the training needed to interpret data or redesign routines. Regions with weak digital infrastructure may be excluded from circular value chains. This capability divide is not a side issue; it is a resilience issue. Industrial ecosystems depend on the weakest links in the network. If SMEs cannot participate in product passports, reverse logistics, or data-based maintenance, circularity will remain partial. Governance must therefore include capability-building, inclusive standards, accessible finance, shared digital infrastructure, and training programs that connect digital, circular, and resilience skills.

3.6. A Governance Framework For The Twin Transition

The framework in Figure 2 summarizes the article's central argument. Digitalization, circular economy, and resilience are treated as interdependent elements. Digitalization provides data and connectivity. Circular economy gives the transition its material and environmental direction. Industrial resilience provides the performance logic under uncertainty. Governance is the layer that links them. It defines how actors share data, allocate responsibility, develop skills, finance transition costs, and evaluate outcomes. Without this layer, digitalization may improve efficiency without reducing material dependence, circular initiatives may remain isolated, and resilience may be reduced to short-term recovery.

Figure 2. Conceptual Framework: Governance As The Linking Layer Of The Twin Transition



Core argument: technology adoption produces circular-resilient outcomes only when governed as an ecosystem process.

Table 4. Conceptual Propositions Derived From The Qualitative Synthesis

Proposition	Statement
P1	Digital technologies contribute to circular economy outcomes when they create actionable visibility over material and product flows.
P2	Circular economy strengthens industrial resilience when it reduces dependence on fragile virgin-resource flows and expands reuse, repair, and recovery options.
P3	Ecosystem governance mediates the relationship between technology adoption and circular-resilient performance.
P4	The twin transition is weakened when SMEs, workers, or regional actors lack the skills and infrastructure needed to participate in digital-circular systems.
P5	Collaboration, trust, data standards, and incentives are not supporting details but core conditions of transition maturity.

3.7. Governance Mechanisms For Implementation

A governance-based approach to the twin transition requires several mechanisms that are easy to name but difficult to institutionalize. The first is shared metrics. Firms often report energy efficiency, carbon emissions, waste reduction, digital adoption, or productivity through separate indicators. The twin transition needs metrics that connect these categories. For instance, a digital maintenance system should not only be evaluated by downtime reduction, but also by its contribution to product-life extension, spare-part efficiency, and avoided material replacement. A digital product passport should not only prove compliance, but also help repairers and recyclers recover value. Shared metrics make it possible to judge whether digitalization actually improves circular and resilient performance.

The second mechanism is data governance. Circular economy depends on information that travels beyond the boundaries of a single firm. Material composition, repair instructions, component origin, carbon information, and end-of-life options are useful only when they are accessible to actors that need them. Yet companies may hesitate to share data because of confidentiality, competitive concerns, cybersecurity risks, or unclear ownership. A practical governance arrangement must clarify what data is mandatory, what data is voluntary, who can access it, how it is protected, and how benefits are distributed. This is why the twin transition cannot be reduced to software procurement; it requires rules and trust around the software.

The third mechanism is incentive alignment. Circular practices can create value for the ecosystem while imposing costs on particular actors. A manufacturer may need to redesign a product for repairability, while the economic benefit appears later in a service network or secondary market. A supplier may be asked to provide detailed material data without receiving compensation for the administrative burden. SMEs may be asked to comply with digital reporting standards that were designed around large-firm capabilities. Governance must solve these misalignments through contracts, subsidies, shared savings, procurement rules, fiscal incentives, or platform arrangements that reward participation.

The fourth mechanism is capability development. Skills are not a soft issue in the twin transition; they are infrastructure. Workers need to interpret data, maintain connected equipment, redesign processes, understand circular design, manage reverse logistics, and collaborate across organizational boundaries. Managers need to evaluate technology not by novelty but by circular value. Public institutions need to design policies that avoid creating compliance burdens without transition capacity. Universities and vocational institutions therefore have a role in building hybrid competences that combine economics, industrial engineering, environmental management, and digital systems.

The fifth mechanism is experimental governance. The twin transition will not be implemented perfectly from the beginning. Firms and regions need controlled spaces for pilot projects, learning alliances, living labs, and demonstration ecosystems. What matters is that experiments are not isolated showcases. They should be designed with learning loops, evaluation criteria, and pathways for scaling. A pilot on digital product passports, for example, should generate practical lessons on data quality, supplier participation, user acceptance, repair behavior, and cost allocation. Experimental governance keeps the transition grounded in real operational problems rather than abstract technological enthusiasm.

The final mechanism is accountability. Without accountability, the twin transition can become a language of aspiration. Companies may claim to be digital and circular while the material footprint remains unchanged. Governments may launch strategies without enforcement. Platforms may improve visibility without improving outcomes. Accountability means that actors are assessed against measurable circular and resilience results, and that responsibilities are clear across the product life cycle. In this sense, governance is not an external administrative burden. It is the architecture that allows digitalization and circular economy to become credible industrial transformation.

3.8. Relevance For Emerging And Developing Industrial Contexts

The governance argument is particularly important for emerging and developing economies. Many of these economies are under pressure to upgrade industrial productivity, attract investment, create jobs, and participate in global value chains. At the same time, they face infrastructure gaps, financing constraints, uneven digital skills, and weaker waste-management systems. A narrow technology-adoption approach may therefore deepen dependency: firms buy imported digital systems, but local ecosystems remain unable to retain material value or develop circular capabilities. A governance approach asks how digitalization can support local repair, remanufacturing, reverse logistics, and secondary-material markets.

For countries with large SME sectors, the twin transition should be designed around accessibility. The most sophisticated platform will not help if suppliers cannot afford the hardware, internet connection, software license, or technical staff required to participate.

Digital circularity must therefore include low-cost tools, shared infrastructure, training programs, and institutional intermediaries. Universities, chambers of commerce, industrial associations, and local governments can act as translation agents that help SMEs understand requirements and convert them into practical routines.

Emerging economies may also have circular practices that are not formally recognized as innovation. Repair shops, informal recyclers, reuse markets, and community-based maintenance systems often keep products in circulation long before circular economy becomes a policy slogan. The governance challenge is not simply to replace these systems with formal digital platforms, but to upgrade them safely, fairly, and productively. This means recognizing informal knowledge, improving working conditions, reducing environmental and health risks, and connecting local circular practices with formal industrial standards.

There is also a strategic opportunity. If digitalization is governed well, it can help emerging economies avoid locking themselves into resource-intensive industrial pathways. Digital tools can support material mapping, industrial symbiosis, predictive maintenance, energy management, and traceability in export-oriented sectors. Circular strategies can reduce import dependence for certain materials and create new employment in repair, refurbishment, logistics, and recycling. The twin transition should therefore be framed not only as environmental compliance, but as industrial upgrading and resilience-building.

3.9. From Framework To Staged Action

The framework developed in this article can be translated into a staged pathway. The first stage is diagnosis. Firms and policy actors should identify which material flows are most important, which digital systems already exist, and where information is missing. The second stage is alignment. Actors need to agree on shared objectives, such as reducing waste, extending product life, increasing recycled input, or improving supply-chain recovery capacity. The third stage is capability building, especially among SMEs and workers. The fourth stage is implementation through pilot projects and ecosystem agreements. The fifth stage is institutionalization, where successful practices become standards, contracts, procurement rules, and performance indicators.

This staged pathway helps avoid two common mistakes. The first mistake is technological leapfrogging without organizational preparation. Firms may invest in advanced analytics or blockchain before clarifying basic process data, supplier responsibilities, or circular objectives. The second mistake is sustainability rhetoric without operational infrastructure. Firms may declare circular ambitions but fail to redesign information systems, incentives, or partnerships. A staged approach makes the transition more realistic by connecting ambition to capability and governance.

For an international conference audience, the value of this framework is that it can travel across contexts while remaining sensitive to local differences. The same governance questions can be asked in Europe, Asia, Africa, or Latin America: What circular problem is digitalization expected to solve? Which actors need to cooperate? What data is needed? Who pays? Who benefits? Who is excluded? How will resilience be measured? These questions make the twin transition concrete and prevent it from becoming another fashionable phrase detached from industrial practice.

Table 5. Practical Roadmap For Governing The Twin Transition

Stage	Main question	Governance action
1. Diagnose	Which flows, risks, and capabilities matter most?	Map material flows, digital systems, actors, dependencies, and waste hotspots.
2. Align	What circular-resilient outcomes should digitalization serve?	Define shared targets, common metrics, data standards, and responsibilities.
3. Build capability	Who lacks skills, finance, or infrastructure?	Support SMEs, workers, and local institutions through training, finance, and shared tools.
4. Experiment	Which pilots can test ecosystem coordination?	Run pilots with learning loops, transparent evaluation, and participation across the value chain.
5. Institutionalize	How can successful practices become normal routines?	Embed results in procurement, contracts, reporting systems, regulation, and sector standards.

4. IMPLICATIONS

For policymakers, the article suggests that twin-transition policy should avoid treating digitalization and circular economy as separate portfolios. Digital infrastructure policies should be connected to circular-economy objectives, and circular-economy regulations should consider data requirements, SME capacity, and interoperability. Public procurement can also be used to reward circular performance, repairability, product transparency, and data-sharing arrangements. Without these mechanisms, firms may adopt technologies that improve efficiency without changing material outcomes.

For managers, the findings imply that digital strategy should start with circular questions: Which material flows are invisible? Which products could be repaired, reused, remanufactured, or upgraded? Which actors need information to close the loop? Which data should be shared, and under what rules? This approach prevents technology adoption from becoming a cosmetic modernization exercise. It also helps managers identify where collaboration is more valuable than internal optimization.

For researchers, the study highlights the need for more qualitative and comparative work on governance arrangements in different industrial contexts. Future research could examine how SMEs negotiate participation in digital-circular platforms, how data governance affects trust in circular ecosystems, and how regional institutions shape the twin transition in emerging economies. There is also room for longitudinal studies that trace how firms move from pilot projects to mature ecosystem-level coordination.

5. LIMITATIONS AND FUTURE RESEARCH

This article is conceptual and qualitative. It synthesizes recent literature and transition indicators, but it does not present primary interview data. This is appropriate for building an interpretive framework, yet future empirical work is needed to examine how the framework operates in specific sectors such as manufacturing, electronics, textiles, automotive components, construction materials, or agro-industry. Future studies could use multiple-case designs, interviews with ecosystem actors, or longitudinal observation of digital-circular platforms.

The article also focuses mainly on industrial ecosystems and firm-related governance. Household behavior, consumer politics, labor relations, and informal economies are discussed only indirectly. In emerging economies, these dimensions may be decisive. Future research should therefore examine how informal repair systems, local reuse markets, and community-level innovation interact with formal digital-circular strategies.

6. CONCLUSION

The twin transition is one of the defining industrial questions of the present decade. It promises a future in which digital technologies support circular material systems and resilient industrial ecosystems. Yet this promise will not be fulfilled by technology adoption alone. The evidence reviewed in this article suggests that digitalization becomes transformative only when it is governed toward circular and resilient outcomes. Circular economy becomes operational only when actors coordinate product design, data, logistics, incentives, and responsibility across the life cycle. Resilience becomes meaningful only when industries are able not merely to recover from disruption, but to reduce the structural vulnerabilities created by linear production and fragmented supply chains. The main contribution of this article is to place governance at the center of the twin transition. It argues that the decisive question is not whether firms adopt AI, IoT, blockchain, or analytics, but whether industrial ecosystems can build the institutional, relational, and capability conditions that allow these tools to serve circular value creation. In short, the future of the twin transition depends less on smarter machines than on smarter coordination among firms, governments, workers, and communities.

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IS SUSTAINABLE BUSINESS FINANCING BY STATE-OWNED SYARIAH BANKS CAPABLE OF REALIZED SUSTAINABLE DEVELOPMENT GOALS (SDGs)? A CRITICAL LITERATURE REVIEW

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Abstract

The main problem is that sustainable financing in state-owned Islamic banks still shows a gap between institutional commitment and substantive implementation, so that it often functions more as an instrument of regulatory compliance and corporate legitimacy than as a mechanism for development transformation. This study aims to analyze the role of sustainable financing in Islamic banks in realizing the achievement of the sustainable business activity category (KKUB) to support the Sustainable Development Goals (SDGs). The study uses a qualitative approach through a systematic literature review with data sources in the form of books, scientific articles, policy documents, and sustainability reports of Bank Syariah Indonesia, which are analyzed systematically using the framework PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)The research results show that sustainable financing has increased nominally, reflected in the growth of green financing and ESG financing, but its distribution remains uneven across categories. The strongest support is concentrated in MSMEs, sustainable natural resource management and land use, and eco-efficient products, while renewable energy, water and wastewater management, and environmentally friendly buildings remain relatively limited or fluctuate. These findings confirm that sustainable financing by Islamic banks has contributed to the SDGs, but its implementation remains selective and has not been fully integrated as a consistent and long-term sustainable development strategy.

Keywords: Sustainable Financing, Sustainable Enterprises, Sustainable Development Goals (SDGs)

JEL Code: Q01, Q56

INTRODUCTION

The phenomenon of sustainable financing at Bank Syariah Indonesia (BSI) deserves academic attention because BSI, as a state-owned Islamic bank, faces dual demands to maintain business performance while simultaneously channeling financing aligned with the sustainable development agenda. The key issue is not simply the existence of green or inclusive financing schemes, but rather the extent to which such financing is truly directed toward business activities that strengthen economic growth, expand social benefits, promote efficient resource utilization, and effectively address environmental challenges (Madah et al., 2023). BSI's strategic position makes this issue even more important, as its status as a state-owned bank positions the institution not only as a market player but also as an instrument of development policy that is expected to have a broader, more measurable, and more sustainable impact (Silvia et al., 2024).

The issue of sustainable financing is increasingly strategic in modern financial studies because its success is not determined by the number of financing products labeled sustainable, but rather by the ability of financial institutions to direct the flow of funds to economic activities that produce real and measurable social, environmental, and economic impacts. The main problem lies in the gap between institutional commitment and substantive implementation, where sustainable financing is often positioned as an instrument of regulatory compliance or corporate image, rather than as a mechanism for development transformation (Murty & Singh, 2026). This situation raises the academic need to assess the quality of financing direction, consistency of governance, the accuracy of target sectors, and the relevance of its impact on the long-term development agenda. This focus is crucial because sustainable financing essentially demands the integration of business orientation, social responsibility, environmental resilience, and policy accountability within a credible financial intermediation framework (Hassan et al., 2026).

Table 1. Portfolio of Environmentally Conscious Projects (In Billions of Rupiah)

No.	Description	2022	2023	2024
1.	Sustainable Financing Portfolio	51,497	57,704	66,499
2.	Green Financing Portfolio	9,327	12,235	14,084
3.	Social Financing Portfolio	41,824	45,469	52,415

Source: Bank Syariah Indonesia's Sustainable Financial Performance Report

The main issue reflected in the environmentally-conscious project portfolio data of Bank Syariah Indonesia (BSI), a state-owned Islamic bank, lies in the consistent nominal growth of sustainable financing, but not yet accompanied by a significant strengthening of the proportion of green financing within its portfolio structure. Data from 2022–2024 shows that

the sustainable financing portfolio increased from IDR 51,497 billion to IDR 66,499 billion, the green financing portfolio increased from IDR 9,327 billion to IDR 14,084 billion, while the social financing portfolio grew from IDR 41,824 billion to IDR 52,415 billion. While this increase does indicate a positive quantitative commitment, substantively, green financing still occupies a relatively small portion, increasing from only around 18.1% in 2022 to 21.2% in 2024, while social financing remains dominant, rising from around 81.2% to 78.8% over the same period. This condition shows that BSI's sustainability agenda still tends to focus on the social dimension, while the environmental dimension has not yet fully become the mainstream of financing, so that the issue that deserves to be studied is no longer just portfolio growth, but rather the imbalance in the direction of sustainable financing in reflecting BSI's strategic mandate as a state-owned bank that is expected to lead the green financial transformation in Indonesia.

The urgency of this research lies in the need to explain more sharply the position of sustainable business financing at Bank Syariah Indonesia (BSI) as a state-owned sharia bank which is expected to not only carry out financial intermediation functions, but also play a role in directing development towards sustainability (Zafar, 2026). This issue is important because sustainable financing in Islamic banking cannot be understood simply as product expansion or compliance with regulatory requirements, but rather as a reflection of the institution's seriousness in linking Islamic principles, institutional responsibility, and the global development agenda (Kang et al., 2026). Academic attention is needed because there is still conceptual room for deepening regarding how such financing translates into a concrete role in providing access to basic resources, strengthening inclusive economic growth, supporting innovation and sustainable infrastructure, strengthening environmental responsibility, and establishing development partnerships. Therefore, this research is urgently needed to position BSI sustainable business financing not only as a banking issue, but as a strategic issue that determines the extent to which Islamic banks are able to contribute substantively to the achievement of the SDGs (Teniola & Abdel, 2026).

The relationship between sustainable business financing, the Sustainable Development Goals (SDGs), and Islamic banks is structural because Islamic banks are institutions that channel financing to business activities that are not only economically viable, but also socially valuable and environmentally responsible (Biancone et al., 2020). Sustainable business financing serves as an operational instrument that connects business orientation with development goals, while the SDGs provide normative guidance on the benefits that should result from such financing. The character of Islamic banking, which is based on the principles of justice, welfare, balance, and the prohibition of destructive activities, demonstrates substantive alignment with the sustainable development agenda (Alhammadi et al., 2022). The stronger the orientation of Islamic bank financing toward productive, inclusive, and

environmentally conscious businesses, the greater its contribution to achieving the SDGs. These three variables form a mutually reinforcing relationship, with Islamic banks as the institutional actor, sustainable business financing as the mechanism, and the SDGs as the direction of development transformation (Daly & Jarboui, 2025).

State of the artThis study shows that the literature on Islamic sustainable finance is still dominated by conceptual studies, bibliometrics, and general evaluations of Islamic banking sustainability practices, so that the discussion emphasizes more on the normative relationship between Islamic finance, ESG, and SDGs at the macro level (Kashi et al., 2024). Studies that overlap with Bank Syariah Indonesia (BSI) also tend to be partial, primarily focusing on MSME financing, green banking, or the maqashid sharia approach, thus not providing a complete reading of sustainable business financing as an institutional strategy (Tuyon et al., 2022). In the literature map, this research is located in a study space that examines BSI in a more focused manner as a state-owned Islamic bank that combines an intermediation mandate, Islamic principles, and a sustainable development orientation, so that sustainable business financing is not read as a separate sectoral program, but rather as part of the bank's institutional role in supporting the achievement of the SDGs (Olanrewaju et al., 2025).

The research gap lies in the limited number of studies that specifically examine sustainable business financing at Bank Syariah Indonesia (BSI) through the Sustainable Business Activity Category (KKUB) framework and systematically link it to the achievement of the Sustainable Development Goals (SDGs). Previous research has focused more on Islamic sustainable finance at a conceptual, partial, or general level, thus failing to demonstrate how sustainable financing translates into concrete business activity structures (Ridwan & Mayapada, 2022). The focus on BSI as a state-owned Islamic bank is also still relatively limited with in-depth studies on sustainable financing, even though this institutional position makes BSI have a strategic role in connecting the financial intermediation function, development mandate, and sustainability responsibilities (Oladapo, 2024). Another limitation is the lack of a holistic, structured, and comprehensive SDG-based reading, so that the contribution of sustainable financing to the dimensions of water, energy, economic growth, infrastructure, sustainable settlements, responsible consumption and production, climate change, terrestrial ecosystems, and development partnerships has not been fully depicted (Andayani et al., 2025).

The novelty of this research lies in the specific integration of the relationship between sustainable business financing, Sustainable Development Goals (SDGs), and Islamic banks in a single, focused analytical framework, by placing Bank Syariah Indonesia (BSI) as a state-owned Islamic bank as the main focus of the study (Mboutchouang et al., 2024). This novelty is reinforced by the use of the Sustainable Business Activity Category (KKUB) as a basis for reading the implementation of sustainable finance, so that the analysis does not stop at the conceptual level, but is directed at how the BSI sustainable financing structure is mapped and

interpreted in relation to the achievement of the SDGs more fully. This approach allows for a holistic, structured, and comprehensive discussion of sustainable finance towards development goals related to clean water and proper sanitation, clean and affordable energy, decent work and economic growth, industry, innovation, and infrastructure, sustainable cities and settlements, responsible consumption and production, climate change management, terrestrial ecosystems, and partnerships to achieve the goals (Ibrahim et al., 2024). The novelty of this research also lies in the use of a descriptive-analytic literature review based on PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), which allows the process of identification, selection, evaluation, and synthesis of literature to be carried out more systematically, thus resulting in a deeper understanding of the position of BSI's sustainable business financing in supporting the achievement of the SDGs (Ghaemi et al., 2024).

This study aims to analyze the role of sustainable financing of Islamic banks inrealization of achievement of sustainable business activity category (KKUB) to realize sustainable development goals (SDGs). Theoretically in Islamic economics, this study contributes to strengthening the maqashid al-shariah framework by emphasizing that sustainable financing of Islamic banks not only functions as a financial intermediation instrument, but also as an institutional mechanism to realize welfare, distributive justice, social balance, and environmental sustainability in development orientation. In financial management science, this study contributes to the sharpening and Legitimacy Theory developed from the foundation of Dowling and Pfeffer's (1975) thinking and Stakeholder Theory initiated by Freeman (1984) through the explanation that the realization of the Sustainable Business Activity Category (KKUB) in Islamic banks represents a form of strategic response of the institution to the demands of stakeholders as well as an effort to maintain institutional legitimacy through financing directions that are aligned with economic, social, and environmental goals within the framework of Sustainable Development Goals (SDGs).

Practically, in Islamic economics, this research contributes by providing an analytical basis for Islamic banks to direct financing to business sectors that are not only in accordance with Islamic principles but also have a real support for social welfare, environmental sustainability, and the achievement of development goals. In financial management science, this research contributes by providing an evaluative framework that helps financial institutions interpret the realization of the Sustainable Business Activity Category (KKUB) as a basis for determining financing priorities, strengthening sustainable portfolio strategies, increasing performance accountability, and developing more targeted fund allocation policies. This practical contribution positions sustainable financing not only as a business instrument, but also as a basis for decision-making that is more adaptive, measurable, and aligned with the Sustainable Development Goals (SDGs) agenda.

1. LITERATURE REVIEW

1.1. Legitimacy Theory

Legitimacy Theory, introduced by John Dowling and Jeffrey Pfeffer in 1975, explains that the sustainability of an organization is largely determined by its ability to maintain alignment between institutional values, actions, and goals and the norms, expectations, and value systems prevailing in society. This theory emphasizes that organizations must not only operate efficiently but also gain social acceptance through activities that are deemed fair, appropriate, and beneficial by stakeholders (Wang et al., 2025). The relationship between this theory and sustainable financing in Islamic banks shows that Islamic banks require legitimacy not only in terms of sharia compliance and financial performance, but also in terms of their ability to channel financing in line with social demands for justice, environmental responsibility, and sustainable development (Khalili & Nasr, 2026). Sustainable financing is a strategic instrument demonstrating that Islamic banks are not merely performing an intermediary function but also responding to public expectations for ethical, inclusive, and responsible financial institutions. The stronger the alignment between Islamic bank financing practices and the sustainability values expected by the public, the stronger the institutional legitimacy gained by Islamic banks in maintaining trust, reputation, and social acceptance (J. Kumar et al., 2026).

1.2. Stakeholder Theory

The Stakeholder Theory, which was proposed by R. Edward Freeman in 1984, emphasizes that organizations do not operate solely to fulfill the interests of shareholders, but must manage their relationships and responsibilities towards all parties who are affected by or influence the organization's activities, such as customers, investors, employees, regulators, society, and the environment (Rahman & Hossain, 2024). This theory views an organization's success as being determined by its ability to balance stakeholder interests in a fair, sustainable, and long-term manner. The relationship of this theory to sustainable financing in Islamic banks demonstrates that financing decisions are not solely based on profitability and asset security, but must also consider their impact on social welfare, environmental sustainability, economic inclusion, and sustainable development. Sustainable financing in Islamic banks represents a form of institutional responsibility that aligns with Islamic principles, as the allocation of funds is directed toward business activities that do not harm the community, do not damage the environment, and provide broader benefits to stakeholders (R. Kumar et al., 2026). The stronger the orientation of Islamic banks in accommodating the interests of stakeholders through ethical, productive, and sustainable financing, the stronger the relevance of Stakeholder Theory in explaining the role of Islamic banks as financial institutions that are

not only business-oriented, but also oriented towards values, responsibility, and social benefits (Habib et al., 2025).

1.3. Sustainable Financing

Sustainable financing in Islamic banks is defined as the distribution of funds that integrates economic feasibility, social benefits, and environmental responsibility within the framework of Islamic principles, so that financing decisions are not only aimed at generating profits, but also at creating long-term value that is fair, responsible, and oriented towards the welfare of the community. The literature shows that this concept stems from the substantive alignment between Islamic principles and the sustainability agenda, particularly in the aspects of justice, balance, business ethics, social responsibility, and the prohibition of activities that are detrimental to the environment (Filippini et al., 2026).

Recent research developments show that sustainable financing in Islamic banks is increasingly understood not merely as compliance with regulations or expanding a green portfolio, but as an institutional strategy to direct the allocation of funds to productive, inclusive, and environmentally friendly business sectors (Damane & Ho, 2026). The literature review also shows that existing research remains largely conceptual and in general evaluation, while more in-depth research into how Islamic banks translate sustainability into financing structures, sector priorities, and development impacts remains relatively limited. This situation confirms that sustainable financing in Islamic banks is a theoretically important and practically relevant concept in building financial intermediation that aligns with sustainable development goals (Zhong & Pu, 2026).

1.4. Sustainable Business

Sustainable business is defined as a business activity that builds, delivers, and maintains economic value while integrating social benefits and environmental responsibility into its objectives, processes, and value creation models, so that business success is no longer measured solely by profit, but also by its capacity to maintain resource sustainability, respond to stakeholder interests, and generate long-term value. The literature shows that this concept has evolved from an initial approach based on eco-efficiency, corporate social responsibility, and negative impact reduction, to a more advanced approach in the form of a sustainable business model that places sustainability at the core of business logic, innovation, and competitive advantage (Masanpally et al., 2026).

The main literature review confirms that the sustainable business model adopts a triple bottom line orientation, takes into account the interests of stakeholders more broadly, and drives a transformation in the way companies operate, rather than simply adding sustainability programs to existing business structures (Khodaei et al., 2026). Recent studies also show that

research on sustainable enterprise remains scattered, with a dominant focus on business model innovation, implementation challenges, drivers of transformation, and the role of technology and digitalization, so the need for a more holistic and integrated reading remains strong in the literature (Cui et al., 2026).

1.5. Sustainable Development Goals (SDGs)

Sustainable Development Goals(SDGs) is defined as a global development agenda adopted by the United Nations in 2015 through the 2030 Agenda for Sustainable Development, which contains 17 goals and 169 targets that are universal, integrated, and inseparable, and designed to balance the economic, social, and environmental dimensions within a long-term development transformation framework (Su et al., 2024). The literature shows that the SDGs are no longer understood merely as a list of normative targets, but rather as a development governance framework that demands policy integration, cross-sector coordination, and an understanding of the reciprocal relationships between objectives (Habib & Asif, 2025). Recent studies emphasize that the central issue in SDGs studies lies in how the principles of integration and indivisibility are translated into practice, as there is no established agreement on the best approach to interpreting interactions between goals. Research gaps remain evident in the weakness of policy innovation, limited integrated monitoring and evaluation, insufficient attention to interactions between actors, geographic spillovers, and a holistic systemic approach. This position positions the SDGs not only as a global development vision but also as an analytical tool that demands a more nuanced, cross-dimensional, and structurally interconnected reading of goals (Yu et al., 2026).

2. METHODS

The research method adopts a qualitative approach using literature studies to explore the role of sustainable financing of Islamic banks in realizing the achievement of the Sustainable Business Activity Category (KKUB) to support the Sustainable Development Goals (SDGs). This study adopts a descriptive-analytical strategy that aims to comprehensively understand the impact of sustainable financing of Islamic banks on the achievement of SDGs, with a primary focus on SDG 6 (clean water and adequate sanitation), SDG 7 (affordable and clean energy), SDG 8 (decent work and economic growth), SDG 9 (industry, innovation, and infrastructure), SDG 11 (sustainable cities and human settlements), SDG 12 (responsible consumption and production), SDG 13 (addressing climate change), SDG 15 (terrestrial ecosystems), and SDG 17 (partnerships to achieve the goals). In this context, the literature study focuses on collecting, evaluating, and analyzing data from various relevant academic sources, including books, journal articles, theses, and official reports related to sustainable financing in Islamic banks, particularly the annual report from Bank Syariah Indonesia (BSI) regarding the implementation and achievement of sustainable finance (Murdiyanto, 2020).

The analytical process of this research consists of three main stages. The first stage is the inventory and classification of library data, in which the researcher collects relevant literature related to sustainable financing and Islamic banks. The second stage involves document content analysis, which is an in-depth evaluation of the collected documents, both theoretical and practical, to identify key findings, trends, and the relationship between sustainable financing and the achievement of the SDGs. The third stage is the synthesis and formulation of conclusions, in which the findings from the document analysis are combined with relevant normative theories to produce a more holistic understanding of the role of sustainable financing in Islamic banks in supporting sustainable development goals (Abdussamad, 2021).

Table 2. Research Support Journal

No.	Journal Title	Research Contribution
1.	Islamic Law, Islamic Finance, and Sustainable Development Goals: A Systematic Literature Review (Harahap et al., 2023)	The findings contribute to the assertion that Islamic finance has structural relevance to achieving the Sustainable Development Goals (SDGs) through the alignment of maqasid al-shariah with social welfare, economic development, and environmental sustainability. This assertion strengthens the argument that sustainable financing by Islamic banks functions not only as financial intermediation but also as a strategic instrument for sustainable development. These findings also provide academic legitimacy for the analysis of the role of sustainable financing by Islamic banks in realizing the sustainable business activity category (KKUB).
2.	Does Islamic Sustainable Finance Support Sustainable Development Goals to Avert Financial Risk in the Management of Islamic Finance Products? A Critical Literature Review (Raimi et al., 2024)	This study's contribution to current research lies in strengthening the conceptual foundation that sustainability-oriented Islamic financing has a dual function: promoting the achievement of the SDGs and maintaining the quality of financial risk management. These findings are relevant to strengthening the analysis that sustainable financing in Islamic banks can be positioned as a financing mechanism that not only has economic value but also has measurable social and environmental implications. Furthermore, the identification of ISF instruments and mechanisms in this study helps current research explore the relationship between sustainable financing in Islamic banks and the category of sustainable business activities (KKUB).
3.	Islamic Finance and Sustainable Development Goals (SDG): A Bibliometric Review (Rusydiana, 2020)	This study's contribution to current research lies in providing an academic map of the direction, focus, and concentration of Islamic finance studies in relation to the SDGs. These findings support current research by demonstrating that the current discourse remains focused on general themes, such as social finance, sukuk, microfinance, financial inclusion, and sustainability, thus clarifying the position of research on sustainable financing of Islamic banks as a more specific field of study. Furthermore, the cluster and keyword mapping in this study helps confirm that the relationship between Islamic finance and the SDGs has been widely recognized in the literature, but has not been specifically directed at analyzing the realization of sustainable business activity categories (KKUB).

No.	Journal Title	Research Contribution
4.	Islamic Finance for Sustainable Development: A Mixed-Methods Systematic Review and Bibliometric Analysis of SDG Alignment (Harun & Rahmat, 2025)	The significance of this study for current research lies in providing a more structured synthesis of Islamic finance's contribution to the SDGs. Findings regarding the dominance of the environmental sustainability dimension, its link to financial inclusion, and the strengthening of green sukuk and fintech themes broaden the analytical basis for positioning sustainable financing in Islamic banks as a relevant instrument in supporting the sustainable development agenda. For current research, this study reinforces the need to shift the discussion from a general mapping of Islamic finance and SDGs to a more operational understanding of sustainable financing in Islamic banks within the framework of sustainable business activity categories (KKUB).
5.	Role of Islamic Sustainable Finance in Promoting Green Entrepreneurship and Sustainable Development Goals in Emerging Muslim Economies (Raimi, 2025)	This study's contribution to current research lies in providing a more concrete explanation of the sustainability-oriented Islamic financing mechanism that connects economic, social, and environmental dimensions. These findings support current research by demonstrating that Islamic financing is not only relevant at the normative level but also has financing instruments and channels that can be directed toward sustainable business activities. This study's emphasis on green projects, support for productive businesses, and impact-based financing reinforces the need to examine sustainable financing in Islamic banks more specifically within the framework of the sustainable business activity category (KKUB).
6.	Alignment of Islamic Banking Sustainability Indicators with Sustainable Development Goals: Policy Recommendations for Addressing the COVID-19 Pandemic (Jan et al., 2021)	This study's primary contribution to current research lies in providing an operational framework for breaking down the relationship between Islamic banking and the SDGs into more measurable indicators. These findings support current research by demonstrating that the link between Islamic banking/financing and the SDGs is not sufficiently addressed at the conceptual level but needs to be mapped into specific instruments, activities, and policy areas.
7.	Re-Thinking Sustainable Development within Islamic Worldviews: A Systematic Literature Review (Al-Jayyousi et al., 2022)	The contribution of these findings to current research lies in confirming that sustainable financing from Islamic banks serves as an instrument that can promote sustainable development based on moral and social values, in line with Islamic principles. This finding is highly relevant to current research, as it confirms that Sharia-based financing (such as green sukuk, Zakat, and Waqf) not only supports financial management but also facilitates the achievement of the SDGs, particularly in the social and environmental dimensions.
8.	Sustainable Development Goals and Islamic Social Finance: From Policy Divide to Policy Coherence and Convergence (Tok et al., 2022)	This contribution to the current research strengthens the argument that Islamic Social Finance can bridge the gap in financing the SDGs, particularly for marginalized communities such as refugees. This study supports the idea that Zakat and Waqf, through their unique Sharia-compliant mechanisms, can be mobilized as important tools for achieving the SDGs. These findings strengthen the theoretical framework for your research on the role of Islamic banks in realizing sustainable development goals.

No.	Journal Title	Research Contribution
9.	The Role of Using Islamic Finance to Boost Infrastructure Development for Sustainable Economic Growth (Taleb et al., 2023)	This study's contribution to current research lies in strengthening the argument that Islamic financing has a concrete operational path to supporting sustainable development through the real sector, particularly infrastructure. These findings support current research by demonstrating that the relationship between Islamic finance and the SDGs extends beyond principles and can be realized through financing instruments, partnership schemes, and measurable indicators of industrial development.
10.	Governance Indicators in Sustainable Banking: A Comprehensive Bibliometric Analysis for Enhanced Sustainability (Ozbek et al., 2025)	This study's contribution to current research lies in its confirmation that the governance dimension is a crucial analytical foundation for understanding sustainable banking financing. These findings support current research by demonstrating that sustainable financing cannot be understood solely from the perspective of the product or financing sector, but also requires an examination of the quality of governance, regulatory effectiveness, and the institutional framework that supports it.

This study uses the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology, which allows for a systematic and transparent evaluation of existing literature and a summary of findings relevant to the research topic. The search process began with a consultation of leading databases such as Google Scholar, JSTOR, ScienceDirect, and ProQuest, resulting in the identification of over 200 articles related to sustainable finance and Islamic banking. These articles were then screened based on the criteria of relevance, credibility, and timeliness, ultimately leaving 50 articles for further analysis. Of these 50 articles, 10 of the most relevant and high-quality articles were selected for in-depth analysis as a basis for exploring the role of sustainable finance in supporting the achievement of the SDGs (Fiantika, 2022).

3. RESULTS AND DISCUSSION

3.1. Result

The Role of Sustainable Financing by Islamic Banks in Realizing the Achievement of the Sustainable Business Activity Category (KKUB)

The role of sustainable financing of Islamic banks in realizing the achievement of the Sustainable Business Activity Category (KKUB) is important because it not only reflects the direction of financing allocation in environmentally, socially, and economically sustainable sectors, but also shows the extent to which sustainability commitments have been integrated into the Islamic banking intermediation strategy. From the perspective of Legitimacy Theory and Stakeholder Theory, the distribution of financing in each KKUB category can be read as a manifestation of the institutional response of Islamic banks to public demands, regulations, and development needs that increasingly emphasize the principles of social responsibility, environmental sustainability, and economic benefits. Therefore, a category-by-category

analysis is needed to identify the growth patterns, concentration, and inequality of sustainable financing, so that the discussion does not stop at the increase in aggregate nominal, but is able to more critically assess which sectors are truly a priority, which sectors are still limited, and how these findings contribute to strengthening the position of Islamic banks as financial institutions aligned with the sustainable development agenda.

Table 3. Realization of Sustainable Finance Implementation Achievements (Rp billion)

No.	Sustainable Business Activity Category (KKUB) (in billion Rupiah)	2021	2022	2023	2024
1.	Renewable energy	905.70	1,135.35	1,072	609
2.	Management of Biological Natural Resources and Sustainable Land Use	1,193.01	3,095.21	4,806	6,865
3.	Environmentally Friendly Transportation	19.50	34.65	47	317
4.	Sustainable Water and Wastewater Management	100.88	114.63	94	91
5.	Products that Reduce Resource Usage and Produce Less Pollution (Eco-Efficient)	3,744.12	4,497.89	5,807	5,813
6.	Environmentally Friendly Buildings that Meet Nationally, Regionally, or Internationally Recognized Standards or Certifications	225.17	190.12	163	134
7.	Business Activities and/or Other Activities from Other Environmentally Aware Business Activities	508.34	258.79	245	256
8.	Green Financing (KKUB)	6,696.72	9,326.65	12,235	14,084
9.	MSME activities	39,461.23	41,823.61	45,469	52,415
10.	ESG Financing/Sustainable Financing (KKUB)	46,157.95	51,150.26	57,704	66,499
11.	ESG Financing Ratio (KKUB) of Sustainable Financing to Total Financing	26.95%	24.70%	24.07%	23.88%

Source: Bank Syariah Indonesia's Sustainable Financial Performance Report

Based on the findings of the Bank Syariah Indonesia (BSI) Sustainable Finance Performance Report, Table 2 shows that the role of sustainable financing in Sharia Banks in achieving the Sustainable Business Activities Category (KKUB) is nominally expansive, but uneven across categories. In aggregate, green financing (KKUB) increased from IDR 6,696.72 billion in 2021 to IDR 14,084 billion in 2024, while ESG financing/sustainable financing increased from IDR 46,157.95 billion to IDR 66,499 billion. However, the ratio of ESG financing to total financing actually decreased from 26.95% to 23.88%. This indicates that although the value of sustainable financing continues to increase, the growth rate of total bank financing as a whole is still faster than the portion of sustainable financing itself. Thus, the role of

sustainable financing has strengthened in nominal terms, but has not yet fully strengthened in terms of structural proportion in the bank's financing portfolio.

Data on the realization of sustainable financing achievements in Islamic banks within the Sustainable Business Activity Category (KKUB) framework shows that sustainable financing expansion is indeed taking place, but its distribution structure still exhibits sectoral concentration and imbalances between categories. In aggregate, green financing increased from IDR 6,696.72 billion in 2021 to IDR 14,084 billion in 2024, while ESG financing/sustainable financing rose from IDR 46,157.95 billion to IDR 66,499 billion during the same period. However, the ratio of ESG financing to total financing actually decreased from 26.95% to 23.88%. This configuration indicates that sustainable financing is growing in absolute value, but has not experienced a commensurate strengthening in the overall financing portfolio structure. Therefore, the data should not be read as evidence of expansion, but rather as an indication that the institutionalization of sustainable financing in Islamic banks is still partial and has not yet completely shifted the structural orientation of conventional financing.

From the perspective of Legitimacy Theory, this pattern can be interpreted as an institutional response by Islamic banks to increasing social demands for ethical, responsible, and sustainable financial practices. This theory asserts that organizations maintain sustainability not only through economic efficiency but also through alignment with public values and expectations. The increase in the nominal amount of sustainable financing demonstrates that Islamic banks are striving to build and maintain social legitimacy by channeling financing to sectors recognized as having sustainable value. However, the decline in the ratio of ESG financing to total financing also indicates that this legitimacy has not yet fully translated into a more fundamental shift in financing orientation. This means that sustainable financing has become part of the institutional legitimacy strategy, but has not yet fully become the dominant logic within the bank's intermediation structure.

This reading aligns with the findings of Harahap et al. (2023), who asserted that Islamic finance has structural relevance to achieving the SDGs through the alignment of maqasid al-shariah with social welfare, economic development, and environmental sustainability. Similarly, Raimi et al. (2024) argues that sustainability-oriented Islamic financing not only fulfills economic functions but also supports socio-environmental goals and maintains high-quality risk management. However, the KKUB data in this study extends this literature by demonstrating that the normative relevance of Islamic sustainable finance does not automatically result in a balanced distribution of financing across sustainability categories. In other words, the relationship between Islamic finance and the SDGs, which in many studies remains conceptual, appears more operational in this data, while simultaneously revealing a gap between normative commitments and sectoral realization.

From a Stakeholder Theory perspective, the dominance of financing in the MSME category, which increased from IDR 39,461.23 billion in 2021 to IDR 52,415 billion in 2024, indicates that Islamic banks' sustainable financing orientation is stronger in the dimensions of economic inclusion and social benefit. Theoretically, this reflects the banks' efforts to balance the interests of various stakeholders, particularly small business groups, productive communities, and the real sector, which have a direct impact on economic equality. This finding is important because it demonstrates that the role of sustainable financing in Islamic banks is not solely synonymous with high-tech green projects but is also closely related to expanding access to financing for a broader range of economic actors. Within the framework of stakeholder theory, this pattern suggests that Islamic banks tend to interpret sustainability in socio-economic terms before considering it in more specific ecological terms.

This interpretation is supported by Tok et al. (2022), who emphasize that Islamic social finance can bridge the financing gap for sustainable development, especially for vulnerable and marginalized groups. Similarly, Al-Jayyousi et al. (2022) demonstrate that sustainable development within the Islamic worldview is indeed deeply rooted in moral, social, and public benefit values. Therefore, the dominance of MSMEs in the KKUB data is not merely a statistical anomaly, but rather a reflection that sustainable financing by Islamic banks is still strongly guided by the logic of social benefit inherent in the Islamic financial framework. However, these findings also demonstrate that the strength of the social dimension has not automatically been accompanied by an equally strong emphasis on the environmental dimension. Thus, the structure of sustainable financing by Islamic banks in practice still more closely resembles socially anchored sustainability finance than environmentally balanced sustainability finance.

At the environmental category level, data shows a concentration of financing in certain sectors and a decline in others. The categories of natural resource management and sustainable land use increased significantly, from IDR 1,193.01 billion to IDR 6,865 billion. The eco-efficient product category also increased from IDR 3,744.12 billion to IDR 5,813 billion. Furthermore, environmentally friendly transportation grew from IDR 19.50 billion to IDR 317 billion, despite a small initial base. Conversely, renewable energy declined from IDR 905.70 billion in 2021 to IDR 609 billion in 2024 after a brief increase in 2022. Sustainable water and wastewater management also declined from IDR 100.88 billion to IDR 91 billion, and environmentally friendly buildings declined from IDR 225.17 billion to IDR 134 billion. This pattern suggests that the expansion of green financing is not uniform, but rather driven by specific categories, particularly those that appear to be closer to the real productive sector and have more mature financing channels.

These findings expand the literature, which has largely emphasized the broad potential of Islamic finance to support the sustainability agenda. Harun and Rahmat (2025) note that

Islamic finance–SDGs studies increasingly emphasize the dimensions of environmental sustainability, financial inclusion, green sukuk, and financing innovation. Raimi (2025) also emphasizes the existence of more concrete mechanisms for linking Islamic financing with green entrepreneurship and sustainable development. However, the KKUB data in this study indicate that in banking practice, the deepening of environmental categories has not developed uniformly. In other words, while the literature correctly positions Islamic finance as a potential instrument for sustainability, this empirical data suggests that its potential is still being selectively realized. Therefore, this study provides an important insight: the primary problem lies not in the lack of a link between Islamic financing and sustainability, but rather in the operational disparities between green financing categories.

More specifically, the weak performance of the renewable energy, water and wastewater, and green buildings categories indicates that sectors often positioned globally as core to the sustainability transition have not yet become the backbone of Islamic banks' green portfolios in this data. In a literature review style, this is important because it highlights the gap between normative aspirations and actual financing preferences. A study by Jan et al. (2021) emphasized the importance of breaking down the relationship between Islamic banking and the SDGs into measurable and operational indicators. The KKUB data in this study confirms the urgency of this argument: without a category-by-category analysis, increasing total green financing can create the illusion of progress, obscuring the reality that some core sustainability sectors are underdeveloped. Therefore, categorical analysis is crucial so that sustainable financing does not stop at the aggregate level but can be assessed based on its depth, equity, and sectoral consistency.

Within a broader framework, this data can also be interpreted as evidence that sustainable financing by Islamic banks in Indonesia is moving from a symbolic-normative phase to an operational-selective phase. This is called symbolic-normative because the legitimacy of sustainability has been established through increasing nominal green financing and ESG financing. It is called operational-selective because its implementation still relies on sectors that are relatively safe, familiar, or closer to the bank's productive orientation, while categories requiring more complex technological, infrastructure, or policy framework development have not shown comparable strengthening. This view aligns with Ozbek et al. (2025), who position the governance dimension as a crucial foundation for sustainable banking. Therefore, the imbalance between categories in the KKUB data can also be interpreted as a reflection of the quality of governance, institutional readiness, and the bank's capacity to internalize sustainability more comprehensively.

From a scientific perspective, the significance of this research lies in its ability to shift the discussion from a conceptual to a categorical-operational level. Bibliometric studies such as those by Rusydiana (2020) have shown that the discourse on Islamic finance and the SDGs is

still dominated by general themes such as social finance, sukuk, microfinance, financial inclusion, and sustainability. This research deepens this discourse by demonstrating how these relationships operate in actual financing structures based on sustainable business categories. In other words, this research not only affirms that Islamic banks are relevant to the SDGs but also shows in which categories that relevance is strengthening, weakening, or not yet consolidated. This contribution makes KKUB-based analysis academically important: it offers a more granular, more critical reading, and is closer to the reality of implementation than the majority of studies, which still focus on general mapping.

Based on this overall synthesis, it can be asserted that the data findings support the literature stating that Islamic financing has substantive relevance to the sustainable development agenda, but simultaneously demonstrate that the realization of this role remains asymmetric. Theoretically, Legitimacy Theory explains why sustainable financing continues to increase nominally in response to social demands for ethical and responsible finance. Meanwhile, Stakeholder Theory explains why sustainable financing is more strongly concentrated in MSMEs and sectors that provide direct socio-economic benefits. However, the data also shows that the strengthening of the environmental dimension has not been evenly distributed across all KKUB categories. Thus, this study produces a more robust analytical proposition: that sustainable financing in Islamic banks has developed as an instrument of institutional legitimacy and fulfillment of stakeholder interests, but the deepening of its role in the green financing structure remains selective, unbalanced, and not yet fully institutionalized proportionally within the overall bank financing portfolio.

3.2. Discussion

Sustainable Financing of Islamic Banks in Support of the Sustainable Development Goals (SDGs)

Sustainable financing by Islamic banks in support of the Sustainable Development Goals (SDGs) needs to be understood not merely as an expansion of the financing portfolio in green and social sectors, but as a manifestation of the transformation of the intermediation function towards a more ethical, inclusive, and long-term-oriented financial system. In this context, the realization of financing in various Sustainable Business Activity Categories (KKUB) is an important indicator for assessing the extent to which sustainability commitments have been operationalized in Islamic banking practices. Reading KKUB data is also relevant because it allows for a more substantive analysis of the relationship between Islamic bank financing orientation, sustainable development demands, and alignment with the values of social legitimacy and responsibility to stakeholders that have been widely emphasized in the literature on sustainable Islamic finance.

The research findings indicate that sustainable financing by Islamic banks has generally provided tangible support for the SDGs agenda, particularly as the value of green financing increased from IDR 6,696.72 billion in 2021 to IDR 14,084 billion in 2024, while ESG financing increased from IDR 46,157.95 billion to IDR 66,499 billion. These findings confirm that Islamic banks no longer view sustainable financing as a peripheral instrument, but as part of a financing expansion that is increasingly visible in nominal terms. However, the decline in the ratio of ESG financing to total financing from 26.95% to 23.88% indicates that this growth has not yet fully shifted the structure of the financing portfolio proportionally. In other words, sustainability commitments are growing in absolute value, but have not yet been fully consolidated as the dominant orientation in overall bank financing.

In relation to the SDGs, the strongest support is seen for SDG 8 (decent work and economic growth) through MSME financing, which increased from IDR 39,461.23 billion in 2021 to IDR 52,415 billion in 2024. The dominance of this category indicates that sustainable financing by Islamic banks still relies heavily on the socio-economic dimension, particularly empowering the real sector, expanding access to financing, strengthening productive businesses, and driving more inclusive economic growth. This finding aligns with Stakeholder Theory, which positions organizations as entities that must balance the interests of stakeholders, including the community, small business owners, and productive economic groups requiring access to funding. From a literature perspective, this pattern is also consistent with previous research findings that confirm that Islamic finance has a strong contribution to social welfare, economic inclusion, and welfare-based development. Therefore, in the context of this research, the role of Islamic banks in supporting SDG 8 can be considered the most tangible, the largest in nominal terms, and the most consistent throughout the observation period.

In addition to the socio-economic dimension, very strong support is also seen for SDG 15 (terrestrial ecosystems) through the category of living natural resource management and sustainable land use, which increased sharply from IDR 1,193.01 billion in 2021 to IDR 6,865 billion in 2024. The consistent and progressive increase in this category indicates that Islamic banks are beginning to position natural resource management as a strategic area in sustainable financing. Conceptually, this finding strengthens the argument in the literature that Islamic finance has high compatibility with the sustainability agenda because it links economic value with ecological responsibility. Within the framework of Legitimacy Theory, financing in this sector can be understood as a response to public demands that financial institutions not only pursue profitability but also support resource management that maintains ecological balance. Thus, support for SDG 15 demonstrates that the sustainable financing role of Islamic banks has moved beyond its traditional intermediation function to a more ecological development function.

For SDG 9 (industry, innovation, and infrastructure) and SDG 12 (responsible consumption and production), the research results also show quite strong trends. This is reflected in the increase in financing for eco-efficient products from IDR 3,744.12 billion to IDR 5,813 billion, as well as the increase in environmentally friendly transportation from IDR 19.50 billion to IDR 317 billion. The eco-efficient category specifically indicates that sustainable financing for Islamic banks has been directed towards production activities that are more efficient in resource use and less polluting, thus supporting the industrial transformation towards more responsible processes. Meanwhile, the increase in environmentally friendly transportation shows a contribution to more sustainable mobility infrastructure. These findings support previous studies stating that Islamic sustainable finance does not stop at the normative level, but has operational channels to support innovation, strengthening the real sector, and financing impact-based business activities. Thus, sustainable financing for Islamic banks in this study can be interpreted as an instrument that supports industrial upgrading and ecological efficiency.

Support for SDG 13 (addressing climate change) is also evident in aggregate, primarily through increases in total green financing, eco-efficient financing, and growth in environmentally friendly transportation. However, the strength of this contribution is not entirely stable, as the renewable energy category, which should be a key pillar of climate action, actually decreased from IDR 905.70 billion in 2021 to IDR 609 billion in 2024, after a brief increase in 2022. This pattern indicates that support for the climate change agenda remains partial: there is expansion in some green sectors, but not yet accompanied by the same consistency in the clean energy sector. In a literature review style, this finding is important because it demonstrates the gap between the substantial potential of Islamic finance to support the green transition, as emphasized in previous research, and the fluctuating sectoral realization. Therefore, these results demonstrate that Islamic banks' contribution to SDG 13 has indeed been established, but the quality of its deepening still needs to be strengthened, particularly in sustainable low-carbon energy financing.

Similar conditions are also evident in SDG 6 (clean water and sanitation) and some aspects of SDG 11 (sustainable cities and human settlements). Financing for sustainable water and wastewater management increased from IDR 100.88 billion in 2021 to IDR 91 billion in 2024, while financing for environmentally friendly buildings decreased from IDR 225.17 billion to IDR 134 billion during the same period. Meanwhile, environmentally friendly transportation increased sharply. This indicates that support for sustainable urban development and basic environmental infrastructure remains uneven. Analytically, these data confirm that sustainable financing for Islamic banks remains stronger in categories directly linked to productive business sectors than in categories requiring support for basic utilities or long-term green infrastructure. This finding reinforces the argument that the aggregate increase in

sustainable financing should not be interpreted simplistically as equitable progress, as a per-category analysis reveals inequalities in financing orientation across SDG sectors.

In relation to SDG 7 (clean and affordable energy), the study results show that Islamic banks have entered the renewable energy sector, but the intensity of their support has not been sustained. The decline in renewable energy financing at the end of the observation period indicates that this sector has not yet become a major driver in green financing portfolios. In fact, previous literature positions green financing, green sukuk, and Islamic sustainable finance as highly potential instruments to support the energy transition. Therefore, the results of this study provide a more critical reading than the literature's optimism: the problem is not the lack of a connection between Islamic finance and clean energy, but rather the lack of strong institutional consistency in maintaining financing for this sector as a strategic priority. This means that Islamic banks are still at the stage of selective strengthening, not yet reaching the stage of full consolidation towards the energy transition agenda.

Meanwhile, SDG 17 (Partnerships to Achieve Goals) is not explicitly reflected in the data indicators, but can be implicitly interpreted through the increase in green financing and ESG financing, which essentially demonstrates the interconnectedness between banks, business actors, regulatory frameworks, and the sustainable development agenda. In this sense, Islamic banks function as intermediary nodes that enable sustainability goals to be translated into real-sector financing. Previous literature also emphasizes that Islamic finance's support for the SDGs requires an institutional framework, governance, and cross-actor collaboration. Therefore, although this research data does not allow for direct identification of partnership forms, the increase in sustainable financing portfolios can still be interpreted as an indication that Islamic banks are participating in the sustainable development partnership ecosystem.

Overall, the results of this study confirm that sustainable financing by Islamic banks has significantly contributed to the achievement of the SDGs, but this contribution is asymmetric across goals. The strongest support was found for SDGs 8 and 15, followed by fairly strong contributions to SDGs 9, 12, and 13. Conversely, support for SDGs 6, 7, and some dimensions of SDG 11 remains relatively limited or inconsistent. These findings demonstrate that sustainable financing by Islamic banks has developed as an instrument of institutional legitimacy and fulfillment of responsibilities to stakeholders, but its deepening contribution to the overall SDG agenda remains concentrated in certain sectors. Therefore, the main implication of this study is that strengthening the role of Islamic banks in sustainable development should not be measured solely by nominal increases in financing, but must also be viewed in terms of sectoral equity, consistency of priority categories, and the institution's ability to integrate sustainability more proportionally into its overall financing structure.

4. CONCLUSION AND RECOMMENDATION

4.1. Conclusion

Based on the research results, it can be concluded that sustainable financing by Islamic banks plays a significant role in realizing the Sustainable Business Activity Category (KKUB) to support the Sustainable Development Goals (SDGs). This is reflected in the increase in green financing from IDR 6,696.72 billion in 2021 to IDR 14,084 billion in 2024, as well as the increase in ESG financing, or sustainable financing, from IDR 46,157.95 billion to IDR 66,499 billion during the same period. However, the ratio of ESG financing to total financing decreased from 26.95% to 23.88%, indicating that the nominal growth in sustainable financing has not been fully accompanied by proportional strengthening in the bank's total financing structure. Substantively, the strongest contributions are seen in financing for MSMEs, as well as the management of biological natural resources and sustainable land use, which confirms the dominance of Islamic banks' support for SDGs 8 and 15. Fairly strong support is also evident for SDGs 9, 12, and 13 through financing for eco-efficient products, environmentally friendly transportation, and increasing aggregate green financing. Conversely, support for SDGs 6, 7, and 11 remains relatively limited and inconsistent, as financing for water and wastewater management, renewable energy, and environmentally friendly buildings tends to stagnate or decline.

This study confirms that sustainable financing of Islamic banks has developed positively as an intermediation instrument oriented towards social, economic, and environmental issues, but its realization is still selective, not evenly distributed across KKUB categories, and not yet fully institutionalized proportionally within the overall financing portfolio. From a literature review perspective, the role of sustainable financing of Islamic banks can be understood as a strategic instrument that conceptually and descriptively supports the sustainable development agenda, but its implementation still tends to be selective across KKUB categories and has not yet fully demonstrated balanced strengthening in the overall direction of financing.

4.2. Policy Recommendations

Based on the results of the qualitative review, strengthening the role of sustainable financing for Islamic banks in realizing the Sustainable Business Activity Category (KKUB) and supporting the Sustainable Development Goals (SDGs) requires coordinated policy interventions across stakeholders. Islamic banks need to rebalance their sustainable financing portfolios so that they are not concentrated in dominant categories, such as MSMEs, natural resource management and sustainable land use, and eco-efficient products, but also expanded to sectors that are still weak, especially renewable energy, water and wastewater management, and environmentally friendly buildings. At the same time, Islamic banks need to strengthen

innovation in financing instruments, ESG-based governance, and impact measurement systems so that sustainable financing not only increases nominally, but also becomes more equitable, targeted, and measurable in its contribution to the SDGs.

At a broader institutional level, regulators, including Bank Indonesia and relevant authorities, need to develop a more operational policy framework through sectoral targets, standardized sustainable financing indicators, and incentive mechanisms and periodic evaluations for Islamic banking. The government needs to strengthen the supporting ecosystem through fiscal policy, financing facilities, and integration of the national development agenda with the KKUB priorities, particularly in sectors that have strategic value for the green transition and inclusive development. Meanwhile, businesses need to increase their business readiness through improved governance, resource efficiency, and adherence to sustainability principles to become more eligible to absorb sustainable financing. Therefore, the effectiveness of sustainable financing in Islamic banks will be determined more by the synergy between internal banking capacity, regulatory support, public policy alignment, and the business sector's readiness to accelerate the achievement of the SDGs in a more proportional and sustainable manner.

4.3. Recommendations for Future Research

Further research needs to be designed with a broader scope and a more robust approach to deepen understanding of the role of sustainable financing by Islamic banks in supporting sustainable development. Given that this research is still limited to discussing sustainable business financing in the economic sector, future studies are recommended to expand the analysis to other relevant sectors to map the contribution of sustainable financing more comprehensively. Furthermore, because this study only focuses on state-owned Islamic banks in Indonesia, future research is important to develop a comparative perspective by examining state-owned Islamic banks in other countries, such as the United Arab Emirates, Qatar, Saudi Arabia, and Egypt, so that differences in policy orientation, institutional structure, and sustainable financing strategies can be identified in an international context. The limitation of this study, which only highlights SDGs 6, SDG 7, SDG 8, SDG 9, SDG 11, SDG 12, SDG 13, SDG 15, and SDG 17, also opens up space for further research to include other SDGs to provide a more comprehensive understanding of the link between sustainable financing and the global development agenda. Furthermore, because this study uses a qualitative approach based on literature review, it is recommended that future studies utilize secondary data and statistical analysis to test the effects of sustainable financing in the short and long term, thus producing findings that are not only descriptive-interpretive, but also more robust empirically and analytically.

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THE ROLE OF EXTRACURRICULAR TAHSIN MANAGEMENT IN ENHANCING STUDENTS' QUR'ANIC READING PROFICIENCY: EVIDENCE FROM STATE ISLAMIC ELEMENTARY SCHOOLS IN INDONESIA

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Abstract

The ability to read the Qur'an accurately and fluently is an essential competency for students in Islamic education. However, differences in students' reading abilities remain a challenge for many Islamic elementary schools. This study aims to analyze the role of extracurricular Tahsin management in enhancing students' Qur'anic reading proficiency at State Islamic Elementary Schools (*Madrasah Ibtidaiyah Negeri*) in Bandar Lampung, Indonesia. The study employed a qualitative approach with a multi-site case study design. Data were collected through semi-structured interviews, observations, and document analysis involving school principals, Tahsin coordinators, instructors, and students. Data were analyzed using the interactive model of Miles, Huberman, and Saldaña, including data condensation, data display, and conclusion drawing. The findings reveal that the success of the Tahsin program is supported by effective planning, organizing, implementation, and evaluation processes. Student participation increased significantly over the two-year implementation period. At MIN 4 Bandar Lampung, participation increased from 64 to 104 students, while at MIN 2 Bandar Lampung, participation increased from 100 to 150 students. In addition, each school recorded ten students who successfully completed *Iqro'* level 6 and progressed to direct Qur'anic reading. These findings indicate that well-managed extracurricular Tahsin programs contribute positively to improving students' Qur'anic reading proficiency and strengthening Qur'anic literacy in Islamic elementary education. The study highlights the importance of educational management in ensuring the effectiveness and sustainability of Qur'anic literacy programs.

Keywords: Extracurricular Tahsin, Educational Management, Qur'anic Literacy, Qur'anic Reading Proficiency, Islamic Elementary School

INTRODUCTION

The ability to read the Qur'an accurately and fluently is a fundamental objective of Islamic education. Qur'anic literacy not only supports the performance of religious obligations but also contributes to the development of students' religious understanding, moral character, and spiritual awareness (Abdullah, 2021). Consequently, improving students' Qur'anic reading proficiency has become an important concern for Islamic educational institutions, particularly at the elementary level where foundational religious competencies are established.

In Indonesia, efforts to strengthen Qur'anic literacy have received increasing attention within Islamic education. Madrasah are expected to ensure that students acquire adequate skills in reading the Qur'an according to the principles of *tajwid* and proper pronunciation (*makharij al-huruf*) (Ministry of Religious Affairs, 2023). Despite these expectations, several studies have reported that a considerable number of students still encounter difficulties in applying tajwid rules, articulating Arabic letters correctly, and achieving fluency in Qur'anic recitation (Rahman & Yusuf, 2022; Fauzi et al., 2023). This condition indicates a gap between the expected standards of Qur'anic literacy and students' actual reading competencies.

To address these challenges, many Islamic elementary schools have developed extracurricular tahsin programs as a complementary learning strategy. These programs provide additional opportunities for students to improve their Qur'anic recitation through structured guidance, intensive practice, and continuous supervision (Anwar, 2022). Previous studies have demonstrated that tahsin programs can significantly improve students' reading accuracy, fluency, and mastery of tajwid when implemented consistently (Karim & Hidayat, 2023).

However, the effectiveness of extracurricular tahsin programs cannot be attributed solely to instructional methods. Educational management scholars argue that successful educational programs require effective planning, organizing, implementation, and evaluation processes to achieve their intended objectives (Terry, 2015; Bush, 2020). In this regard, management serves as a strategic instrument that ensures educational activities are conducted systematically, resources are utilized efficiently, and program outcomes are continuously improved.

Initial observations in State Islamic Elementary Schools (*Madrasah Ibtidaiyah Negeri*) in Bandar Lampung revealed considerable variation in students' Qur'anic reading proficiency. While some students demonstrated satisfactory recitation skills, others continued to experience difficulties related to pronunciation, tajwid application, and reading fluency. These findings suggest that the implementation of tahsin programs has not yet produced optimal outcomes for all students and highlight the importance of examining the managerial aspects of program implementation.

Although numerous studies have explored Qur'anic teaching methods and learning outcomes, limited research has investigated extracurricular tahsin programs from the perspective of educational management. Most existing studies emphasize pedagogical approaches, whereas the role of management functions in supporting program effectiveness remains underexplored (Huda, 2024). This limitation represents an important gap in the field of Islamic Educational Management and calls for a more comprehensive understanding of how management practices contribute to improving students' Qur'anic reading proficiency.

Therefore, this study examines the management of extracurricular tahsin programs in State Islamic Elementary Schools in Bandar Lampung, Indonesia. Specifically, it investigates how planning, organizing, implementation, and evaluation are carried out within the program and how these management functions contribute to optimizing students' Qur'anic reading proficiency. The study is expected to provide both theoretical contributions to Islamic Educational Management and practical recommendations for strengthening Qur'anic literacy programs in madrasah.

1. METHODS

This study employed a qualitative approach with a multi-site case study design to examine the management of extracurricular tahsin programs in enhancing students' Qur'anic reading proficiency at State Islamic Elementary Schools (*Madrasah Ibtidaiyah Negeri*) in Bandar Lampung, Indonesia. The qualitative approach was selected because it enables an in-depth exploration of educational management practices within their natural settings and facilitates a comprehensive understanding of participants' experiences and perspectives (Creswell & Poth, 2018; Brown, 2024).

Data were collected through semi-structured interviews, participant observations, and document analysis involving school principals, tahsin coordinators, Qur'anic instructors, and students. The collected data were analyzed using the interactive model of data condensation, data display, and conclusion drawing proposed by Miles, Huberman, and Saldaña (2019). To ensure data trustworthiness, source triangulation, method triangulation, and member checking were applied throughout the research process (Sasnal et al., 2024). The multi-site design enabled cross-case analysis to identify common patterns and effective management practices in the implementation of extracurricular tahsin programs.

2. RESULTS AND DISCUSSION

2.1. Planning of the Tahsin Extracurricular Program

The findings revealed that the planning stage was conducted systematically by the participating madrasah before the implementation of the extracurricular tahsin program. Planning activities included determining learning objectives, identifying students' initial

Qur'anic reading abilities, preparing learning schedules, and establishing achievement targets. The primary objective of the program was to improve students' Qur'anic reading proficiency, particularly in the areas of pronunciation (*makharij al-huruf*), fluency, and the application of *tajwid* rules.

Based on interview data, school administrators and tahsin coordinators emphasized the importance of setting measurable learning targets to ensure that students could progress gradually according to their reading abilities. This finding indicates that planning serves as the foundation for effective program implementation. According to Bush (2020), educational planning enables institutions to allocate resources efficiently and establish clear directions for achieving educational goals.

2.2. Organizing of the Tahsin Extracurricular Program

The organizing process involved assigning instructors, grouping students according to their reading levels, and coordinating learning activities. Students were generally classified based on their ability to read the Qur'an, ranging from beginner-level learners using the *Iqro'* method to students who had already progressed to direct Qur'anic reading.

The grouping system enabled instructors to provide more focused guidance according to students' individual needs. Furthermore, coordination among school leaders, program coordinators, and instructors facilitated the smooth implementation of learning activities. These findings support Terry's (2015) view that organizing is essential for ensuring that human and material resources are effectively utilized to achieve organizational objectives.

2.3. Implementation of the Tahsin Extracurricular Program

The implementation stage was carried out through regular and structured learning sessions. Students participated in guided recitation activities focusing on letter recognition, pronunciation accuracy, tajwid application, and reading fluency. Observational data indicated that instructors consistently monitored students' progress and provided corrective feedback during learning sessions.

An important finding of this study is the increase in student participation during the two-year implementation period. At MIN 4 Bandar Lampung, the number of students participating in the tahsin program increased from 64 students in the first year to 104 students in the second year. Similarly, participation at MIN 2 Bandar Lampung increased from 100 students to 150 students during the same period.

This increase suggests that the program has gained positive acceptance among students and parents. The growing number of participants reflects increased awareness of the importance of Qur'anic literacy and demonstrates the ability of the program to attract sustained student

engagement. These findings are consistent with Alnashr (2022), who argued that structured Qur'anic literacy programs can strengthen students' motivation and participation in religious learning activities.

2.4. Evaluation and Students' Qur'anic Reading Achievement

Evaluation was conducted periodically to assess students' learning progress and determine the effectiveness of the program. Assessment focused on reading accuracy, fluency, pronunciation, and mastery of tajwid rules. The evaluation process also served as a basis for determining students' progression to higher learning levels.

Document analysis showed that both madrasah achieved notable learning outcomes. At MIN 4 Bandar Lampung, ten students successfully completed *Iqro'* level 6 and progressed to direct Qur'anic reading. Similar results were observed at MIN 2 Bandar Lampung, where ten students also completed *Iqro'* level 6 and advanced to reading the Qur'an.

Although the number represents only a portion of total participants, the achievement demonstrates measurable progress in students' Qur'anic literacy development. The transition from *Iqro'* to Qur'anic reading indicates that students have mastered fundamental reading competencies and are ready to engage with the Qur'an more independently.

Table 1. Student Participation and Learning Achievement in Tahsin Extracurricular Programs

Madrasah	Year 1	Year 2	Increase	Students Completing Iqro' 6
MIN 4 Bandar Lampung	64	104	40	10
MIN 2 Bandar Lampung	100	150	50	10

Source: Research documentation collected from MIN 2 Bandar Lampung and MIN 4 Bandar Lampung (2025).

Note: The table shows the growth in student participation in extracurricular tahsin programs over a two-year period and the number of students who successfully completed Iqro' level 6 and progressed to direct Qur'anic reading.

2.5. Discussion

The findings demonstrate that effective management contributes significantly to the success of extracurricular tahsin programs. The integration of planning, organizing, implementation, and evaluation functions created a structured learning environment that supported students' Qur'anic literacy development.

The increase in student participation at both madrasah indicates that well-managed programs can enhance students' interest in religious learning activities. Furthermore, the successful progression of students from *Iqro'* level 6 to direct Qur'anic reading illustrates that the

program has achieved its primary educational objective. These findings support previous studies highlighting the importance of educational management in improving program effectiveness and learning outcomes (Bush, 2020; Maziliana et al., 2025).

From the perspective of Islamic Educational Management, the study suggests that extracurricular tahsin programs should not be viewed merely as supplementary activities. Instead, they function as strategic instruments for strengthening Qur'anic literacy and supporting the religious development of students. The findings further indicate that sustainable program implementation, continuous evaluation, and effective resource management are essential factors in achieving long-term educational outcomes.

Overall, the study confirms that extracurricular tahsin management plays a significant role in enhancing students' Qur'anic reading proficiency. The positive growth in participation and learning achievement demonstrates that systematic management practices can contribute to the development of effective Qur'anic literacy programs in Islamic elementary schools.

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NEGOTIATING QIWĀMAH IN CONTEMPORARY MUSLIM FAMILIES

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Abstract

This study examines the negotiation of qiwāmah within contemporary Muslim families, with a particular focus on socioeconomically privileged Muslim women participating in majelis taʿlīm in Lampung, Indonesia. While classical Islamic jurisprudence conceptualizes qiwāmah as a form of male authority grounded in economic responsibility and gender hierarchy, this study argues that its contemporary enactment is more fluid and relational. Employing a qualitative research design, data were collected through in-depth interviews, participant observation, and document analysis across three majelis taʿlīm.

The findings reveal that qiwāmah is no longer practiced as a fixed structure of unilateral authority, but as a negotiated relational responsibility shaped by deliberation, flexible role distribution, and situational authority. Decision-making processes are predominantly dialogical, domestic roles are increasingly shared, and authority is exercised based on capacity and involvement rather than formal status alone. These patterns indicate a shift from a normative-hierarchical model toward a relational-functional configuration of family relations.

Analytically, the study engages the frameworks of mubādalah and maqāṣid al-sharīʿa to interpret these transformations, highlighting the centrality of reciprocity, justice, and welfare in the rearticulation of marital relations. It argues that the reinterpretation of qiwāmah should not be understood as a deviation from Islamic norms, but as an effort to actualize their substantive ethical foundations in changing social contexts.

By foregrounding the lived experiences of Muslim families, this study contributes to the field of Islamic family law by proposing the concept of relational qiwāmah as an alternative analytical framework. This concept captures how authority and responsibility are dynamically negotiated, offering a more context-sensitive understanding of Islamic normativity that bridges the gap between doctrinal formulations and social practice.

Keywords: Qiwāmah, Relational Justice, Mubādalah, Contemporary Muslim Family

Abstrak

Penelitian ini menganalisis negosiasi qiwāmah dalam keluarga Muslim kontemporer dengan menempatkan perempuan Muslim elit sebagai subjek analisis, khususnya yang terlibat dalam majelis taʿlīm di Provinsi Lampung, Indonesia. Dalam konstruksi fikih klasik, qiwāmah diposisikan sebagai otoritas laki-laki yang dilegitimasi melalui tanggung jawab ekonomi dan diferensiasi gender, yang kemudian membentuk relasi keluarga yang bersifat komplementer sekaligus hierarkis. Artikel ini berargumen bahwa dalam praktik kontemporer, qiwāmah tidak lagi beroperasi sebagai struktur otoritas yang stabil, melainkan sebagai konstruksi normatif yang mengalami rekontekstualisasi melalui praktik relasional sehari-hari. Penelitian ini menggunakan pendekatan kualitatif dengan teknik wawancara mendalam, observasi partisipatif, dan analisis dokumen pada tiga majelis taʿlīm.

Temuan penelitian menunjukkan bahwa qiwāmah tidak dijalankan sebagai otoritas unilateral, tetapi sebagai tanggung jawab relasional yang dinegosiasikan melalui musyawarah, fleksibilitas pembagian peran, dan distribusi otoritas yang bersifat situasional. Pengambilan keputusan dalam keluarga berlangsung secara dialogis, peran domestik mengalami redistribusi, dan legitimasi otoritas tidak lagi bertumpu pada status formal semata, melainkan pada kapasitas dan keterlibatan dalam praktik kehidupan keluarga. Pola ini merefleksikan pergeseran dari model normatif-hierarkis menuju konfigurasi relasional-fungsional yang lebih adaptif terhadap dinamika sosial.

Secara analitis, penelitian ini mengintegrasikan perspektif mubādalah dan maqāṣid al-syarīʿah untuk menjelaskan transformasi tersebut. Prinsip kesalingan dalam mubādalah menegaskan bahwa relasi suami–istri bersifat resiprokal dan non-subordinatif, sementara pendekatan maqāṣid menempatkan keadilan dan kemaslahatan sebagai orientasi utama dalam memahami norma. Dengan demikian, reinterpretasi qiwāmah tidak dipahami sebagai deviasi dari kerangka normatif Islam, melainkan sebagai aktualisasi nilai-nilai substantif syariat dalam konteks sosial yang terus berubah.

Penelitian ini berkontribusi pada pengembangan hukum keluarga Islam dengan menawarkan konsep qiwāmah relasional sebagai kerangka analitis alternatif. Konsep ini menegaskan bahwa otoritas dan tanggung jawab dalam keluarga tidak bersifat statis, melainkan dibentuk melalui proses negosiasi yang kontekstual dan intersubjektif. Dengan demikian, artikel ini memperluas pemahaman tentang bagaimana norma Islam dioperasionalkan dalam praktik, sekaligus menjembatani kesenjangan antara formulasi doktrinal dan realitas sosial dalam keluarga Muslim kontemporer.

Kata Kunci: Qiwāmah, Keadilan Relasional, Mubādalah, Keluarga Muslim Kontemporer

PENDAHULUAN

Islam has historically operated as a normative framework structuring the allocation of authority and responsibility between spouses within the family. In classical fiqh, qiwāmah was constructed as a legally and morally sanctioned form of male authority, grounded primarily in the obligation of economic maintenance (al-infāq) and supported by assumptions of gendered differentiation. This doctrinal formulation produced a model of marital relations that was at once complementary and hierarchical. Importantly, such a construction did not remain confined to juristic discourse but became embedded in modern state law, including Indonesia's Marriage Law No. 1 of 1974 and the Compilation of Islamic Law (KHI), thereby transforming a juristic concept into a regulatory principle within positive legal systems.

Yet, as a growing body of scholarship has shown, the normative stability of qiwāmah has been increasingly unsettled in contemporary Muslim contexts. Rather than functioning as a fixed doctrinal category, it has become a site of contestation shaped by broader socio-economic transformations and shifting gender relations (Ali 2010; Mir-Hosseini 2019; 2020). In Indonesia, for instance, the legal codification of qiwāmah through the designation of the husband as head of the household and the wife as domestic manager reflects not merely a division of labor but an epistemic commitment to hierarchical ordering within the family. However, this normative structure is increasingly at odds with lived realities.

Empirical developments point to significant reconfigurations of Muslim family life. Expanding access to education for women, their increasing participation in the labor market, and their substantial economic contributions have facilitated the emergence of dual-earner households that destabilize conventional gendered role distinctions (Nuroniyah 2022). Within such contexts, decision-making processes are less frequently unilateral and instead tend to emerge through negotiation, deliberation, and mutual adjustment between spouses. These shifts call into question the continued viability of a strictly hierarchical model of marital authority.

This disjuncture may be analytically framed as a tension between das sollen (normative prescriptions) and das sein (social realities). While the former remains anchored in a hierarchical legal imagination, the latter increasingly reflects relational, cooperative, and negotiated forms of authority. The resulting gap not only generates normative dissonance but also destabilizes the legitimacy of authority within the family. Under such conditions, qiwāmah risks becoming a formal legal construct devoid of substantive regulatory force. Moreover, the persistence of misaligned norms may contribute to unequal distributions of responsibility, role ambiguity, and intra-familial conflict rooted in competing claims to authority (Wadud 1999; Auda 2018; Ali 2022).

From a socio-legal perspective, the central question is therefore not whether qiwāmah ought to be retained or rejected, but how it may be rearticulated in ways that preserve its normative coherence while responding to evolving social conditions. This requires moving beyond a binary opposition between hierarchy and equality toward a more nuanced conceptualization that foregrounds relationality, negotiation, and contextual responsiveness. The absence of such a framework has contributed to the persistence of what may be described as normative formalism in Islamic family law—where legal categories remain intact despite their diminishing correspondence with social practice (Mir-Hosseini 2020; Auda 2021).

At the level of everyday practice, particularly among socioeconomically privileged Muslim women, qiwāmah appears less as a fixed structure than as a relational process subject to ongoing negotiation. Within majelis ta'lim networks, women occupy not only religious roles but also positions of economic and social influence. In such settings, authority within the family is neither singular nor predetermined; rather, it is co-constructed through interaction, encompassing domains such as financial management, decision-making, and the distribution of domestic responsibilities. This suggests that qiwāmah, as lived practice, is better understood as a dynamic relational arrangement rather than a static normative prescription.

Recent scholarship reinforces this shift in perspective. Aisyah and Hidayah (2023) demonstrate that the legitimacy of family leadership is increasingly tied to competence and responsibility rather than gender alone. Similarly, Nuroniyah (2022) shows that women who assume the role of household heads do not merely compensate for economic absence but actively participate in decision-making processes. Meanwhile, Kodir's (2019; 2021) articulation of the mubādalah approach advances a hermeneutics of reciprocity, emphasizing that rights and obligations within marriage are mutually constituted and cannot be asymmetrically assigned.

Within broader theoretical debates, Wadud (1999; 2021) critiques essentialist readings of gender hierarchy in scriptural interpretation, while Ali (2010; 2022) underscores the historical contingency of Islamic legal doctrines. Mir-Hosseini (2019; 2020) highlights the ways in which modern legal codifications reproduce patriarchal assumptions, whereas Auda (2018; 2021), through a maqāṣid-oriented framework, advocates for a reorientation of Islamic law toward justice and human welfare. Taken together, these perspectives position qiwāmah not as a fixed doctrinal category but as a contested and evolving concept situated at the intersection of text, interpretation, and social practice.

Building on this analytical landscape, the present study seeks to examine how qiwāmah is negotiated within contemporary Muslim families, with particular attention to socioeconomically elite women, and to explore how relational justice and spousal authority are constituted in everyday life. In doing so, it advances the concept of relational qiwāmah as

an alternative paradigm, one that reconceptualizes family leadership in terms of shared responsibility, negotiated authority, and reciprocal engagement, thereby offering a more contextually grounded and normatively responsive framework for Islamic family law.

1. METHODS

This study employs a qualitative research design to examine the negotiation of qiwāmah within contemporary Muslim families, with particular attention to the dynamics of spousal authority and relational justice among socioeconomically privileged Muslim women. The research was conducted in three majelis taʿlīm in Lampung Province: Majelis Taklim Al-Karim Rasyid and Majelis Taklim Al-Ikhlas Babussalam in Bandar Lampung, and Majelis Taklim Baitul Mukhlishin in West Lampung. These sites were selected due to their function as active socio-religious spaces in which religious knowledge is produced, circulated, and internalized, particularly in relation to family norms and gender relations.

Primary data were generated through in-depth, semi-structured interviews with participants, organizers, and female religious instructors (ustādhāt) who possess direct experience in family life and sustained engagement in majelis taʿlīm activities. Informants were purposively selected based on the relevance of their lived experiences in interpreting and enacting qiwāmah in everyday contexts. The interviews explored how participants understand qiwāmah, negotiate roles and responsibilities, and make decisions within the household.

In addition, participant observation was conducted during study sessions across the three majelis to capture how discourses on marital relations are articulated, transmitted, and received. This was complemented by documentary analysis of teaching materials, study notes, and other textual resources used within the majelis, allowing for an examination of the discursive construction of family relations.

Data were analyzed thematically through an iterative process of coding and categorization, integrating interview, observational, and documentary materials. Analytical attention was directed toward patterns of qiwāmah negotiation, configurations of authority, and the distribution of familial responsibilities. Emerging relational patterns were classified into ideal-typical categories, normative-hierarchical, consultative, and relational-cooperative, to identify shifting forms of relational justice.

The analysis is interpretive in nature, situating empirical findings within broader theoretical frameworks, including qiwāmah, mubādalah, and maqāṣid al-sharīʿa. To enhance validity, the study employs methodological triangulation by cross-referencing data from multiple sources and methods. This approach enables a more robust and contextually grounded understanding of how marital authority and relational ethics are constructed and negotiated in contemporary Muslim family life.

2. FINDINGS

The findings of this study reveal that the meaning and practice of qiwāmah among socioeconomically privileged Muslim women across the three majelis taʿlīm in Lampung Province are far from monolithic. Rather than functioning as a fixed and uniformly applied doctrinal principle, qiwāmah emerges as a negotiated construct, shaped through everyday familial interactions and embedded within broader socio-economic and religious contexts. While, at the level of normative discourse, informants consistently acknowledge the husband's position as head of the household, such recognition does not automatically translate into unilateral or absolute authority in practice.

Instead, family decision-making is predominantly characterized by open communication, deliberation, and mutual consultation between spouses. As one informant explained, family decisions are "usually discussed together, rather than being determined by one party alone" (Interview with I-02, university lecturer, Majelis Taklim Al-Karim Rasyid, 20 February 2026). Similar patterns were observed among participants from the other two majelis, suggesting a consistent tendency toward dialogical relational practices across different research sites. These findings indicate that, at the empirical level, qiwāmah operates less as a rigid structure of authority and more as a normative framework that is continuously interpreted and renegotiated in response to lived realities.

The study further identifies a significant shift in how rights and obligations between spouses are conceptualized. Informants no longer interpret marital roles through a rigid dichotomy, as commonly reflected in classical normative constructions, but instead recalibrate them in accordance with their socio-economic conditions, professional engagements, and personal experiences. Women who are actively engaged in public life, whether in economic, professional, or socio-religious spheres, tend to position themselves as agents with substantial contributions to the family unit. This is reflected in one informant's statement: "in practice, I also play a major role in the family, so it cannot be understood in rigid terms" (Interview with I-08, university lecturer, Majelis Taklim Al-Ikhlas Babussalam, 18 February 2026).

Such narratives point to a reconfiguration of marital obligations from a fixed division of roles toward a more fluid and contribution-based arrangement. Rights and responsibilities are thus no longer perceived as predetermined or inherently gendered, but as contingent upon context, capacity, and negotiated agreement. This shift reflects a broader transformation in the moral economy of the family, where legitimacy is increasingly derived from participation and responsibility rather than formal status alone.

In the domain of domestic practice, the data demonstrate a notable degree of flexibility in the division of labor between spouses. Although many informants rely on domestic assistants, they continue to exercise managerial authority over household organization, including child-

rearing and the coordination of family needs. At the same time, husbands' involvement in domestic tasks, while not always routine, is nonetheless present and socially recognized. As one participant noted, "in certain situations, my husband also helps with household chores or takes care of the children" (Interview with I-04, entrepreneur, Majelis Taklim Al-Karim Rasyid, 20 February 2026).

This pattern suggests that domestic responsibilities are no longer strictly governed by rigid gender differentiation but are instead distributed through pragmatic and cooperative arrangements. The presence of such flexibility signals a gradual redefinition of domestic roles, in which traditional expectations are neither entirely abandoned nor strictly enforced, but selectively adapted to contemporary circumstances.

With regard to decision-making authority, the study finds that power within the family is situational and relational rather than centralized and fixed. In certain domains, particularly those related to the management of everyday domestic life, wives may assume a more dominant role. As one informant articulated, "in some matters, I take the lead because I better understand the family's situation" (Interview with I-10, school teacher, Majelis Taklim Baitul Mukhlishin, 15 April 2025). Importantly, such forms of dominance are not perceived as a challenge to the husband's authority, but rather as a functional outcome of differentiated expertise and involvement in daily practices.

This finding underscores that authority within the family is not a static attribute attached to a particular individual, but a dynamic process produced through ongoing interaction, negotiation, and experiential knowledge. Authority, in this sense, becomes relationally constituted—distributed across domains and contingent upon context rather than uniformly vested in a single actor.

Taken together, these findings point to a broader transformation from a normatively hierarchical model of marital relations toward a more flexible, dialogical, and negotiation-based relational pattern. While qiwāmah continues to be recognized as a normative principle within Muslim family structures, its practical enactment involves reinterpretation and adaptation that allow for greater participation and agency on the part of wives. Consequently, spousal relations in this context are no longer determined solely by formalized structures of authority but are shaped by participatory processes, contextual considerations, and evolving expectations of relational justice.

To synthesize these patterns, the key tendencies identified in this study are summarized in the following table:

Table 1. Synthesis of Qiwāmah Negotiation in Contemporary Muslim Families

Analytical Dimension	**Empirical Findings**	**Relational Pattern**
Qiwāmah	Interpreted as responsibility rather than absolute authority	Dialogical
Rights and Obligations	Contextual and contribution-based	Relational
Decision-Making	Conducted through deliberation and situational negotiation	Consultative
Domestic Roles	Non-exclusive and increasingly shared	Cooperative
Authority	Non-fixed and dependent on practical context	Situational

The table above illustrates a consistent pattern across all examined dimensions of family relations: a discernible shift from rigid normative structures toward more flexible, negotiated relational configurations. Rather than reflecting isolated variations, these patterns collectively indicate a broader transformation in how marital relations are organized, understood, and enacted in contemporary Muslim contexts.

In particular, qiwāmah is no longer operationalized as a form of absolute or unilateral authority. Instead, it is reinterpreted as a normative principle that is mediated through everyday interaction and shaped by the practical realities of family life. This rearticulation situates qiwāmah within a dialogical and participatory framework, in which authority is neither assumed nor imposed, but continuously produced through communication, mutual recognition, and shared responsibility.

The relational patterns identified, dialogical, relational, consultative, cooperative, and situational, suggest that authority and responsibility within the family are increasingly distributed rather than centralized. Such distribution does not necessarily negate the normative framework of qiwāmah, but rather transforms its mode of operation. Authority becomes contingent, context-sensitive, and embedded in practice, while legitimacy is derived less from formal designation and more from participation, competence, and contribution.

From a socio-legal perspective, these findings highlight the emergence of what may be termed a "negotiated normativity," in which legal-religious concepts are neither wholly abandoned nor rigidly enforced, but are actively reinterpreted in light of changing social conditions. In this sense, qiwāmah persists not as a static doctrinal category, but as a dynamic and evolving principle that accommodates relational complexity within contemporary Muslim families.

This shift has important implications for the study of Islamic family law. It suggests that the gap between normative frameworks and social practice is not merely a site of tension, but also a space of transformation, where new forms of relational justice and authority are being

articulated. Consequently, understanding qiwāmah today requires moving beyond textual or formal legal analysis toward an engagement with lived realities, where meaning is continuously negotiated and redefined.

3. DISCUSSION

3.1. Negotiating Qiwāmah in Contemporary Muslim Families

The findings of this study reveal that qiwāmah in contemporary Muslim families cannot be adequately reduced to a fixed or deterministic structure of authority, as commonly implied in classical juridical formulations. Instead, it emerges as a normative construct that is continuously reworked through everyday relational practices. Empirical accounts from informants consistently point to deliberation and shared decision-making as the dominant mode of organizing family life, as reflected in the statement that "decisions are usually discussed together, rather than determined by one party alone" (Interview with I-02). This pattern suggests that the operative meaning of qiwāmah is not located in formal designation, but in how authority is enacted and negotiated in practice. In this regard, the study departs from readings that treat qiwāmah as inherently hierarchical and instead situates it within a dynamic field of relational interaction.

While informants continue to affirm the husband's position as head of the household, this affirmation appears to function more as a symbolic reference point than as a directive structure of power. The persistence of this symbolic layer reflects the durability of fiqh-based normativity and its institutional embedding within modern legal systems. However, what is particularly notable is the extent to which this symbolic hierarchy coexists with practices that are fundamentally dialogical. Rather than indicating contradiction, this coexistence points to a subtle but important reconfiguration: hierarchy is retained at the level of discourse, while relationality governs the level of practice. This suggests that contemporary Muslim families are not merely reproducing inherited norms, but actively recalibrating them in response to lived realities.

The centrality of musyawarah in the empirical data marks a shift in how authority is distributed and exercised within the family. Decision-making processes are no longer anchored in unilateral prerogative, but unfold through negotiation and mutual recognition. In this context, Kodir's formulation of mubādalah provides a compelling interpretive lens, particularly in its insistence that norms must operate within a framework of reciprocity (Kodir, 2019). What emerges from the data is not merely the application of this principle, but its lived articulation: authority becomes something that is produced through interaction rather than assumed as a given. This reorientation challenges the implicit asymmetry embedded in classical constructions of qiwāmah.

A similar pattern is evident in the way informants articulate rights and obligations within marriage. Rather than adhering to rigid role divisions, they frame responsibilities in terms of contribution, capacity, and situational demands. As one informant noted, “in practice, I also play a major role in the family, so it cannot be understood in rigid terms” (Interview with I-08). This articulation reflects a deeper shift in the moral logic of the family, where legitimacy is increasingly tied to participation rather than predefined roles. In this respect, the findings resonate with Barlas’ critique of patriarchal hermeneutics (Barlas, 2002) and Wadud’s call for contextual readings that foreground justice as a guiding principle (Wadud, 1999).

Importantly, these reinterpretations are not confined to abstract discourse but are embedded in everyday practice. The families observed in this study do not explicitly position themselves within feminist or reformist frameworks, yet their practices implicitly reflect similar concerns with fairness, reciprocity, and shared responsibility. This suggests that transformation in Islamic family relations may not always proceed through formal doctrinal reform, but through incremental shifts in lived experience. In this sense, everyday practice functions as a site of ongoing reinterpretation, where normative meanings are continuously reconstructed in alignment with changing social conditions.

From the perspective of maqāṣid al-sharīʿa, particularly in the thought of Ibn ʿĀshūr, these patterns can be understood as reflecting an orientation toward the substantive objectives of justice (al-ʿadl) and welfare (al-maṣlaḥa) (Ibn ʻĀshūr, 2006). The emphasis on shared decision-making, flexible role distribution, and situational authority indicates a prioritization of equitable outcomes over rigid adherence to formal structures. This raises an important analytical implication: the contemporary relevance of qiwāmah may lie less in its structural consistency and more in its capacity to sustain just and balanced relationships. In this study, therefore, qiwāmah is approached not as a static institutional arrangement, but as an ethical principle whose validity is measured through its relational consequences.

At the same time, the transformation of qiwāmah cannot be separated from broader socio-economic changes, particularly the shifting position of women. Increased access to education, participation in professional life, and engagement in religious networks have significantly reshaped family dynamics. These developments introduce new forms of agency that inevitably affect how authority is distributed and exercised. What is particularly noteworthy is that this shift does not result in the rejection of qiwāmah, but in its reinterpretation. Authority becomes contingent upon involvement, competence, and relational engagement, rather than fixed by gender alone (Wadud, 1999).

Taken together, these findings point toward a reconfiguration of qiwāmah that is best understood as relational rather than structural. What persists is not the rigidity of hierarchy, but the ethical concern with responsibility, care, and balance within the family. In this light,

qiwāmah appears less as a rule to be applied and more as a principle to be interpreted. Its contemporary significance lies precisely in its ability to accommodate change while maintaining normative continuity. It is within this tension between continuity and transformation that the meaning of qiwāmah is being renegotiated in contemporary Muslim family life.

What is particularly significant in these findings is that they call into question the widespread assumption, both in classical jurisprudence and its modern legal codifications, that qiwāmah necessarily entails a stable and hierarchical structure of male authority. The empirical evidence presented here suggests that such an assumption no longer adequately captures the lived realities of contemporary Muslim families, where authority is increasingly negotiated, situational, and relationally constituted. This does not imply that qiwāmah has lost its normative relevance; rather, it indicates that its meaning has shifted from a status-based entitlement to a responsibility contingent upon practice and engagement. In this sense, the persistence of qiwāmah lies not in its formal structure, but in its capacity to be reinterpreted in ways that sustain relational justice.

More broadly, these findings invite a reconsideration of how Islamic family law is theorized, particularly the tendency to privilege textual and doctrinal coherence over lived complexity. If authority within the family is indeed produced through interaction rather than predetermined by normative hierarchy, then analytical attention must shift toward understanding how legal concepts are enacted, negotiated, and transformed in everyday life. Such a shift does not undermine the normative foundations of Islamic law, but instead foregrounds its adaptive and interpretive dimensions. It is precisely within this space of negotiation that new forms of relational ethics, and, by extension, renewed articulations of Islamic normativity, are being generated.

3.2. The Dynamics of Relational Justice and Spousal Authority in Everyday Practice

The findings of this study indicate that the construction of justice in contemporary Muslim families cannot be adequately captured through prescriptive normative frameworks inherited from classical fiqh. Rather, justice emerges as a relational and context-sensitive process that is continuously negotiated within the lived realities of family life. Empirical evidence shows that domestic roles and responsibilities are no longer rigidly structured along fixed gender lines, but are instead organized in response to situational demands and practical considerations. As one informant noted, “my husband also helps with household tasks or takes care of the children when needed” (Interview with I-04, entrepreneur, Majelis Taklim Al-Karim Rasyid, 20 February 2026). This suggests that justice is increasingly understood not as conformity to predefined roles, but as the capacity to sustain balance and functionality within the family.

What is analytically significant here is that such practices do not merely reflect adaptation at the level of behavior, but signal a deeper transformation in the underlying logic of justice itself. The data point toward a shift from a normatively codified understanding of justice, grounded in fixed allocations of rights and duties, toward a functional conception in which justice is evaluated through outcomes and relational effectiveness. In this sense, the study argues that contemporary Muslim families are not abandoning normative frameworks, but are reinterpreting them through a pragmatic-ethical lens. This challenges the assumption that fidelity to Islamic family law must be expressed through rigid structural conformity. Instead, it suggests that normativity is sustained through its capacity to remain responsive to lived conditions.

A parallel transformation can be observed in the configuration of authority, which increasingly departs from a structural model toward a functional one. Authority is no longer exclusively anchored in the husband's formal designation as qawwām, but is instead produced through participation, competence, and experiential engagement in family life. As reflected in the statement, "in some matters, I take the lead because I better understand the family's situation" (Interview with I-10, school teacher, Majelis Taklim Baitul Mukhlishin, 15 April 2025), authority becomes situational rather than absolute. This finding suggests that legitimacy within the family is shifting away from status-based entitlement toward capacity-based recognition. In this regard, authority is not diminished, but redistributed across relational contexts.

This redistribution can be more precisely conceptualized as a transition from positional authority to functional authority. In the former, authority is predetermined by normative status, while in the latter, it emerges from the ability to effectively fulfill relational roles. The significance of this shift lies in its implications for how qiwāmah itself is understood. Rather than serving as a fixed locus of authority, qiwāmah operates as a flexible regulatory principle that accommodates variation in roles and responsibilities. This interpretation moves beyond binary debates between hierarchy and equality, and instead proposes a more nuanced framework in which authority is relationally constituted and contextually enacted.

Within the framework of mubādalah, these dynamics reflect the operationalization of reciprocity as a foundational ethical principle. Rights and obligations are no longer conceptualized as asymmetrical distributions, but as mutually reinforcing elements within a shared relational structure (Kodir, 2019). However, what is particularly noteworthy is that this reciprocity is not articulated in abstract normative terms by the informants themselves, but is embedded in their everyday practices. This suggests that ethical transformation in Muslim family life may be occurring not through explicit doctrinal reform, but through the gradual internalization of reciprocal norms in lived experience. In this sense, practice precedes theory, and social interaction becomes a site of normative production.

From the perspective of maqāṣid al-sharīʿa, particularly as elaborated by Ibn ʿĀshūr (Ibn ʻĀshūr, 2006), the observed flexibility in roles and authority can be interpreted as an effort to realize the higher objectives of justice (al-ʿadl) and welfare (al-maṣlaḥa). What emerges from the data is not a departure from Islamic legal principles, but a reorientation toward their substantive aims. This raises a critical analytical point: adherence to the maqāṣid framework may, in practice, require deviation from rigid structural applications of normative rules. In other words, the pursuit of justice may necessitate flexibility, rather than uniformity.

This insight carries broader implications for the study of Islamic family law. It suggests that the dominant analytical focus on normative structures, particularly those derived from classical jurisprudence, may be insufficient to capture the complexity of contemporary family practices. Instead, greater attention must be paid to how legal concepts are enacted, negotiated, and transformed within everyday life. In this study, relational justice emerges not as a derivative of legal prescription, but as a primary organizing principle of family life. This repositions justice from a static norm to a dynamic process.

Moreover, the findings invite a reconsideration of the relationship between normativity and social change. Rather than viewing change as a challenge to normative stability, this study demonstrates that normativity itself can be reconstituted through adaptive practice. The persistence of Islamic legal concepts such as qiwāmah does not depend on their rigid application, but on their capacity to be reinterpreted in ways that remain meaningful within changing contexts. This suggests that continuity in Islamic family law is achieved not through preservation of form, but through transformation of meaning.

Taken together, these dynamics point to a paradigmatic shift from a normative-hierarchical model of family relations toward a relational-functional one. In this emerging configuration, justice is not defined by structural compliance, and authority is not secured by positional status. Instead, both are produced through ongoing interaction, negotiation, and ethical engagement. This study therefore argues that contemporary Muslim families are not moving away from Islamic norms, but are actively redefining them in ways that are more responsive, participatory, and aligned with the substantive objectives of the Sharīʿa.

4. CONSLUSION

This study demonstrates that qiwāmah in contemporary Muslim families, particularly among socioeconomically privileged Muslim women, can no longer be adequately understood as a form of absolute structural authority. Rather, it operates as a relational responsibility that is continuously negotiated through everyday practices. The findings show that such negotiation takes place through deliberative processes, flexible role distribution, and the situational redistribution of authority based on capacity and involvement. As a result, spousal relations are no longer determined solely by rigid normative structures, but are shaped through

interactional processes that enable both parties to participate actively and contextually in family life. This transformation reflects a broader shift from a normative-hierarchical model toward a relational-functional configuration of qiwāmah.

At a conceptual level, this study advances an understanding of Islamic family law that moves beyond formalistic interpretations toward a more dynamic and context-sensitive framework. The reinterpretation of qiwāmah presented here should not be seen as a departure from Islamic norms, but as an effort to actualize their substantive ethical foundations in changing social conditions. In this sense, qiwāmah is best understood as an adaptive ethical principle that regulates relational responsibility in ways that are responsive to the demands of justice, balance, and family well-being.

More broadly, the findings highlight the importance of rethinking how Islamic family law is theorized and studied. Rather than privileging doctrinal consistency alone, greater attention must be given to how legal concepts are enacted and transformed within lived realities. This study shows that continuity in Islamic legal tradition does not depend on the preservation of rigid structures, but on the capacity of its concepts to be reinterpreted in ways that remain meaningful and effective in practice. In this regard, relational qiwāmah offers a productive framework for bridging the gap between normative ideals and social realities.

Based on these insights, this study underscores the need to strengthen contextual approaches in the study and development of Islamic family law. Integrating normative frameworks with empirical realities allows for a more grounded and responsive understanding of family relations. Furthermore, efforts to promote family ethics grounded in reciprocity, shared responsibility, and social well-being are essential to ensure that Islamic family law remains relevant in addressing the complexities of contemporary Muslim life.

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STRATEGIES FOR MANAGING EMOTIONAL DYNAMICS IN INTERFAITH MARRIAGES IN INDONESIA: A PSYCHOLOGICAL REVIEW

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Abstract

Interfaith marriage in Indonesia involves complex emotional dynamics and identity conflicts. This study aims to understand the psychological experiences of interfaith couples and explore how the application of psychological theories and local wisdom can mediate these conflicts. Using a qualitative approach based on *library research*, this study analyzes data from reputable scientific journals, books, and other documents through the frameworks of relationship psychology and cultural theory. The results indicate that social pressure, anxiety, and cognitive dissonance frequently arise in interfaith relationships, yet can be managed through communication strategies and strong commitment. Meanwhile, local wisdom functions as a mediator in fostering harmony among interfaith couples. The novelty of this study lies in the psychological framework used to understand the challenges of interfaith marriage, highlighting emotional negotiation and adaptive mechanisms. This study contributes to the academic discourse by positioning local wisdom as a psychological support system in interfaith marriages fraught with emotional challenges, particularly in societies with cultural and religious diversity such as Indonesia. These findings recommend the importance of integrating local wisdom into psychological approaches and social policies to support the resilience of interfaith couples.

Keywords: Emotional Dynamics, Interfaith Marriage, Local Wisdom, Relationship Psychology

INTRODUCTION

The phenomenon of interfaith marriage in Indonesia is becoming increasingly evident in the context of a modern society that is growing more fluid and flexible. In a society as religiously and culturally pluralistic as Indonesia's, interfaith interactions are inevitable, particularly in urban and/or rural settings where diverse social and religious backgrounds converge. Interfaith marriage often becomes a space of conflict between traditional values and modern practices, creating instability between community norms, state law, and individual personal autonomy (Widyawati, 2024). Couples who choose to marry outside their own religious faith often face social challenges such as family rejection, social stigma, and even internal conflicts within their households. Previous research has revealed that doctrinal differences between religions are not the sole cause of these issues, but also include pressure to maintain group identity, the expectations of the social environment, and legal uncertainty (Muchimah et al., 2024; Wong & Seng Neo, 2024). In this context, this study is important for understanding how these couples cope with emotional and social pressures, as well as how local values can provide support in that process.

Academic studies on interfaith marriage generally focus on legal, normative, and theological aspects (Nasir, 2022; Rillyanugraha & Endi, 2024). Some of these studies investigate how state law and religious law impose limitations on the legality of interfaith marriages, while others explore the negotiation of the couple's religious identities within a pluralistic context (Dewatara & Agustin, 2021). However, psychological approaches to understanding the emotional dynamics of interfaith couples remain limited. In fact, conflicts arising in such relationships often stem from cognitive dissonance, group pressure, and an imbalance of personal values (Supanichwatana & Laeheem, 2024; Zhou, 2023). In this regard, a study by Pertiwi & Faturochman highlights the importance of integrating social and psychological identities in nurturing interfaith relationships (Pertiwi & Faturochman, 2023), while findings from Fonda and Muttaqin indicate that social pressure is significantly associated with a decline in individual psychological well-being (Fonda & Muttaqin, 2023). This gap highlights the need for research that integrates theories of relationship psychology, social identity, and emotional adaptation within the context of interfaith marriage, while also considering cultural contexts and local wisdom.

Based on the theoretical framework and the gaps identified, this study aims to investigate two main research questions: (1) What are the emotional dynamics experienced by couples in interfaith marriages in Indonesia? and (2) How can local wisdom values help interfaith couples manage psychological conflicts and maintain harmony in their domestic and social relationships? Using an interdisciplinary approach grounded in the theories of relationship psychology, social identity, and cultural sociology, this study seeks to address the theoretical

and practical challenges in understanding interfaith couple relationships in a more contextual and in-depth manner.

This article is based on the fundamental assumption that interfaith couples not only face external conflicts from society or religious institutions, but also grapple with internal struggles stemming from the tension between personal identity and social pressure. This study argues that couples' emotional resilience and communication skills are significantly influenced by the extent to which they can utilize cultural values and local support systems to manage conflict (Gottman, 2015; Regan, 2011). The hypothesis posited is that local wisdom _such as the principles of consensus-building (*musyawarah*), mutual aid (*gotong royong*), or kinship-based solidarity (*menyama braya*), in Balinese tradition_ while not entirely decisive, can at least function as social and emotional tools that help individuals find balance and acceptance within their surrounding community (Fuqoha et al., 2024; Gede Agung et al., 2024; Raya et al., 2023). This study is expected to provide a conceptual contribution to the development of a psychosocial approach based on local values in the management of interpersonal conflicts within multicultural societies.

1. RESEARCH METHODOLOGY

This study employs a qualitative approach using *library research*, specifically a literature review of written sources relevant to the central issue of this study, such as books, reputable scientific journals, religious documents, and relevant scientific articles. This approach was chosen because it allows the researcher to explore the phenomenon of interfaith marriage through psychological and local wisdom perspectives in a deep and holistic manner. This study applies an interdisciplinary framework that encompasses theories of relationship psychology, social identity, and cultural theory within the context of local values in Indonesian society.

Data were collected through a literature review of primary and secondary sources, including textbooks covering the relevant theories, journals in psychology, family sociology, and cultural studies, as well as legal and anthropological documents pertaining to interfaith marriages. Data validity was assessed using source triangulation, while analysis was conducted through interpretive and content analysis. The analysis focused on answering two main research questions regarding emotional dynamics and the contribution of local wisdom in maintaining harmony among interfaith couples.

2. RESULTS

2.1. Emotional Dynamics in Interfaith Marriages

From an anthropological perspective, marriage is not only viewed as a personal relationship between two individuals, but also as a social institution that reflects power dynamics, social

norms, and cultural values within society. Interfaith marriage, in this context, often serves as a reflection of social transformation processes, including shifts in values that occur when different cultures and religions interact within the same family framework. In various cultures, marriage is not merely about the bond between two people but also connects extended families and broader communities. Anthropologist Claude Lévi-Strauss, in his theory of social exchange as it relates to marriage (*theory of exchange*), as discussed in his book *The Elementary Structures of Kinship* (Lévi-Strauss, 2016) explains that marriage is a crucial means of maintaining social ties between different groups. Through marriage, there is an exchange of human, social, and economic resources that play a vital role in maintaining the balance of society (Korn, 1973).

Interfaith marriage can be seen as another form of this exchange, in which two different religious groups interact with one another. However, this process often creates tension due to fundamental and deeply principled differences in belief. In traditional societies, which are known for strictly maintaining religious and communal homogeneity, interfaith marriage can be seen as a serious threat to the integrity of social groups and the identity of a religious group. Local wisdom often provides solutions to alleviate such tensions by offering a middle ground that allows both parties to maintain their respective identities. Furthermore, they must also be adept at managing the differences that arise within their relationship, so that they can jointly derive and accept the benefits of those differences.

Interfaith marriages create psychologically complex situations that affect aspects of a person's identity, commitment, and relationship harmony. Unlike conventional marriages, couples with different religious backgrounds face deeper value dissonance stemming from the incompatibility of prevailing religious norms, family expectations, and the social pressures that often arise. This leads to the emergence of emotional conflicts such as anxiety, guilt, and even social alienation (Zhou, 2023). The theory of *cognitive dissonance* developed by Festinger (Festinger, 2001) explains that contradictions between personal beliefs and surrounding external conditions can cause significant emotional distress (Wilsner, 2022). In the Indonesian context, this kind of pressure is often exacerbated by dominant religious narratives, in which diversity is viewed as a deviation from the norm. Couples often feel they must hide their relationship or take complicated legal routes, such as getting married abroad to obtain legal recognition.

Based on *the social identity theory* framework (Guan, 2022), membership in a religious group plays a crucial role in shaping an individual's social identity. Therefore, when a person enters into a relationship with a partner from outside their religious group, they may experience identity friction _that is, tension between their personal commitments and their social affiliations_. However, a number of studies indicate that interfaith couples who manage to stay together generally possess high levels of emotional resilience, which enables them to

adaptively manage both internal and external conflicts. This is supported by *Commitment Theory* (Regan, 2011) which states that individuals will invest greater commitment and emotional involvement in relationships they perceive as meaningful, especially if there is an established emotional and social foundation (Reis & Rusbult, 2004). In other words, couples who have gone through many struggles together will be better prepared to manage conflicts that often arise due to religious differences (Puri & E, 2024).

2.2. Local Wisdom and Changing Values in Interfaith Marriages

Local wisdom refers to the knowledge, values, and way of life of a community that have developed within a specific community, passed down from generation to generation in a continuous and sustainable manner, and serving as a guide for maintaining social harmony, managing conflicts that arise, and preserving the balance of relationships between individuals and their social environment. According to Geertz in his book titled *The Interpretation of Cultures* (Geertz, 1973): local wisdom is the result of the formation of cultural values that reflect the "web of meaning/system of meanings" possessed by a society as a response to the challenges of daily life. Local wisdom functions not only as an adaptation tool but also as a social foundation in shaping the identity and norms of a specific community (Tohari, 2025). This local wisdom is closely tied to customs, beliefs, and social norms applied in the daily lives of communities. For example, in Indonesia, many communities rely on traditional principles such as mutual cooperation (*gotong royong*) and prioritize harmony in social life, which supports the realization of social harmony amidst diversity, as highlighted in (Amin & Ritonga, 2024). Furthermore, local wisdom is often viewed as a flexible value capable of adapting to changing times without losing its essence, thereby remaining relevant in a modern context (Ayu Kurniasih et al., 2024).

Value transformation is a change that occurs within the value system embraced by a group or society as a response to cultural interactions, the challenges of globalization, or other social changes that are constantly evolving and undergoing transformation. Value transformation encompasses shifts in perspectives, norms, and behaviors that are accepted or internalized by society (Giouvanopoulou et al., 2023). It is said that values are fundamental beliefs that influence the choices of individuals and groups in determining what is considered right or wrong, good or bad (Schnell, 2020). Therefore, value transformation occurs when these fundamental beliefs change as society adapts to external influences or the need to adjust to new social contexts (Mehta, 2020).

In the context of interfaith marriage, a transformation of values can mean a shift from traditional values _which may oppose such a marriage_ toward a more inclusive and tolerant perspective, so that societal acceptance becomes the prevailing sentiment. This often occurs through a process of cultural negotiation, in which society begins to open up to new concepts

that reflect pluralism and diversity, and does not close itself off from socio-cultural encounters as one of the impacts of globalization. For example, most urban communities in Indonesia show signs of a values transformation regarding acceptance of interfaith couples, where social norms that were once exclusive are shifting toward greater tolerance of religious differences (Suryadi & Puspita, 2023). In practice, local wisdom not only provides a foundation for resolving conflicts arising from interfaith marriages but also plays a role in facilitating value changes within society. When two individuals from different religious backgrounds marry, they are often engaged in complex value negotiations, both between themselves and with their extended families (Bukido et al., 2021).

a. Negotiating values in interfaith marriages

In interfaith marriages, the negotiation of values is a crucial process. The couple must reach an agreement on how they will practice their respective religious beliefs, how they will celebrate religious holidays, and how they will raise their children in an environment with differing beliefs (Stanford et al., 2025). In this context, it is relevant to refer to Geertz's definition of culture as a *system of meanings* woven by humans themselves; thus, in interfaith marriages, these meanings often must be renegotiated to be maintained jointly. Every interfaith couple essentially creates a "new culture" that combines elements from their respective religions. In many traditional societies, customary rituals are often adapted to include elements from different religions. In wedding ceremonies in some Javanese communities, for example, customary rituals often accommodate both Islamic and Hindu elements simultaneously. This demonstrates the flexibility of local wisdom in responding to the challenges presented by interfaith marriages.

b. The role of the community in maintaining a balance of values

Although interfaith marriages are often viewed as a private matter, in many societies, communities play an important role in maintaining a balance of values within such marriages. Religious communities, in particular, often play a significant role in helping interfaith couples manage and wisely address the challenges they face (Khatun et al., 2024). In some cases, religious communities serve as mediators in resolving conflicts arising from religious differences. In India, for example, Muslim and Hindu communities have a long tradition of resolving interfaith marital conflicts through community mediation, known as *the Panchayat* (Chauhan & Deshta, 2024). This tradition allows a community to take an active role in maintaining social harmony and ensuring that interfaith marriages do not cause greater tension within society (Yadav, 2025).

c. The transformation of values as a result of globalization

Globalization also plays a significant role in accelerating the transformation of values related to interfaith marriage. With increasing social mobility and cross-cultural interaction, interfaith couples are becoming increasingly common almost everywhere in the world (Tirimanna, 2024). Globalization also introduces new values, such as individualism, human rights, and religious pluralism, which demand tolerance and respect for the differing beliefs held by each individual (Hamdani et al., 2023). In Indonesia, for example, the influence of globalization is evident in the changing attitudes of society toward interfaith marriage. While such marriages were once considered taboo and often rejected by extended families, there is now a greater tendency to accept and respect each individual's choice (Fitryansyah & Sofiyati, 2024). This is reflected in statistical data showing an increase in the number of interfaith couples, particularly in major cities such as Jakarta, Bandung, and Surabaya (Silfanus, 2022).

Globalization also influences how children from interfaith marriages are raised. Many interfaith couples now choose to raise their children with values of pluralism and tolerance, rather than forcing them to choose a specific religion. These are some examples of significant shifts in societal values, reflecting the influence of globalization on social norms in Indonesia and around the world (Saepullah et al., 2020). Based on research conducted by Fitryansyah, young Muslims in major cities tend to exhibit a more open attitude toward modernity and individual choice, including regarding interfaith marriage. They view marriage not merely as a religious institution, but as a social contract that can be negotiated within a personal and emotional context (Fitryansyah & Sofiyati, 2024).

3. DISCUSSION

3.1. Psychological Adaptation Strategies: Communication and Negotiation

From a psychological perspective, marriage is a highly intimate interpersonal relationship involving complex processes of adaptation, interaction, and communication between individuals. Interfaith marriages are, in practice, considered to potentially add another layer of difficulty because the couple must be able to effectively manage fundamental differences in beliefs, values, and religious practices (Kesavamani, 2023). This can be linked to several related assumptions and theories, including the following:

a. Emotional dynamics in interfaith marriages

Interfaith marriages can lead to intense emotional conflict due to the clash between personal identity and the religious beliefs held by each individual. According to relationship psychology theory, differences in religious beliefs can trigger significant emotional tension if the couple lacks effective communication mechanisms to address these differences. Additionally, social identity theory explains that every individual has a tendency to identify

with groups that share the same values or beliefs, including religion (Harwood, 2020). Therefore, when someone marries an individual from a different religious background, this religious identity may be disrupted, thereby creating internal conflict within the couple's family.

b. Commitment Theory and Conflict Management

Commitment theory in relationships explains that a person's commitment to a relationship is based not only on satisfaction with the relationship itself, but also on the level of emotional and social readiness and the contributions made to the relationship (Horowitz & Strack, 2011). Interfaith couples with strong commitment tend to be better able to navigate religious differences through open dialogue and tolerance for each other's beliefs (Chandler et al., 2024). Additionally, Gottman in his book titled *Seven Principles for Making Marriage Work* (Gottman, 2015) emphasizes the importance of communication skills in resolving conflicts that frequently arise within a marital relationship. In the context of interfaith marriages, a couple's ability to resolve conflicts regarding religious practices _such as worship methods or the celebration of major holidays_ is a key factor in maintaining the integrity of the relationship.

Interfaith couples generally need to develop open and transformative communication strategies. The results of Gottman's study indicate that effective communication serves as a key indicator in maintaining harmony and stability within the household. For interfaith couples, communication encompasses discussions about religious practices, children's education, and the limits of tolerance regarding each partner's religious practices. A study by Rahmadania indicates that interfaith couples in urban areas _such as Jakarta and Bandung_ tend to possess better dialogue skills compared to those in rural areas, attributed to greater exposure to values of pluralism and tolerance (Rahmadania, 2024). This underscores the importance of social context in mediating the psychological stability of interfaith couples (Jayadi, 2025).

3.2. The Role of Local Wisdom as a Social-Emotional Mediator

Local wisdom in various regions has proven to be a key tool in mitigating conflicts that frequently arise in interfaith matters. Concepts such as deliberation, *adat basandi syara'* (customs grounded in Islamic law), and a sense of kinship create informal spaces for negotiation where customary norms can accommodate religious differences without forcing a change in belief. A concrete example can be seen in research findings among the Toraja community, where traditional ceremonies often incorporate symbols from various existing religions. Research conducted by Imran notes that traditional leaders often serve as mediators in interfaith marriage cases, replacing the role of formal religious figures embraced by the community (Imran et al., 2024). In Minangkabau, the matrilineal system allows for the

adjustment of a child's identity in interfaith marriages, as the child's religion often follows the mother's (Sebastian, 2022). On the other hand, the Balinese community facilitates interfaith marriages through additional traditional rituals as a symbol of compromise, which ultimately requires conversion to the Hindu faith (Mutiarany & Agustini, 2023). All of this reflects that local wisdom is not merely limited to moral values but can also serve as an adaptive and evolutionary conflict resolution mechanism.

As a point of international comparison, cases in Albania and India demonstrate that tolerance toward interfaith marriage is significantly influenced by the role of the community and the prevailing legal system. In Albania, as detailed in Hysni Skura's dissertation (Skura, 2024), the role of interfaith communities is highlighted as playing a crucial role in fostering social harmony. The strategies employed include engaging interfaith leaders, interfaith education, and respecting local cultural symbols. Meanwhile, in India (Patil, 2021), community-based approaches such as *the Panchayat* _with its diverse perspectives_ can at least serve as a deliberative forum considered capable of resolving interfaith marriage conflicts through customary means (Yadav, 2025). Although political and sectarian challenges remain, the existence of customary forums helps prevent escalation into open conflict. This comparison offers insight that flexible and participatory social structures facilitate easier and more peaceful conflict resolution.

Table 1. Synthesis of Psychological Theories and Research Findings

Psychological Aspects	Related Theories	Findings
Identity Conflict	Social Identity Theory (Henri Tajfel and John Turner) + (Harwood)	Identity disruption in exclusive religious communities
Emotional Adaptation	Cognitive Dissonance (Festinger)	Internal tension when personal values clash
Relationship Resilience	Investment Model (Rusbult)	Emotional contributions strengthen a couple's tolerance
Couple Communication	Gottman's Theory	Open communication mitigates ritual/religious conflicts (communication skills)

Table 2. Psychosocial Adaptation Model for Interfaith Couples

Stages of Adaptation	Psychological Components	Social Mediators
1. Initial tension	Stress, identity conflict	Family and social rejection
2. Value negotiation	Communication, reinterpretation	Dialogue between families & communities (creating new meaning)
3. Identity integration	Spiritual adjustment	Local wisdom, religion, and social symbols
4. Relationship stability	Resilience, tolerance	Community support, new patterns

4. CONCLUSION

The results of this study indicate that interfaith marriages in Indonesia create highly complex emotional challenges, including identity conflicts, family pressure, and social anxiety. However, couples with high commitment and effective communication skills demonstrate significant emotional resilience. *Commitment theory* and *cognitive dissonance theory* explain how couples can jointly invest emotional effort to maintain the harmony of their marital relationship despite facing conflicting values.

In this context, local wisdom has proven to play a crucial role as a strategic socio-emotional mediator in efforts to mitigate conflicts that frequently arise among interfaith couples. Traditional mechanisms and local values _such as consensus-building, mutual aid in various regions of Indonesia, and the *menyama braya* tradition in Bali_ provide a space for interfaith couples to adapt and be accepted within their communities. The main contribution of this study is the integration of the relationship psychology perspective with local values as an alternative approach to understanding and maintaining the stability of interfaith marriages in Indonesia's pluralistic society.

5. RECOMMENDATIONS

As a follow-up to the findings in this article, it is recommended that future studies adopt an interdisciplinary approach incorporating aspects of psychology, sociology, and cultural anthropology, particularly through field research that directly explores the lived experiences of interfaith couples from various regions in Indonesia and/or around the world. From a practical standpoint, it is important to establish and/or develop community-based counseling centers that involve religious and traditional leaders, staffed by counselors trained in interdisciplinary approaches and conflict resolution. Additionally, the government needs to formulate more inclusive policies through ethical and administrative guidelines that allow for the recognition of interfaith marriages without requiring forced conversion.

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THE RECOGNITION OF 'CAREGIVING' AS A BASIS FOR INHERITANCE CLAIMS: A COMPARATIVE REVIEW OF ISLAMIC LAW IMPLEMENTATION IN INDONESIA AND MALAYSIA

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Abstract

This study examines the recognition of caregiving as a potential basis for inheritance-related claims within Islamic family law through a comparative socio-legal analysis of Indonesia and Malaysia. The research is motivated by demographic ageing and the increasing reliance on unpaid informal care work, which remains largely unrecognized within formal inheritance systems. Using a qualitative socio-legal and comparative doctrinal approach, the study analyses statutory frameworks, judicial reasoning, and selected case law, interpreted through Maqasid al-Shariah and distributive justice perspectives. The findings indicate that both jurisdictions maintain faraid as the core normative structure of Islamic inheritance law, ensuring legal certainty in wealth distribution. However, neither Indonesia nor Malaysia explicitly integrates caregiving as a legal entitlement within inheritance rules. In Indonesia, limited flexibility emerges through judicial interpretation of instruments such as wasiat wajibah and hibah, reflecting a case-based and interpretative judicial reasoning model developed by Religious Courts and the Supreme Court. This allows partial accommodation of social considerations, although outcomes remain inconsistent and highly dependent on judicial discretion. In contrast, Malaysia adopts a more structured legal approach through codified mechanisms such as harta sepencarian and inter vivos hibah, which indirectly recognize non-financial domestic contributions within marital property regimes rather than inheritance law itself. The study concludes that both systems reveal complementary yet incomplete mechanisms for addressing caregiving contributions. Indonesia demonstrates interpretative flexibility, while Malaysia emphasizes structural legal certainty. Nevertheless, caregiving remains outside the formal inheritance framework in both jurisdictions, highlighting a normative gap between classical Islamic inheritance doctrine and contemporary demands for distributive justice.

Keywords: Islamic Inheritance Law, Caregiving, Wasiat Wajibah, Harta Sepencarian, Maqasid Al-Shariah.

INTRODUCTION

The world is currently facing a significant demographic shift, characterized by an increasing proportion of the elderly population (*Aging Population*) globally. United Nations report through *World Population Ageing 2020* It shows that the number of people aged 65 and over is projected to more than double by 2050, thus posing serious implications for the social welfare system and family law (see: https://www.un.org/development/desa/pd/content/world-population-ageing-2020). In the Southeast Asian region, especially Indonesia and Malaysia, the trend of increasing the number of elderly people is also seen significantly based on data from the Central Statistics Agency in *Statistics of the Elderly Population* (https://www.bps.go.id/publication.html) and the Department of Statistics Malaysia through official demographic reports (https://www.dosm.gov.my. However, the increase has not been fully offset by the strengthening of the formal care system, so that caregiving responsibilities tend to be shifted to the domestic realm in the form of unpaid caregiving work (*Unpaid Care Work*). According to the International Labour Organization in its report *Care Work and Care Jobs for the Future of Decent Work* (httpswww n.d.) and UN Women (httpswww n.d.), this workload is disproportionately more borne by women, especially girls in the family, who often have to sacrifice economic opportunities, career development, and personal time. In the context of inheritance law, this condition has the potential to create normative tensions, especially when the system of division of inheritance is good in the Compilation of Islamic Law (https://peraturan.bpk.go.id) or the Civil Code (https://peraturan.bpk.go.id) do not explicitly consider the contribution of parenting as a variable in the distribution of inheritance. The study by Jecker et al. also showed that primary caregivers often receive an equal share of other heirs who are not involved in parenting, thus raising the issue of distributive justice in the family (Jecker 2002). Therefore, this condition gives rise to academic urgency to revisit whether and to what extent parenting dedication can be converted into legally recognized values in inheritance-sharing systems, both through the reinterpretation of existing norms and through the development of a concept of justice that is more responsive to social realities.

In the perspective of Islamic Law, the division of inheritance (*Farā'iḍ*) is normative and *Qat'i* because it is based on the Qur'an, but in practice it still opens up the space for ijtihad to respond to modern socio-economic dynamics (Simatupang and Nasution 2025). The socio-legal studies approach was then used to assess the ability of Islamic inheritance law in answering the demands of justice in the contemporary family (Bachri, Roibin, and Ramadhita 2024). In this context, the issue of parenting (*caregiving*) emerges as an important variable that is not only moral-religious in dimension, but also has economic and social consequences for caregivers, who have the potential to experience vulnerability when their contributions are not recognized in the formal legal system (Setyawati et al. 2024). Therefore, it is necessary to explore alternative instruments such as mandatory wills, grants, and arrangements of joint

property in Indonesia and joint property in Malaysia as an adaptive mechanism in accommodating non-economic contributions (Azwar and Armi 2024). A number of studies also affirm the importance of reinterpretation of inheritance law based on substantive justice and protection of vulnerable parties (Azizah, Lestari, and Qosim 2025), including through a gender perspective that highlights inequality due to neglect of parenting work (Sholihah, Widiawati, and Awang 2024). In a broader context, recognition of caregiving work is also related to the well-being of the elderly in Muslim societies (Syed Elias et al. 2026), so that the transformation of the value of parenting into legal rights becomes an important part of realizing distributive justice and social protection in contemporary Islamic law.

As two Muslim-majority countries in Southeast Asia, Indonesia and Malaysia offer an interesting comparison in the administration of Islamic inheritance law, where Indonesia through the Compilation of Islamic Law shows a more adaptive tendency, particularly in the application of compulsory wills for parties who are not formal heirs such as adopted children or parties with certain social ties, while Malaysia has a more structured system of estate administration based on authority Institutions and Practices of the Shafi'i School (Ibrahim, Shazali, and Rusgianto 2024). On the other hand, social dynamics in Malaysia show that the practice of family carers is still dominant and can impose an economic, social, and psychological burden on caregivers, especially when such contributions are not recognized in the formal system (Jawahir et al. 2021). This condition encourages the development of a discourse on the concept of shared property as a mechanism that can accommodate direct and indirect contributions in the family, including parenting work (YAZID et al. 2020). This difference in approach shows that Islamic law in both countries is dynamic and continues to adapt to social changes and societal justice needs, especially in responding to the realities of caregiving and the demands of distributive justice in the modern family.

This research has a strong *novelty* because it relates the physical and emotional contributions of caregivers directly to inheritance claims in a formal framework. Focusing on the question "whether a caregiver's dedication can be converted into material value" challenges the status quo of traditional inheritance law. By presenting an in-depth comparative analysis, the study not only contributes to the development of Islamic family law, but also offers policy solutions for governments in dealing with the social impacts of an ageing society. In the midst of the lack of protection for family caregivers, legal recognition through the inheritance route can be a strategic incentive to ensure that the welfare of the elderly is maintained in the family environment without neglecting justice for those who care for them.

1. RESEARCH METHODS

This study uses a comparative socio-legal approach to examine how Islamic inheritance law in Indonesia and Malaysia accommodates (or has not accommodated) the contribution of

parenting (*caregiving*) as the basis of claims in the distribution of inheritance. The socio-legal approach is used to bridge the gap between normative legal doctrine and its implementation in social practice, particularly in the context of informal parenting in the family. This approach is widely used in contemporary Islamic legal studies to understand the interaction between legal norms and social reality (see Socio-Legal Studies), as shown in Heliyon's study highlighting caregiving as a social-religious practice in Muslim societies (Setyawati et al. 2024).

From a doctrinal perspective, this study analyzes the primary legal sources that govern Islamic inheritance law in both jurisdictions. In Indonesia, the analysis includes the Compilation of Islamic Law (KHI), related laws and regulations, and the decisions of the Religious Courts. Meanwhile, in Malaysia, the study focused on the principle of faraid in Islamic inheritance law, the administration of inheritances based on *National Land Code*, as well as the decision of the Syariah Court. The legal framework was analyzed to identify the extent to which non-economic contributions, especially parenting, are recognized in the formal inheritance distribution system. Studies in Islamiyyat show that the inheritance system in Malaysia remains firmly rooted in faraid but develops through additional instruments (Abd Majid et al. 2024), while a study in the Journal of Friends of ISNU emphasizes that Islamic inheritance law is normative but still leaves room for reinterpretation in the modern social context.

In addition to normative analysis, this study also uses a *case-based approach* by examining a number of court decisions related to inheritance disputes, where parenting contributions or other indirect contributions appear as considerations, both explicitly and implicitly. This approach allows research to go beyond mere textual analysis and assess how legal norms are interpreted and applied in judicial practice. A similar approach is used in the empirical study of Islamic inheritance law which emphasizes the importance of judgment analysis to understand substantive justice.

A comparative method is used to identify the main similarities and differences between Indonesia and Malaysia in responding to parenting issues (*caregiving*) within the framework of Islamic inheritance law. This comparison is prepared based on three dimensions of analysis that are in line with the focus of the research, namely: (1) how the legal framework in Indonesia through the Compilation of Islamic Law (KHI) and in Malaysia through the faraid system administered by the Sharia Court and regulations such as *National Land Code* balancing the distribution of permanent inheritance and recognition of economic contributions and care services; (2) the extent of alternative legal instruments such as *Obligatory Will* and grants in Indonesia and *Treasure Hunt* and grants in Malaysia can be used as the basis for legal claims for caregivers to acquire shares that go beyond the standard portion of inheritance; and (3) how judges' considerations in judicial practice in both countries in assessing non-economic contribution claims, including the extent to which the judicial

approach taken reflects more progressive legal protections for family caregivers. This cross-jurisdictional comparative approach is in line with the approach in Comparative Law which emphasizes the importance of comparative analysis to understand the variation in the implementation of Islamic inheritance law in different countries (Azwar and Armi 2024).

Analytically, this research is based on the theoretical framework of Maqasid al-Shariah, especially the principles of justice ('adl) and benefit (maslahah), as well as the theory of Distributive Justice. These two frameworks are used to assess whether existing inheritance law mechanisms have reflected substantive justice for family members who contribute through parenting. The use of maqasid as a tool for justice analysis in Islamic law confirms that maqasid functions as a normative foundation in responding to social change. By integrating doctrinal analysis, case studies, and comparative approaches, this study aims to provide a comprehensive assessment of legal recognition of the contribution of parenting in the Islamic inheritance legal system in both countries.

2. RESULTS AND DISCUSSION

2.1. Balancing Faraid and Caregiving in Islamic Inheritance Law: Indonesia and Malaysia

The legal framework of Islamic inheritance in Indonesia and Malaysia is both based on the Faraid principle as a system of property distribution that is normative and has a section structure that has been explicitly determined in the source of Islamic law (Çizakça 2020). In both jurisdictions, faraid serves as the main mechanism to ensure legal certainty and the distribution of wealth that is considered fair based on the provisions of the sharia (Safi 1990). However, in the context of contemporary society characterized by changes in family structure, increasing life expectancy, and increasing role of caregivers in the family, the faraid system faces challenges in accommodating non-economic contributions such as caregiving. Studies in *Social Science & Medicine* shows that caregiving is a form of *Unpaid Labor* that have a significant economic impact on individuals, especially women, so that their lack of recognition in the resource distribution system can reinforce social inequality (Bauer and Sousa-Poza 2015). These findings are also supported by other studies that confirm that unpaid parenting contributes to gender inequality and limited economic access for women (Hoskyns and Rai 2007).

In the Indonesian context, the implementation of Islamic inheritance law through the Compilation of Islamic Law (KHI) shows that there is normative flexibility that allows adaptation to social realities (Nurlaelawati 2025). Although the structure of faraid was not changed directly, the Indonesian legal system provides additional instruments such as *Obligatory Will* and grants that can be used as a corrective mechanism against faraid limitations (Azhar 2024). In the practice of Religious Courts, judges in some cases show a

tendency to use a substantive justice approach by considering social relationships and non-formal contributions within the family, although caregiving is not explicitly recognized as the basis of legal claims (Azizah et al. 2025). This reflects the character of the Indonesian legal system that is more open to interpretation, as seen in socio-legal studies that show that legal pluralism in Indonesia allows for variation in the application of inheritance legal norms (Yusmita et al. 2025).

However, this flexibility is inconsistent and highly dependent on the judge's interpretation. In many cases, the division of inheritance remains strictly following the faraid structure without considering the parenting contribution. This suggests that while there is normative room for adaptation, there is no clear legal standard for integrating caregiving in inheritance distribution (Isra, Ferdi, and Tegnan 2025). Thus, flexibility in the Indonesian system can be categorized as *interpretative flexibility*, that is, the flexibility that arises from judicial practice, not from the design of the legal system itself (Feener 2012).

In contrast, in Malaysia, the Islamic inheritance law system shows a more structured approach with a clear separation between faraid-based inheritance distribution and recognition of economic contributions within the family (Hussain 2011). Faraid is still strictly applied in the process of distributing inheritance through the Sharia Court, but recognition of non-economic contributions is facilitated through the concept of Inheritance (Yusoff 2024). This instrument allows the spouse, especially the wife, to claim a share of the property acquired during the marriage based on direct or indirect contributions, including domestic work and upkeep. A study in the Journal of Islamic Accounting and Business Research shows that wealth has become an important mechanism in integrating the principle of justice in the distribution of family wealth in Malaysia (Hussin and Daud 2020).

This approach reflects what can be termed as *Structural flexibility*, i.e. flexibility built into the legal system through the separation of functions between the recognition of contributions and the distribution of inheritance (Abd and Faishal 2025). In other words, caregiving contributions are recognized, but not within the framework of faraid itself, but rather through other legal mechanisms that run before the inheritance distribution process is carried out (Whiting 2010). This provides a higher level of legal certainty compared to the Indonesian system, but at the same time limits the scope of caregiving recognition to only certain relationships, especially in the context of marriage.

Although the two countries show different forms of flexibility, the recognition of caregiving as the basis for legal claims in the division of inheritance is still indirect. Neither Indonesia nor Malaysia have integrated caregiving as an explicit variable in faraid structures, so such contributions can only be accommodated through additional instruments. This condition reflects the tension between the normative principle of faraid that emphasizes legal certainty

and the need for distributive justice in modern society (Feener 2012). In the perspective of Distributive Justice, the inability of the legal system to recognize non-economic contributions such as caregiving can result in a distribution of resources that is disproportionate to the actual contribution of individuals in the family (Bauer and Sousa-Poza 2015).

Further, within the framework of Maqasid al-Shariah, the main purpose of Islamic law is to bring about justice (*'adl*) and benefits (*Maslahah*) (Tohari, Fawwaz, and Swadjaja 2022). Therefore, the inability of faraid systems to directly accommodate caregiving can be seen as a limitation in achieving such goals in the modern social context. A number of contemporary studies have shown that a maqasid-based reinterpretation of inheritance law can open up space for broader recognition of non-economic contributions in the family without having to ignore the basic principles of sharia (Opwis 2017). This approach places maqasid as a normative framework that allows legal adaptation to modern social realities, especially in an effort to realize distributive justice. In addition, the literature on social justice also confirms that the recognition of non-economic work such as caregiving is an important part of the expansion of the concept of justice in contemporary society (Shufutinsky et al. 2022).

Thus, the comparison between Indonesia and Malaysia shows that the two countries developed different strategies in balancing the normative certainty of faraid and the demands of substantive justice. Indonesia offers flexibility through judicial interpretation, while Malaysia provides flexibility through a more structured institutional design. However, both still face challenges in integrating caregiving as an integral part of the inheritance law system. This points to the need for the development of a legal framework that is more responsive to social realities, in which the contribution of parenting is recognized not only as a moral obligation, but also as a legitimate basis for economic claims in the distribution of inheritance.

2.2. Legitimacy of Caregiver Claims through Obligatory Wills and Assets

Legal instruments such as *Obligatory Will* in Indonesia and *Treasure Hunt* and *Grants* in Malaysia serves as a corrective mechanism against the rigidity of the faraid system (Nasrul et al. 2021). However, its effectiveness as a basis for legal claims for caregivers to obtain a share that exceeds the standard inheritance portion is still limited and indirect. In Indonesia, *Obligatory Will* is a normative innovation designed to provide protection to individuals who do not fall into the category of formal heirs, such as adopted children and non-Muslim relatives (Akhsanty 2025). Judicial practice shows the application of this mechanism, one of which is in the Supreme Court of the Republic of Indonesia Decision Number 721 K/Ag/2015, where non-Muslim biological children are still declared not entitled to inherit faraid, but the Court affirms the granting of shares through *Obligatory Will* as a corrective path to ensure justice (Zubair and Latif 2022). This decision shows that the court used *Obligatory Will* as an instrument to achieve substantive justice without changing the basic structure of the Faraid.

Nonetheless, the practice reflects what can be categorized as *interpretative flexibility*, i.e. flexibility that depends on the discretion of the judge, not on explicit recognition in legal norms. In this context, *caregiving* is not codified as a legal criterion, so the caregiver can only obtain an additional share if it is constructed as a party worthy of protection (Hassan et al. 2014). As a result, the legitimacy of parenting-based claims remains casuistic and does not provide consistent legal certainty.

On the other hand, Malaysia showed a *Structural flexibility*, where the legal system institutionally separates between the recognition of contributions and the distribution of inheritance. Concept *Treasure Hunt*, as applied in the practice of the Shari'a Court, allows recognition of direct or indirect contributions, including domestic work in the marital relationship, before the division of faraid is carried out (Norhusairi and Hussin n.d.). This mechanism serves as a claim of ownership (*ownership claim*) pre-distribution, which allows certain parties, particularly spouses, to acquire a share of the common property before the rest of the property is distributed according to the faraid. However, this recognition is structurally limited because it applies only in spousal relationships and does not cover other forms of care, such as those carried out by daughters or relatives who care for the elderly. Therefore, the Malaysian approach is more appropriately understood as a "more structured but limited" system, rather than as a blanket recognition of the contribution of nurturing.

In addition, the instrument *Grants* in Malaysia provides additional flexibility through a lifetime wealth grant mechanism that could potentially benefit caregivers (Zulkepli and Bustami 2019). However, due to its nature that depends on the will of the giver (*voluntary disposition*), its effectiveness is largely determined by individual awareness and planning. In contrast to *Obligatory Will* which in certain practices have a semi-imperative character, *Grants* does not create a legal claim that can be enforced after the heir dies if it is not previously established (Azhar and Nor 2019). Thus, *Grants* does not provide systematic legal protection for caregivers in inheritance disputes.

Comparatively, both Indonesia and Malaysia show a structural gap in Islamic inheritance law, namely it does not recognize it *caregiving* as an independent legal variable within the Faraid framework (Azizah et al. 2025). Indonesia relies on *interpretative flexibility* through the role of judges (Aini et al. 2026), while Malaysia uses *Structural flexibility* through institutional mechanisms beyond the core structure of the inheritance (Radzi and Jaafar 2025). However, both have not formally integrated non-economic contributions into the legacy distribution system. This gap reflects the tension between the rules-based legal certainty in faraid and the demands of distributive justice in contemporary society, where unpaid parenting work has a significant socio-economic contribution. In the framework *Maqasid al-Shariah*, which emphasizes justice (*'adl*) and benefits (*Maslahah*), this condition raises normative questions about the compatibility between legal doctrine and social reality.

Thus, although existing legal instruments can serve as corrective mechanisms, they have not yet established a comprehensive and systematic legal framework for recognizing *caregiving* in Islamic inheritance law. These findings suggest the need for a more explicit doctrinal and legislative approach to bridge the gap between fixed inheritance norms and modern socio-economic dynamics, particularly in recognizing parenting as a legally relevant form of non-economic contribution.

2.3. Judicial Reasoning in Inheritance Disputes Involving Caregiving Claims: A Comparative Study of Indonesia and Malaysia

In the Indonesian context, the consideration of judges of the Religious Court in inheritance disputes generally moves within the framework of positive Islamic inheritance law as stipulated in the Compilation of Islamic Law (KHI), which then develops through the dynamics of Supreme Court jurisprudence (Reskiani et al. 2022). Normatively, KHI limits mandatory wills to adopted children and adoptive parents as stipulated in Article 209 of the KHI, so that it does not explicitly regulate other parties outside the relationship, including caregivers (Handayani, Khisni, and Sulchan 2020). However, in judicial practice, there is a tendency for extensive interpretation based on considerations of justice and benefit (maslahah), especially in cases that show inequality in the distribution of property due to the limitation of faraid norms (Kasim and David 2022). The development of Supreme Court jurisprudence shows that there is an expansion of the application of compulsory wills under certain conditions, especially through several important decisions such as the Supreme Court of the Republic of Indonesia Decision No. 368 K/AG/1995 and the Supreme Court of the Republic of Indonesia Decision No. 51 K/AG/1999, which is the basis for the recognition of compulsory wills for parties outside the heirs in certain contexts, especially non-Muslims who have close family relations with the heirs (Wahab and Kamaluddin 2023).

In addition, the development of Supreme Court jurisprudence in the following period also strengthened the position of compulsory wills as an instrument of distributive justice in Indonesian Islamic inheritance law, although it should be emphasized that its application remains casuistic and does not develop into an explicitly binding general norm in the KHI (Akhsanty 2025). Therefore, the expansion of this concept to caregivers cannot be considered as an established legal doctrine, but is still in the realm of case-based judicial reasoning. Thus, the role of judges in Indonesia can be understood as a form of case-based judicial reasoning that integrates positive legal texts with substantive justice considerations through the judicial ijtihad approach, rather than as a form of general norms that are legislative in nature (Supardin et al. 2025).

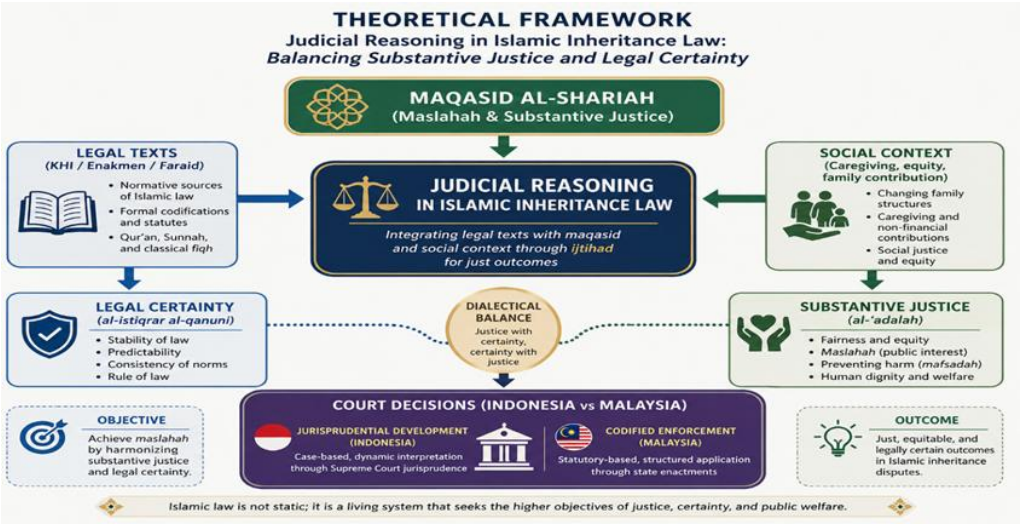
In contrast to Indonesia, the Syariah Court system in Malaysia operates within the framework of the Islamic Family Law Enactment which is decentralized at the state level, so that the

structure of Islamic inheritance law is relatively more codified and uniform in the application of the faraid principle (Peletz 2013). In this system, the division of inheritance is strictly determined based on the relationship of the nasab and the provisions of classical Islamic law, so that non-nasab contributions such as parenting are not recognized as the basis of direct inheritance. However, Malaysian law provides alternative legal mechanisms that can accommodate contributions in the household, such as matrimonial property and inter vivos grants (Akinola, Drame, and Masruh n.d.). Property in principle recognizes financial and non-financial contributions in marriage, including domestic roles, but this mechanism is in the realm of family law and not inheritance law (faraid). Thus, caregiving contributions are not directly recognized as the basis of inheritance, but can only be considered in the division of marital assets at the time of divorce or death of the spouse.

Therefore, the discretion of Sharia Court judges in Malaysia in inheritance cases is relatively more limited than in Indonesia, because it is strictly tied to the legislative structure at the state level. Legal changes depend more on enactment amendments than on the development of judicial jurisprudence as a whole. The main difference between Indonesia and Malaysia does not lie in the level of "progressivity", but in the model of legal development used. Indonesia tends to adopt a jurisprudential-dynamic approach, in which the Supreme Court has an important role in the development of law through the interpretation of concrete cases (Hariri, Babussalam, and Saleh 2025). Instead, Malaysia adopts a codifying-structural approach, which emphasizes legal certainty through written regulation at the state level (Wahidah, Ab Rahman, and Hasan 2024).

In contemporary Islamic legal theory, especially through the maqasid al-shariah approach, there is an attempt to strike a balance between substantive justice (al-'adalah) and legal certainty (al-istiqrar al-qanuni), where judges are not only bound by positive legal texts, but also consider the value of benefits in the judicial reasoning process (Solikhudin et al. 2024). Indonesia shows a tendency towards interpretive flexibility in judicial practice (Hariri et al. 2025), while Malaysia demonstrates normative consistency through legal codification (Khoirunnisa et al. 2025). Thus, the comparison of the two countries is more appropriately reconstructed as a difference in the institutional model of Islamic law development, where Indonesia represents a model based on contextual judicial ijtihad, while Malaysia represents a model based on legislative codification. Both reflect different forms of adaptation to the dynamics of Islamic inheritance law in the modern social context in Southeast Asia.

Figure 1. Conceptual Framework Of Judicial Reasoning In Islamic Inheritance Law: Balancing Maqasid Al-Shariah, Legal Certainty, And Substantive Justice In Indonesia–Malaysia Comparative Context



3. CONCLUSION

This study demonstrates that Islamic inheritance law in Indonesia and Malaysia continues to be fundamentally structured around the normative framework of Faraid, which ensures legal certainty and systematic distribution of estate in accordance with classical Islamic jurisprudence. However, contemporary socio-economic transformations particularly the increasing significance of unpaid caregiving within family structures have exposed inherent limitations in the traditional faraid system in addressing distributive justice concerns. In response, both jurisdictions reveal distinct doctrinal adaptations that reflect different modes of balancing substantive justice and legal certainty within the framework of maqasid al-shariah, which emphasizes justice (‘adl) and welfare (maslahah) as core objectives of Islamic law.

In Indonesia, the legal system demonstrates a tendency toward interpretative and jurisprudential flexibility, primarily driven by the role of the Supreme Court and Religious Courts in developing case-based reasoning. Instruments such as wasiat wajibah and hibah function as corrective mechanisms that allow judges to incorporate considerations of equity and social contribution, including indirect recognition of caregiving roles, although such recognition remains implicit and highly dependent on judicial discretion. This results in a

dynamic but relatively inconsistent legal landscape, where legal development is predominantly judge-driven rather than codified within statutory law.

In contrast, Malaysia adopts a structurally codified approach through the Enakmen Undang-Undang Keluarga Islam at the state level, ensuring a higher degree of normative consistency and legal predictability. While faraid remains strictly applied in inheritance distribution, recognition of non-financial contributions, including caregiving, is institutionally channeled through mechanisms such as harta sepencarian and inter vivos gifts. This structural separation between inheritance and marital property claims provides clearer legal certainty, although it simultaneously limits the scope of caregiving recognition outside marital relationships. Overall, the comparative analysis reveals that Indonesia prioritizes judicial flexibility, whereas Malaysia emphasizes codified legal stability, representing two distinct institutional responses to the challenge of integrating caregiving justice within Islamic inheritance law.

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MODEL OF CONVERSION DEVELOPMENT BY RELIGIOUS EXTENSION WORKERS IN REALIZING MASLAHAT FAMILIES IN LAMPUNG PROVINCE

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Abstract

The phenomenon of increasing the number of converts in Lampung Province poses challenges in fostering and forming families that are oriented towards the value of benefits. The main problems lie in the lack of institutional coordination, the limited number of religious extension workers, and the lack of socio-economic support for converts' families. This study aims to identify and analyze the pattern of conversion coaching and the obstacles faced by religious extension workers in realizing the benefit family in Lampung Province. This study uses a descriptive qualitative approach with in-depth interview, observation, and documentation techniques on religious extension workers, da'wah institutions, and converts' families in East Lampung Regency, Lampung Province. Data analysis was carried out with the Miles and Huberman interactive model through reduction, presentation, and conclusion drawn. The results of the study show two main findings: first, the pattern of converting is carried out through spiritual, social, and economic approaches that emphasize strengthening faith, family counseling, and sharia-based entrepreneurship training. Second, the main challenge lies in the limited human resources of extension workers and the lack of supporting budgets that cause low program sustainability. Theoretically, this study enriches the social da'wah discourse based on the family of maslahat, while practically providing recommendations to strengthen synergy between religious extension workers, da'wah institutions, and local governments.

Keywords: Converts, Coaching, Religious Extension Workers, Maslahat Family, Lampung

INTRODUCTION

Conversion to religion or becoming a convert is a socio-religious phenomenon that has great implications, not only on the change of individual beliefs but also on the dynamics of their new family life. Before becoming Muslims, converts had diverse religious backgrounds—for example, those who came from Christianity saw the purpose of marriage in terms of having children as mentioned in Genesis 1:28 in the Bible. Similarly, for those from Hinduism, the challenges that often arise in family life are the burden of complex religious rituals and the dominant domestic responsibilities on the part of women, such as taking care of banten and religious ceremonies. This condition shows that each religious group of origin has its own perspective and problems in family life. The process of conversion to Islam requires converts to adapt to new values, worship practices, and social structures that are different from previous traditions. This phenomenon is also reflected in various studies that highlight the psychological, social, and family experiences of converts, both from Christian and Hindu backgrounds, which shows that religious conversion is not only theological but also has an impact on social relationships and family resilience (Ridwan, 2017).

When a person becomes a convert, they enter a new religious and social system with different demands, values, and practices. In the context of the convertible family, there are a number of typical problems that arise: first, the inability of the husband or wife to make the necessary adjustments for the relationship to be harmonious; second, self-preparation (both men and women) before marriage is still lacking, so that facing the duties and roles of marriage in Islam is not ready; third, inappropriate perceptions of marriage—for example, seeing love only as an attraction or wanting to have without understanding the elements of compatibility, commitment and responsibility; Fourth, family economic instability is the source of conflict. If this condition is not handled, then the convert's family has the potential to fail to realize a beneficial family (Salma & Jarudin, 2025).

Furthermore, the guidance of converts is very important because they as part of Muslims who have just embraced Islam need guidance so that their religious awareness and understanding are solid. Example of research in Indonesia, article "Converting Development: Innovative Strategies for Improving Religious Education in Patikalain Village" (Rezani et al., 2024) shows that inclusive religious education is able to improve basic Islamic understanding for converts. In addition, through the research "Conversion Education Model (Case Study: Pesantren for the Development of Converts of the An-Naba Center Indonesia Foundation)" identified a pesantren-based coaching model that is effective in building Islamic commitments, but has not touched the family aspect (Sapiudin & Syarifah, 2018).

Local studies in Lampung Province also show important variation in results. For example, in "Faith Education in Converts Families in Banjar Sari Village, Metro City" found that most of

the converts' families did not have regular assistance from religious counselors. (Wahyudi, 2017) Meanwhile, Syaibani in "Strategies for Fostering Converts in Sumber Arum Village, Kotabumi District" highlighted the lack of a pre-marriage program that prepares converts to face Islamic marriage. (Syaibani, 2018) Furthermore, Safitri in "Optimizing the Role of KUA in Fostering Convertible Families in North Lampung" found that religious extension workers do not yet have a systematic coaching model to strengthen converts' families. (Safitri, 2022) In addition, Setiawati & Romli emphasized that religious and economic guidance for converts by the Indonesian Islamic Da'wah Council in Lampung is still focused on spiritual aspects, not the socio-economic aspects of the family (Setiawati & Romli, 2019).

However, in practice in the field, the development of converts' families has not been running optimally. Research on "Problems of Converting Coaching in Singkawang City" stated that the main obstacle to coaching is the lack of structure, companions, and a sustainable integrative model. For the context of Lampung itself, the results of the field survey show that in Mandala Sari Village, Mataram Baru District, East Lampung Regency, there are 40 converts, but from the last coaching data on February 16, 2023, only 21 converts who actively participated in formal coaching consisted of 11 women and 10 men. The reason why converts to Islam is not only voluntary, but also because of marriage, and because of their predominantly Muslim social environment [Observation, February 2023].

From these previous studies, it can be seen that most of the studies on conversion development in Indonesia, including in Lampung, still focus on the aspect of individual religious education, not touching on the aspect of family development as a whole, which involves the active role of religious extension workers as social mediators, family counselors, and religious facilitators. There has been no research that specifically formulates a model for converting to be coached by religious extension workers to realize a family that includes spiritual, social, and economic dimensions. Therefore, this research is important to fill this gap by developing a more comprehensive coaching model in Lampung Province.

1. METHOD

This study uses a qualitative approach with a case study type to understand in depth the model of converting development by religious extension workers in realizing a beneficial family in Lampung Province. The qualitative approach was chosen because it was able to explore the meaning, values, and social experiences experienced by converts in the context of religious and family life. According to Creswell and Poth (2018), qualitative research focuses on understanding complex phenomena through direct interaction with research subjects and using various data sources such as interviews, observations, and documentation (Ismail, 2024).

The data analysis in this study uses the Miles and Huberman interactive model which consists of three main stages, namely data reduction, data presentation, and conclusion drawing or verification. The three stages are carried out cyclically and repeatedly until credible and meaningful findings are obtained. The data reduction process is carried out by selecting and focusing important data according to the research objectives, while the presentation of data is carried out in the form of descriptive narratives and thematic matrices. Conclusions are drawn based on patterns, relationships, and meanings that emerge from the field data (Miles et al., 2019).

To maintain the validity of the data, this study applies the source and method triangulation technique. Triangulation was carried out by comparing the data of interviews with religious extension workers, observations of coaching activities, and the review of local Ministry of Religion program documents. This step is intended so that the research results are more objective and can be accounted for scientifically (Miles & Huberman, 1994).

In addition, this case study approach follows the principle of inference-based qualitative research which emphasizes the importance of integration between theory and empirical data in explaining social phenomena. With this approach, the research not only describes the phenomenon of converting development in a descriptive way, but also seeks to find a conceptual model that can be widely applied in the context of converting families in Indonesia (King et al., 2021).

2. RESULT/FINDINGS

2.1. Pattern of Conversion Development by Religious Extension Workers in Lampung Province

The findings of the study show that the pattern of converts development in Lampung Province is carried out comprehensively through a spiritual-religious and socio-economic approach.(Mukmin, 2024) This approach is not only oriented towards strengthening the faith, but is also directed at the formation of social independence and improving the welfare of converts' families. In some areas, such as Central Lampung and Pesawaran, coaching activities are carried out through basic Islamic recitation, sharia based entrepreneurship training, and Islamic family counseling facilitated by da'wah institutions and religious extension workers. This pattern is in line with the results of studies that affirm the importance of integration between religious education and economic empowerment in the process of converting to education, as explained in the research on the economic empowerment of converts through Islamic social funds and the model of converts' education in modern da'wah institutions (Setiawati & Romli, 2019). However, the results of field observations show that the sustainability of the coaching program still faces structural challenges, especially the limited number of extension workers and budget support from the local government.

Table 1. Data of converts in Mandala Sari Village, Mataram Baru District, East Lampung Regency

NO	NAME	DATE OF BORN	ADDRESS	THE YEAR OF ISLAMIC ENTRY
1	Tri Mulyani	22-02-1970	Mandalasari	1995
2	Winarsih	15-01-1985	Mandalasari	2006
3	Yuliati	08-07-1976	Mandalasari	1992
4	Purwaning Lestari	21-09-1975	Mandalasari	1999
5	Saminah	11-12-1961	Mandalasari	2014
6	Endang Setiani	22-06-1978	Mandalasari	1999
7	Krisnah	16-03-1977	Mandalasari	1995
8	Sri Rahayu	30-03-1980	Mandalasari	2001
9	Latini	-	Mandalasari	1981
10	Susilowati	14-09-1978	Mandalasari	1995
11	Mrihayu Kadarwati	22-10-1980	Mandalasari	1998
12	Mudesta Andriani	02-12-1982	Mandalasari	2007
13	Helena Puspa Hayati	18-08-1982	Mandalasari	2000
14	Krisna Utami	-	Mandalasari	2015
15	Haryono	23-01-1972	Mandalasari	1999
16	Bekti Waryani	28-12-1969	Mandalasari	1986
17	Lusia Kasemi	10-04-1975	Mandalasari	1994
18	Martialis	09-07-1983	Mandalasari	2014
19	Nur Sukamto	02-05-1981	Mandalasari	2016
20	Tri Puspo Adi	15-10-1980	Mandalasari	1990
21	Yanto	-	Mandalasari	1979
22	Nur Fijianto	20-02-1987	Mandalasari	2015
23	Komang Darte	10-11-1985	Mandalasari	2014
24	Sutarno	16-04-1965	Mandalasari	1986
25	Yanto	-	Mandalasari	1979
26	Nur Fijianto	20-02-1987	Mandalasari	2015
27	Arif Hartoyo	25-03-1970	Mandalasari	1995
28	Bambang Tri Suwarno	09-08-1969	Mandalasari	-
29	Budi Prayitno	03-031973	Mandalasari	-
30	Eko Wiranastuti	30-06-1966	Mandalasari	-
31	Sarwono	21-01-1970	Mandalasari	-
32	Sri wahyuni Pamujiati	30-10-1975	Mandalasari	-
33	Supinah	20-04-1948	Mandalasari	-
34	Tri Sujarwo	15-10-1980	Mandalasari	-
35	Dewi Purwanti	-	Mandalasari	-
36	Ketut Eka Sudaya	-	Mandalasari	-
37	Muhadi	-	Mandalasari	-
38	Yohanes	-	Mandalasari	-
39	Yosmen	-	Mandalasari	-
40	Hardi	-	Mandalasari	-

Source: Data processed April 2024

Table 2. Status of Converts in the Lampung Development Program (2024)

Status	Quantity	Percentage (%)
Actively Participating in Coaching	21	52.50
Inactive / Disconnected	19	47.50
Total Enlisted	**40**	**100.00**

Of the 40 converts registered as of February 2023, only about 21 [52.50%] are actively participating in coaching regularly and around 19 [47.50%] people are no longer active in coaching activities. This phenomenon shows that the mentoring process has not fully reached all target groups. Some of the factors that affect the inactivity include limited transportation facilities to the coaching location, busy work, lack of support for the nuclear family, and lack of communication intensity between extension workers and participants. In addition, the limited number of religious extension workers and the allocation of the program budget are also structural obstacles that cause some converts to not receive optimal assistance.

This inequality shows that there is a gap between national policies and local implementation, where coaching programs have not been fully integrated in the regional da'wah institutional system. These findings are consistent with the results of research showing that in some Muslim minority areas, the effectiveness of conversion coaching has decreased due to weak cross-agency coordination and lack of program supervision by the local Ministry of Religious Affairs Office (putri Saragi & Qarni, 2023).

In addition to structural factors, the psychosocial aspect of converts is also an important challenge. Many converts have difficulty adapting to new social norms and religious practices, especially for those from non-Muslim families who still reject conversion decisions. This condition often causes emotional distress and hinders the process of internalizing Islamic values. The findings of the study show that this kind of problem requires a comprehensive counseling approach and a continuous support system in order for converts to integrate well into Muslim society (Hidayati, 2014).

Thus, the results of this field finding show that the development of converts in Lampung has not been fully institutionalized systemically. The pattern is still dependent on the personal initiative of religious extension workers and the support of the local community. A collaborative development model based on family benefits is needed, which involves synergy between religious extension workers, da'wah institutions, local governments, and economic institutions of the people. This approach will strengthen the sustainability of coaching, increase the resilience of converts, and support the Islamic vision of rahmatan lil-'ālamīn in multicultural areas such as Lampung Province.

2.2. Theoretical and Practical Implications of the Collaborative Coaching Model

Theoretically, the collaborative coaching model enriches the treasures of da'wah studies and religious guidance by presenting an integrative perspective between the theory of the maslahat family and the sociological approach in community da'wah. This research contributes to the development of Islamic extension theory by emphasizing that the success of da'wah is not only measured by the aspect of individual religiosity, but also by the extent to which Islamic values are able to form family harmony and social welfare. This concept expands the function of da'wah from simply the delivery of teachings to a social transformation oriented towards spiritual and material balance, as affirmed by Qardhawi in Fiqh al-Usrah fi al-Islam (Cairo: Dar al-Syuruq). Qardhawi's view is also strengthened by the study of the Conception of the Sakinah Family for Migrant Families in Rejoagung Village, Jombang Regency, Maslahah Imam al-Ghazali's Perspective, which emphasizes the importance of the principle of maslahat in building a family with spiritual and social justice (Afiat & Noho, 2025).

In addition, this research supports the Miles, Huberman, and Saldaña paradigm which emphasizes that every social phenomenon should be analyzed through triangulation between empirical data, social context, and researcher interpretation. In the context of converting coaching, this means that the counseling strategy must adapt to local social and economic realities, so that the results obtained are contextual and sustainable. This view is in line with findings in the Journal of Islamic Counseling Guidance, which shows that religious counselors play a role as social and psychological mediators in helping marginalized communities adapt to socio-religious changes (Nabilah & Darmaningrum, 2023).

Meanwhile, practically, the results of this study show that the success of converting in Lampung is highly dependent on the synergy between religious extension workers, religious institutions, local governments, and civil society. Religious extension workers need to be positioned not only as field implementers, but also as community facilitators who are able to identify the needs of converts and connect them with economic, educational, and social empowerment programs. These findings are in line with the results of various studies that affirm that religious extension workers play an important role in realizing sakinah families through collaborative services across institutions (Husaini et al., 2024).

The participation rate of converts of 52.50%, as shown in the previous table, is empirical evidence that this collaborative strategy effectively increases the involvement and confidence of converts in the coaching process. However, the presence of 47.50% of inactive participants indicates the need to improve mentoring management, especially in terms of data collection, monitoring, and moral and economic support. These findings are also in line with various studies that show that innovations in methods of fostering and assisting converts can increase the effectiveness of religious programs in rural areas (Rezani et al., 2024). In addition, the

application of the value of maslahat in coaching provides a normative basis that the success of da'wah must be oriented towards social benefits, not just ritual compliance (Syarifuddin, 2020).

Thus, overall, this collaborative coaching model has the potential to become a new conceptual framework in Islamic social da'wah, which places converts not only as an object of da'wah, but as an active subject in building a beneficial family and society. This approach is expected to be replicated in other regions by adapting according to socio cultural contexts, as suggested in the research of Husaini et al. (2024) and Rezani et al. (2024), so that the development of converts can be a strategic instrument for social development based on Islamic values.

3. CONCLUSION

This study confirms that religious extension workers have a strategic role in forming a maslahat family among converts in Lampung Province. These roles include spiritual, social, and economic functions that are integrated in a collaborative development model based on benefit values. The findings show that religious extension workers not only function as preachers but also as faith guides, social mediators, and economic empowerment companions.

Field data shows that of the 40 registered converts, 52.50% are still actively participating in coaching, which indicates the initial effectiveness of this integrative approach. This activeness is directly proportional to the increase in understanding of Islam, family resilience, and a sense of confidence in converts as part of the Muslim community. However, 47.50% of participants were no longer active, due to limited facilities, distance, family support, and lack of extension workers. This indicates that the sustainability of coaching is still constrained by institutional and resource factors.

Theoretically, this collaborative coaching model enriches the study of Islamic da'wah by emphasizing that the success of da'wah is not only measured from individual religiosity, but also from social welfare and family resilience. This approach represents Yusuf al-Qardhawi's priority fiqh principles that balance spiritual, rational, and human values. Thus, religious extension workers in Lampung can be categorized as transformative actors in building an inclusive, empowered, and civilized Muslim society.

4. REKOMENDASI

There is a need to strengthen the capacity and role of religious extension workers, the Government and the Ministry of Religion through professional training in the fields of family counseling, community da'wah, and economic empowerment of the people. Extension workers must be positioned as community facilitators who are able to handle the spiritual, social, and economic needs of converts in an integrated manner. In addition, it needs to be supported by strong institutional policies and sustainable budget support. Collaboration

between the Ministry of Religious Affairs, zakat institutions, Islamic organizations, and local governments is important to ensure the sustainability of coaching through integrated social, educational, and economic activities. It is also necessary that the Innovation and Replication of the Collaborative Coaching Model is proven to be effective in Lampung, it needs to be developed with innovative methods, such as online training, community-based mentoring, and local economic empowerment. The success of this model can be replicated in other regions by adjusting the socio cultural context of each region.

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IMPACT ON DIGITALIZATION ON MODERN MARKETING

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Abstract

The appearance of digitalization had great influence on modern marketing because of an advanced strategy that is used for promoting company's products and selling them as well as communicating with clients. Because of usage of advanced digital technology, such as social media, artificial intelligence, analysis of big data, mobile applications, and online advertisement, companies managed to establish productive communication with their clients and reached their target audience. In the process of this literature review, the effects of digitalization on marketing practices will be analyzed, as well as advantages and disadvantages of digitalization for companies. At first, the role of digitalization in research of consumer behavior, as well as providing custom-made services and increasing the effectiveness of the organization, will be discussed. Additionally, concepts like e-commerce, digital brand management, and online customer relationship management will be highlighted. Also, security problems will be discussed.

Therefore, it can be concluded that digitalization has greatly improved modern marketing practices by helping businesses connect with customers more effectively, increase their market reach, and enhance overall business performance.

Keywords: Digitalization, Modern Marketing, Social Media, E-commerce, Consumer Behavior, Digital Technology

GOVERNANCE, INDUSTRIAL TRANSFORMATION AND SOCIETAL IMPACTS OF THE TWIN TRANSITION IN INDIA

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Abstract

This paper examines the governance of the twin transition in India, which combines digital transformation and environmental sustainability. It focuses on how public policies, regulatory frameworks, and institutions support industrial transformation and address societal impacts. The study aims to understand how Industry 4.0 technologies and circular economy practices are shaping India's development pathway. The paper uses a policy-based and analytical approach to explore key government initiatives, industrial strategies, and digital infrastructure development. It highlights how digitalisation, including data-driven systems and platform economies, is improving productivity and supporting sustainable industrial growth. At the same time, circular economy practices are promoting resource efficiency and waste reduction.

The findings show that while India is making progress in aligning digital and green goals, challenges remain in policy coordination, infrastructure gaps, and regulatory implementation. Industrial transformation is also affecting labour markets, creating new opportunities but also risks of job displacement and inequality.

The paper further discusses societal impacts, including inclusion, skill development, and the need for a just transition. It emphasizes that effective governance must be adaptive, inclusive, and well-coordinated across sectors.

The paper concludes that integrated policy frameworks, strong institutions, and sustainable investment are essential to ensure that the twin transition in India supports economic growth, environmental sustainability, and social equity.

Keywords: Twin Transition, Governance, Industrial Transformation, India, Digitalisation, Circular Economy, Industry 4.0, Public Policy, Social Inclusion, Just Transition

SÜRDÜRÜLEBİLİR İLETİŞİM PERSPEKTİFİNDEN ULUSLARARASI TİCARETTE YEŞİL YIKAMA RİSKLERİ: ANONİM VAKA TEMELLİ BİR DEĞERLENDİRME

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Özet

Bu çalışma, sürdürülebilir iletişim perspektifinden uluslararası ticarette yeşil yıkama risklerini anonim vaka temelli bir değerlendirme aracılığıyla incelemektedir. Küresel tedarik zincirlerinde çevresel uygunluk, izlenebilirlik ve kurumsal şeffaflık beklentilerinin güçlenmesi, sürdürülebilirlik beyanlarını dış ticaret ilişkilerinde stratejik bir unsur hâline getirmiştir. Bununla birlikte, çevresel performansa ilişkin beyanların yeterli kanıtla desteklenmemesi, belirsiz kavramlarla sunulması veya fiilî uygulamalarla tutarlı biçimde ilişkilendirilmemesi yeşil yıkama riskini artırabilmektedir. Çalışmada, firma isimlerini teşhir etmeyen bir analiz yolu tercih edilmiştir. Bu kapsamda, ihracata yönelik hazır giyim ürünlerinde "daha sürdürülebilir koleksiyon" beyanı ile uluslararası lojistikte "karbon azaltımı ve karbon dengeleme" beyanları iki anonim vaka olarak ele alınmıştır. Değerlendirme; beyanın açıklığı, kanıt düzeyi, uygulamayla tutarlılığı ve paydaşlar açısından denetlenebilirliği ölçütleri üzerinden yapılmıştır. Analiz, yeşil yıkama riskinin çoğu zaman açık yanlış beyandan değil; sınırlı kanıt, seçici vurgu, teknik kavramların belirsiz kullanımı ve çevresel iddia ile operasyonel gerçeklik arasındaki zayıf bağlantıdan kaynaklandığını göstermektedir. Hazır giyim vakasında risk, sınırlı bir çevresel özelliğin bütünsel sürdürülebilirlik göstergesi gibi sunulmasıyla; lojistik vakasında ise karbon azaltımı ve dengeleme kavramlarının yeterli metodolojik açıklama olmadan kullanılmasıyla ortaya çıkmaktadır. Bu bağlamda, uluslararası ticarette sürdürülebilir iletişimin güvenilirliği, çevresel beyanların görünürlüğünden çok açıklık, ölçülebilirlik, doğrulanabilirlik ve uygulamayla tutarlılık düzeyine bağlıdır.

Anahtar Kelimeler: Uluslararası Ticaret, Yeşil Yıkama, Sürdürülebilir İletişim

RISKS OF GREENWASHING IN INTERNATIONAL TRADE FROM A SUSTAINABLE COMMUNICATION PERSPECTIVE: AN ANONYMOUS CASE-BASED ASSESSMENT

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Abstract

This study examines greenwashing risks in international trade from the perspective of sustainable communication through an anonymous case-based evaluation. The strengthening of expectations regarding environmental compliance, traceability, and corporate transparency in global supply chains has transformed sustainability claims into a strategic element in foreign trade relations. However, the failure to support claims concerning environmental performance with sufficient evidence, their presentation through ambiguous concepts, or their lack of consistent association with actual practices may increase the risk of greenwashing. In this study, an analytical approach that does not disclose company names has been preferred. Within this scope, the claim of a "more sustainable collection" in export-oriented ready-to-wear products and the claims of "carbon reduction and carbon offsetting" in international logistics have been addressed as two anonymous cases. The evaluation has been conducted on the basis of the clarity of the claim, the level of evidence, consistency with practice, and verifiability from the perspective of stakeholders. The analysis shows that the risk of greenwashing often arises not from explicitly false claims, but from limited evidence, selective emphasis, ambiguous use of technical concepts, and the weak connection between environmental claims and operational reality. In the ready-to-wear case, the risk emerges from the presentation of a limited environmental attribute as an indicator of holistic sustainability; in the logistics case, it emerges from the use of carbon reduction and offsetting concepts without sufficient methodological explanation. In this context, the credibility of sustainable communication in international trade depends less on the visibility of environmental claims than on their clarity, measurability, verifiability, and consistency with practice.

Keywords: International Trade, Greenwashing, Sustainable Communication

GİRİŞ

Sürdürülebilirlik, uluslararası ticaretin yalnızca üretim ve lojistik boyutunu değil, aynı zamanda firmaların çevresel sorumluluklarını nasıl açıkladığını, belgelendirdiğini ve paydaşlara nasıl sunduğunu da dönüştürmektedir. Küresel tedarik zincirlerinde çevresel standartların, izlenebilirlik beklentilerinin ve sürdürülebilir üretim taahhütlerinin önem kazanmasıyla birlikte, sürdürülebilir iletişim dış ticaret ilişkilerinde stratejik bir unsur hâline gelmiştir. Bu iletişim biçimi, firmaların çevresel ve sosyal performanslarına ilişkin bilgi aktarımını/paylaşımını işaret etmekle birlikte, yalnızca tanıtım veya imaj oluşturma faaliyeti olarak değerlendirilememektedir. Sürdürülebilir iletişimin güvenilirliği; açıklanan bilgilerin doğrulanabilirliği, kullanılan kavramların açıklığı, iddiaların ölçülebilirliği ve kurumsal uygulamalarla uyumu üzerinden şekillenmektedir (Siano vd., 2016; Sirén, 2023).

Bu bağlamda yeşil yıkama (greenwashing) riski, uluslararası ticaret aktörleri açısından giderek daha önemli bir sorunlu alan oluşturmaktadır. Yeşil yıkama, çevresel performansa ilişkin olumlu beyanların fiilî uygulamalarla yeterince desteklenmemesi, olumsuz bilgilerin görünmez kılınması, belirsiz ifadelerin kullanılması veya sınırlı bir çevresel uygulamanın bütünsel sürdürülebilirlik başarısı gibi sunulması durumlarında ortaya çıkabilmektedir. Literatürde yeşil yıkamanın yalnızca açık biçimde yanlış beyanlardan ibaret olmadığı; seçici açıklama, sembolik sürdürülebilirlik anlatısı, eksik kanıtlama ve karmaşık teknik dil kullanımı gibi daha örtük iletişim biçimleriyle de ilişkili olduğu belirtilmektedir (Janik ve Ryszko, 2026; Lorincz, 2021). Bu durum, özellikle uluslararası ticarette bilgi asimetrisi (information asymmetry) koşullarını güçlendirmekte ve alıcılar, tedarikçiler, düzenleyici aktörler ve nihai tüketiciler açısından güven sorunu yaratabilmektedir.

Önceki çalışmalar, sürdürülebilir iletişimin dijital kanallar, kurumsal internet siteleri, raporlar ve pazarlama materyalleri aracılığıyla giderek daha görünür hâle geldiğini göstermiştir. Siano ve diğerleri (2016), sürdürülebilir iletişimde içerik, yapı, yönelim ve erişilebilirlik gibi unsurların değerlendirilmesi gerektiğini vurgulamıştır. Sirén (2023), etkili sürdürülebilir iletişimin gerçek kurumsal başarılarla desteklenmesi, hedef kitleye uygun biçimde tasarlanması ve açık mesajlara dayanması gerektiğini belirtmiştir. Yeşil yıkama literatüründe ise iletişim ile gerçek performans arasındaki ayrışma (decoupling), sembolik ve özsel eylemler arasındaki fark, seçici açıklama ve manipülatif anlatım kalıpları öne çıkmaktadır (Janik ve Ryszko, 2026). Bu çalışma, söz konusu literatürle bağlantı kurmakla birlikte, doğrudan söylem analizi ya da belirli firmaların teşhiri amacı taşımamaktadır. Çalışmanın ayırt edici yönü, uluslararası ticaret bağlamında karşılaşılabilecek yeşil yıkama risklerini vaka tartışmaları üzerinden değerlendirmesidir.

Bu çalışmada nitel ve kavramsal bir araştırma deseni benimsenmiştir. Anonim vaka temelli yaklaşım, tekil firmaların performansını değerlendirmek yerine, uluslararası ticaret

süreçlerinde tekrar edebilen iletişimsel risk kalıplarını görünür kılmayı amaçlamaktadır. Çalışmanın temel araştırma önermesi, uluslararası ticarette sürdürülebilirlik beyanlarının güvenilirliğinin, beyanların yoğunluğundan ziyade kanıtlanabilirlik, açıklık ve uygulamayla tutarlılık düzeyine bağlı olduğudur. Belirsiz çevresel kavramların kullanımı yeşil yıkama algısını güçlendirebilir; seçici bilgi sunumu sürdürülebilir iletişimin güvenilirliğini zayıflatabilir; kurumsal beyan ile operasyonel uygulama arasındaki ayrışma ise dış ticaret ilişkilerinde itibar ve güven riskini artırabilir. Buradan hareketle çalışma, yeşil yıkama riskinin hangi iletişimsel göstergeler üzerinden tanımlanabileceğini ve uluslararası ticaret pratiklerinde nasıl değerlendirilebileceğini tartışmayı hedeflemektedir.

1. KAVRAMSAL ÇERÇEVE

Sürdürülebilir iletişim, bu çalışmada çevresel ve sosyal performans iddialarının paydaşlar tarafından değerlendirilebilir hâle getirilmesini sağlayan kurumsal açıklama pratiği olarak ele alınmaktadır. Bu yönüyle kavram, yalnızca olumlu çevresel mesajların dolaşıma sokulmasını değil, beyan edilen performans ile fiilî uygulamalar arasındaki ilişkinin açık, izlenebilir ve denetlenebilir biçimde kurulmasını ifade etmektedir. Siano ve diğerleri (2016) gerçekleştirdikleri çalışmada, sürdürülebilirlik iletişiminin çevrim içi ortamlarda yönelim, yapı, ergonomi ve içerik boyutları üzerinden değerlendirilebileceğini belirtmişlerdir. Bu çerçeve, sürdürülebilir iletişimin; bilginin yapılandırılma biçimi, erişilebilirliği, paydaş katılımını mümkün kılan süreçler ve yönetişim araçlarıyla nasıl desteklendiği ile ilişkili olduğunu göstermektedir. Dolayısıyla sürdürülebilir iletişim, kurumsal beyanların ötesine geçen ve hesap verebilirliği güçlendiren stratejik bir yönetim alanı olarak konumlandırılmalıdır.

Bu yaklaşım, sürdürülebilir iletişimin güvenilirliğini belirleyen temel ölçütleri de gündeme getirmektedir. Sirén (2023), etkili sürdürülebilir iletişimin stratejik bir temele dayanması, kurumsal gerçeklikten beslenmesi, hedef kitleye uygun biçimde tasarlanması, anlaşılır olması ve ölçülebilir amaçlarla ilişkilendirilmesi gerektiğini vurgulamıştır. Bu değerlendirme, uluslararası ticaret açısından oldukça önemlidir. Çünkü dış ticaret süreçlerinde taraflar çoğu zaman aynı kurumsal, hukuki ve kültürel bilgi alanını paylaşmamaktadır. İhracatçı firmanın çevresel performansına ilişkin bir beyan, alıcı firma, ithalatçı, dağıtıcı, nihai tüketici veya düzenleyici kurum tarafından aynı biçimde yorumlanmayabilir. Bu nedenle sürdürülebilirlik beyanlarının açık, ölçülebilir ve doğrulanabilir olması, yalnızca iletişimsel bir tercih değil aynı zamanda güven ilişkisini koruyan ticari bir gereklilik niteliği taşımaktadır.

Yeşil yıkama riski, sürdürülebilir iletişimin bu güven ilişkisini zayıflatan temel sorun alanlarından biridir. Kavram, çevresel performansın olduğundan daha olumlu sunulması, olumsuz bilgilerin geri planda bırakılması, sınırlı bir uygulamanın geniş kapsamlı sürdürülebilirlik başarısı gibi temsil edilmesi veya çevresel beyanların yeterli kanıtla

desteklenmemesi durumlarında ortaya çıkabilmektedir. Janik ve Ryszko (2026), yeşil yıkamanın sürdürülebilirlik raporlamasında; açıklama ile performans arasındaki farklılıklar, sembolik ve özsel sürdürülebilirlik eylemlerinin ayrışması ve seçici açıklama pratikleri üzerinden değerlendirilebileceğini ileri sürmektedir. Bu perspektif, yeşil yıkamayı yanlış veya yanıltıcı beyanlarla sınırlı bir iletişim sorunu olmaktan çıkararak, eksik, dengesiz ya da aşırı olumlu kurumsal söylemleri de kapsayan daha geniş bir açıklama çerçevesi sunmaktadır.

Uluslararası ticaret bağlamında bu ayrım daha da kritik hâle gelmektedir. Çünkü ticari ilişkiler çoğu zaman çok katmanlı tedarik zincirleri, farklı üretim coğrafyaları ve değişen düzenleyici beklentiler üzerinden kurulmaktadır. Bir ürünün "çevre dostu", "daha sürdürülebilir", "karbon nötr" veya "sorumlu kaynaklardan elde edilmiş" olarak sunulması, bu beyanların sınırları açıkça belirlenmediğinde yanlış yönlendirici sonuçlar doğurabilmektedir. Lorincz'in (2021) moda sektörü özelinde yürüttüğü çalışma, belirsiz ve muğlak kavramların, önemli bilgilerin dışarıda bırakılmasının, sorgulanabilir liderlik iddialarının ve teknik/bilimsel ifadelerin anlaşılması güç biçimde kullanılmasının yanıltıcılık riskini artırabildiğini göstermiştir. Bu bulgu, her sektör için doğrudan genellenmemekle birlikte, çevresel beyanların nasıl kurulduğuna ilişkin önemli bir uyarı niteliği taşımaktadır.

Sürdürülebilirlik beyanlarının güvenilirliği, beyanların içeriğinden çok, kurumsal uygulamalarla ne ölçüde örtüştüğü üzerinden değerlendirilmektedir. Bu noktada sembolik ve özsel eylem ayrımı önem kazanmaktadır. Sembolik eylemler, sürdürülebilirlik algısını güçlendirmeye yönelik açıklama, raporlama ve kurumsal iletişim faaliyetlerini ifade ederken; özsel eylemler, üretim, tedarik, lojistik, enerji kullanımı, atık yönetimi ve yönetişim süreçlerinde somut ve ölçülebilir dönüşümleri kapsamaktadır. Sisdyani ve diğerleri (2025) gerçekleştirdikleri çalışmada, sürdürülebilirlik raporlarında kullanılan retorik stratejilerin kimi durumlarda kurumsal itibarı koruma ve olumlu algı oluşturma işlevi görebildiğini ifade etmişlerdir. Bu bulgu, sürdürülebilir iletişimin her durumda otomatik olarak hesap verebilirlik üretmediğini; bazı koşullarda kurumsal meşruiyeti destekleyen sembolik bir araç hâline gelebileceğini düşündürmektedir.

Paydaş yorumu da yeşil yıkama riskinin anlaşılmasında belirleyici bir unsurdur. Ylä-Outinen ve diğerleri (2020), kuruluşların sürdürülebilirlik ve kurumsal sosyal sorumluluk taahhütlerini farklı biçimlerde sunduklarını ve bu iletişimin paydaşlar tarafından farklı biçimlerde yorumlanabildiğini ortaya koymuşlardır. Bu değerlendirme, uluslararası ticaret bakımından önemlidir; çünkü aynı çevresel beyan bir pazarda yeterli ve güvenilir bulunabilirken, başka bir pazarda eksik kanıt, belirsiz terminoloji veya seçici bilgi sunumu nedeniyle yeşil yıkama riskine ilişkin algıyı güçlendirebilir. Bu nedenle sürdürülebilir iletişim, yalnızca firmanın niyetine değil, paydaşların değerlendirme kapasitesine ve bilgiye erişim koşullarına göre de ele alınmalıdır.

Bu çalışmanın kavramsal çerçevesi, sürdürülebilir iletişim ile yeşil yıkama riskini uluslararası ticaretin bilgi, güven ve uygunluk dinamikleri içinde birlikte değerlendirmektedir. Anonim vaka temelli yaklaşım, belirli firmaları hedef almadan tekrar eden risk örüntülerini tartışmaya imkân tanımaktadır. Bu çerçevede çevresel beyanların dört temel eksende incelenmesi önerilmektedir: beyanın açıklığı, beyanın kanıt düzeyi, beyan ile uygulama arasındaki tutarlılık ve beyanın paydaşlar açısından denetlenebilirliği. Açıklık, kullanılan kavramların sınırlarının belirli olup olmadığını; kanıt düzeyi, iddianın veri, rapor, sertifika veya üçüncü taraf doğrulamasıyla desteklenip desteklenmediğini; tutarlılık, iletişimde sunulan iddianın operasyonel süreçlerle ne ölçüde uyumlu olduğunu; denetlenebilirlik ise paydaşların bu iddiaları bağımsız biçimde değerlendirme imkânına sahip olup olmadığını ifade etmektedir.

Özetle sürdürülebilir iletişim, uluslararası ticarette olumlu çevresel imaj üretiminin ötesinde, ticari güvenin, piyasa kabulünün ve kurumsal sorumluluğun parçası olarak değerlendirilmelidir. Yeşil yıkama riski, çoğu zaman çevresel beyanların varlığından ziyade, bu beyanların belirsiz, kanıtsız, seçici veya uygulamadan kopuk biçimde yapılandırılmasından kaynaklanmaktadır. Bu nedenle çalışmanın kavramsal zemini, çevresel iletişimi mesaj yoğunluğu üzerinden değil; açıklık, kanıtlanabilirlik, tutarlılık ve denetlenebilirlik üzerinden değerlendirmektedir. Bu çerçeve, firmaları hedef göstermeden söz konusu riskleri tartışmaya ve uluslararası ticarette daha güvenilir sürdürülebilir iletişim ilkelerinin geliştirilmesine yönelik bir araştırma zemini sunmaktadır.

2. ANALİZ

Bu bölümde, uluslararası ticarette sürdürülebilir iletişim ile yeşil yıkama riski arasındaki ilişki iki anonim vaka üzerinden değerlendirilmektedir. Vakalar, belirli firmaları teşhir etmeyi ya da tekil kurumsal performans hakkında kesin hüküm vermeyi amaçlamamaktadır. Bunun yerine, literatürde tanımlanan iletişimsel risk örüntülerinin dış ticaret süreçlerinde nasıl ortaya çıkabileceğini göstermeye yönelik tipikleştirilmiş örnekler olarak ele alınmaktadır. Bu nedenle vakalar, ampirik firma incelemesi olarak ele alınmamış, literatürde tanımlanan risk örüntülerini görünür kılmaya yönelik analitik senaryolar olarak değerlendirilmiştir.

Değerlendirme; çevresel beyanın açıklığı, beyanın kanıt düzeyi, beyan ile uygulama arasındaki tutarlılık ve beyanın paydaşlar açısından denetlenebilirliği olmak üzere dört ölçüt üzerinden yapılmıştır. Bu ölçütler, sürdürülebilir iletişimin yalnızca mesaj üretimiyle değil, bilginin erişilebilirliği, doğrulanabilirliği ve kurumsal uygulamalarla ilişkisiyle de değerlendirilmesi gerektiği varsayımına dayanmaktadır (Siano vd., 2016; Sirén, 2023).

Vaka 1: İhracata Yönelik Hazır Giyim Ürünlerinde "Daha Sürdürülebilir Koleksiyon" Beyanı

Birinci vaka, uluslararası pazarlara ürün satan bir hazır giyim firmasının, belirli bir ürün grubunu "daha sürdürülebilir", "sorumlu kaynaklardan üretilmiş" ve "çevreye daha duyarlı koleksiyon" ifadeleriyle tanıtması üzerine kuruludur. Firma, ihracata konu ürünlerinde geri dönüştürülmüş elyaf, organik pamuk veya alternatif malzeme kullanımını vurgulamakta; ancak bu malzemelerin toplam ürün içindeki oranı, tedarik zincirinin hangi aşamasında doğrulandığı, üretim sürecinde kullanılan enerji kaynakları ve ürün yaşam döngüsü etkileri yeterince açık biçimde sunulmamaktadır. Bu tür bir iletişim, ilk bakışta çevresel duyarlılığı destekleyen bir kurumsal girişim olarak değerlendirilebilir. Bununla birlikte, beyanın sınırları netleştirilmediğinde, sürdürülebilir iletişim ile yeşil yıkama riski arasındaki mesafe daralmaktadır. Bu tür beyanlar, özellikle alıcı firmaların sürdürülebilir tedarik kriterleri, perakende zincirlerinin etik satın alma politikaları ve ihracat pazarlarındaki çevresel uygunluk beklentileri nedeniyle ticari değer kazanmaktadır.

Bu vakada ilk risk, kavramların belirsizliğinden kaynaklanmaktadır. "Daha sürdürülebilir" ifadesi, karşılaştırmanın hangi ürün grubuna, hangi üretim dönemine veya hangi çevresel göstergeye göre yapıldığını açıklamadığında, paydaşlar açısından sınırlı bir değerlendirme imkânı sağlamaktadır. Lorincz (2021), sürdürülebilir moda iletişiminde belirsiz ve muğlak kavram kullanımının yanıltıcılık riskini artırdığını belirtmiştir. Bu bulgu, hazır giyim ihracatı bağlamında önemli derecede anlamlıdır. Çünkü ürünlerin çevresel niteliği yalnızca kullanılan materyalle değil aynı zamanda su tüketimi, kimyasal kullanımı, enerji yoğunluğu, lojistik mesafe, işçilik koşulları ve atık yönetimi gibi çok sayıda unsurla ilişkilidir. Dolayısıyla tek bir olumlu unsurun tüm ürün grubunun sürdürülebilirliğini temsil edecek biçimde sunulması, seçici açıklama riskini artırmaktadır.

İkinci risk, kanıt düzeyinin sınırlı kalmasıdır. Firma tarafından kullanılan sertifika, etiket veya çevresel standartların kapsamı açık biçimde belirtilmediğinde, bu araçlar doğrulama mekanizması olmaktan çok ikna edici semboller hâline gelebilmektedir. Siano ve diğerleri (2016) gerçekleştirdikleri çalışmada, sürdürülebilirlik iletişiminde açıklık, doğrulanabilirlik, tutarlılık ve güvenilir kaynaklarla desteklenmiş bilgi sunumunun önemini vurgulamaktadır. Bu açıdan değerlendirildiğinde, hazır giyim ihracatında çevresel beyanın yalnızca ürün etiketinde veya dijital pazarlama içeriğinde yer alması yeterli değildir. Beyanın hangi veri, sertifika, üretim standardı veya üçüncü taraf doğrulamasıyla desteklendiğinin de erişilebilir olması gerekmektedir.

Üçüncü risk, ürün düzeyindeki çevresel beyan ile firmanın genel iş modeli arasındaki ilişkiden doğmaktadır. Hızlı üretim, sık koleksiyon yenileme ve yüksek hacimli satış stratejileri devam ederken, belirli bir koleksiyonun sürdürülebilirlik göstergesi olarak öne çıkarılması, iletişim

ile operasyonel gerçeklik arasında bir gerilim yaratabilir. Bu durum, doğrudan yeşil yıkama olarak adlandırılmak zorunda değildir ancak açıklama ile performans arasındaki farkın büyümesi, yeşil yıkama riskinin değerlendirilmesini gerektirmektedir. Janik ve Ryszko (2026), yeşil yıkama ölçümünde açıklama-performans farkı, sembolik ve özsel sürdürülebilirlik ayrımı ve seçici açıklama pratiklerinin önemli olduğunu belirtmiştir. Bu vakada risk, çevresel iddianın tamamen yanlış olmasından ziyade iddianın kapsamının olduğundan geniş algılanabilecek biçimde kurulmasından kaynaklanmaktadır.

Bu nedenle birinci vaka, sürdürülebilir iletişim açısından üç temel ders sunmaktadır. Öncelikle, çevresel beyanlarda göreli ifadeler yerine ölçülebilir göstergelere yer verilmelidir. İkinci olarak, ürün bazlı sürdürülebilirlik iddiaları tedarik zinciri ve üretim süreciyle ilişkilendirilmelidir. Üçüncü olarak, çevresel iletişim yalnızca başarıları değil, sınırlılıkları da içermelidir. Aksi halde görünürlük artarken güvenilirlik zayıflayabilmektedir.

Vaka 2: Uluslararası Lojistikte Karbon Azaltımı Beyanları

İkinci vaka, ihracat süreçlerinde taşıma ve lojistik hizmeti sunan bir firmanın, uluslararası müşterilerine "düşük karbonlu taşıma", "karbon dengelenmiş teslimat" veya "iklim dostu lojistik çözümü" gibi ifadelerle hizmet sunması üzerine kuruludur. Firma, karbon dengeleme (carbon offsetting) programlarına katılımını, yakıt verimliliği sağlayan teknolojileri veya geleceğe dönük net sıfır hedeflerini pazarlama iletişiminde öne çıkarmaktadır. Ancak bu beyanlarda hangi emisyon kapsamının dikkate alındığı, dengeleme projelerinin niteliği, hesaplama metodolojisi, üçüncü taraf doğrulaması ve taşıma hizmetinin toplam karbon etkisi yeterince ayrıntılandırılmamaktadır.

Bu vaka, uluslararası ticaret açısından kritik bir alana işaret etmektedir. Dış ticarette ürünün rekabet gücü artık yalnızca üretim maliyeti ve teslim süresiyle değil, taşıma sürecinin çevresel etkisiyle de bağlantılı hâle gelmiştir. Özellikle sınır ötesi tedarik zincirlerinde lojistik kaynaklı emisyonlar, alıcı firmaların sürdürülebilirlik raporlaması ve tedarikçi seçimleri açısından önem kazanmaktadır. Bununla birlikte, karbon azaltımı ve dengeleme beyanları teknik bilgi gerektiren alanlara dayandığı için bilgi asimetrisi riski yüksektir.

Bu vakadaki ilk sorun, karbon azaltımı ile karbon dengeleme arasındaki farkın yeterince açıklanmamasıdır. Karbon azaltımı, operasyonel süreçlerde emisyonların fiilen düşürülmesini ifade ederken; karbon dengeleme, ortaya çıkan emisyonların farklı projeler aracılığıyla telafi edilmesi iddiasına dayanmaktadır. Bu iki mekanizmanın aynı iletişimsel düzlemde sunulması, paydaşlarda taşıma hizmetinin doğrudan düşük emisyonlu olduğu izlenimini oluşturabilir. Oysa dengeleme uygulamaları, kullanılan metodolojiye, projenin ek katkı niteliğine, kalıcılığına ve doğrulama mekanizmasına bağlı olarak farklı güvenilirlik düzeylerine sahiptir. Bu nedenle "karbon dengelenmiş teslimat" ifadesi tek başına yeterli bir sürdürülebilirlik göstergesi olarak değerlendirilmemelidir.

İkinci sorun, hedef ve performans arasındaki ilişkinin belirsiz kalmasıdır. Net sıfır, düşük karbonlu taşımacılık veya sürdürülebilir lojistik gibi gelecek yönelimli hedefler; ara hedefler, yıllık performans göstergeleri ve doğrulama süreçleriyle desteklenmezse, sembolik iletişim alanına kayabilir. Janik ve Ryszko (2026), sembolik sürdürülebilirlik açıklamalarının geniş taahhütler, olumlu anlatılar ve kanıtlanması güç hedefler üzerinden kurulabildiğini; özsel açıklamaların ise ölçülebilir, doğrulanabilir ve somut uygulamalarla desteklendiğini belirtmiştir. Bu vaka söz konusu ayrım üzerinden okunabilir. Lojistik firmasının çevresel girişimleri gerçek olabilir; ancak bu girişimler sayısal emisyon azaltımı, kapsam açıklaması ve bağımsız doğrulama ile desteklenmediğinde, uluslararası müşteriler açısından güven sorunu doğabilir.

Üçüncü sorun, çevresel beyanın ticari ilişkide rekabet avantajı üretmek için kullanılmasıdır. Sürdürülebilir lojistik iddiası, ihracatçı firmaların alıcı nezdinde daha uygun tedarikçi olarak görünmesine katkı sağlayabilir. Ancak bu iddia kanıtlanabilir değilse, lojistik firmasının yanı sıra bu hizmeti kullanan ihracatçı firmanın da sürdürülebilirlik iletişimini zayıflatabilir. Sisdyani ve diğerleri (2025) gerçekleştirdikleri çalışmada, sürdürülebilirlik raporlarının ve açıklamalarının yalnızca bilgi verme aracı değil, aynı zamanda kurumsal imajı şekillendiren stratejik anlatılar olarak işlev görebildiğini göstermektedir. Bu nedenle karbon beyanlarının retorik bir kurumsal konumlandırma aracı hâline gelmemesi için ölçüm, açıklama ve doğrulama bileşenleri birlikte tasarlanmalıdır.

İkinci vaka, sürdürülebilir iletişimde teknik kavramların sadeleştirilmesi gereğini de ortaya koymaktadır. Karbon dengeleme, biyoyakıt, düşük karbon teknolojisi, net sıfır ve emisyon kapsamı gibi kavramlar, uzman olmayan paydaşlar açısından anlaşılması güç olabilir. Sirén (2023), sürdürülebilirlik iletişiminde mesajların açık, anlaşılır, hedef kitleyle uyumlu ve gerçek başarılarla desteklenmiş olması gerektiğini vurgulamaktadır. Bu nedenle uluslararası taşımacılıkta çevresel beyanlar hem teknik doğruluk hem de paydaşlar tarafından anlaşılabilirlik bakımından değerlendirilmelidir.

Bu iki vaka, yeşil yıkama riskinin özellikle belirsiz kapsam, sınırlı kanıt, seçici vurgu ve uygulamayla zayıf bağlantı noktalarında yoğunlaştığını göstermektedir.

3. SONUÇ

Bu çalışmada, sürdürülebilir iletişim perspektifinden uluslararası ticarette yeşil yıkama riskleri anonim vaka temelli bir değerlendirme aracılığıyla ele alınmıştır. Çalışmanın temel hareket noktası, sürdürülebilirlik beyanlarının uluslararası ticarette yalnızca kurumsal imaj veya pazarlama iletişimi açısından değil, aynı zamanda güven, uygunluk, tedarik zinciri ilişkileri ve rekabetçi konumlanma açısından da önem taşıdığı varsayımına dayanmaktadır. Bu bağlamda çevresel beyanların değeri, beyanların görünürlüğünden veya sıklığından ziyade açıklık, kanıtlanabilirlik, tutarlılık ve denetlenebilirlik düzeyi üzerinden değerlendirilmiştir.

Anonim vaka değerlendirmeleri, yeşil yıkama riskinin çoğu zaman açık biçimde yanlış bilgi verilmesinden değil, daha örtük iletişimsel zayıflıklardan kaynaklandığını göstermektedir. Hazır giyim ihracatı örneğinde risk, belirli bir çevresel özelliğin ürünün ya da koleksiyonun genel sürdürülebilirlik performansını temsil edecek biçimde sunulmasından doğmaktadır. Bu durumda sürdürülebilirlik beyanı bütünüyle geçersiz olmayabilir; ancak beyanın kapsamı, ölçüm sınırları ve tedarik zinciriyle ilişkisi açıkça belirtilmediğinde, paydaşlar açısından yanıltıcı bir algı oluşabilmektedir. Uluslararası lojistik örneğinde ise karbon azaltımı, karbon dengeleme ve net sıfır gibi teknik kavramların yeterli metodolojik açıklama olmadan kullanılması temel risk alanı olarak öne çıkmaktadır. Bu tür beyanlar, özellikle üçüncü taraf doğrulaması, emisyon kapsamı ve ölçüm yöntemiyle desteklenmediğinde sürdürülebilir iletişimin güvenilirliğini zayıflatabilmektedir.

Bu sonuçlar, çalışmanın temel araştırma önermesini desteklemektedir. Uluslararası ticarette sürdürülebilirlik beyanlarının güvenilirliği, beyanların yoğunluğundan çok, beyan ile uygulama arasındaki ilişkinin ne ölçüde açık ve izlenebilir kurulduğuna bağlıdır. Bu nedenle sürdürülebilir iletişim, firmaların çevresel performanslarını idealize eden bir anlatı alanı olarak değil, kurumsal sorumluluk ile ticari güven arasında bağlantı kuran bir açıklama pratiği olarak değerlendirilmelidir. Siano ve diğerlerinin (2016) sürdürülebilirlik iletişiminde içerik, yapı ve erişilebilirlik boyutlarına yaptığı vurgu ile Janik ve Ryszko'nun (2026) açıklama-performans farkı ve sembolik-özsel eylem ayrımına ilişkin değerlendirmeleri bu çerçeveyi desteklemektedir. Benzer biçimde Sirén'in (2023) şeffaflık, gerçek başarı ve hedef kitleye uygunluk vurgusu, çevresel beyanların teknik doğrulukla olduğu kadar anlaşılabilirlik ve paydaş güveniyle de ilişkili olduğunu göstermektedir.

Çalışmanın teorik katkısı, sürdürülebilir iletişim ve yeşil yıkama tartışmalarını uluslararası ticaret bağlamında birlikte ele almasında ortaya çıkmaktadır. Mevcut literatürde yeşil yıkama çoğunlukla tüketici iletişimi, kurumsal raporlama veya dijital iletişim kanalları üzerinden incelenmektedir. Bu çalışma ise çevresel beyanların dış ticaret ilişkilerinde tedarikçi seçimi, alıcı güveni, pazara erişim ve kurumsal uygunluk bakımından taşıdığı anlamı öne çıkarmaktadır. Böylece yeşil yıkama, yalnızca etik olmayan iletişim riski olarak değil, uluslararası ticaret aktörleri açısından ticari ve kurumsal güveni etkileyen yapısal bir sorun alanı olarak değerlendirilmiştir. Anonim vaka yaklaşımı ise firma düzeyinde özdeşleştirmeye gitmeden tekrar eden iletişimsel risk kalıplarının tartışılmasına olanak sağlamıştır.

Analize göre, çevresel beyanların daha güvenilir hâle gelebilmesi için kullanılan kavramların sınırları açıkça belirtilmeli, sürdürülebilirlik iddiaları ölçülebilir göstergelerle desteklenmeli, sertifika ve etiketlerin kapsamı açıklanmalı ve beyanların üretim, tedarik ve lojistik süreçleriyle ilişkisi görünür kılınmalıdır. Ayrıca firmaların yalnızca olumlu çevresel başarıları değil, sınırlılıkları, geçiş sürecindeki eksiklikleri ve iyileştirme alanlarını da açıklaması, sürdürülebilir iletişimin güvenilirliğini artırabilecek bir unsur olarak değerlendirilebilir.

Sonuç olarak, uluslararası ticarette yeşil dönüşüm, bir yandan üretim süreçlerinin çevresel niteliğiyle, diğer yandan ise bu niteliğin nasıl açıklandığı, kanıtlandığı ve paydaşlar açısından nasıl değerlendirilebilir kılındığıyla ilişkili bir süreçtir. Sürdürülebilir iletişim, bu nedenle çevresel sorumluluk iddialarını ticari güvene dönüştürebilecek önemli bir araçtır. Ancak bu aracın güvenilirliği, beyanların açıklığı, kanıt gücü ve uygulamayla tutarlılığı ölçüsünde mümkün olabilmektedir. Bu çerçevede yeşil yıkama riskinin azaltılması, sürdürülebilirlik söylemi üretimini artırmaktan ziyade, ölçülebilir, doğrulanabilir ve sınırları açık biçimde yapılandırılmış çevresel iletişim pratiklerinin geliştirilmesini gerektirmektedir.

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ENDÜSTRİYEL EKOSİSTEMLER, ENDÜSTRİ 4.0 VE AKILLI ÜRETİM: DİJİTAL DÖNÜŞÜM, SERVİTİZASYON VE SÜRDÜRÜLEBİLİRLİK ÜZERİNE KAPSAMLI BİR ARAŞTIRMA RAPORU

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Özet

Dördüncü Sanayi Devrimi olarak bilinen Endüstri 4.0, geleneksel üretim paradigmalarını temelden sarsarak yerini siber-fiziksel sistemlere, birbirine bağlı dijital ağlara ve otonom üretim süreçlerine bırakmaktadır (Lasi vd., 2014). Bu devasa dönüşüm süreci yalnızca fiziksel makinelerin sensörlerle donatılması anlamına gelmemekte; aynı zamanda değer yaratma mekanizmalarının lineer tedarik zincirlerinden çıkıp, çok taraflı, eşgüdümlü ve modüler "endüstriyel ekosistemlere" evrilmesini zorunlu kılmaktadır (Jacobides vd., 2018). Gelişen bu yeni yapıda yapay zeka (AI), nesnelerin interneti (IoT), büyük veri analitiği ve dijital ikiz (Digital Twin) gibi yıkıcı teknolojiler, akıllı üretim (Smart Manufacturing) mimarisinin teknolojik omurgasını oluşturmaktadır (Kusiak, 2018). Bu bildiri formatındaki araştırma raporu, Endüstri 4.0 teknolojilerinin endüstriyel süreçlerdeki salt verimlilik artışının ötesine geçerek, iş modellerini "dijital servitizasyon" (ürün-hizmet sistemleri) yönünde nasıl dönüştürdüğünü ve bu yapıların döngüsel ekonomi prensipleriyle (endüstriyel simbiyoz) nasıl entegre olduğunu çok boyutlu bir perspektifle incelemektedir (Frank vd., 2019; Chertow, 2000). Ayrıca, uluslararası ampirik veriler ve pazar büyüme metrikleri ışığında, Türkiye'nin ulusal inovasyon ekosistemi bağlamında karşılaşılan yapısal engeller ve ekosistem dinamikleri derinlemesine değerlendirilmektedir (Yiğit, 2018). Araştırma bulguları, akıllı üretime geçişin sadece donanım ve yazılım yatırımlarıyla başarılamayacağını; teknoloji, organizasyonel kültür ve çevresel uyumu (TOE çerçevesi) entegre eden bütüncül ekosistem orkestrasyonunun hayati bir gereklilik olduğunu kanıtlamaktadır (Ghobakhloo, 2020).

Anahtar Kelimeler: Akıllı Üretim, Endüstri 4.0, Sürdürülebilirlik, Yenilik, İnovasyon, Dijital Servitizasyon, İş Modelleri

GİRİŞ VE KAVRAMSAL ÇERÇEVE

Sanayi devrimlerinin tarihsel evrimi incelendiğinde; buhar gücünün mekanizasyonu sağladığı birinci devrimi, elektrik enerjisiyle kitle üretiminin başladığı ikinci devrim ve bilgisayar destekli otomasyonun devreye girdiği üçüncü devrim izlemiştir. Günümüzde ise, siber-fiziksel sistemler (CPS) ve endüstriyel ağlar üzerinden ilerleyen dördüncü döneme, yani Endüstri 4.0 evresine girilmiş bulunmaktadır (Lasi vd., 2014). İlk olarak 2011 yılında Almanya'daki Hannover Fuarı'nda kamuoyuna duyurulan ve 2013 yılında Acatech (Alman Ulusal Bilim ve Mühendislik Akademisi) tarafından stratejik bir referans modeli (RAMI 4.0) olarak yayınlanan bu vizyon, üretim dünyasında bir paradigma kaymasını temsil etmektedir (Kagermann vd., 2013).

Geleneksel otomasyon sistemlerinde makineler izole edilmiş adacıklar halinde çalışırken, Endüstri 4.0 yaklaşımında sistemler arası karşılıklı çalışabilirlik (interoperability), makine-makine (M2M), uygulama-uygulama (A2A) ve işletme-işletme (B2B) etkileşimleri esastır. Akıllı üretim (Smart Manufacturing), üretim varlıklarının internet, bulut bilişim ve hizmet odaklı mimariler aracılığıyla birbirine bağlandığı, fiziksel ve siber dünyaların gerçek zamanlı verilerle entegre edildiği veri güdümlü bir dönemdir (Kusiak, 2018; Tao vd., 2018). Söz konusu geçişin arkasındaki temel motivasyon kaynakları; küresel rekabet ortamında hiper-kişiselleştirilmiş ürün taleplerini karşılamak, çevresel sürdürülebilirlik hedeflerine ulaşmak (ESG) ve tedarik zincirlerindeki öngörülemez dalgalanmalara anında yanıt verebilecek dayanıklı (resilient) sistemler inşa etmektir.

Literatür incelendiğinde Endüstri 4.0'ın "ne" olduğu ve "neden" gerekli olduğu konusunda güçlü bir fikir birliği bulunmasına rağmen, bu dönüşümün "nasıl" ve hangi ekosistem dinamikleri içerisinde orkestre edileceği konusu hala geniş çaplı akademik tartışmalara konu olmaktadır (Lasi vd., 2014). Bu araştırma, teknolojik altyapılardan iş modeli inovasyonuna, sürdürülebilirlikten Türkiye örneğindeki yerel uygulamalara kadar uzanan geniş bir yelpazede, endüstriyel ekosistemlerin dijitalleşme serüvenini incelemeyi amaçlamaktadır.

1. AKILLI ÜRETİM MİMARİSİ VE TEKNOLOJİK TEMELLER

Akıllı üretim vizyonu tekil bir teknolojinin icadı değil; nesnelerin interneti, yapay zeka, uç bilişim ve gelişmiş sensörlerin yarattığı sinerjistik ve kombinatoryal etkinin doğrudan bir sonucudur (Ghobakhloo, 2018). Bu yapının çalışabilmesi için üretim sahasındaki fiziksel varlıkların sanal ortamdaki dijital altyapılarla kusursuz bir uyum içinde eşleşmesi gerekmektedir.

1.1. Siber-Fiziksel Sistemler ve Dijital İkizler (Digital Twins)

Siber-fiziksel sistemler, hesaplama (computing), iletişim ve kontrol unsurlarını fiziksel nesnelerle entegre eden akıllı mekanizmalardır. Bu sistemlerin en sofistike yansıması "Dijital

İkiz" teknolojisidir. Dijital ikiz, gerçek dünyadaki bir ürünün, makinenin veya tüm fabrikanın; sensörlerden akan gerçek zamanlı veriler kullanılarak oluşturulan dinamik sanal kopyasını ifade eder (Tao vd., 2018). ISO 23247 standardında tanımlanan referans mimarisine göre dijital ikizler, üretim süreçlerinin sürekli izlenmesine, darboğazların henüz fiziksel ortamda gerçekleşmeden sanal ortamda tespit edilip optimizasyon senaryolarının (what-if) test edilmesine olanak tanımaktadır. Çalışmalar, üretim yürütme sistemleri (MES) ile entegre edilmiş dijital ikizlerin, ekipman güvenilirliğini dramatik ölçüde artırdığını ve makine arıza süresini minimize ettiğini göstermektedir.

1.2. Endüstriyel IoT, Uç Bilişim ve Otonom Veri İşleme

Akıllı endüstriyel ekosistemlerin temel veri kaynağını, fabrikalara entegre edilmiş milyonlarca akıllı sensör ve aktüatör oluşturmaktadır. Ancak toplanan bu muazzam verinin (Big Data) tamamının bulut sistemlerine (Cloud Computing) gönderilerek işlenmesi, bant genişliği sınırları ve gecikme (latency) sorunları yaratmaktadır. Bu noktada "Uç Bilişim" (Edge Computing), verinin üretildiği yere en yakın ağ kenarında işlenmesini sağlayarak, milisaniyelik tepki süreleri gerektiren endüstriyel süreçlerde kritik bir rol oynamaktadır. Küresel ölçekte üretim yapan dev sanayi kuruluşlarının yaklaşık %54'ünün, bağlantılı otomasyon ve makine öğrenimi uygulamalarını desteklemek amacıyla uç bilişim özellikli akıllı üretim platformlarına geçiş yaptığı raporlanmaktadır.

1.3. Bilişsel Üretim ve Ajan Yapay Zeka (Agentic AI) Uygulamaları

Yapay zekanın imalattaki rolü "Kestirimci Bakım" (Predictive Maintenance) yeteneklerinin çok ötesine geçmektedir. Eski nesil sistemlerde statik gösterge panelleri (dashboards) kullanılarak anomali tespiti yapılırken; günümüzdeki akıllı üretim platformlarında otonom akıl yürütme ve bağımsız aksiyon alma kapasitesine sahip "Ajan Yapay Zeka" (Agentic AI) devreye girmektedir. Ajan yapay zeka sistemleri sadece titreşim ve sıcaklık gibi verilerdeki anormallikleri tespit etmekle kalmaz; aynı zamanda Kurumsal Kaynak Planlama (ERP) sistemine entegre olarak yedek parça stokunu kontrol eder, dijital ikiz üzerinden optimum bakım zamanını belirler ve insan operatör onayına dahi ihtiyaç duymadan ilgili iş emrini (work order) bağımsız bir dijital iş arkadaşı gibi otonom olarak düzenler.

Ampirik çalışmalar yapay zeka entegrasyonunun yarattığı etkiyi sayısal verilerle kanıtlamaktadır. Tayland'da Gelişen Ekonomiler ekseninde 1150 imalat şirketi üzerinde yapılan bir araştırma (Ghobakhloo, 2020); teknolojik, organizasyonel ve çevresel boyutların (TOE-RBV-TAM çerçevesi) eşzamanlı olarak uygulandığı işletmelerde yapay zeka uygulama başarısının %76,8'e ulaştığını ve hatalı üretim oranlarının ortalama %47,3 düştüğünü göstermektedir.

1.4. Akıllı Üretim Platformları ve Pazar Dinamikleri

Bugün hiçbir teknoloji satıcısı, akıllı bir fabrikanın ihtiyaç duyduğu tüm katmanları tek başına sağlayamamaktadır. Bu durum, "En İyilerin Birleşimi" (Best-of-Breed) yaklaşımıyla oluşturulmuş akıllı platform pazarlarının patlamasına neden olmuştur. Fortune Business Insights verilerine göre 2025 yılı itibarıyla 13,42 milyar ABD doları olan Küresel Akıllı Üretim Platformu pazar büyüklüğünün, yıllık %18.26'lık bileşik büyüme oranıyla (CAGR) 2034 yılında 60,72 milyar ABD dolarına ulaşması öngörülmektedir. Vantage Market Research ise daha geniş kapsamlı genel Akıllı Üretim Pazarının 2025'te 485 milyar dolardan 2035'te 1,12 trilyon dolara büyüyeceğini tahmin etmektedir. Bu devasa ekonomik ivme, donanım merkezli varlıklardan (hardware deployment), yazılım tanımlı zeka orkestrasyonuna (intelligence orchestration) geçişin açık bir göstergesidir.

Söz konusu veri orkestrasyonu sürecindeki yapısal değişim Tablo 1'de özetlenmiştir.

Tablo 1. Geleneksel Üretim ile Akıllı Üretim Sistemlerinin Karşılaştırmalı Analizi

Karşılaştırma Boyutu	Geleneksel Üretim Mimarisi (Endüstri 3.0)	Akıllı Üretim Ekosistemi (Endüstri 4.0)
Sistem Yapısı	Katı hiyerarşik piramit, kapalı protokoller	Dağıtık, ağ bağlantılı, açık API tabanlı mimari
Veri Analitiği	Geçmişe dönük (Reaktif) durum raporlama	Gerçek zamanlı (Prescriptive), otonom yönlendirme
Bakım ve Arıza	Planlı (Periyodik) veya arıza sonrası müdahale	Fizik tabanlı yapay zeka ile kestirimci bakım
Üretim Esnekliği	Düşük esneklikli büyük hacimli kitle üretimi	Kişiselleştirilmiş, otonom ayarlanabilen parti hacimleri
Bilişim Altyapısı	Yerel (On-Premise) izole sunucular	Hibrit Bulut, Uç Bilişim (Edge Computing) ağları

2. ENDÜSTRİ 4.0 OLGUNLUK MODELLERİ VE DÖNÜŞÜM STRATEJİLERİ

Akıllı üretime geçiş ani bir teknoloji satın alma eylemi değil, aşamalı ve stratejik bir dönüşüm yolculuğudur. İşletmelerin bu yolculukta mevcut durumlarını analiz edebilmeleri için çeşitli olgunluk modelleri geliştirilmiştir. Bunlar arasında en yaygın kabul göreni, Acatech'in Endüstri 4.0 Olgunluk İndeksidir (Kagermann vd., 2018). Acatech modeline göre dönüşüm altı ardışık seviyeden oluşmaktadır:

1. **Bilgisayarlaştırma (Computerisation):** Çeşitli süreçlerde farklı bilgi teknolojilerinin birbirlerinden bağımsız olarak (izole şekilde) kullanıldığı temel aşama.

2. **Bağlantısallık (Connectivity):** Bilgi teknolojileri sistemlerinin yatay ve dikey olarak birbirine bağlanması. İşletmenin ana kurumsal sistemlerinin entegre edilmesi. Bu ilk iki aşama "Dijitalleşme" sürecini ifade eder.
3. **Görünürlük (Visibility):** Sistemlerin "Ne oluyor?" sorusuna yanıt verebildiği, sensörler aracılığıyla gerçek zamanlı verilerin dijital bir gölge (Digital Shadow) yarattığı aşama.
4. **Şeffaflık (Transparency):** Büyük veri analitiği ile "Neden oluyor?" sorusuna yanıt arandığı, mühendislik bilgisinin sisteme entegre edilerek anormalliklerin kök neden analizlerinin yapılabildiği evre.
5. **Öngörülebilirlik (Predictability):** Yapay zeka ve simülasyon sistemleri ile "Gelecekte ne olacak?" sorusunun yanıtlandığı, olası arıza veya darboğazların oluşmadan önce hesaplandığı seviye.
6. **Uyarlanabilirlik (Adaptability):** "Nasıl otonom tepki verebilirim?" ilkesiyle hareket eden sistemin insan müdahalesi olmadan karar alıp, üretim hattını otonom şekilde yeniden konfigüre ettiği en üst seviye akıllı ekosistem evresi.

Firmaların çoğu henüz 3. veya 4. seviyeye geçiş mücadelesi vermektedir. Teknolojik silolar, siber güvenlik açıkları ve entegrasyon kapasitesindeki eksiklikler şirketlerin "Uyarlanabilirlik" düzeyine ulaşmasının önündeki başlıca yapısal engellerdir.

3. ENDÜSTRİYEL EKOSİSTEMLER TEORİSİ VE ORKESTRASYON DİNAMİKLERİ

Modern imalat sanayisinde işletmeler artık tek başına var olmamakta; farklı sektörleri, yazılım geliştiricilerini, ham madde tedarikçilerini ve son kullanıcıları kapsayan karmaşık ekosistemlerin bir parçası olarak faaliyet göstermektedir. Jacobides, Cennamo ve Gawer (2018) tarafından kuramsallaştırılan "Ekosistem Teorisi", bu yeni endüstriyel yapılanmanın anatomisini çok boyutlu bir şekilde ortaya koymaktadır.

Geleneksel tedarik zincirleri katı sözleşmelere ve hiyerarşik bir otoriteye (hiyerarşik fiat) dayanırken; ekosistemler, hiyerarşik bir denetim mekanizması olmadan bağımsız ancak birbirine organik bağlarla bağımlı organizasyonların koordinasyonuna dayanmaktadır (Jacobides vd., 2018). Ekosistemlerin ortaya çıkmasını sağlayan en kritik unsur "Modülerlik" kavramıdır. Endüstri 4.0 altyapıları, açık arayüzler (API) ve standartlaştırılmış protokoller aracılığıyla modüler bir mimari sunar; bu da binlerce farklı aktörün sisteme bağlanarak "tamamlayıcılık" (complementarity) esasına göre inovasyon yapmasına olanak tanır.

Örneğin, bir üretim ekosisteminde bir orkestratör şirket (focal firm), bir dijital veri paylaşım platformu kurarak makine üreticilerini, kestirimci bakım algoritması yazan girişimleri ve

yedek parça lojistik ağlarını aynı masa etrafında toplar. Bu platform odaklı ortak değer yaratımı (value co-creation), bireysel şirketlerin tek başlarına üretemeyecekleri düzeyde verimlilik ve inovasyon sıçramaları meydana getirir.

4. DEĞER MÜHENDİSLİĞİ 4.0 (VALUE ENGİNEERİNG 4.0)

Endüstriyel ekosistemlerin entegrasyonu, tasarım ve maliyet optimizasyonu yaklaşımlarını da kökten değiştirmiştir. Geleneksel Değer Mühendisliği (VE), bir ürünün veya hizmetin fonksiyonlarını analiz ederek maliyeti düşürmeye yönelik manuel bir analiz metodolojisidir. Ancak endüstri 4.0 devrimi ile birlikte "Değer Mühendisliği 4.0" (VE 4.0) paradigması doğmuştur. VE 4.0, inovasyon ve optimizasyon süreçlerine siber-fiziksel sistemleri, doğal dil işleme (NLP) algoritmalarını ve bulut tabanlı eşzamanlı mühendislik platformlarını entegre eder. NLP teknolojileri geçmiş müşteri geri bildirimlerinden yapılandırılmamış (unstructured) teknik ihtiyaçları otomatik olarak analiz ederken; yapay zeka fonksiyonel alternatiflerin prototiplenmesinde otonom destek sağlar. Böylece üretim daha konsept aşamasındayken atık oranları düşürülür ve kullanım ömrü boyu değer maksimize edilmiş olur.

5. DİJİTAL SERVİTİZASYON (DİGİTAL SERVİTİZATİON) VE İŞ MODELİ İNOVASYONU

Endüstri 4.0 altyapılarının sağladığı gerçek zamanlı veri akışı, imalat sanayisinin iş modellerinde "Dijital Servitizasyon" (dijital hizmetleşme) adı verilen devrim niteliğinde bir değişimi tetiklemiştir (Frank vd., 2019). Servitizasyon kavramı temelde üretici firmaların yalnızca donanım satmaktan vazgeçerek, fiziksel ürünlerle birlikte değer yaratan hizmetler (Ürün-Hizmet Sistemleri - PSS) satmasını ifade eder. Dijital servitizasyon ise IoT, dijital ikizler ve yapay zeka aracılığıyla bu hizmetlerin dijital yollarla sağlanarak firmaların çözüm sağlayıcı (solution provider) kimliğine evrilmesidir.

Frank vd. (2019) modeline göre dijital servitizasyon üç ana tipolojide sınıflandırılmaktadır:

- **Düzleştirici Hizmetler (Smoothing Services):** Ürünün asıl satışını kolaylaştıran, nesnelerin interneti tabanlı uzaktan izleme (remote condition monitoring) ve dijital garanti yönetimini kapsayan temel dijital eklentilerdir.
- **Uyarlayıcı Hizmetler (Adapting Services):** Makineden gelen verileri kullanarak ürünün performansını müşteri ihtiyaçlarına göre anlık olarak optimize eden süreçlerdir. Kestirimci bakım, operasyonel verimlilik danışmanlığı ve yazılım yükseltmeleri bu gruba girer.
- **İkame Edici Hizmetler (Substituting Services):** Geleneksel mülkiyet kavramını tamamen ortadan kaldıran ve "Servis Olarak Ürün" (Product-as-a-Service) modelini merkeze alan ileri seviye dönüşümlerdir. Müşteri ürünü satın almaz; ürünün ürettiği

"sonuca" ödeme yapar (örneğin kompresör almak yerine basılan hava miktarına göre ödeme yapılması veya uçak motorlarında saat başına güç ödemesi).

Tablo 2, dijital servitizasyon seviyeleri ve bu seviyelerin teknolojik gereksinimlerini özetlemektedir:

Tablo 2. Dijital Servitizasyon Türleri ve Teknolojik Temelleri

Servitizasyon Türü	Odak Noktası	Sağlanan Müşteri Değeri	Endüstri 4.0 Teknoloji Gereksinimi
Düzleştirici (Smoothing)	Ürün satışı garantisi	Uzaktan izleme ve temel güvenilirlik	Basit IoT sensörleri, bulut tabanlı log kaydı
Uyarlayıcı (Adapting)	Operasyonel Optimizasyon	Makine kullanımının verimli hale gelmesi	Yapay Zeka tabanlı kestirimci bakım, Büyük Veri
İkame Edici (Substituting)	Sonuç/Performans Odaklı	Sıfır sermaye yatırımı (Kiralama/Kullanım bazlı)	Uçtan uca dijital ikiz, blokzincir akıllı sözleşmeleri

Bu noktada firmalar "Servitizasyon Paradoksu" olarak adlandırılan büyük bir zorlukla karşılaşmaktadır: Şirketler ileri dijital teknolojilere devasa bütçeler yatırmalarına rağmen, kısa vadede bekledikleri oranda karlılığa ulaşamayabilirler. Bu durum, dijital servis yetenekleri ile işletmenin genel organizasyonel stratejisinin eşgüdümlü (aligned) olmamasından kaynaklanmaktadır. Bu uyumsuzluğun giderilmesi ancak işletmelerin açık platform stratejilerini benimsemesi ve ürün modüllerinden ziyade "bilgi modüllerini" ana eksene almalarıyla mümkündür.

6. ÇEVRESEL SÜRDÜRÜLEBİLİRLİK, DÖNGÜSEL EKONOMİ VE ENDÜSTRİYEL SİMBİYOZ 4.0

Dördüncü sanayi devriminin teknoloji ve karlılık vurgusunun ötesindeki en hayati boyutu, ekolojik sürdürülebilirliğe sağladığı derin katkıdır. Geleneksel üretimin karbon yoğun, atık üreten ve "al-yap-at" (take-make-dispose) prensibine dayalı doğrusal modeli, yerini değerin sistem içinde maksimum süre tutulduğu "Döngüsel Ekonomi" (Circular Economy) modellerine bırakmaktadır.

6.1. Kurumsal Sürdürülebilirlik ve IoT'nin Etkisi

IoT ve büyük veri analitiğinin kurumsal sürdürülebilirlik (Çevresel, Sosyal ve Kurumsal Yönetişim - ESG) üzerindeki etkilerini analiz eden PRISMA 2020 standartlarındaki sistematik literatür taramaları, dijital teknolojilerin dört ana eksende sürdürülebilirlik sağladığını ortaya koymaktadır (Çevresel, 2025):

1. Gerçek zamanlı sensör algılama ve kestirimci analitik yoluyla etkin kaynak kullanımlı operasyonlar (Resource-efficient operations),
2. Enerji optimizasyonu ve yeşil dijital dönüşüm süreçleri,
3. Veri odaklı döngüsel ekonomi uygulamaları,
4. Yeşil İnsan Kaynakları Yönetimi (GHRM) pratikleri.

Buna ek olarak XGBoost ve Random Forest gibi ileri makine öğrenimi algoritmalarıyla yapılan performans analizleri, yüksek düzeyde dijital analitik yeteneklerine sahip şirketlerde ESG uygulamalarının çok daha yüksek doğruluğa ulaştığını ve sürdürülebilir değer yaratımının (R^2=0.87) katlanarak arttığını kanıtlamaktadır.

6.2. Endüstriyel Simbiyoz Teorisi ve Dijitalleşme

Çevresel atıkların yönetiminde en yenilikçi konseptlerden biri olan "Endüstriyel Simbiyoz", Marian Chertow (2000) tarafından literatüre kazandırılmıştır. Chertow'a göre endüstriyel simbiyoz, birbirinden bağımsız işletmelerin coğrafi yakınlıklarını kullanarak birinin atığının, yan ürününün veya enerji fazlasının diğer işletme için hammadde haline geldiği işbirliğine dayalı eko-park yapılarıdır. Danimarka'daki Kalundborg Eko-Endüstriyel Parkı, bir enerji santrali, petrol rafinerisi, ilaç fabrikası ve şehrin ısıtma sisteminin su, buhar ve malzeme takası yaptığı ikonik bir modeldir.

Endüstri 4.0 ile birlikte bu yapı "Endüstriyel Simbiyoz 4.0" (Industrial Symbiosis 4.0) ve "Sanal Simbiyoz" aşamasına evrilmiştir. Geleneksel simbiyoz fiziksel coğrafyaya bağımlıyken, IoT tabanlı sensör ağları ve blokzincir teknolojileri, atık veya yan ürün verilerinin gerçek zamanlı ve mekandan bağımsız olarak dijital pazar yerlerinde (platformlarda) şeffaf hale getirilmesini sağlar. Yapay zeka algoritmaları atık malzemelerin kimyasal özelliklerini analiz ederek, bunların hangi farklı endüstriyel süreçlerde verimli girdi olabileceğini otonom olarak eşleştirir. BRICS (Brezilya, Rusya, Hindistan, Çin, Güney Afrika) ülkeleri üzerine 2011-2021 dönemi için yapılan kapsamlı bir panel veri analizi (CS-ARDL modellemesi), Endüstriyel Simbiyoz, Nesnelerin İnterneti ve Yapay Zekanın entegre kullanımının döngüsel ekonomi verimliliğini istatistiksel olarak anlamlı düzeyde artırdığını ispatlamıştır. Danimarka Hirtshals Limanı gibi stratejik endüstriyel vakalarda ise (CO_2 hub projeleri), elektrik, ısınma, soğutma ve ulaşım ağlarının uçtan uca dijital ikizleri kurularak "Isı Simbiyozu" (Heat Symbiosis) sağlanmış ve karbondan arındırma hedeflerinde kritik adımlar atılmıştır.

7. TÜRKİYE'NİN ULUSAL İNOVASYON EKOSİSTEMİ BAĞLAMINDA ENDÜSTRİ 4.0 PRATİĞİ

Endüstriyel ekosistemlerin teorik altyapısı küresel bir geçerliliğe sahip olsa da, bu vizyonun pratiğe yansıması ulusal inovasyon ekosistemlerinin kapasitesiyle doğrudan ilişkilidir. Sema Yiğit (2018) tarafından yapılan araştırmalar, Türkiye'nin inovasyon ekosisteminin genel anatomisini ve karşılaşılan bölgesel engelleri net bir biçimde ortaya koymaktadır. Türkiye'de TÜBİTAK, KOSGEB, üniversite-sanayi işbirliği merkezleri ve teknokentler gibi aktörler üzerinden önemli bir teşvik ve pazar altyapısı kurulmuş olsa da, akıllı üretime geçişte işletmeler (özellikle KOBİ'ler) ciddi zorluklar yaşamaktadır.

Akademik literatür (Verimlilik Dergisi vb. platformlardaki saha analizleri) incelendiğinde, Türkiye ekosistemindeki temel dar boğazların şu noktalarda yoğunlaştığı görülmektedir:

- **Organizasyonel Kültür ve Yetenek Açığı:** Teknolojik dönüşüm salt bir donanım meselesi değil, yönetimsel bir vizyon işidir. Çalışanların dijital okuryazarlık oranlarının düşük olması ve kurumsal dönüşüme gösterilen kültürel direnç, akıllı üretim projelerinin iptal edilmesine yol açabilmektedir.
- **Siber Güvenlik Açıkları ve Güven Eksikliği:** Açık mimariye geçen fabrikalarda (IoT cihazları vb.), dış ağlara bağlanmak demek siber saldırı yüzeyinin (attack surface) genişlemesi demektir. Endüstriyel kontrol sistemlerine yönelik muhtemel DDoS (hizmet reddi) saldırıları veya fidye yazılımı tehditleri, yerel sanayicilerde tedirginlik yaratmakta; bu da işletmelerin endüstriyel veri paylaşım platformlarına entegre olmalarını engellemektedir.
- **Yüksek Yatırım Maliyetleri ve Pilot Arafı (Pilot Purgatory):** Akıllı üretim sistemlerine geçişin ilk aşamalarında gereken yüksek otomasyon bütçeleri ve lisans bedelleri, kısa vadeli yatırım getirisini (ROI) belirsizleştirmektedir. Çoğu işletme küçük çaplı pilot projeler yapsa da (ölçeklendirme sorunu nedeniyle), bu projeleri tüm fabrika geneline yayamamakta ve "pilot arafı"nda sıkışıp kalmaktadır.

8. GELECEK PROJEKSİYONLARI: BİLİŞSEL ÜRETİM VE ENDÜSTRİ 5.0'IN YÜKSELİŞİ

Tamamen teknoloji odaklı ve "karanlık fabrikalar" (insansız üretim) vizyonu çizen Endüstri 4.0 paradigması, yaşanan küresel tedarik zinciri krizleri ve sosyo-ekonomik dinamikler sonucunda şekil değiştirmeye başlamıştır. Modern literatür, "insan merkezli", "dirençli" (resilient) ve "sürdürülebilir" kavramlarını teknolojiyle birleştiren Endüstri 5.0 konseptine doğru hızlı bir geçişin sinyallerini vermektedir (Ghobakhloo vd., 2024).

Endüstri 5.0, teknolojiyi insanı üretimden dışlayan bir tehdit olarak değil, aksine insanın bilişsel sınırlarını genişleten (augmentation) bir işbirliği aracı olarak konumlandırır. İşbirlikçi robotlar (Cobot'lar) ve karma gerçeklik (AR/VR) donanımları sayesinde uzman çalışanlar, sistemin merkezinde kalmaya devam ederek daha stratejik ve karmaşık kararları alacaklardır. Geleceğin üretim mimarisinde rekabet, kimin en modern robota sahip olduğuna göre değil; öngörülemez jeopolitik ve lojistik şoklar karşısında (pandemi vb.), sistemin otonom olarak rotasını ne kadar hızlı çizebileceğine (ekosistem direnci) göre şekillenecektir.

9. SONUÇ

Endüstriyel ekosistemler, akıllı üretim ve dijital servitizasyon olgularını çok boyutlu olarak inceleyen bu çalışma, endüstride yaşanan değişimin basit bir teknolojik sürüm güncellemesi olmadığını kanıtlamaktadır. Aksine bu durum, iş modellerinin, rekabet koşullarının ve çevre politikalarının kökünden sarsıldığı bir evrim sürecidir.

Geleneksel stratejik yönetim teorileri, firmaların değer zincirlerindeki dahili kaynaklarını optimize etmeye odaklanırken; günümüzün hiper-bağlantılı dünyasında rekabet üstünlüğü, bir işletmenin içinde bulunduğu ekosistemin ne kadar çevik, modüler ve açık inovasyona uygun tasarlandığına bağlıdır (Jacobides vd., 2018). Üretim işletmeleri varlıklarını koruyabilmek için, salt ürün satıcısı olmaktan vazgeçip; dijital ikizler, uç bilişim ve yapay zekayı birleştirerek müşterilerine veri güdümlü "sonuçlar" ve katma değerli hizmetler sunan "servitizasyon" yapılarına dönüşmelidir.

Bu dijital rasyonalizasyonun en değerli yan ürünü ekolojik refahtır. Karbon ayak izinin izlenmesi, kapalı döngü ekonomi mekanizmalarının tesis edilmesi ve yapay zeka destekli sanal endüstriyel simbiyoz ağlarının yaygınlaşması, endüstriyel karlılığı çevresel sorumlulukla birleştirmektedir.

Gelişmekte olan inovasyon ekosistemleri (Türkiye örneğinde görüldüğü gibi) bu trendleri yakalamak istiyorsa; devlet-üniversite-sanayi sarmalındaki veri silolarını kırarak güvene dayalı açık platformlar kurmalı, siber güvenlik politikalarını ulusal bir strateji haline getirmeli ve Endüstri 4.0'ı sadece bir donanım yatırımı değil, kültürel bir insan kaynakları dönüşümü olarak ele almalıdır. Akıllı üretim vizyonu, veriyi kurumsal zekaya, zekayı ise sürdürülebilir insan ve çevre değerine dönüştürebilen organizasyonların elinde şekillenecektir.

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SİVİL SAVUNMADA DİJİTALLEŞME VE DAYANIKLILIK: AFETLERE HAZIRLIKTA YENİ YAKLAŞIMLAR: KÜRESEL LİTERATÜRÜN BİBLİYOMETRİK ANALİZİ VE SİSTEMATİK LİTERATÜR TARAMASI

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Özet

Bu çalışmanın amacı, sivil savunmada dijitalleşme ve dayanıklılık alanındaki bilimsel yayınların bibliyometrik özelliklerini inceleyerek mevcut araştırma eğilimlerini, iş birliği ağlarını ve alandaki etkili araştırmacıları ortaya koymaktır. Bu doğrultuda Web of Science Core Collection veri tabanında gerçekleştirilen tarama sonucunda toplam 248 makale analiz kapsamına alınmıştır. Verilerin analizinde Web of Science analiz araçları ve VOSviewer yazılımı kullanılmıştır. Çalışma kapsamında yıllara göre yayın dağılımı, ülkelere göre yayın performansı, anahtar kelime birlikte görülme analizi, ülkeler arası iş birliği ağı, yazar eş-atıf analizi ve yazar yoğunluk haritaları incelenmiştir. Elde edilen bulgular, sivil savunmada dijitalleşme ve dayanıklılık alanındaki yayın sayısının özellikle 2020 yılından sonra önemli ölçüde arttığını göstermektedir. Çin ve Amerika Birleşik Devletleri'nin yayın üretkenliği ve uluslararası iş birlikleri açısından öncü konumda olduğu belirlenmiştir. Ayrıca afet dayanıklılığı, afet yönetimi, dijital dönüşüm ve acil durum yönetimi kavramlarının araştırma alanının temel temalarını oluşturduğu tespit edilmiştir. Sonuç olarak bulgular, dijital teknolojilerin afet risk azaltımı ve toplumsal dayanıklılık bağlamında giderek daha görünür bir araştırma alanı oluşturduğunu göstermektedir.

Anahtar Kelimeler: Sivil Savunma, Dijitalleşme, Dayanıklılık, Afet Yönetimi, Bibliyometrik Analiz, VOSviewer

DIGITALISATION AND RESILIENCE IN CIVIL DEFENCE: NEW APPROACHES TO DISASTER PREPAREDNESS: A BIBLIOMETRIC ANALYSIS AND SYSTEMATIC LITERATURE REVIEW OF THE GLOBAL LITERATURE

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Abstract

The aim of this study is to examine the bibliometric characteristics of scientific publications in the field of digitalization and resilience in civil defense and to reveal current re-search trends, collaboration networks, and influential authors in the field. A total of 248 articles retrieved from the Web of Science Core Collection database were included in the analysis. Web of Science analytical tools and VOSviewer software were used for data analysis. Publication trends over time, country productivity, keyword co-occurrence analysis, international collaboration networks, author co-citation analysis, and author density visualizations were examined. The findings indicate that the number of publications in the field of digitalization and resilience in civil defense has increased significantly, particularly after 2020. China and the United States emerged as leading countries in terms of publication productivity and international collaborations. Furthermore, disaster resilience, disaster management, digital transformation, and emergency management were identified as the main themes of the research field. In conclusion, the findings indicate that digital technologies are emerging as an increasingly prominent area of research in the context of disaster risk reduction and social resilience.

Keywords: Civil Defense, Digitalization, Resilience, Disaster Management, Bibliometric Analysis, VOSviewer

GİRİŞ

Afetler, toplumların sosyal, ekonomik ve çevresel yapıları üzerinde önemli etkiler yaratan olaylar arasında yer almaktadır. İklim değişikliği, hızlı kentleşme, nüfus artışı ve teknolojik riskler nedeniyle afetlerin sıklığı ve etkilerinde önemli artışlar gözlenmektedir. Bu durum, geleneksel sivil savunma yaklaşımlarının yeniden değerlendirilmesini ve dijital teknolojilerle desteklenen yenilikçi stratejilerin geliştirilmesini gerekli kılmaktadır.

Bu dönüşüm, afet yönetiminin yalnızca afet sonrasında müdahaleye dayalı bir yapı olarak değil; riskin önceden belirlenmesi, azaltılması, hazırlık kapasitesinin geliştirilmesi ve afet sonrası toparlanmayı da kapsayan bütünleşik bir süreç olarak ele alınmasını gerekli kılmaktadır. Nitekim Sendai Afet Risk Azaltma Çerçevesi 2015–2030, afet riskinin anlaşılması, risk yönetişiminin güçlendirilmesi ve dayanıklılığın artırılmasına yönelik yatırımların ge-liştirilmesini modern afet risk yönetiminin temel öncelikleri arasında konumlandırmaktadır (UNDRR, 2015).

Dijital dönüşüm; yapay zekâ, büyük veri analitiği, nesnelerin interneti (IoT), coğrafi bilgi sistemleri (CBS), uzaktan algılama teknolojileri ve erken uyarı sistemleri gibi teknolojilerin afet yönetimi süreçlerine entegre edilmesini ifade etmektedir. Bu teknolojiler, afet risklerinin önceden belirlenmesi, etkili müdahale planlarının oluşturulması ve afet sonrası iyileştirme süreçlerinin hızlandırılmasında önemli katkılar sağlamaktadır.

Dayanıklılık (resilience) kavramı ise bireylerin, toplulukların ve sistemlerin afetlere hazırlıklı olma, olumsuz etkileri en aza indirme ve afet sonrasında hızlı toparlanabilme kapasitesini ifade etmektedir. Günümüzde afet yönetiminde dayanıklılık yaklaşımı, yalnızca krizlere müdahaleyi değil, aynı zamanda risk azaltma ve sürdürülebilir kalkınma hedeflerini de içeren bütüncül bir bakış açısı sunmaktadır.

Bu çerçevede dijitalleşme ve dayanıklılık, afet yönetiminde birbirinden bağımsız iki araştırma alanı olmaktan ziyade giderek daha fazla kesişen bir yapı oluşturmaktadır. Yapay zekâ ve büyük veri analitiği risklerin tahmin edilmesi ve karar destek süreçlerinde; CBS ve uzaktan algılama mekânsal risklerin belirlenmesi ve izlenmesinde; nesnelerin interneti ve gerçek zamanlı veri sistemleri ise erken uyarı, durum farkındalığı ve müdahale kapasitesinin geliştirilmesinde kullanılmaktadır. Bu teknolojik kapasitenin afetlere hazırlık, müdahale ve toparlanma süreçleriyle bütünleştirilmesi, toplumsal ve kurumsal dayanıklılığın güçlendirilmesine yönelik yeni bir araştırma ekseni ortaya çıkarmaktadır. Dolayısıyla dijital dönüşüm, güncel afet yönetimi literatüründe yalnızca operasyonel etkinliği artıran bir araç olarak değil, afet risk azaltımı ve dayanıklılık kapasitesinin geliştirilmesinin önemli bile-şenlerinden biri olarak değerlendirilmektedir.

Bu çalışmanın amacı, sivil savunma bağlamında ve sivil savunmayla doğrudan ilişkili afet ve acil durum yönetimi literatüründe dijitalleşme ve dayanıklılık konularını ele alan bilimsel yayınların bibliyometrik özelliklerini inceleyerek araştırma eğilimlerini, etkili yazarları, uluslararası iş birliklerini ve öne çıkan araştırma temalarını ortaya koymaktır.

1. KAVRAMSAL ÇERÇEVE

1.1. Sivil Savunma Kavramı ve Önemi

Sivil savunma; savaş, doğal afetler, teknolojik kazalar ve diğer olağanüstü durumlarda toplumun can ve mal güvenliğinin korunması amacıyla yürütülen hazırlık, müdahale ve iyileştirme faaliyetlerinin bütününü ifade etmektedir. Geleneksel olarak savaş dönemlerine odaklanan sivil savunma anlayışı, günümüzde afet risk yönetimi, kriz yönetimi ve toplumsal dayanıklılık yaklaşımlarını kapsayacak şekilde genişlemiştir. Güncel literatürde "civil defense", "civil protection", "emergency management" ve "disas-ter management" kavramları tamamen özdeş olmamakla birlikte, toplumların afet ve olağanüstü durumlara hazırlanması, risklerin azaltılması, müdahale kapasitesinin geliştirilmesi ve toparlanmanın sağlanması bakımından önemli ölçüde kesişen araştırma alanlarını ifade etmektedir. Bu nedenle sivil savunmanın güncel kapsamı değerlendirilirken, kavramın afet ve acil durum yönetimi ile sivil koruma literatüründeki yakın ilişkileri de dikkate alınmaktadır.

Birleşmiş Milletler Afet Risklerinin Azaltılması Ofisi (UNDRR) tarafından benimsenen modern afet yönetimi yaklaşımında sivil savunma, yalnızca afetlere müdahale eden bir yapı olmaktan çıkmış; risk azaltma, hazırlık, müdahale ve iyileştirme süreçlerini kapsayan bütünleşik bir sistem haline gelmiştir. Bu kapsamda sivil savunma, toplumların afetlere karşı dirençli hale gelmesinde önemli bir role sahiptir.

Türkiye'de sivil savunma hizmetleri ağırlıklı olarak İçişleri Bakanlığı bünyesinde faaliyet gösteren Afet ve Acil Durum Yönetimi Başkanlığı (AFAD) tarafından yürütülmektedir. AFAD'ın koordinasyonunda gerçekleştirilen çalışmalar, afet öncesi hazırlık faaliyetleri ile afet sonrası müdahale süreçlerini kapsamaktadır. Özellikle son yıllarda yaşanan büyük ölçekli afetler, sivil savunma sistemlerinin güçlendirilmesi ve teknolojik altyapılarının geliştirilmesi gerekliliğini ortaya koymuştur.

Sivil savunmanın temel amaçları arasında toplumun afetlere hazırlıklı hale getirilmesi, erken uyarı sistemlerinin etkin kullanılması, müdahale kapasitesinin artırılması ve afet sonrası toparlanma süreçlerinin hızlandırılması yer almaktadır. Bu amaçlara ulaşabilmek için dijital teknolojilerin kullanımı giderek önem kazanmaktadır.

1.2. Dijitalleşme ve Dijital Dönüşüm Kavramı

Dijitalleşme, bilgi ve iletişim teknolojilerinin süreçlere entegre edilmesi yoluyla mevcut uygulamaların daha etkin ve verimli hale getirilmesini ifade etmektedir. Dijital dönüşüm ise teknolojik yeniliklerin kurumların iş yapış biçimlerinde köklü değişikliklere yol açmasını kapsayan daha geniş bir kavramdır.

Afet yönetimi ve sivil savunma alanında dijital dönüşüm; büyük veri analitiği, yapay zekâ, nesnelerin interneti (IoT), coğrafi bilgi sistemleri (CBS), uzaktan algılama teknolojileri ve bulut bilişim uygulamalarının kullanımını içermektedir. Bu teknolojiler, afet risklerinin belirlenmesi, erken uyarı mekanizmalarının geliştirilmesi ve müdahale süreçlerinin etkin yönetilmesine katkı sağlamaktadır.

Özellikle yapay zekâ destekli tahmin sistemleri ve gerçek zamanlı veri analizleri sayesinde afetlerin etkilerinin azaltılması ve kaynakların daha verimli kullanılması mümkün hale gelmiştir. Dijital teknolojiler ayrıca afet anında kurumlar arası koordinasyonu artırmakta ve karar verme süreçlerini desteklemektedir.

Afet yönetiminde dijital teknolojilerin önemi, farklı teknolojilerin afet yönetimi döngüsünün farklı aşamalarında sağladığı işlevlerle daha belirgin hâle gelmektedir. CBS ve uzaktan algılama teknolojileri tehlike ve kırılganlıkların mekânsal olarak belirlenmesine ve risk haritalarının oluşturulmasına katkı sağlarken (Pradhan, 2010), yapay zekâ, makine öğrenmesi ve büyük veri uygulamaları çok boyutlu verilerin analiz edilerek risk tahmini ve karar destek süreçlerinde kullanılmasına imkân vermektedir. Nesnelerin interneti ve gerçek zamanlı veri sistemleri ise erken uyarı, olay takibi ve müdahale koordinasyonunu güçlendirmektedir. Bu nedenle dijitalleşme, modern sivil savunma ve afet yönetiminde yalnızca teknolojik modernizasyon olarak değil; hazırlık, risk azaltımı, müdahale ve toparlanma kapasitesini bütüncül biçimde destekleyen bir dönüşüm süreci olarak ele alınmaktadır.

1.3. Dayanıklılık ve Dijital Afet Risk Yönetimi

Dayanıklılık, afet yönetimi literatüründe bireylerin, toplulukların ve sistemlerin şoklara karşı koyabilme, değişen koşullara uyum sağlayabilme ve temel işlevlerini sürdürebilecek biçimde toparlanabilme kapasitesiyle ilişkilendirilmektedir. Kavram, kırılganlığın azaltılmasının ötesinde sosyal, kurumsal ve mekânsal sistemlerin afetler karşısındaki uyum ve toparlanma kapasitesine odaklanmaktadır (Adger, 2006; Cutter et al., 2008). Afet risk azaltımına ilişkin kavramsal çerçevenin uluslararası düzeyde ortaklaştırılması bakımından Bir-leşmiş Milletler Genel Kurulu bünyesinde hazırlanan uzman çalışma grubu raporu da önem-li bir referans oluşturmaktadır. Raporda afet riski, kırılganlık, maruziyet, kapasite ve dayanıklılık gibi temel kavramlara ilişkin terminoloji güncellenmiş ve afet risk azaltımındaki ilerlemenin izlenmesine yönelik göstergeler ortaya konulmuştur (United Nations General Assembly

[UNGA], 2016). Bu yaklaşım doğrultusunda afet yönetiminde amaç yalnızca kayıpları azaltmak değil, afet öncesinden başlayarak daha dirençli toplumsal ve kurumsal yapıların oluşturulmasıdır. Dayanıklılığın ölçülmesine yönelik çalışmalar da söz konusu kavramın afet risk yönetimi süreçlerine aktarılmasında önemli bir araştırma alanı hâline geldiğini göstermektedir (Sharifi, 2016).

Dijital dönüşüm bu noktada dayanıklılığın geliştirilmesine yönelik yeni araçlar ve yönetişim kapasitesi sunmaktadır. Gerçek zamanlı veri üretimi, risklerin mekânsal analizi, tahmine dayalı modeller, erken uyarı sistemleri ve dijital karar destek mekanizmaları; afet öncesi hazırlığın geliştirilmesi, kaynakların daha etkin yönlendirilmesi ve afet sonrası toparlanma süreçlerinin hızlandırılması açısından önem taşımaktadır. Böylece dijitalleşme ile dayanıklılık arasındaki ilişki, teknolojinin yalnızca afet anında kullanılmasından daha geniş bir çerçevede; risk bilgisinin üretilmesi, riskin azaltılması, müdahale kapasitesinin geliştirilmesi ve sistemlerin değişen koşullara uyum sağlayabilmesi üzerinden kurulmaktadır. Bu kesişim, sivil savunma ve afet yönetiminde dijitalleşme ve dayanıklılık literatürünün giderek belirginleşen disiplinler arası bir araştırma alanı hâline gelmesini açıklamaktadır.

2. METODOLOJİ

2.1. Araştırmanın Tasarımı

Bu çalışma, sivil savunmada dijitalleşme ve dayanıklılık alanındaki bilimsel yayınların yapısını ve gelişim eğilimlerini ortaya koymak amacıyla bibliyometrik analiz yöntemi kullanılarak gerçekleştirilmiştir. Bibliyometrik analiz, belirli bir araştırma alanında yayımlanmış bilimsel çalışmaların nicel yöntemlerle incelenmesini sağlayan ve araştırma eğilimlerinin sistematik olarak değerlendirilmesine imkân tanıyan bir yöntemdir. Bu yöntem sayesinde yayın performansı, iş birliği ağları, atıf ilişkileri ve araştırma temaları kapsamlı bir biçimde analiz edilebilmektedir.

2.2. Veri Kaynağı ve Veri Toplama Süreci

Araştırmada kullanılan veriler, bilimsel yayınların uluslararası düzeyde indekslendiği **Web of Science Core Collection (WoSCC)** veri tabanından elde edilmiştir. Veri toplama işlemi Haziran 2026 tarihinde gerçekleştirilmiştir.

Sivil savunma kavramının uluslararası literatürde farklı terminolojik karşılıklar ve ilişkili kavramlar üzerinden ele alınması nedeniyle arama stratejisi yalnızca “civil defense” ifadesiyle sınırlandırılmamıştır. Alanın güncel ve genişleyen kavramsal yapısını kapsayabilmek amacıyla “civil protection”, “emergency management” ve “disaster management” terimleri de arama dizgesine dahil edilmiştir. Bu terimlerin kullanılması, söz konusu kavramların birbirinin tam karşılığı olduğu varsayımına değil; dijitalleşme, dayanıklılık ve afetlere hazırlık bağlamında ortak bir araştırma alanı oluşturmalarına dayanmaktadır.

Araştırma kapsamında aşağıdaki gelişmiş arama stratejisi kullanılmıştır:

TS=(("civil defense" OR "civil protection" OR "emergency management" OR "disaster management")
AND
("digitalization" OR "digital transformation" OR "digital technologies" OR "information technology")
AND
(resilience OR "community resilience" OR "disaster resilience"))

Tarama sonucunda elde edilen kayıtlar belirlenen dahil edilme kriterleri doğrultusunda filtrelenmiştir.

Dahil edilme kriterleri:

- Yayın türünün **makale (Article)** olması,
- Yayın dilinin **İngilizce (English)** olması,
- Yayın yıllarının **2015–2025** arasında olması,
- Web of Science Core Collection veri tabanında indekslenmiş olması.

Belirlenen kriterler doğrultusunda analiz için uygun bulunan **248 makale** çalışma kapsamına alınmıştır.

2.3. Veri Analizi

Araştırma verilerinin analizinde **Web of Science analiz araçları** ve **VOSviewer (sürüm 1.6.20)** yazılımı kullanılmıştır.

Web of Science analiz araçları aracılığıyla;

- Yıllara göre yayın dağılımları,
- Ülkelere göre yayın performansları

incelenmiştir.

VOSviewer yazılımı kullanılarak ise;

- Anahtar kelime birlikte görülme (co-occurrence) analizi,
- Ülkeler arası iş birliği (co-authorship) analizi,
- Yazar eş-atıf (co-citation) analizi,
- Yoğunluk (density visualization) haritaları

oluşturulmuştur.

Anahtar kelime analizinde minimum birlikte görülme eşiği **5** olarak belirlenmiştir. Ülkeler arası iş birliği analizinde ülkeler arasındaki ortak yazarlık ilişkileri değerlendirilmiş; yazar eş-atıf analizinde ise yazarlar için minimum atıf eşiği **11** olarak kabul edilmiştir.

2.4. Araştırmanın Etik Boyutu

Bu araştırmada yalnızca açık erişimli bibliyografik veriler kullanılmış olup insan katılımcılardan veri toplanmamıştır. Bu nedenle etik kurul onayı gerektirmemektedir. Çalışma sürecinde bilimsel araştırma ve yayın etiği ilkelerine uygun hareket edilmiştir.

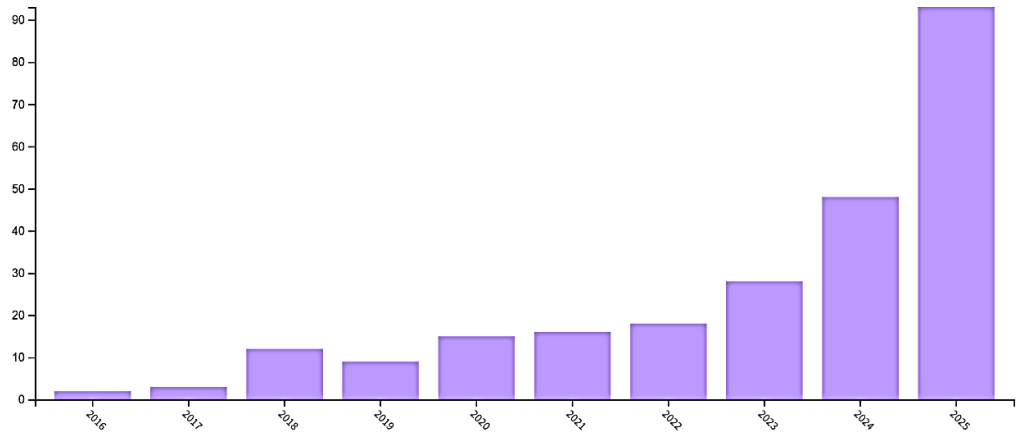
2.5. Araştırmanın Sınırlılıkları

Bu çalışmanın bazı sınırlılıkları bulunmaktadır. Öncelikle araştırma yalnızca Web of Science Core Collection veri tabanında yer alan yayınlarla sınırlandırılmıştır. Ayrıca yalnızca İngilizce dilinde yayımlanan makaleler değerlendirmeye alınmıştır. Farklı veri tabanlarının (Scopus, PubMed vb.) ve farklı yayın türlerinin dahil edilmesi, gelecekte yapılacak çalışmalarda daha kapsamlı sonuçlar elde edilmesine katkı sağlayabilir.

3. BULGULAR

Bu bölümde, sivil savunmada dijitalleşme ve dayanıklılık alanında gerçekleştirilen bibliyometrik analiz sonuçlarına yer verilmiştir. Web of Science Core Collection veri tabanından elde edilen 248 makale; yayın yıllarına göre dağılım, ülkelere göre yayın performansı, ülkeler arası iş birliği ağları ve yazar eş-atıf ilişkileri açısından incelenmiştir. Ayrıca VOSviewer yazılımı kullanılarak oluşturulan görselleştirme haritaları aracılığıyla araştırma alanındaki iş birliği yapıları ve bilgi ağları ortaya konulmuştur.

Şekil 1. 2015-2025 Yılları Arasında Yıllara Göre Yayın Sayılarının Dağılımı

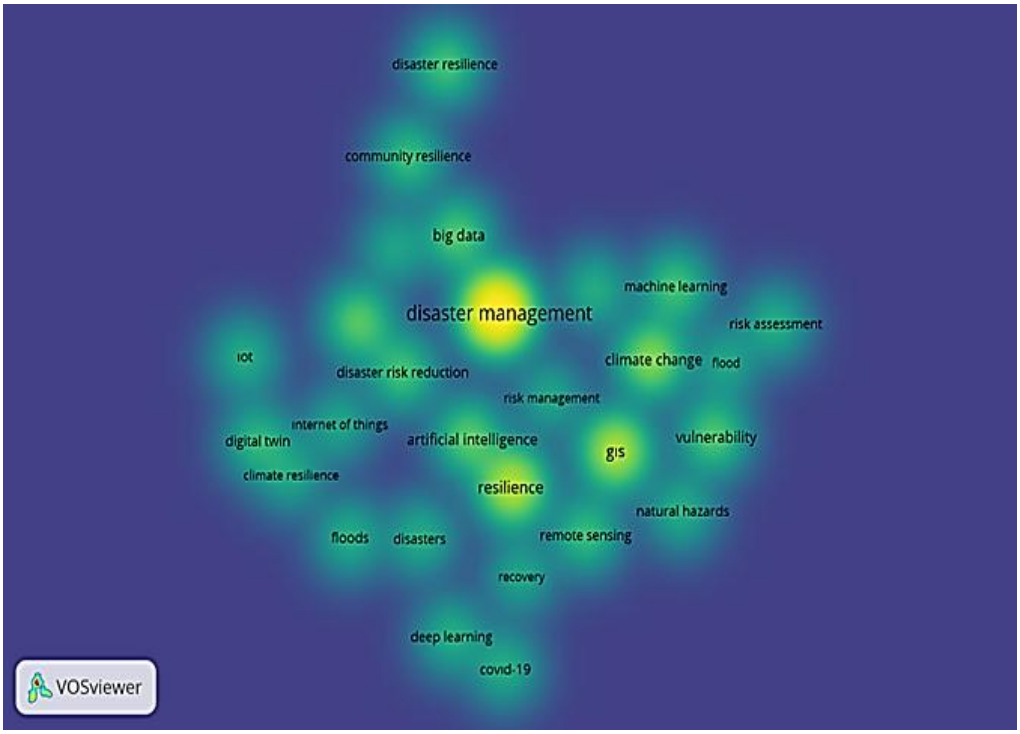


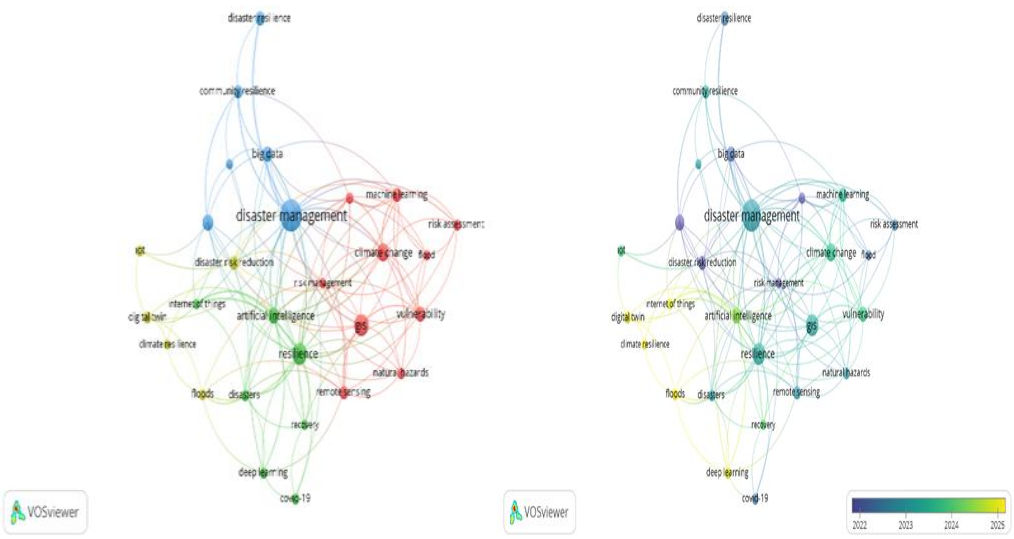
Araştırma kapsamında analiz edilen 248 yayının yıllara göre dağılımı incelendiğinde, sivil savunmada dijitalleşme ve dayanıklılık konularına yönelik bilimsel ilginin son yıllarda önemli ölçüde arttığı görülmektedir. Özellikle 2020 yılından itibaren yayın sayılarında belirgin bir artış eğilimi dikkat çekmektedir.

Yayın sayıları incelendiğinde, 2015 yılında 4, 2016 yılında 2, 2017 yılında 3 ve 2018 yılında 12 yayın tespit edilmiştir. 2019 yılında yayın sayısı 9 olarak belirlenirken, 2020 yılında 15 yayına ulaşılmıştır. Takip eden yıllarda artış eğilimi devam etmiş; 2021 yılında 16, 2022 yılında 18 ve 2023 yılında 28 yayın saptanmıştır. Araştırma alanındaki en yüksek artış ise son iki yılda gözlenmiş olup, 2024 yılında 48 ve 2025 yılında 93 yayın yayımlanmıştır.

Elde edilen bulgular, dijital teknolojilerin afet yönetimi süreçlerine entegrasyonunun ve toplumsal dayanıklılık kavramının giderek daha fazla önem kazandığını göstermektedir. Özellikle son yıllarda yaşanan küresel afetler ve teknolojik gelişmeler, bu alandaki akademik üretimin artmasına katkı sağlamış olabilir.

Şekil 2. Anahtar Kelime Ağ, Overlay ve Yoğunluk Görselleştirmeleri





VOSviewer kullanılarak gerçekleştirilen anahtar kelime birlikte görülme (keyword co-occurrence) analizinde minimum tekrar sayısı 5 olarak belirlenmiştir. Eşik değerini sağlayan anahtar kelimeler arasındaki ilişkiler; ağ görselleştirmesi, zamansal overlay görselleştirmesi ve yoğunluk haritası aracılığıyla incelenmiştir.

Ağ görselleştirmesi (Şekil 2a), araştırma alanının birbiriyle güçlü biçimde bağlantılı dört temel tematik küme etrafında şekillendiğini göstermektedir. Birinci kümede "disaster management" kavramı ağın en büyük ve en merkezi düğümü olarak öne çıkmakta; "big data", "community resilience" ve "disaster resilience" kavramlarıyla birlikte alanın afet yönetimi ve dayanıklılık eksenini oluşturmaktadır. Bu kümenin diğer kümelerle kurduğu yoğun bağlantılar, afet yönetiminin araştırma alanındaki farklı teknolojik ve risk temelli yaklaşımları bir araya getiren temel kavramsal odak olduğunu göstermektedir.

İkinci küme; "climate change", "risk assessment", "vulnerability", "natural hazards", "flood", "GIS", "remote sensing" ve "machine learning" kavramlarının oluşturduğu afet riski, kırılganlık ve mekânsal-teknolojik analiz ekseninde yoğunlaşmaktadır. Bu kümede coğrafi bilgi sistemleri, uzaktan algılama ve makine öğrenmesi gibi teknolojilerin iklim değişikliği, doğal tehlikeler, taşkın riski ve kırılganlık analizleriyle birlikte konumlanması, dijital teknolojilerin afet risklerinin belirlenmesi ve değerlendirilmesinde giderek daha fazla kullanıldığını ortaya koymaktadır.

Üçüncü kümede "resilience" kavramı merkezi konumda bulunurken; "artificial intelligence", "internet of things", "disasters", "recovery", "deep learning" ve "COVID-19" gibi

kavramların aynı tematik yapı içerisinde yer aldığı görülmektedir. Bu küme, afet sonrası toparlanma ve sistem dayanıklılığının yapay zekâ, nesnelerin interneti ve derin öğrenme gibi dijital teknolojilerle ilişkilendirildiği araştırma yönelimini temsil etmektedir. Dolayısıyla dayanıklılık kavramının yalnızca afetlerin etkilerine karşı koyabilme kapasitesi bağlamında değil, dijital teknolojiler aracılığıyla müdahale ve toparlanma kapasitesinin geliştirilmesi çerçevesinde de ele alındığı anlaşılmaktadır.

Dördüncü küme ise "IoT", "digital twin", "climate resilience", "floods" ve "disaster risk reduction" kavramları etrafında oluşmaktadır. Bu küme, özellikle yeni nesil dijital teknolojilerin afet risk azaltımı ve iklim dayanıklılığı uygulamalarıyla bütünleşmesine işaret etmektedir. Dijital ikiz ve IoT kavramlarının aynı kümede yer alması, gerçek zamanlı veri üretimi, fiziksel sistemlerin dijital olarak modellenmesi ve afetlere ilişkin erken değerlendirme kapasitesinin literatürde giderek gelişen bir araştırma hattı oluşturduğunu göstermektedir.

Overlay görselleştirmesi (Şekil 2b), anahtar kelimelerin araştırma literatüründe öne çıktıkları dönemlerin farklılaştığını göstermektedir. Haritadaki renk skalası yaklaşık olarak 2022–2025 dönemindeki değişimi yansıtmaktadır. Daha erken dönemi temsil eden mavi ve mor tonlarda "disaster resilience", "disaster risk reduction", "risk management" ve "risk assessment" gibi kavramların öne çıktığı görülmektedir. Bu görünüm, incelenen literatürün başlangıç döneminde afet risklerinin değerlendirilmesi, risk azaltımı ve dayanıklılık kapasitesinin geliştirilmesi üzerinde yoğunlaştığına işaret etmektedir.

Buna karşılık daha güncel araştırma yönelimlerini temsil eden yeşil ve özellikle sarı tonlarda "digital twin", "climate resilience", "floods" ve "internet of things" gibi kavramların öne çıktığı görülmektedir. "Artificial intelligence", "machine learning" ve "IoT" gibi dijital teknoloji kavramlarının da görece güncel araştırma eksenleri içerisinde yer alması, alanın zaman içerisinde teknoloji yoğun bir yapıya doğru evrildiğini göstermektedir. Özellikle "digital twin" kavramının en yeni araştırma temalarından biri olarak görünmesi, afet yönetiminde fiziksel sistemlerin dijital modeller aracılığıyla izlenmesi, simülasyonu ve risk senaryolarının değerlendirilmesi yönündeki araştırmaların yakın dönemde önem kazandığına işaret etmektedir.

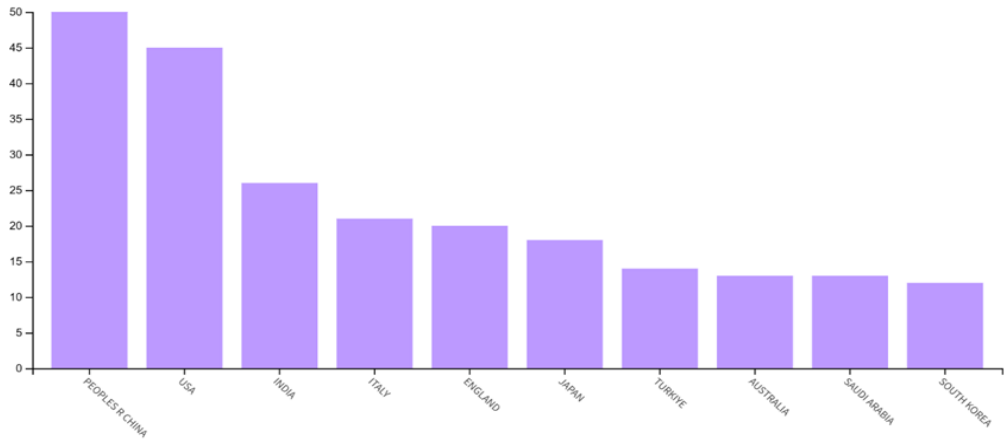
Overlay haritası genel olarak değerlendirildiğinde, literatürdeki araştırma gündeminin risk değerlendirmesi ve afet dayanıklılığı merkezli daha geleneksel yaklaşımlardan; IoT, dijital ikiz, yapay zekâ ve veri temelli sistemlerin afet risk azaltımı ve iklim dayanıklılığına entegrasyonunu inceleyen daha teknoloji yoğun bir araştırma hattına doğru genişlediği söylenebilir. Bununla birlikte "disaster management" kavramının farklı dönemlere ait anahtar kelimelerle güçlü bağlantılar kurması, afet yönetiminin söz konusu tematik dönüşüm boyunca alanın merkezi araştırma konusu olmayı sürdürdüğünü göstermektedir.

Yoğunluk görselleştirmesi (Şekil 2c), araştırma alanında hangi kavramların daha yüksek birlikte görülme yoğunluğuna sahip olduğunu ortaya koymaktadır. Haritada "disaster management" kavramının en yüksek yoğunluğa sahip merkezi araştırma teması olduğu açık biçimde görülmektedir. "resilience" ve "GIS" kavramları da yüksek yoğunluk gösteren diğer temel odak noktaları olarak öne çıkmaktadır. Bunun yanında "big data", "machine learning", "climate change", "risk assessment", "vulnerability", "artificial intelligence", "remote sensing" ve "disaster risk reduction" kavramlarının çevresinde de belirgin yoğunluk alanları oluşmaktadır.

Yoğunluk dağılımı, afet yönetimi literatürünün yalnızca müdahale ve risk azaltma süreçleriyle sınırlı olmadığını; CBS, büyük veri, yapay zekâ, makine öğrenmesi ve uzaktan algılama gibi dijital teknolojilerle güçlü biçimde bütünleştiğini göstermektedir. Buna karşılık "digital twin", "IoT" ve "climate resilience" gibi kavramların ağ içerisinde görünür olmakla birlikte merkezdeki kavramlara kıyasla daha düşük yoğunlukta bulunması, bu temaların henüz görece gelişmekte olan araştırma alanları olduğuna işaret etmektedir.

Üç şekil, sivil savunma ve afet yönetiminde dijitalleşme ve dayanıklılık literatürünün merkezinde afet yönetimi ve dayanıklılık kavramlarının bulunduğu; alanın giderek yapay zekâ, büyük veri, makine öğrenmesi, IoT, GIS, uzaktan algılama ve dijital ikiz gibi teknolojilerle genişlediği görülmektedir. Özellikle overlay analizinde yeni teknolojilere ilişkin kavramların daha yakın dönemlerde öne çıkması ve ağ analizinde bu kavramların afet riski, dayanıklılık ve iklim kaynaklı tehlikelerle bağlantı kurması, araştırma alanında klasik afet risk yönetiminden veri temelli ve teknoloji destekli dayanıklılık yaklaşımına doğru belirgin bir tematik dönüşüm yaşandığını ortaya koymaktadır.

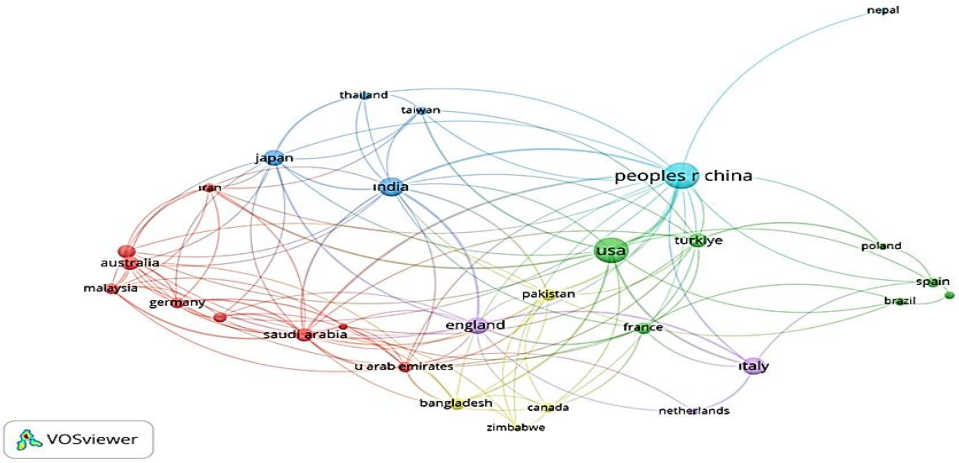
Şekil 3. Ülkelere Göre Yayın Dağılımı



Web of Science veri tabanından elde edilen 248 yayının ülkelere göre dağılımı incelendiğinde, sivil savunmada dijitalleşme ve dayanıklılık alanında en fazla yayının **Çin** tarafından üretildiği görülmüştür (**n=50**). Çin'i sırasıyla **Amerika Birleşik Devletleri (n=45)** ve **Hindistan (n=26)** takip etmektedir. Bunun yanı sıra **İtalya (n=21)**, **İngiltere (n=20)** ve **Japonya (n=18)** alan yazına önemli katkılar sunan ülkeler arasında yer almaktadır. Ayrıca **Türkiye'nin 14 yayın ile ilk 10 ülke arasında bulunması**, bu araştırma alanındaki akademik görünürlüğüne işaret etmektedir.

Elde edilen bulgular, sivil savunma ve ilişkili afet ve acil durum yönetimi literatüründe dijitalleşme ve dayanıklılık konularındaki bilimsel üretimin ülkeler arasında farklılaştığını göstermektedir. Çin ve Amerika Birleşik Devletleri'nin yayın sayısı bakımından öne çıkması, bu ülkelerin incelenen literatürde yüksek akademik görünürlüğe sahip olduğunu ortaya koymaktadır. Türkiye'nin ilk 10 ülke arasında yer alması ise Türkiye kaynaklı çalışmaların söz konusu araştırma alanındaki uluslararası literatüre belirgin bir katkı sunduğunu göstermektedir.

Şekil 4. Ülkeler Arası İş Birliği Ağı Analizi



Ülkeler arası iş birliği ağı analizi, sivil savunmada dijitalleşme ve dayanıklılık alanındaki uluslararası araştırma ortaklıklarını ortaya koymak amacıyla VOSviewer programı kullanılarak gerçekleştirilmiştir. Analiz sonucunda toplam **248 yayında** yer alan ülkeler arasındaki ortak yazarlık ilişkileri incelenmiş ve ülkeler arasındaki bilimsel iş birliği ağları görselleştirilmiştir.

Elde edilen bulgular, **Çin (People's R China)** ve **Amerika Birleşik Devletleri'nin (USA)** uluslararası araştırma iş birliklerinde merkezi bir konumda bulunduğunu göstermektedir.

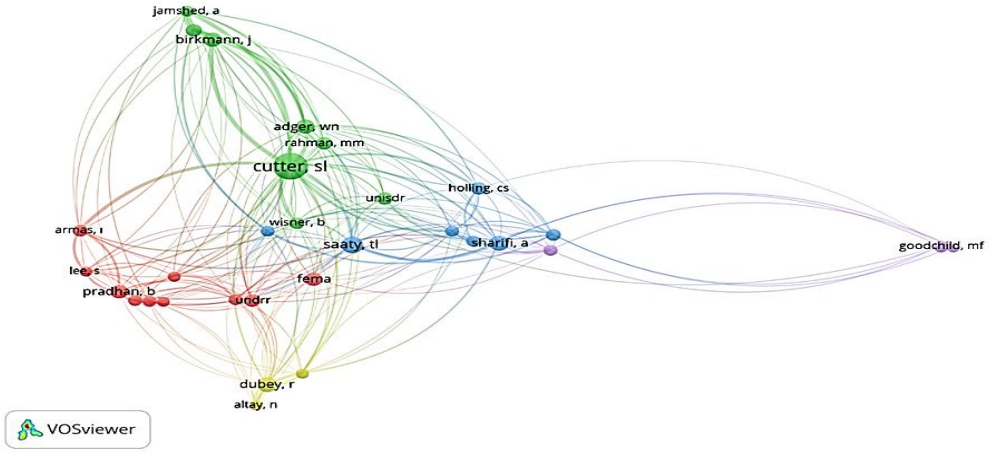
Özellikle Çin'in Hindistan, Türkiye, İspanya ve Polonya gibi birçok ülke ile güçlü bağlantılar kurduğu belirlenmiştir. Amerika Birleşik Devletleri'nin ise Fransa, Pakistan ve çeşitli Avrupa ülkeleriyle iş birlikleri geliştirdiği görülmüştür.

Ağ haritasında **Hindistan, Japonya ve Tayvan'ın** Asya merkezli araştırma kümeleri içerisinde aktif rol oynadığı, **İngiltere ve İtalya'nın** ise Avrupa ülkeleri ile bağlantılı iş birlikleri yürüttüğü tespit edilmiştir. Ayrıca **Türkiye'nin** Çin ve Amerika Birleşik Devletleri başta olmak üzere farklı ülkelerle ortak yayınlar gerçekleştirdiği ve uluslararası iş birliği ağı içerisinde yer aldığı belirlenmiştir.

VOSviewer analizinde farklı renklerle gösterilen kümeler, benzer iş birliği eğilimlerine sahip ülke gruplarını temsil etmektedir. Ağ üzerindeki düğüm büyüklüğü ülkelerin yayın üretim düzeyini, düğümler arasındaki çizgiler ise ülkeler arasındaki iş birliği yoğunluğunu ifade etmektedir. Çizgilerin kalınlaşması, ülkeler arasındaki ortak yayın sayısının arttığını göstermektedir.

Bu bulgular, sivil savunmada dijitalleşme ve dayanıklılık konularının küresel nitelikte araştırma alanları olduğunu ve uluslararası iş birliklerinin bilgi paylaşımı ile yenilikçi çözümlerin geliştirilmesinde önemli bir rol oynadığını ortaya koymaktadır. Özellikle afet yönetimi, krizlere hazırlık ve dijital dayanıklılık gibi disiplinler arası yaklaşımlar gerektiren alanlarda ülkeler arası akademik iş birliklerinin gelecekte daha da artacağı öngörülmektedir.

Şekil 5. Yazar Eş-Atıf (Co-citation) Analizi



Yazar eş-atıf analizi, sivil savunmada dijitalleşme ve dayanıklılık alanında etkili yazarlar arasındaki entelektüel ilişkileri ortaya koymak amacıyla VOSviewer programı kullanılarak gerçekleştirilmiştir. Analiz sonucunda belirlenen eşik değeri doğrultusunda en az 11 atıf alan

yazarlar değerlendirmeye alınmış ve yazarlar arasındaki eş-atıf ilişkileri ağ haritası ile görselleştirilmiştir.

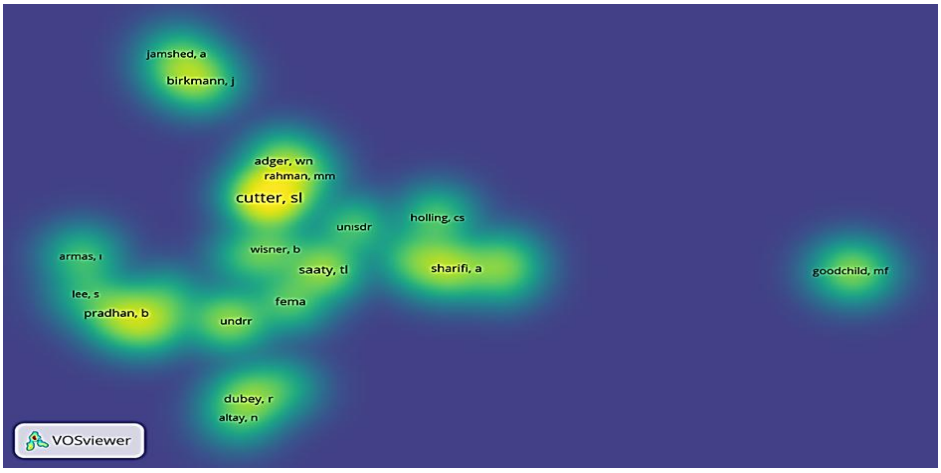
Elde edilen bulgular, **Cutter, S.L.** yazarının ağ içerisinde en merkezi konumda yer aldığını ve diğer birçok araştırmacıyla güçlü eş-atıf ilişkilerine sahip olduğunu göstermektedir. Cutter'ın özellikle afet dayanıklılığı, kırılganlık değerlendirmesi ve toplumsal dirençlilik konularındaki çalışmaları alan yazında temel referans kaynakları arasında yer almaktadır.

Ayrıca **Birkmann, J.**, **Adger, W.N.**, **Sharifi, A.**, **Saaty, T.L.** ve **Holling, C.S.** gibi yazarların da yüksek düzeyde eş-atıf aldığı belirlenmiştir. Bu yazarların çalışmaları; afet risk azaltımı, sürdürülebilir dayanıklılık, karar verme süreçleri ve sosyal-ekolojik sistemlerin dayanıklılığı gibi temel araştırma alanlarını temsil etmektedir.

Ağ haritasında farklı renklerle gösterilen kümeler, benzer araştırma temalarına odaklanan yazar gruplarını ifade etmektedir. Düğüm büyüklüğü yazarların eş-atıf sıklığını gösterirken, düğümler arasındaki bağlantılar ise yazarların birlikte atıf alma düzeylerini temsil etmektedir. Özellikle Cutter, Birkmann ve Sharifi'nin farklı kümeler arasında köprü görevi üstlenmesi, bu yazarların alanın teorik ve kavramsal gelişiminde önemli bir role sahip olduğunu göstermektedir.

Bu bulgular, sivil savunmada dijitalleşme ve dayanıklılık alanındaki araştırmaların disiplinler arası bir yapıya sahip olduğunu ve afet yönetimi, dayanıklılık teorisi, sürdürülebilirlik ve karar verme süreçleri üzerine çalışan öncü araştırmacıların alan yazını şekillendirdiğini ortaya koymaktadır. Bu yapı, alanın entelektüel temelinin afet dayanıklılığı, kırılganlık, sosyal-ekolojik sistemler ve karar verme literatürlerinin kesişiminde oluştuğuna işaret etmektedir.

Şekil 6. Yazar Eş-Atıf Yoğunluk (Density) Analizi



Yazar eş-atıf yoğunluk analizi, sivil savunmada dijitalleşme ve dayanıklılık alanında en etkili araştırmacıları ve bu araştırmacıların alan yazındaki görünürlük düzeylerini belirlemek amacıyla VOSviewer programı kullanılarak gerçekleştirilmiştir. Yoğunluk haritasında sarı renge yakın bölgeler daha yüksek eş-atıf yoğunluğunu, yeşil ve mavi tonlar ise daha düşük yoğunluk düzeylerini ifade etmektedir.

Analiz sonuçlarına göre, **Cutter, S.L.** en yüksek yoğunluğa sahip yazar olarak öne çıkmaktadır. Cutter'ın özellikle afet dayanıklılığı, sosyal kırılganlık ve toplumsal dirençlilik konularındaki çalışmaları alan yazında önemli referans kaynakları olarak değerlendirilmektedir. Bunun yanı sıra **Adger, W.N.**, **Sharifi, A.**, **Birkmann, J.** ve **Pradhan, B.** gibi araştırmacıların da yüksek yoğunluk bölgelerinde yer aldığı belirlenmiştir.

Yoğunluk haritasında **Sharifi, A.** ve **Holling, C.S.** gibi yazarların sürdürülebilir şehirler ve sosyal-ekolojik dayanıklılık konularındaki çalışmalarıyla dikkat çektiği görülmektedir. Ayrıca **Saaty, T.L.**, **Wisner, B.**, **UNISDR** ve **FEMA** gibi araştırmacı ve kurumların afet risk yönetimi ve karar verme süreçleri kapsamında önemli referans kaynakları arasında yer aldığı tespit edilmiştir.

Yoğunluk haritası, alanın bilgi tabanının birkaç güçlü teorik odak etrafında yoğunlaştığını göstermektedir. Özellikle afet dayanıklılığı, sosyal kırılganlık, risk yönetimi ve sosyal-ekolojik dayanıklılık yaklaşımlarının yüksek görünürlüğe sahip olması, sivil savunmada dijitalleşme çalışmalarının teknolojik bir literatürden ibaret olmadığını; daha geniş dayanıklılık ve risk araştırmaları üzerine inşa edildiğini ortaya koymaktadır.

4. TARTIŞMA

Çalışmadan elde edilen bulgular, sivil savunma ve ilişkili afet ve acil durum yönetimi literatüründe dijitalleşme ve dayanıklılık konularına yönelik akademik ilginin özellikle son yıllarda arttığını göstermektedir. Yayın sayısındaki artışın 2020 sonrasında belirginleşmesi ve 2024–2025 döneminde hız kazanması, bu iki konunun afet yönetimi araştırmalarında daha görünür hâle geldiğine işaret etmektedir. Bu gelişme, afet yönetimi anlayışının yalnızca afet sonrasında müdahaleye odaklanan bir yapıdan risk azaltma, hazırlık ve dayanıklılığı da kapsayan daha bütüncül bir yaklaşıma yönelmesiyle birlikte değerlendirilebilir. Bununla birlikte bibliyometrik veriler, yayın sayısındaki artışın nedenlerini doğrudan açıklamadığından, söz konusu eğilim alanın artan akademik ilgisinin bir göstergesi olarak ele alınmalıdır.

Anahtar kelime analizleri, literatürdeki değişimin yalnızca yayın sayısıyla sınırlı olmadığını, araştırma konularında da belirgin bir dönüşüm yaşandığını göstermektedir. “Disaster management”, “resilience”, “disaster risk reduction”, “vulnerability” ve “risk assessment” gibi kavramların alanın temel konuları arasında yer almaya devam ettiği görülürken; yapay

zekâ, makine öğrenmesi, büyük veri, IoT ve digital twin gibi kavramların daha güncel çalışmalarda öne çıktığı belirlenmiştir. GIS ve uzaktan algılama gibi teknolojilerin risk değerlendirme ve kırılganlık analizleriyle birlikte ele alınması, dijital araçların afet yönetimine entegrasyonunun tamamen yeni bir gelişme olmadığını göstermektedir (Pradhan, 2010). Buna karşılık IoT ve digital twin gibi kavramların daha yakın dönemlerde görünürlük kazanması, gerçek zamanlı veri kullanımı, izleme, simülasyon ve tahmin kapasitesine yönelik ilginin gelişmekte olduğunu düşündürmektedir. Dolayısıyla dijital teknolojilerin afet yönetimindeki rolünün müdahale aşamasının ötesine geçerek hazırlık, risk tespiti, erken uyarı ve toparlanma süreçlerine yayıldığı görülmektedir.

Yazar eş-atıf analizinde Cutter, Adger, Birkmann, Sharifi ve Holling gibi araştırmacıların öne çıkması, alanın bilgi birikiminin önemli ölçüde dayanıklılık, kırılganlık ve afet risk yönetimi literatürü üzerine kurulduğunu göstermektedir. Özellikle toplumsal kırılganlık ve dayanıklılık yaklaşımları (Adger, 2006; Cutter et al., 2008), afetlerin yalnızca fiziksel zararlar üzerinden değil, toplumların hazırlık, uyum ve toparlanma kapasiteleri üzerinden de ele alınmasına katkı sağlamaktadır. Sharifi'nin (2016) toplumsal dayanıklılığın değerlendirilmesinde kullanılan araçlara yönelik incelemesi de dayanıklılığın farklı boyutlarının ölçülmesine ilişkin literatürün gelişimini göstermektedir. Bu çerçevede dijitalleşmenin sivil savunma ve afet yönetiminde ayrı ve bağımsız bir araştırma hattı olarak değil, mevcut dayanıklılık ve risk yönetimi yaklaşımlarını yeni teknolojik araçlarla genişleten bir gelişme olarak değerlendirilmesi mümkündür.

Ülkelere göre yayın dağılımı ve ortak yazarlık ağı birlikte değerlendirildiğinde, Çin ve Amerika Birleşik Devletleri'nin hem bilimsel üretim hem de uluslararası iş birlikleri bakımından öne çıktığı görülmektedir. Türkiye'nin de yayın sayısı ve iş birliği ağı açısından görünür bir konumda bulunması dikkat çekicidir. Bununla birlikte bu bulgular, ülkeler arasındaki farklılıkların nedenlerini açıklamamaktadır. Araştırma kapasitesi, finansman yapısı, teknolojik altyapı, afet risk profili ve ulusal politika öncelikleri gibi faktörlerin bu farklılıklar üzerindeki etkisi mevcut bibliyometrik analiz kapsamında doğrudan test edilmemiştir. Bu nedenle ülke bulgularının, neden-sonuç ilişkisi kurmaktan ziyade araştırma alanındaki bilimsel üretim ve iş birliği yapısını gösteren bir sonuç olarak değerlendirilmesi daha uygun olacaktır.

5. SONUÇ VE ÖNERİLER

Bu çalışmada, 2015–2025 döneminde sivil savunma ve ilişkili afet ve acil durum yönetimi literatüründe dijitalleşme ve dayanıklılık konularını ele alan 248 makalenin bibliyometrik yapısı incelenmiştir. Bulgular, söz konusu araştırma alanının özellikle son yıllarda büyüdüğünü ve afet yönetimi ile dayanıklılık kavramlarının literatürün temel eksenini oluşturduğunu ortaya koymaktadır. Bunun yanında dijital teknolojilerin araştırma

gündemindeki ağırlığının giderek arttığı ve alanın klasik risk yönetimi yaklaşımından daha veri temelli ve teknoloji destekli uygulamalara doğru genişlediği görülmektedir.

Analiz araştırma alanında bazı boşluklara da işaret etmektedir. GIS ve uzaktan algılama gibi teknolojilerin daha yerleşik bir literatüre sahip olduğu görülürken, IoT, digital twin ve benzeri yeni nesil uygulamalar daha güncel ve görece gelişmekte olan araştırma konuları olarak öne çıkmaktadır. Bu nedenle gelecekteki çalışmalarda yalnızca söz konusu teknolojilerin afet yönetimindeki kullanım alanlarının tanımlanması yerine, afetlere hazırlık, müdahale süresi, kaynakların etkin kullanımı, kurumlar arası koordinasyon ve afet sonrası toparlanma üzerindeki somut etkilerinin ölçülmesi önem taşımaktadır. Böylece dijitalleşmenin sivil savunma kapasitesine sağladığı katkı daha doğrudan değerlendirilebilir.

Ülkeler arasındaki yayın ve iş birliği farklılıkları da gelecekteki araştırmalar açısından ayrı bir çalışma alanı oluşturmaktadır. Özellikle araştırma kapasitesi, afet risk düzeyi, teknolojik altyapı ve ulusal afet politikalarının bilimsel üretim üzerindeki etkilerinin karşılaştırmalı biçimde incelenmesi, bibliyometrik bulguların daha geniş bir politika çerçevesinde değerlendirilmesine katkı sağlayabilir. Türkiye açısından ise farklı ülke uygulamalarıyla yapılacak karşılaştırmalar, dijital afet yönetimi kapasitesinin güçlü ve geliştirilmesi gereken yönlerinin belirlenmesine yardımcı olabilir.

Bu çalışma genel olarak sivil savunma ve afet yönetiminde dijitalleşme ile dayanıklılık arasındaki ilişkinin gelişmekte olan disiplinler arası bir araştırma alanı olduğunu göstermektedir. Gelecek çalışmalar açısından temel ihtiyaç ise yeni dijital teknolojilerin varlığını ve kullanım potansiyelini ortaya koymaktan ziyade, bu teknolojilerin afet yönetimi ve dayanıklılık kapasitesi üzerinde ne ölçüde ve hangi koşullarda etkili olduğunu ampirik olarak belirlenmesidir.

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FINANCING THE GREEN TRANSITION: EVIDENCE FROM EUROPE

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Abstract

The transition toward a low-carbon economy increasingly depends on the ability of financial systems and public institutions to mobilize resources toward environmentally sustainable activities. This study investigates the determinants of the green transition by examining the roles of financial development, environmental government spending, regulatory quality, and economic development in ten European economies (Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, and the United Kingdom) over 2002–2020. Renewable energy consumption serves as a proxy for the green transition, while financial development, GDP per capita, regulatory quality, and general government expenditure on environmental protection (% of GDP) are the main explanatory variables. The empirical strategy explicitly accounts for cross-sectional dependence and slope heterogeneity, both of which are confirmed by preliminary tests. Accordingly, the analysis employs the cross-sectionally augmented IPS (CIPS) unit root test and the LM bootstrap panel cointegration test. The results show that the variables become stationary after first differencing and exhibit a long-run equilibrium relationship. Long-run coefficients are estimated using the Augmented Mean Group (AMG) estimator, with the robust Common Correlated Effects Mean Group (rCCE) estimator used as a robustness check. The findings reveal substantial cross-country heterogeneity in the determinants of renewable energy consumption. At the panel level, regulatory quality is negatively associated with renewable energy consumption, though this relationship is statistically significant only in Denmark, Finland, Germany, and Spain at the country level. Environmental government spending has a positive and significant effect in Italy and the Netherlands, suggesting that public environmental expenditure can advance the green transition in some economies. Financial development positively and significantly affects renewable energy consumption only in Germany, underscoring the country-specific role of financial systems in supporting renewable energy adoption. GDP per capita shows heterogeneous effects as well, negatively associated with renewable energy consumption in Finland however positively associated in Germany. Overall, the findings indicate that the contribution of financial development and environmental spending to the green transition is highly country-specific, and that regulatory quality alone does not guarantee greater renewable energy adoption. The study offers policy implications for designing country-specific sustainable finance and environmental expenditure strategies to accelerate the green transition.

Keywords: Green Transition, Renewable Energy Consumption, Financial Development, Regulatory Quality, Environmental Government Expenditure

YEŞİL DÖNÜŞÜMÜN FİNANSMANI: AVRUPA'DAN KANITLAR

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Özet

Düşük karbonlu bir ekonomiye geçiş, giderek artan bir şekilde finansal sistemlerin ve kamu kurumlarının kaynakları çevresel olarak sürdürülebilir faaliyetlere yönlendirme yeteneğine bağlıdır. Bu çalışma, 2002-2020 yılları arasında on Avrupa ekonomisinde (Danimarka, Finlandiya, Fransa, Almanya, İtalya, Hollanda, Norveç, İspanya, İsveç ve Birleşik Krallık) finansal gelişme, çevresel kamu harcamaları, düzenleyici kalite ve ekonomik gelişmenin rollerini inceleyerek yeşil geçişin belirleyicilerini araştırmaktadır. Yenilenebilir enerji tüketimi yeşil geçiş için bir gösterge olarak kullanılırken, finansal gelişme, kişi başına GSYİH, düzenleyici kalite ve çevre koruma amaçlı genel kamu harcamaları (GSYİH'nin %'si) ana açıklayıcı değişkenlerdir. Ampirik strateji, kesitsel bağımlılığı ve eğim heterojenliğini açıkça hesaba katmaktadır ve her ikisi de ön testlerle doğrulanmıştır. Buna göre, analizde kesitsel olarak artırılmış IPS (CIPS) birim kök testi ve LM bootstrap panel eşbütünleşme testi kullanılmaktadır. Sonuçlar, değişkenlerin birinci fark alma işleminden sonra durağan hale geldiğini ve uzun vadeli bir eşbütünleşme ilişkisi sergilediğini göstermektedir. Uzun vadeli katsayılar Genişletilmiş Ortalama Grup (AMG) tahmincisi kullanılarak tahmin edilmiş ve sağlamlık kontrolü olarak sağlam Ortak İlişkili Etkiler Ortalama Grup (rCCE) tahmincisi kullanılmıştır. Bulgular, yenilenebilir enerji tüketiminin belirleyicilerinde ülkeler arası önemli bir heterojenlik olduğunu ortaya koymaktadır. Panel düzeyinde, düzenleyici kalite yenilenebilir enerji tüketimiyle negatif bir ilişki göstermektedir, ancak bu ilişki ülke düzeyinde yalnızca Danimarka, Finlandiya, Almanya ve İspanya'da istatistiksel olarak anlamlıdır. Çevreye yönelik kamu harcamaları İtalya ve Hollanda'da pozitif ve anlamlı bir etkiye sahiptir ve bu da kamu çevre harcamalarının bazı ekonomilerde yeşil geçişi ilerletebileceğini göstermektedir. Finansal gelişme, yenilenebilir enerji tüketimini yalnızca Almanya'da pozitif ve anlamlı bir şekilde etkilemekte olup, finansal sistemlerin yenilenebilir enerji benimsenmesini desteklemedeki ülke özelindeki rolünü vurgulamaktadır. Kişi başına düşen GSYİH de heterojen etkiler göstermekte olup, Finlandiya'da yenilenebilir enerji tüketimiyle negatif, Almanya'da ise pozitif bir ilişki göstermektedir. Genel olarak, bulgular finansal gelişme ve çevre harcamalarının yeşil geçişe katkısının ülkeye özgü olduğunu ve yalnızca düzenleyici kalitenin daha fazla yenilenebilir enerji benimsenmesini garanti etmediğini göstermektedir. Bu çalışma, yeşil dönüşümü hızlandırmak için ülkeye özgü sürdürülebilir finans ve çevre harcama stratejilerinin tasarlanmasına yönelik politika önerileri sunmaktadır.

Anahtar Kelimeler: Yeşil Dönüşüm, Yenilenebilir Enerji Tüketimi, Finansal Gelişme, Düzenleyici Kalite, Çevresel Hükümet Harcamaları

TÜRKİYE'DE SIFIR ATIK YÖNETİMİNİN DÖNGÜSEL EKONOMİ PERSPEKTİFİNDEN DEĞERLENDİRİLMESİ

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Özet

Bu çalışmanın amacı, 2017 yılında Türkiye'de hayata geçirilen Sıfır Atık Projesi doğrultusunda elde edilen kazanımları döngüsel ekonomi perspektifinden değerlendirmektir. Çalışmada; geri kazanılan atık miktarı, geri kazanım faaliyetleri sonucunda sağlanan ekonomik katkı, çevresel ve enerji tasarrufları ile sistemin avantaj ve dezavantajları ikincil veri analizi ve doküman incelemesi yöntemiyle ele alınmıştır. Bu doğrultuda, Çevre, Şehircilik ve İklim Değişikliği Bakanlığı, Türkiye Çevre Ajansı yayımları ve ilgili akademik literatür incelenerek değerlendirme yapılmıştır. Elde edilen bulgular, projenin başlangıcından 2025 yılı sonuna kadar yaklaşık 90 milyon ton atığın geri kazanıldığını ve ekonomik sisteme yeniden dâhil edildiğini göstermektedir. Geri kazanım oranı 2017 yılında %13 iken 2025 itibarıyla %37,53'e yükselmiş; 2035 yılı için %60 hedefi belirlenmiştir. Sistem, kaynak verimliliği, enerji tasarrufu, istihdam ve çevresel sürdürülebilirlik açısından önemli avantajlar sunarken altyapı eksiklikleri, bölgesel farklılıklar, kaynağında ayrıştırma davranışındaki yetersizlikler ve veri şeffaflığına ilişkin sınırlılıklar başlıca dezavantajlar olarak öne çıkmaktadır. Çalışma, Türkiye'nin sıfır atık politikasının döngüsel ekonomiye geçişte güçlü bir araç olduğunu; ancak sürdürülebilir başarının bireysel, kurumsal ve toplumsal düzeyde bütüncül bir yaklaşımı gerektirdiğini ortaya koymaktadır.

Anahtar Kelimeler: Sıfır Atık, Döngüsel Ekonomi, Atık Yönetimi, Geri Kazanım, Sürdürülebilirlik

ASSESSMENT OF ZERO WASTE MANAGEMENT IN TÜRKİYE FROM A CIRCULAR ECONOMY PERSPECTIVE

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Abstract

The aim of this study is to assess the achievements made under the Zero Waste Project, which was launched in Turkey in 2017, from the perspective of the circular economy. In this study, the amount of waste recovered, the economic benefits generated by recovery activities, environmental and energy savings, and the advantages and disadvantages of the system were examined using secondary data analysis and document review. In this regard, the analysis was carried out by reviewing publications by the Ministry of Environment, Urbanization and Climate Change, the Turkish Environment Agency, and related academic literature. The findings indicate that, from the start of the project until the end of 2025, approximately 90 million tonnes of waste were recovered and reintroduced into the economic system. The recovery rate, which was 13% in 2017, increased to 37.53% by 2025, with a target of 60% set for 2035. While the system offers significant advantages in terms of resource efficiency, energy savings, employment, and environmental sustainability, infrastructure deficiencies, regional disparities, inadequate source-separation behavior, and limitations regarding data transparency emerge as the main disadvantages. The study demonstrates that Türkiye's zero waste policy is a powerful instrument in the transition to a circular economy; however, sustainable success requires a holistic approach at the individual, institutional, and societal levels.

Keywords: Zero Waste, Circular Economy, Waste Management, Waste Recovery, Sustainability

GİRİŞ

Kentleşme ve hızlı nüfus artışı, sanayileşme, değişen bireysel tüketim alışkanlıkları, küresel ölçekte atık miktarlarının sürekli artmasına yol açmaktadır. Doğrusal ekonomi modeli olarak adlandırılan "al-üret-kullan-at" yaklaşımı, doğal kaynakların hızla tükenmesine, çevresel bozulmaya ve atık yönetimi sorunlarının derinleşmesine neden olmuştur. Bu durum, ekonomik büyüme ile çevresel sürdürülebilirlik arasındaki dengenin yeniden kurulmasını ve kaynakların daha verimli kullanıldığı alternatif ekonomik modellerin geliştirilmesini zorunlu kılmıştır (Kirchherr et al., 2017; Yusufoğlu & Türkmen, 2020).

Bu bağlamda döngüsel ekonomi yaklaşımı, geleneksel doğrusal modele alternatif olarak öne çıkmaktadır. Döngüsel ekonomi; doğal kaynak kullanımını sınırlandırmayı, üretim süreçlerinde kullanılan kaynakları sisteme yeniden dâhil ederek mümkün olduğunca uzun süre ekonomik döngü içinde tutmayı, ürünlerin faydalı ömürlerini uzatmayı, yeniden kullanım, onarım ve geri dönüşüm uygulamalarını yaygınlaştırmayı ve ürün kaynaklı atık oluşumunu en aza indirmeyi hedefleyen bütüncül bir sistem yaklaşımıdır (Geissdoerfer et al., 2017; Türkmen, 2025). Avrupa Birliği başta olmak üzere pek çok ülke ve uluslararası kuruluş, döngüsel ekonomiyi sürdürülebilir kalkınma ve iklim hedeflerinin temel bileşenlerinden biri olarak benimsemiştir (European Commission, 2020).

Döngüsel ekonomiye geçişin en somut araçlarından biri, atıkların kaynağında ayrıştırılması ve geri kazanılması esasına dayanan sıfır atık yaklaşımıdır. Sıfır atık kavramı kaynakların daha verimli kullanılmasını mümkün kılarak israfın azaltılması/önlenmesi, bu esnada ise atık oluşumunu mümkün olan en düşük düzeyde tutarak verimli üretim ve sürdürülebilir çevreyi aynı anda mümkün kılmayı odaklayan bir hedef ve felsefe olarak tanımlanmaktadır (Yusufoğlu & Türkmen, 2020; Song et al., 2015). Türkiye, bu yaklaşımı ulusal bir politika hâline getirerek 2017 yılında, Sayın E.Erdoğan'ın himayelerinde ÇŞB (Çevre, Şehircilik ve İklim Değişikliği Bakanlığı) koordinasyonunda Sıfır Atık projesini başlatmıştır. Proje kısa sürede ulusal ölçekte yaygınlaşmış ve uluslararası alanda da tanınan bir çevre hareketine dönüşmüştür.

Sıfır Atık Projesi, yalnızca çevresel bir girişim olmanın ötesinde; geri kazanılan materyallerin ekonomik sisteme yeniden dâhil edilmesi, enerji, su ve doğal kaynak tasarrufu sağlanması ve istihdam yaratması yönüyle önemli ekonomik çıktılar da üretmektedir. Bununla birlikte, sistemin uygulanmasında altyapı, katılım, bölgesel farklılıklar ve veri şeffaflığı gibi çeşitli zorluklarla da karşılaşılmaktadır (Gül & Yaman, 2021). Bu nedenle projenin yalnızca başarılarının değil, aynı zamanda sınırlılıklarının da bütüncül biçimde değerlendirilmesi büyük önem taşımaktadır.

Bu çalışmanın amacı, Türkiye Sıfır Atık Projesi kapsamında elde edilen kazanımları döngüsel ekonomi perspektifinden değerlendirmektir. Bu çalışmada özellikle (i) geri kazanılan atık

miktarı ve bu miktarın atık türlerine göre dağılımı, (ii) elde edilen ekonomik gelir ve katkı, (iii) çevresel ve enerji kazanımları ile (iv) sistemin avantaj ve dezavantajları boyutlarıyla Türkiye'nin döngüsel ekonomiye geçiş sürecindeki politika çıktılarını sayısal verilerle ortaya koyması ve gelecekte yapılacak araştırmalara yol gösterici bir çerçeve sunması amaçlanmaktadır.

1. KAVRAMSAL ÇERÇEVE

1.1. Döngüsel Ekonomi Kavramı

Döngüsel ekonomi, geleneksel doğrusal üretim-tüketim modeline alternatif olarak geliştirilen sürdürülebilir bir ekonomik sistem yaklaşımıdır. Doğrusal ekonomi modeli; hammaddenin çıkarılması, işlenmesi, kullanılması ve kullanım sonrasında atık olarak sistem dışına atılması esasına dayanmaktadır. Buna karşılık döngüsel ekonomi; ürünlerin yaşam döngüsünün uzatılması, yeniden kullanım, onarım, yeniden üretim ve geri dönüşüm gibi döngüsel stratejiler yoluyla ürünlerin, bileşenlerin ve materyallerin ekonomik sistem içinde mümkün olduğunca uzun süre tutulmasını hedeflemektedir (Kirchherr et al., 2017).

Döngüsel ekonomi yalnızca bir atık yönetimi perspektifi değil; aynı zamanda sürdürülebilir üretim, kaynak verimliliği, çevresel performans ve ekonomik dayanıklılık bakımından kapsamlı bir dönüşüm modeli olarak değerlendirilmektedir. Yaklaşımın temel amacı, ekonomik büyüme ile kaynak tüketimi arasındaki bağı zayıflatmak (decoupling) ve çevresel yükleri en aza indirmektir (Korhonen et al., 2018). Avrupa Birliği, Avrupa Yeşil Mutabakatı ve Döngüsel Ekonomi Eylem Planı kapsamında bu modeli iklim nötrlüğü hedefleriyle bütünleşik biçimde ele almaktadır (European Commission, 2020).

1.2. Sıfır Atık Yaklaşımı ve Atık Yönetimi Hiyerarşisi

Sıfır atık, üretim ve tüketim süreçlerinde israfın önlenmesini, kaynakların verimli kullanılmasını, atık oluşumunun en aza indirilmesini ve oluşan atıkların geri kazanılarak yeniden değerlendirilmesini amaçlayan bir yaklaşımdır. Kavram, atıkların bertaraf edilecek bir "sorun" olarak değil, ekonomiye yeniden kazandırılacak bir "kaynak" olarak görülmesi anlayışına dayanmaktadır. Sıfır atık stratejisi, artan katı atık miktarının azaltılmasında en kapsamlı yaklaşımlardan biridir ve ürün tasarımından tüketim sonrası süreçlere kadar tüm yaşam döngüsünü kapsamaktadır (Song et al., 2015).

Sıfır atık yaklaşımı, modern atık yönetimi hiyerarşisiyle doğrudan ilişkilidir. Bu hiyerarşide öncelik sırası; atık oluşumunun önlenmesi, azaltılması, yeniden kullanım, geri dönüşüm, geri kazanım (enerji elde edilmesi) ve son olarak bertaraf biçimindedir. Önleme ve azaltma en üst öncelik iken, düzenli depolama ve bertaraf en son tercih edilen seçenektir. Bu yönüyle sıfır atık yaklaşımı, döngüsel ekonominin operasyonel düzeydeki en somut uygulama araçlarından biri olarak kabul edilmektedir.

Bu çalışmada kavramsal tutarlılığın sağlanabilmesi amacıyla geri kazanım, geri dönüşüm ve yeniden kullanım kavramları birbirinden ayrıştırılarak kullanılmaktadır. Geri kazanım, atıkların ekonomik veya işlevsel bir değer oluşturacak biçimde yeniden değerlendirilmesini sağlayan ve geri dönüşüm ile enerji geri kazanımı gibi farklı işlemleri kapsayan üst kavramı ifade etmektedir. Geri dönüşüm, atık materyallerin fiziksel, kimyasal veya biyolojik işlemlerden geçirilerek yeni ürünlere, materyallere ya da ikincil hammaddelere dönüştürülmesini kapsamaktadır. Yeniden kullanım ise ürün veya bileşenlerin esaslı bir işleme tabi tutulmaksızın aynı ya da benzer amaçlarla tekrar kullanılmasını ifade etmektedir. "Ekonomiye kazandırma" kavramı ise ayrı bir atık işleme yöntemi olarak değil, geri kazanım işlemleri sonucunda ortaya çıkan ekonomik değeri tanımlamak amacıyla kullanılmaktadır. Bu doğrultuda çalışmada, resmî kaynaklarda "geri kazanım oranı" ve "geri kazanılan atık miktarı" olarak sunulan nicel göstergeler aynı terminoloji korunarak aktarılmakta; geri dönüşüm ifadesi yalnızca atık materyallerin ikincil ürün veya hammaddeye dönüştürülmesi sürecini belirtmek amacıyla kullanılmaktadır.

1.3. Türkiye'de Sıfır Atık Projesinin Gelişimi ve Yasal-Kurumsal Çerçeve

Türkiye'de Sıfır Atık Projesi, 27 Eylül 2017 tarihinde Sayın Emine Erdoğan'ın himayelerinde ve ÇŞB koordinasyonunda başlatılmıştır. Projenin temel hedefleri; atık oluşumunun önlenmesi, atıkların kaynağında ayrı toplanması, geri kazanımın artırılması ve kaynak verimliliğinin geliştirilmesi olarak belirlenmiştir. Sürecin hukuki altyapısı, 12 Temmuz 2019 tarihli ve 30829 sayılı Resmî Gazete'de yayımlanan Sıfır Atık Yönetmeliği ile oluşturulmuş; kamu kurumları, belediyeler, eğitim kurumları ve işletmeler için sıfır atık yönetim sistemine geçiş kademeli olarak zorunlu hâle getirilmiştir (Resmî Gazete, 2019).

Projenin yürütülmesinde kurumsal kapasitenin güçlendirilmesi amacıyla Türkiye Çevre Ajansı (TÜÇA) kurulmuştur. Ajans; çevre bilincinin geliştirilmesi, geri kazanılabilir atıkların geri kazanım sistemine yönlendirilmesi ve ekonomik değere dönüştürülmesi ve özellikle Depozito Yönetim Sistemi'nin (DYS) hayata geçirilmesi gibi alanlarda görev üstlenmiştir. Ayrıca Bakanlık tarafından atık yönetiminin orta ve uzun vadeli yol haritasını belirleyen 2025–2035 Ulusal Atık Yönetimi Stratejisi ve Planı hazırlanmıştır (ÇŞB, 2025a).

Uluslararası düzeyde ise Sıfır Atık hareketi, Türkiye'nin öncülüğünde küresel bir nitelik kazanmıştır. Birleşmiş Milletler Genel Kurulu, 2022 yılında aldığı kararla 30 Mart'ı "Uluslararası Sıfır Atık Günü" olarak ilan etmiş ve bu süreçte Türkiye'nin girişimi belirleyici rol oynamıştır. Bu gelişme, projenin yalnızca ulusal değil, uluslararası bir çevre politikası markası hâline geldiğini göstermektedir.

2. METODOLOJİ

Bu çalışma, Türkiye'de 2017 yılında uygulamaya konulan Sıfır Atık Projesi'nin döngüsel ekonomi perspektifinden ortaya çıkardığı ekonomik, çevresel ve kurumsal sonuçları değerlendirmeyi amaçlayan, ikincil verilere dayalı betimleyici bir politika değerlendirmesi niteliğindedir. Çalışmada kamu kurumları tarafından yayımlanan resmî istatistikler, politika belgeleri, mevzuat düzenlemeleri, kurumsal açıklamalar ve ilgili akademik çalışmalar birlikte incelenmiştir. Bu doğrultuda Sıfır Atık Projesi'nin temel politika çıktılarının mevcut resmî veriler üzerinden betimlenmesine ve döngüsel ekonomi literatürü çerçevesinde yorumlanmasına odaklanılmıştır.

İncelenen dokümanlar, Sıfır Atık Projesi'nin başlatıldığı 2017 yılından Temmuz 2026'ya kadar olan dönemi kapsamaktadır. Veri taraması, Temmuz 2026 itibarıyla erişilebilen en güncel dokümanlar esas alınarak tamamlanmıştır. Araştırmanın resmî ikincil veri kaynaklarını ÇŞB, Türkiye Çevre Ajansı, Sıfır Atık resmî portalı, Resmî Gazete'de yayımlanan ilgili mevzuat düzenlemeleri ve kamu kurumlarının kurumsal açıklamaları oluşturmaktadır. Bu kaynaklardan geri kazanım oranları, geri kazanılan atık miktarları, atık türlerine göre dağılımlar, raporlanan ekonomik katkı, enerji ve su tasarrufu, sera gazı salımındaki azalma, eğitim faaliyetleri ve Depozito Yönetim Sistemi'ne ilişkin veriler derlenmiştir. Resmî verilerin yorumlanmasında ise döngüsel ekonomi, sıfır atık, geri kazanım, kaynak verimliliği ve atık yönetimi alanlarında yayımlanmış ulusal ve uluslararası akademik çalışmalardan yararlanılmıştır.

Bir kaynağın çalışmaya dâhil edilmesinde, kurumsal veya akademik niteliğinin açık olması, yayımlanma tarihinin ve veri döneminin belirlenebilmesi, doğrudan Türkiye'deki sıfır atık politikası veya döngüsel ekonomi uygulamalarıyla ilişkili olması ve çalışmada ele alınan göstergelerden en az birine ilişkin doğrulanabilir bilgi içermesi ölçütleri esas alınmıştır. Kaynağı, yayımlanma tarihi veya veri dönemi belirlenemeyen içerikler; aynı veriyi tekrar eden ikincil haber metinleri; güncel bir resmî veriyle değiştirilmiş eski açıklamalar ve hesaplama temeli tespit edilemeyen tahmini değerler değerlendirme dışında bırakılmıştır. Akademik çalışmaların seçiminde ise sıfır atık uygulamalarının ekonomik, çevresel, toplumsal veya kurumsal boyutlarını ele almaları temel ölçüt olarak benimsenmiştir. Farklı kurumlar veya farklı raporlama dönemleri tarafından açıklanan veriler arasında farklılık bulunması durumunda, aynı göstergeye ilişkin en güncel tarihli resmî kaynak esas alınmıştır. Bununla birlikte, göstergenin kapsadığı dönemin farklı olması hâlinde veriler doğrudan birleştirilmemiş; ilgili veri kesim tarihleri tablo açıklamalarında belirtilmiştir. Özellikle kümülatif ekonomik ve çevresel göstergelerin farklı tarihlerde güncellenebilmesi nedeniyle, her bir gösterge kendi raporlama dönemi içinde değerlendirilmiştir. Resmî kaynaklarda doğrudan açıklanan geri kazanım oranları ve toplam değerler değiştirilmeden aktarılmıştır.

3. BULGULAR

Bu bölümde, Sıfır Atık Projesi kapsamında elde edilen bulgular, geri kazanım oranlarının yıllara göre gelişimi, geri kazanılan atık miktarı ve bu miktarın atık türlerine göre dağılımı, ekonomik kazanımlar, çevresel ve enerji kazanımları ile DYS başlıkları altında sunulmaktadır.

Sıfır Atık Projesi'nin en somut çıktılarından biri, ulusal geri kazanım oranındaki istikrarlı artıştır. Proje başlangıcında %13 düzeyinde olan geri kazanım oranı, sonraki yıllarda kademeli olarak yükselmiştir. Tablo 1'de geri kazanım oranının yıllara göre gelişimi sunulmaktadır.

Tablo 1. Türkiye'de Geri Kazanım Oranının Yıllara Göre Gelişimi (%)

Yıl	Geri Kazanım Oranı (%)
2017	13,00
2021	27,20
2022	30,13
2023	34,92
2024	36,08
2025	37,53
2035 (Hedef)	**60,00**

Kaynak: ÇYGM (2026) ve Sıfır Atık (2025) verilerinden derlenmiştir.

Tablo 1 incelendiğinde, geri kazanım oranının 2017 yılındaki %13 düzeyinden 2025 yılı itibarıyla %37,53'e yükseldiği görülmektedir. Bu artış, sekiz yıllık süreçte oranın yaklaşık üç katına çıktığını göstermektedir. 2035 yılı için belirlenen %60'lık hedef, projenin uzun vadeli kararlılığını ortaya koymakla birlikte, mevcut artış hızının sürdürülebilmesi için ek altyapı ve katılım çalışmalarının gerekliliğine işaret etmektedir (ÇŞB, 2025a).

Projenin başlangıcından 2025 yılı sonuna kadar geçen dönemde, lisanslı tesislerde işlenerek geri kazanılan toplam atık miktarı yaklaşık 90 milyon tona ulaşmıştır (Resmî kaynaklarda bu değer toplam geri kazanılan atık miktarı olarak raporlandığından, çalışmada aynı terminoloji esas alınmıştır). Bu miktarın atık türlerine göre dağılımı Tablo 2'de gösterilmektedir.

Tablo 2. Geri Kazanılan Atık Miktarının Türlerine Göre Dağılımı (2017–2025)

Atık Türü	Miktar (milyon ton)	Pay (%)
Kâğıt-Karton	36,1	40,1
Organik ve Diğer Atıklar	30,6	34,0
Plastik	10,2	11,3
Metal	9,6	10,7
Cam	3,5	3,9
TOPLAM	**≈ 90,0**	**100**

Kaynak: ÇYGM (2026), Sıfır Atık (2025) ve ÇŞB (2025b, 2026a) verilerinden derlenmiştir.

Tablo 2'ye göre geri kazanılan atıklar içinde en büyük payı 36,1 milyon ton ile kâğıt-karton atıkları oluşturmaktadır. Bunu 30,6 milyon ton ile organik ve diğer atıklar, 10,2 milyon ton ile plastik, 9,6 milyon ton ile metal ve 3,5 milyon ton ile cam atıkları izlemektedir. Bu dağılım, ambalaj atıklarının ve organik atıkların geri kazanımda öncelikli alanlar olduğunu göstermektedir. Özellikle plastik ve metal gibi yüksek ekonomik değere sahip malzemelerin geri kazanımı, hem hammadde ithalatına olan bağımlılığı azaltmakta hem de döngüsel ekonomiye doğrudan katkı sağlamaktadır.

Sıfır Atık Projesi'nin ekonomik boyutu, geri kazanılan materyallerin ülke ekonomisine sağladığı katkı üzerinden değerlendirilmektedir. Proje başlangıcından 2025 yılı sonuna kadar gerçekleştirilen geri kazanım faaliyetleri sonucunda ülke ekonomisine yaklaşık 365 milyar ₺ düzeyinde katkı sağlandığı raporlanmıştır (ÇYGM, 2026). Bu katkı, hem geri kazanılan ikincil hammaddelerin ekonomik değerinden hem de bertaraf, depolama ve hammadde tedariki maliyetlerinde sağlanan tasarruftan kaynaklanmaktadır.

Ekonomik kazanımın yıllar içindeki seyri de dikkat çekicidir. 2024 yılı sonu itibarıyla yaklaşık 256 milyar ₺ olarak açıklanan ekonomik katkı, 2025 yılı sonunda 365 milyar ₺ düzeyine ulaşmıştır (ÇYGM, 2026; Sıfır Atık, 2025). Ekonomik kazanımların yanında, atık yönetimi ve geri kazanım sektörünün büyümesiyle birlikte yeni istihdam alanları ve yeşil iş kolları oluşması, projenin dolaylı ekonomik etkileri arasında değerlendirilmektedir (Gül & Yaman, 2021).

Sıfır Atık Projesi'nin çevresel kazanımları, ekonomik çıktılarla doğrudan ilişkilidir. Geri kazanım uygulamaları, özellikle atık materyallerin geri dönüşüm yoluyla ikincil hammaddeye dönüştürülmesi sayesinde doğal kaynak tüketiminin azaltılmasına, enerji ve su tasarrufu sağlanmasına ve sera gazı salımlarının sınırlandırılmasına katkıda bulunmaktadır. Resmî verilere göre proje kapsamında bugüne kadar yaklaşık 270 milyar kWh enerji tasarrufu

sağlanmış olup, bu miktar yaklaşık 54 milyon hanenin yıllık elektrik tüketimine eşdeğerdir (ÇYGM, 2026). Ayrıca yüz milyonlarca ağacın kesilmekten kurtarıldığı, önemli miktarda su tasarrufu sağlandığı ve milyonlarca ton sera gazı salımının önlendiği belirtilmektedir. Projenin başlıca birikmiş (kümilatif) kazanımları Tablo 3'te özetlenmiştir.

Tablo 3. Sıfır Atık Projesinin Başlıca Kümülatif Kazanımları (2017–2025)

Gösterge	Kümülatif Değer (2017–2025)
Toplam geri kazanılan atık	≈ 90 milyon ton
Ekonomiye sağlanan katkı	≈ 365 milyar ₺
Enerji tasarrufu	≈ 270 milyar kWh (≈ 54 milyon hanenin yıllık elektriği)
Geri kazanım oranı (2025)	%37,53 (2017: %13)
Sıfır atık eğitimi verilen kişi sayısı	≈ 25 milyon kişi
Kurtarılan ağaç (kümülatif)	≈ 552 milyon ağaç
Su tasarrufu (kümülatif)	≈ 819 milyon m^3
Önlenen sera gazı salımı	≈ 5,9 milyon ton CO_2e

Kaynak: ÇYGM (2026), Sıfır Atık (2025) verilerinden derlenmiştir. Çevresel göstergeler farklı raporlama dönemlerine ait kümülatif tahmini değerlerdir.

Tablo 3'te görüldüğü üzere, projenin çevresel ve enerji kazanımları yalnızca atık miktarının azaltılmasıyla sınırlı kalmamakta; iklim değişikliğiyle mücadele, su güvenliği ve enerji verimliliği gibi geniş bir sürdürülebilirlik yelpazesine katkı sunmaktadır.

3.1. DYS ve DOA Uygulaması

Türkiye'nin sıfır atık ve döngüsel ekonomi politikalarının güncel bileşenlerinden biri, Çevre, Şehircilik ve İklim Değişikliği Bakanlığı koordinasyonunda Türkiye Çevre Ajansı tarafından yürütülen Depozito Yönetim Sistemi'dir. DYS, zorunlu depozito kapsamındaki içecek ambalajlarının piyasaya sürülmesi, tüketim sonrasında ayrı toplanması, doğrulanması, taşınması ve geri kazanım tesislerine yönlendirilmesi süreçlerini kapsayan bütüncül bir yönetim sistemidir. Depozitosu Olan Ambalajlar (DOA) ise tüketicilerin depozitolu ambalajları iade ederek teşvik bedellerini dijital cüzdanlarında biriktirmelerine olanak sağlayan uygulamayı ve sistemin tüketiciye yönelik operasyonel yüzünü ifade etmektedir (ÇŞB, 2025b, 2026a).

Sistemin uygulamaya geçirilmesi aşamalı bir gelişim izlemiştir. İlk aşamada uygulama, Şubat 2025'te Sakarya'da pilot olarak başlatılmıştır. Pilot uygulamayı, Temmuz 2025 itibarıyla "7

Bölge 7 İl" yaklaşımıyla yürütülen bölgesel yaygınlaştırma süreci izlemiştir. Bu dönemde depozito iade makinelerinin teknik işleyişi, dijital ödeme altyapısı, ambalajların doğrulanması, tüketici katılımı ve saha operasyonlarının uygulanabilirliği test edilmiştir (ÇŞB, 2026b).

İkinci aşamada, 1 Temmuz 2026 tarihi itibarıyla ulusal entegrasyon dönemi başlatılmış ve DOA uygulaması 81 il ile 973 ilçeyi kapsayacak biçimde ülke genelinde devreye alınmıştır. Bu tarihten itibaren DOA logolu uygun plastik, cam ve alüminyum içecek ambalajları için birim başına 1 ₺ teşvik bedeli uygulanmaya başlanmıştır. Tüketiciler, ambalajları depozito iade makinelerine veya manuel iade noktalarına teslim ederek teşvik bedelini DOA mobil uygulamasındaki dijital cüzdanlarına aktarabilmektedir. Otel, restoran ve kafeler başta olmak üzere içecek ambalajlarının tüketildiği işletmeler de toplama ve iade sistemine dâhil edilmiştir (ÇŞB, 2026a; Karaosmanoğlu, 2026).

Ulusal entegrasyon döneminin ilk on gününde 18.775.861 ambalajın toplandığı ve sisteme kayıtlı kullanıcı sayısının 1.992.006'ya ulaştığı bildirilmiştir. İlk dönem sonuçları, tüketicilerin uygulamaya yönelik ilgisinin yüksek olduğunu göstermektedir. Bununla birlikte, bu veriler sistemin başlangıç aşamasındaki kullanım yoğunluğunu yansıttığından, uzun dönemli performansın değerlendirilmesinde tek başına yeterli değildir. Sistemin sürdürülebilirliği; kullanıcıların devamlılığı, ambalaj iade oranları, bölgesel erişilebilirlik, işletmelerin sisteme katılımı ve geri kazanılan materyallerin üretim süreçlerinde kullanılma düzeyi gibi göstergeler üzerinden izlenmelidir (Karaosmanoğlu, 2026).

Üçüncü aşama, ulusal entegrasyonun ardından fiziksel ve operasyonel altyapının ülke genelinde derinleştirilmesini kapsamaktadır. Bu çerçevede depozito iade makinelerinin, manuel iade noktalarının, depo ve aktarma merkezlerinin, sayma-doğrulama tesislerinin ve yetkilendirilmiş saha operatörlerinin kapasitesinin geliştirilmesi gerekmektedir. Uygulamanın idari ve dijital olarak 81 il ve 973 ilçeyi kapsaması, fiziksel iade altyapısının bütün yerleşim birimlerinde aynı erişilebilirlik ve kapasite düzeyine ulaştığı anlamına gelmemektedir. Bu nedenle nüfus yoğunluğu, yerleşim yapısı, tüketim hacmi ve ulaşım olanakları dikkate alınarak iade altyapısının ülke genelinde dengeli biçimde yaygınlaştırılması önem taşımaktadır (ÇŞB, 2025b, 2026a).

Sistemin tam kapasiteye ulaşmasıyla yılda yaklaşık 25 milyar içecek ambalajının geri kazanım zincirine dâhil edilmesi ve ülke ekonomisine yıllık yaklaşık 30 milyar ₺ düzeyinde doğrudan katkı sağlanması öngörülmektedir (ÇŞB, 2026a, 2026b). Bununla birlikte, 30 milyar ₺ tutarındaki parasal büyüklüğün dayandığı ikincil hammadde fiyatları, maliyet tasarrufları ve diğer hesaplama bileşenleri kamuya açık kaynaklarda ayrıntılı biçimde sunulmadığından, söz konusu değer kesinleşmiş bir ekonomik sonuçtan ziyade resmî bir politika projeksiyonu olarak değerlendirilmelidir.

DYS'nin döngüsel ekonomi bakımından temel önemi, içecek ambalajlarının diğer belediye atıklarıyla karışmadan ayrı toplanmasını ve materyal niteliği korunarak geri dönüşüm süreçlerine yönlendirilmesini sağlamasından kaynaklanmaktadır. Üretim, piyasaya sürme, tüketim sonrası iade, doğrulama, taşıma ve geri kazanım aşamalarında oluşturulan dijital izlenebilirlik; malzeme kayıplarının, kayıt dışılığın ve yanlış beyanların azaltılması bakımından önemli bir potansiyel taşımaktadır. Bununla birlikte sistemin başarısı yalnızca toplanan ambalaj sayısıyla değil; ambalaj iade oranı, geri dönüştürülen materyalin niteliği, elde edilen ikincil hammaddenin birincil hammaddeyi ikame etme düzeyi, sistemin maliyet etkinliği ve bölgesel erişilebilirliği üzerinden değerlendirilmelidir.

4. SİSTEMİN AVANTAJLARI VE DEZAVANTAJLARI

Sıfır Atık Projesi'nin döngüsel ekonomiye geçişteki rolü değerlendirilirken, sistemin sağladığı avantajların yanı sıra uygulamada karşılaşılan zorlukların da bütüncül biçimde ele alınması gerekmektedir. Tablo 4'te sistemin başlıca avantaj ve dezavantajları karşılaştırmalı olarak sunulmaktadır.

Tablo 4. Sıfır Atık Yönetim Sisteminin Avantaj ve Dezavantajları

Avantajlar	Dezavantajlar ve Zorluklar
• Doğal kaynak tüketimini azaltarak kaynak verimliliğini artırması • Geri kazanılan materyallerin ekonomik sisteme yeniden dâhil edilmesi yoluyla ekonomik değer oluşturması • Enerji ve su tasarrufu ile sera gazı salımının azaltılması • Atık yönetimi ve geri kazanım sektörlerinde yeni istihdam ve yeşil iş alanları oluşturması • Düzenli depolama alanlarına giden atık miktarını azaltması • Toplumsal çevre bilinci ve davranış değişikliğini desteklemesi • AB Yeşil Mutabakatı ve döngüsel ekonomi hedefleriyle uyum sağlaması • Uluslararası düzeyde tanınan (BM) bir politika markası hâline gelmesi	• Kaynağında ayrı toplama altyapısının iller arasında eşit dağılmaması • Bireysel ayrıştırma alışkanlıklarının ve katılımın yetersiz kalması • Kentsel/kırsal ve bölgesel uygulama farklılıkları • Resmî verilerde dönemlere göre tutarsızlık ve metodolojik şeffaflık eksikliği • Yüksek kuruluş/işletme maliyetleri ve finansman ihtiyacı • Personel ve kurumsal kapasite ile denetim eksiklikleri • Kayıt dışı (sokak toplayıcıları) ile entegrasyon sorunları • 2035 hedefine ulaşmada belediyeler arası kapasite farkları

Kaynak: Gül ve Yaman (2021), ÇYGM (2026) ve ÇŞB (2025b, 2026a) verilerinden yararlanılarak oluşturulmuştur.

Sistemin en belirgin avantajı, ekonomik ve çevresel faydaları eş anlı olarak üretmesidir. Geri kazanımın ve özellikle malzeme geri dönüşümünün yaygınlaştırılması yoluyla doğal kaynak tüketiminin azaltılması, birincil ve ithal hammadde bağımlılığının sınırlandırılması ve ekonomiye yüksek katma değer sağlanması, kaynak verimliliği açısından önemli kazanımlardır. Enerji ve su tasarrufu ile sera gazı salımının azaltılması, projenin iklim hedeflerine doğrudan katkı sunmasını sağlamaktadır. Ayrıca geri dönüşüm sektörünün büyümesi, yeni istihdam alanları ve yeşil iş kolları oluşturmaktadır. Toplumsal düzeyde ise yaygın eğitim faaliyetleri sayesinde çevre bilincinin ve sürdürülebilir tüketim davranışlarının güçlendiği görülmektedir. Son olarak Projenin AB Yeşil Mutabakatı ve döngüsel ekonomi hedefleriyle uyumlu olması ve tanınan bir politika markasına dönüşmesi yönüyle Türkiye'nin uluslararası çevre diplomasisine de katkı sağlamaktadır.

Projenin başarılarına rağmen, uygulamada bazı önemli zorluklarla karşılaşılmaktadır. Birincisi, kaynağında ayrı toplama altyapısının iller ve bölgeler arasında eşit dağılmaması, geri kazanım oranlarında belirgin farklılıklara yol açmaktadır. İkincisi, bireysel düzeyde atık ayrıştırma alışkanlıklarının ve katılımın yeterli düzeye ulaşamaması, sistemin etkinliğini sınırlandırmaktadır. Nitekim alan çalışmaları, sıfır atık uygulamalarının büyük ölçüde bireysel ve yönetimsel sorunlara karşı kırılgan olduğunu ve etkin uygulamanın bireysel, kurumsal ve toplumsal çabanın eş zamanlı sağlanmasına bağlı olduğunu ortaya koymaktadır.

Üçüncü olarak, resmî verilerin farklı raporlama dönemlerinde değişkenlik göstermesi ve hesaplama yöntemlerine ilişkin ayrıntıların sınırlı düzeyde paylaşılması, verilerin izlenebilirliği ve karşılaştırılabilirliği açısından şeffaflık eksikliği yaratmaktadır.

Dördüncü olarak, geri dönüşüm tesislerinin kuruluş ve işletme maliyetlerinin yüksek olması ile belediyeler arasındaki kapasite farklılıkları, özellikle 2035 hedefine ulaşmada önemli bir zorluk oluşturmaktadır. Son olarak ise kayıt dışı atık toplama faaliyetlerini yürüten sokak toplayıcılarının formel sisteme entegre edilememesi hem sosyal hem de operasyonel açıdan çözülmesi gereken bir sorun alanı olarak öne çıkmaktadır.

5. SONUÇ VE ÖNERİLER

Bu çalışmada, Türkiye'de 2017 yılında uygulamaya konulan "Sıfır Atık Projesi"nin döngüsel ekonomiye geçiş sürecindeki rolü; geri kazanılan atık miktarı, geri kazanım oranı, ekonomik katkı, enerji ve su tasarrufu, sera gazı salımındaki azalma ile sistemin kurumsal ve operasyonel güçlü ve zayıf yönleri çerçevesinde değerlendirilmiştir. Çalışmada incelenen veriler, Sıfır Atık Projesi'nin atık yönetiminin doğrusal üretim ve tüketim yapısından döngüsel bir kaynak yönetimi modeline doğru dönüştürülmesinde önemli bir politika aracı niteliği taşıdığını göstermektedir.

Elde edilen bulgulara göre, Türkiye'de geri kazanım oranının sekiz yıllık dönemde %13 seviyesinden %37,53'e yükselmiş olması, atıkların ekonomik sisteme yeniden kazandırılması bakımından kayda değer bir ilerlemeye işaret etmektedir. Aynı dönemde yaklaşık 90 milyon ton atığın geri kazanılması, projenin yalnızca sınırlı ölçekli veya dönemsel bir çevre uygulaması olmadığını; ulusal ölçekte yürütülen, süreklilik gösteren ve yüksek miktarda materyal akışını kapsayan bir politika girişimine dönüştüğünü ortaya koymaktadır. Bununla birlikte, söz konusu gelişmelerin yalnızca geri kazanılan atık miktarı üzerinden değerlendirilmesi yeterli değildir. Döngüsel ekonomiye geçişin başarısı, geri kazanılan materyalin miktarının yanı sıra niteliği, ikincil hammadde olarak üretim süreçlerine yeniden dâhil edilme kapasitesi, ekonomik değeri ve üretim süreçlerine ne ölçüde dâhil edilebildiği üzerinden de ele alınmalıdır.

Başta malzeme geri dönüşümü olmak üzere geri kazanım faaliyetleri sonucunda ekonomiye yaklaşık 365 milyar ₺ düzeyinde katkı sağlanmış olması, atıkların yalnızca bertaraf edilmesi gereken bir maliyet unsuru olarak değil, ikincil hammadde olarak üretim süreçlerine yeniden dâhil edilebilecek iktisadi bir kaynak olarak değerlendirilmesinin önemini göstermektedir. Bu sonuç, sıfır atık yaklaşımının temelinde yer alan kaynak verimliliği anlayışıyla uyumludur. Nitekim döngüsel ekonomi yaklaşımı, doğal kaynak kullanımını azaltmayı, ürün ve materyallerin ekonomik sistem içerisindeki kullanım süresini uzatmayı ve atıklardan ekonomik değer yaratmayı amaçlamaktadır.

Projenin iktisadi etkileri yalnızca geri kazanılan materyallerin parasal değeriyle sınırlı değildir. Malzeme geri dönüşümü yoluyla birincil hammadde ihtiyacının azaltılması, enerji ve su tüketiminde tasarruf sağlanması, üretim maliyetlerinin düşürülmesi ve dışa bağımlı olunan belirli girdilere yönelik talebin sınırlandırılması gibi dolaylı ekonomik etkiler de ortaya çıkmaktadır. Bu çerçevede sıfır atık politikaları, kaynak ithalatına bağımlılığın ve küresel emtia fiyatlarındaki dalgalanmalara karşı kırılganlığın azaltılmasına katkıda bulunabilecek araçlardan biri olarak değerlendirilebilir. Bununla birlikte, bu etkilerin büyüklüğünün ortaya konulabilmesi için geri kazanılan materyallerin türü, piyasa değeri, ithal girdileri ikame kapasitesi ve üretim zincirlerinde kullanım oranı gibi göstergelere dayalı daha ayrıntılı ekonomik analizlere ihtiyaç duyulmaktadır.

Enerji ve su tasarrufu ile sera gazı salımının azaltılmasına ilişkin kazanımlar ise Sıfır Atık Projesi'nin yalnızca atık yönetimi veya ekonomik kaynak verimliliği kapsamında değerlendirilmemesi gerektiğini göstermektedir. Proje, iklim değişikliğiyle mücadele, düşük karbonlu üretim yapısına geçiş ve sürdürülebilir kalkınma hedeflerinin gerçekleştirilmesi bakımından da stratejik bir işlev üstlenmektedir. Atıkların düzenli depolama sahalarına yönlendirilmesi yerine geri kazanılması hem depolama ihtiyacının hem de atıkların bertarafından kaynaklanan çevresel dışsallıkların azaltılmasını mümkün kılmaktadır. Bu nedenle sıfır atık yaklaşımı, ekonomik büyüme ile kaynak tüketimi ve çevresel baskılar

arasındaki ilişkinin zayıflatılmasına yönelik daha geniş kapsamlı sürdürülebilirlik politikalarının bir bileşeni olarak ele alınmalıdır.

Bununla birlikte, elde edilen kazanımlar Sıfır Atık Projesi'nin uygulama sürecinde herhangi bir yapısal sorun bulunmadığı anlamına gelmemektedir. Sistemin uzun dönemli başarısı; merkezî yönetim tarafından belirlenen politika hedeflerinin yerel yönetimler, işletmeler, kamu kurumları, hanehalkı ve diğer paydaşlar tarafından ne ölçüde uygulanabildiğine bağlıdır. Coğrafi bölgeler arasındaki teknik altyapı, toplama kapasitesi, geri dönüşüm tesisi sayısı ve kurumsal yetkinlik farklılıkları, ulusal hedeflere eşit düzeyde katkı sağlanmasını güçleştirmektedir. Özellikle kaynağında ayrıştırarak toplama altyapısının yeterince yaygınlaşmadığı alanlarda, geri dönüştürülebilir atıkların diğer atıklarla karışması hem materyal kalitesinin düşmesine hem de ayrıştırma ve geri kazanım maliyetlerinin artmasına yol açmaktadır.

Bireysel katılım düzeyi de sistemin etkinliği üzerinde belirleyici bir unsur oluşturmaktadır. Atıkların kaynağında doğru biçimde ayrıştırılmasına ilişkin bilgi eksikliği, yerleşik tüketim alışkanlıkları ve bireylerin gerçekleştirdikleri ayrıştırmanın nihai sonucu konusunda yeterli bilgiye sahip olmamaları, sıfır atık uygulamalarına katılımı sınırlandırabilmektedir. Bu nedenle toplumsal farkındalık faaliyetlerinin yalnızca genel çevre bilinci oluşturmaya yönelik kampanyalarla sınırlı tutulmaması gerekmektedir. Atık türlerinin nasıl ayrıştırılacağı, hangi toplama kanallarının kullanılacağı ve bireysel katılımın ekonomik ve çevresel sonuçları konusunda sürekli ve farklılaştırılmış eğitim programlarının geliştirilmesi önem taşımaktadır.

Bu değerlendirmeler doğrultusunda, Türkiye'nin 2035 yılı için belirlenen geri kazanım hedeflerine ulaşabilmesi amacıyla öncelikle kaynağında ayrı toplama altyapısının ülke genelinde yaygınlaştırılması gerekmektedir. Yatırımların özellikle geri kazanım oranlarının ve belediyelerin teknik kapasitelerinin görece düşük olduğu illere yönlendirilmesi, bölgesel farklılıkların azaltılmasına katkı sağlayacaktır. Yerel yönetimlere finansman, teknik personel, dijital izleme ve tesis altyapısı bakımından destek sağlanmalıdır.

İkinci olarak, toplumsal katılımı güçlendirmek amacıyla ekonomik teşvik mekanizmalarının kapsamı genişletilmelidir. Depozito uygulamaları, ödül-puan sistemleri, belediye hizmetlerinde kullanılabilecek teşvikler ve geri dönüştürülebilir atıkların teslimine bağlı mikro ödeme modelleri, bireysel davranışların dönüştürülmesinde kullanılabilecek araçlar arasındadır.

Üçüncü olarak, geri kazanım oranı, geri kazanılan atık miktarı, ikincil materyal çıktısı ve raporlanan ekonomik katkı gibi göstergelerin hesaplanmasında kullanılan yöntemlerin şeffaf biçimde kamuoyuyla paylaşılması önem taşımaktadır. Veri üretim süreçlerinde kurumlar arasında ortak tanımların ve hesaplama standartlarının kullanılması, yıllar ve bölgeler itibarıyla karşılaştırılabilirliği güçlendirecektir. Kamu kurumlarınca yayımlanan verilerin

bağımsız araştırmacılar tarafından incelenmesine olanak sağlayacak açık veri sistemlerinin geliştirilmesi, politika değerlendirmelerinin güvenilirliğini artıracaktır. Ayrıca bağımsız izleme ve doğrulama mekanizmalarının kurulması, uygulama sonuçlarının yalnızca toplam miktarlar üzerinden değil; maliyet etkinliği, materyal kalitesi, emisyon azaltımı bakımından da değerlendirilmesini mümkün kılacaktır.

Dördüncü olarak, kayıt dışı atık toplayıcılarının mevcut sistem içerisindeki rolü göz ardı edilmemelidir. Bu kesimin formel atık yönetimi sistemine sosyal güvence, çalışma güvenliği, eğitim ve kooperatifleşme mekanizmaları yoluyla entegre edilmesi sosyal kapsayıcılığı artıracaktır. Bu bağlamda geçimini atık toplama faaliyetinden sağlayan hanelerin ekonomik haklarını ve çalışma koşullarını koruyan kapsayıcı bir yönetişim modeli geliştirilmesi elzemdir.

Son olarak, DYS'nin ülke genelinde etkin biçimde yaygınlaştırılması, özellikle içecek ambalajlarının ayrı toplanması ve yüksek kalitede geri kazanılması bakımından önem taşımaktadır. Sistemin başarılı olabilmesi; iade noktalarının erişilebilirliği, tüketiciye yapılan geri ödemenin kolaylığı, dijital altyapının güvenilirliği ve üretici, perakendeci, yerel yönetim ile tüketici arasındaki sorumluluk dağılımının açık biçimde belirlenmesine bağlıdır. DYS'nin yaygınlaştırılması, ambalaj atıklarının diğer atıklarla karışmasını önleyerek ikincil hammaddenin kalitesini yükseltme ve geri dönüşüm zincirindeki değer kaybını azaltma potansiyeline sahiptir.

Sonuç olarak, Sıfır Atık Projesi Türkiye'nin döngüsel ekonomiye geçiş sürecinde önemli ve çok boyutlu bir politika girişimidir. Projenin itici gücüyle geri kazanım oranında sağlanan artış, geri kazanılan atık miktarı ve bu atıklardan elde edilen materyallerin ekonomik sisteme yeniden dâhil edilmesi sonucunda ortaya çıkan ekonomik ve çevresel faydalar, önemli bir kurumsal ve operasyonel kapasitenin oluştuğunu göstermektedir. Bununla birlikte, mevcut kazanımların kalıcı hâle getirilmesi ve 2035 hedeflerine ulaşılması; teknik altyapının güçlendirilmesine, bölgesel eşitsizliklerin azaltılmasına, veri şeffaflığının geliştirilmesine, toplumsal katılımın artırılmasına ve ilgili paydaşlar arasında etkili bir yönetişim mekanizmasının kurulmasına bağlıdır. Bu koşulların sağlanması durumunda Sıfır Atık Projesi, atık yönetiminin ötesine geçerek kaynak verimliliğini, ekonomik dayanıklılığı, düşük karbonlu kalkınmayı ve çevresel sürdürülebilirliği birlikte destekleyen bütünleşik bir politika çerçevesine dönüşecektir.

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