

The Role of AI in Driving Accountability and Transparency in Global Supply Chains: The Fragmented Bridge Between Research and Practice

Boutayna Elghomri

National School of Applied Sciences, Sidi Mohamed Ben Abdellah University, Morocco

Email: boutayna.elghomri@usmba.ac.ma

Fayçal Messaoudi

National School of Business and Management, Sidi Mohamed Ben Abdellah University, Morocco

Email: faycal.messaoudi@usmba.ac.ma

Nihal Touti

National School of Business and Management, Sidi Mohamed Ben Abdellah University, Morocco

Email: nihal.touti@usmba.ac.ma

ABSTRACT

Amid growing concerns over ethical sourcing, regulatory compliance, and operational transparency, global supply chains are under mounting pressure to adopt intelligent and accountable systems. Artificial Intelligence (AI) has emerged as a pivotal enabler in addressing these challenges, particularly within the context of digital transformation and sustainability. This study conducts a comprehensive bibliometric analysis to examine the evolving role of AI in driving accountability and transparency within global supply chains, while critically exploring the persistent gap between academic research and practical implementation. Drawing on 421 peer-reviewed articles published between 1998 and January 2025, extracted from Scopus and Web of Science, the analysis utilizes VOSviewer for network visualization and clustering. The findings reveal an exponential growth of research in this domain, particularly after 2020, driven by technological advancements and increasing regulatory pressures for transparency and ethical governance. The geographical distribution of contributions highlights India, China, and the United States as dominant knowledge producers, alongside growing engagement from emerging economies such as Malaysia and Morocco. The keyword analysis and thematic clustering uncover four key research streams: foundational AI technologies (e.g., blockchain, machine learning, IoT), AI-driven decision-making, blockchain-AI integration for supply chain transparency, and AI-IoT synergy within sustainable and circular economy frameworks. Beyond mapping intellectual structures and research trends, this study identifies a persistent gap between theory and practice. While technological solutions have advanced rapidly, organizational readiness, governance challenges, and ethical

considerations remain underexplored. Addressing these gaps requires future research to adopt more integrative frameworks that link technological innovation with managerial practices, regulatory frameworks, and socio-cultural contexts, particularly in emerging markets. This study contributes to the literature by providing a structured overview of global research developments and by offering valuable insights for academics, practitioners, and policymakers aiming to foster responsible, inclusive, and context-sensitive AI adoption in supply chain governance.

Keywords: *accountability, artificial intelligence, blockchain, emerging economies, governance, supply chain management, theory-practice gap, transparency.*

1. INTRODUCTION

The integration of AI technologies into global supply chains is reshaping accountability and transparency mechanisms, addressing long-standing challenges such as operational inefficiencies, fraud, and ethical misconduct. AI-driven solutions, including machine learning, blockchain, and predictive analytics, are increasingly used to enhance supply chain visibility, streamline decision-making, and build trust among diverse stakeholders (Vandana *et al.*, 2024). These technological advancements align with growing regulatory pressures and consumer expectations for responsible, transparent, and sustainable supply chain practices (Gardner *et al.*, 2018). In particular, AI plays a crucial role in improving traceability, automating compliance verification, and enabling real-time monitoring of supply chain activities (Ofodile *et al.*, 2024; Hasan & Habib, 2022). Blockchain-based infrastructures ensure data immutability and auditability (Patel *et al.*, 2025), while predictive analytics allow for the early detection of disruptions and optimization of logistics operations (Modgil

et al., 2021). Collectively, these technological applications foster the emergence of more resilient, efficient, and ethically governed supply chains.

Notably, emerging economies have shown rapid adoption of AI-driven solutions in their supply chains, leveraging these technologies to overcome resource constraints and operational vulnerabilities, particularly in the wake of global disruptions such as the COVID-19 pandemic (Ejairu *et al.*, 2024). The accelerated deployment of AI applications in these regions highlights their strategic role in achieving operational excellence, risk mitigation, and sustainability goals. Moreover, recent research has underscored the intersection of AI with broader sustainability-oriented frameworks, including the circular economy, Internet of Things (IoT), and Industry 4.0, to build more resilient and accountable supply chains (Cobbe *et al.*, 2023). These integrated technological ecosystems not only facilitate transparency but also support ethical sourcing, waste reduction, and sustainable business practices.

Despite the growing research on AI applications in supply chains, significant knowledge gaps remain. Specifically, existing studies tend to focus on isolated technologies, for instance, blockchain (Kouhizadeh *et al.*, 2020; Saberi *et al.*, 2018; Wang *et al.*, 2019) or big data and analytics (Chatterjee *et al.*, 2022; Mishra *et al.*, 2016), without sufficiently exploring the synergies between AI, IoT, and blockchain in enhancing accountability and transparency. Furthermore, while the literature has expanded rapidly, there remains a shortage of comprehensive bibliometric analyses that systematically map the field's intellectual structure, identify influential contributors, delineate thematic clusters, and trace research trajectories, especially in the context of emerging markets. Addressing this gap is essential for a cohesive understanding of how research is evolving, identifying influential scholarship and emerging trends, and guiding future work. Most previous studies provide fragmented perspectives and do not holistically capture the dynamic interplay among technological innovation, governance challenges, and the increasing demands for sustainable and transparent supply chain management.

To address these gaps, this study conducts a comprehensive bibliometric analysis of AI-driven accountability and transparency mechanisms within global supply chains. By examining scientific production patterns, influential authors, collaborative networks, and thematic developments, the study provides critical insights into the intellectual foundations and evolving directions of the field. It further identifies emerging trends, research gaps, and future research directions, thereby contributing to both academic knowledge and managerial practice in advanced and emerging economies. This analysis offers a systematic perspective on the ways AI technologies are influencing accountability mechanisms, emphasizing both theoretical progress and the persistent practical challenges that organizations face.

Specifically, this study seeks to answer the following research questions:

- *RQ1*: What are the main thematic clusters and research trends in the field of AI-driven accountability and transparency in supply chains?

- *RQ2*: Who are the most influential authors, institutions, and countries contributing to this field?
- *RQ3*: What are the critical research gaps and future directions for integrating AI technologies into supply chain accountability frameworks, particularly in emerging markets?

To address these questions, the next section outlines the methodological approach used to collect, analyze, and visualize the relevant scientific literature.

2. LITERATURE REVIEW

The adoption of AI in Supply Chain Management (SCM) has become a major catalyst for innovation, offering new opportunities to enhance resilience, transparency, and accountability. Over the past decade, a growing number of studies have explored how AI is reshaping supply chains. However, closer examination reveals that technological advances have often outpaced organizational and ethical preparedness, particularly in emerging economies.

Singh *et al.* (2023) explore how AI enhances supply chain resilience, particularly by improving transparency and predictive analytics. Their empirical study highlights that higher levels of transparency within supply chains significantly strengthen organizations' ability to mitigate disruptions, especially in critical processes like last-mile delivery. Similarly, Modgil *et al.* (2021) analyze the role of AI in improving risk management, distribution strategies, and sourcing decisions, demonstrating that real-time data processing facilitated by AI enables firms to anticipate and respond to supply chain disruptions more effectively. Extending this line of inquiry, Ejjami and Boussalham (2024) examine the application of AI in predictive maintenance and risk mitigation within Industry 5.0 supply chains, emphasizing the growing importance of algorithmic transparency, bias mitigation, and ethical governance in ensuring trust and accountability.

Beyond resilience, transparency represents another pillar of supply chain transformation enabled by AI and emerging digital technologies. Vinay *et al.* (2024) highlight that AI-driven systems can optimize logistics, automate compliance checks, and enable real-time monitoring of supply chain operations, especially when integrated with blockchain networks to ensure data traceability and ethical sourcing. Hasan and Habib (2023) further emphasize that supply chain transparency, once considered an optional competitive advantage, has become a regulatory necessity, driven by rising consumer demand for ethical practices and increasing global compliance pressures. Similarly, Ofodile *et al.* (2024) underline the critical role of AI in strengthening blockchain-integrated supply chains, ensuring immutable decentralized ledgers for real-time tracking, verification, and fraud prevention.

However, the widespread deployment of AI is not without its pitfalls; in particular, ethical, governance, and managerial challenges have attracted growing scholarly concern. Chettiar (2024) examines AI's capacity to address ethical dilemmas within supply chains, particularly regarding labor rights, environmental sustainability, and responsible sourcing, and underscores the need for governance frameworks that protect stakeholder interests. In parallel, Ofodile *et al.* (2023) analyze how AI contributes to supplier accountability through automated decision-making

systems, arguing that AI-driven mechanisms can support more robust governance structures and promote sustainable SCM. Building on this, Jia *et al.* (2024) propose a strategic roadmap for future research, emphasizing AI's role in advancing economic, social, and environmental sustainability and calling for more context-sensitive approaches that align technological adoption with ESG objectives. Nevertheless, a disconnect persists between academic innovation and empirical application, with most studies conducted in idealized or experimental settings. Moreover, AI's ability to improve operational efficiency, agility, and responsiveness remains a dominant theme in supply chain literature. Vandana *et al.* (2024) investigate key AI applications such as demand forecasting, inventory optimization, predictive maintenance, and supplier relationship management, demonstrating that AI empowers organizations to adapt to rapidly changing market conditions with greater precision. Similarly, Zhang (2024) examines how AI enhances supply chain visibility, enabling firms to proactively identify potential bottlenecks, mitigate risks, and optimize resource allocation.

Taken together, these thematic streams underscore a pressing need for research that not only advances technical solutions but also incorporates managerial, institutional, and societal perspectives. Despite these substantial contributions, the existing literature remains predominantly technology-oriented and is often developed within controlled or idealized research contexts, offering limited empirical investigation of real-world complexities. The integration of governance models, ethical principles, and contextual factors into AI-driven supply chain solutions remains relatively underexplored, particularly in emerging economies where infrastructural, institutional, and regulatory challenges are more pronounced. This fragmented research landscape reinforces the central argument of this study: while AI technologies offer transformative potential for enhancing supply chain accountability and transparency, their practical implementation continues to face substantial gaps related to managerial readiness, regulatory alignment, stakeholder engagement, and ethical governance. Bridging this gap will require future research to establish more integrative, interdisciplinary frameworks that connect technological innovation with organizational realities and socio-institutional factors, ensuring that AI adoption in supply chains is not only technically feasible but also socially responsible and operationally viable.

3. METHODOLOGY

The growing integration of AI in SCM has generated a rapidly expanding body of literature. However, a structured synthesis of this research remains limited, particularly regarding AI's contribution to enhancing accountability and transparency within global supply chains. To address this gap, the present study employs a bibliometric analysis approach, widely recognized for its ability to systematically map the structure, development, and dynamics of scientific knowledge within a specific research field (Mukherjee *et al.*, 2022). This approach enables the identification of publication trends, geographical patterns of research contributions, scholarly impact, keyword evolution, and thematic clusters, in direct alignment with the structure of the results presented in this study.

3.1 Research Methodology

Bibliometric analysis provides a quantitative and objective exploration of large volumes of academic publications, uncovering the intellectual structure of a research domain. In this study, we employ this approach to investigate how AI technologies foster transparency and accountability in SCM, focusing on five key dimensions: temporal trends in publications, geographical distribution of research contributions, journal and citation impact analysis, keyword co-occurrence and trend analysis, and thematic clustering of research areas. By structuring the analysis around these dimensions, the methodology ensures a comprehensive examination of the evolution, impact, and thematic landscape of AI-driven accountability in supply chains. The selection of these analytical dimensions is motivated by the need to capture both the breadth and depth of the literature on AI in SCM. Temporal trends reveal shifts in research attention and highlight emerging topics over time. Geographical distribution offers insight into regional research strengths and potential disparities in global knowledge production. Journal and citation impact analysis identifies the most influential publications and sources, spotlighting leading debates and authorities in the field. Keyword co-occurrence and trend analysis uncovers core themes, evolving concepts, and areas of convergence or divergence within the literature. Finally, thematic clustering allows for a nuanced mapping of interconnected research areas and gaps, thereby guiding future investigations. Collectively, these dimensions provide a multidimensional perspective essential for understanding research progress, knowledge diffusion, and opportunities for further exploration.

3.2 Data Sources and Search Strategy

Data were retrieved from two leading academic databases, Scopus and Web of Science (WoS), following a sequential process: Scopus was consulted first due to its extensive coverage of technology and management research, followed by Web of Science to ensure the inclusion of highly cited and complementary works. The search strategy was carefully designed to capture studies at the intersection of AI technologies, SCM, accountability mechanisms, and emerging market contexts. Accordingly, a comprehensive search string was applied across both Scopus and Web of Science databases using the following keywords:

*("Artificial Intelligence" OR "AI" OR "Machine Learning"
OR "Deep Learning")
AND
("Supply Chain" OR "Supply Chain Management" OR
"SCM")
AND
("Accountability" OR "Transparency" OR "Traceability"
OR "Blockchain")
AND
("Emerging Economies" OR "Emerging Markets" OR
"Developing Countries")*

This approach enabled a broad yet targeted retrieval of literature addressing the application of AI to enhance accountability and transparency in supply chains, with particular attention to the context of emerging economies.

3.3 Inclusion and Exclusion Criteria

To ensure the relevance and scientific rigor of the dataset, the following criteria were applied: ***Inclusion Criteria and Exclusion Criteria***. The inclusion criteria required that studies be peer-reviewed journal articles published in English and that they address the application of artificial intelligence in supply chains, with a particular focus on transparency, accountability, or sustainability. Conversely, exclusion criteria eliminated conference papers, book chapters, editorials, and any non-peer-reviewed sources, as well as studies that did not directly relate to either artificial intelligence or SCM.

These steps ensured that only high-quality, directly relevant literature formed the basis of the analysis. Duplicate records across Scopus and Web of Science were carefully identified and removed to ensure the integrity of the final dataset. The stepwise process of article identification, screening, and inclusion is visually summarized in Figure 1.

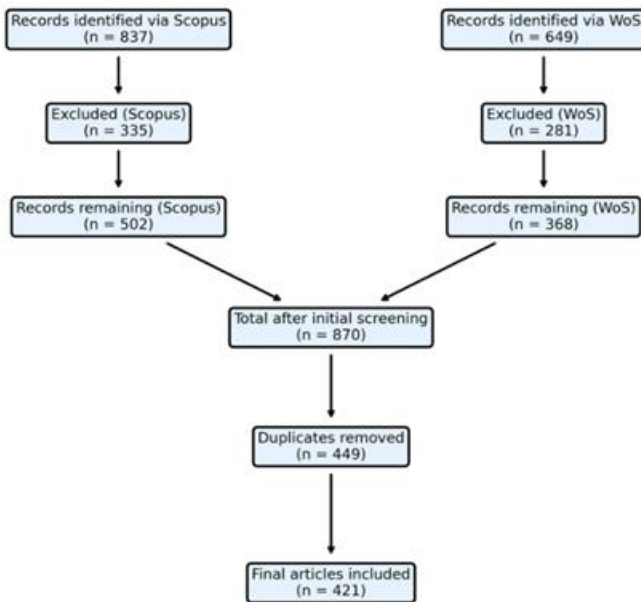


Figure 1 Article selection flowchart for the bibliometric review.

As shown in Figure 1, the selection process involved several systematic stages to ensure the scientific quality and relevance of the dataset. Beginning with a broad initial pool of articles from both Scopus and Web of Science, we applied stringent eligibility criteria and removed non-peer-reviewed, non-English, and out-of-scope publications. The merging and deduplication steps were essential to avoid redundancy and to provide a reliable foundation for subsequent bibliometric analysis. This rigorous multi-stage filtering resulted in a final dataset of 421 peer-reviewed articles that accurately represent the intersection of artificial intelligence, SCM, accountability, and transparency, particularly in the context of emerging economies. By following this structured approach, the study not only guarantees replicability and objectivity but also enhances the validity of the subsequent analytical findings. The resulting dataset was then subjected to comprehensive bibliometric mapping and network analysis as described in the following sections.

3.4 Final Dataset and Temporal Considerations

The search was limited to peer-reviewed journal articles published in English between 1998 and January 2025, a timeframe chosen to enable a longitudinal analysis that captures the early development of AI applications in supply chains, the acceleration of research during the COVID-19 pandemic, and the emergence of recent post-pandemic innovations. The final dataset comprised articles retrieved from both Scopus and Web of Science, which were subsequently cleaned and validated to ensure accuracy and relevance. It is important to highlight that the data for the year 2025 is only partial, as the extraction process was conducted in January 2025. Therefore, any apparent decline in publication output for this year should not be interpreted as a decrease in research activity but rather as a result of the temporal limitation of the data collection period.

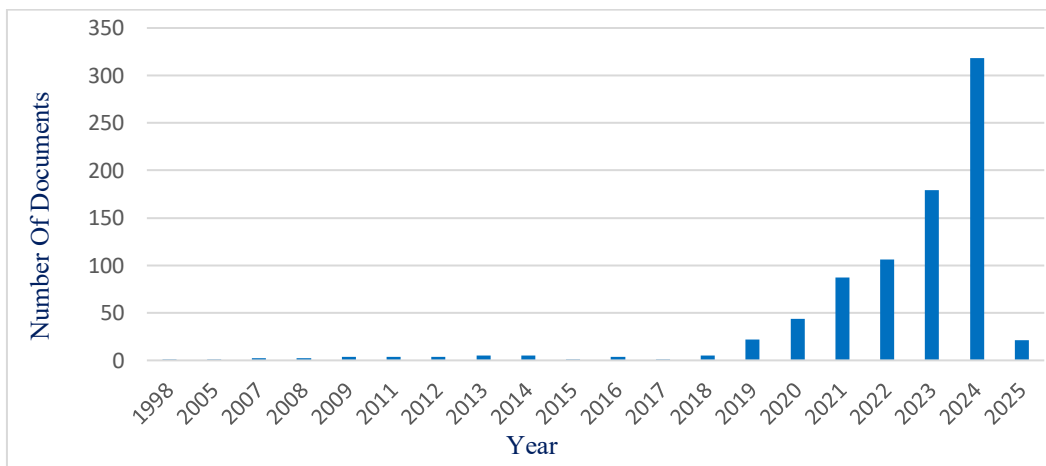


Figure 2 Publication trends over time

4. RESULTS AND DISCUSSION

4.1 Temporal Trends in AI-Driven Supply Chain Research: Publication Analysis by Year

The publication trends, as depicted in Figure 2, reveal a clear progression in academic interest in the role of AI in driving accountability and transparency in global supply chains. Between 1998 and 2014, research activity was minimal, reflecting the early developmental stage of AI and the limited global emphasis on supply chain transparency. From 2015 to 2020, a gradual growth phase is evident, marked by a steady increase in publications, particularly from 2019 onward, when studies surged to 22 and doubled to 44 by 2020. This growth coincides with significant advancements in AI technologies, such as blockchain integration, and heightened awareness of vulnerabilities in global supply chains, especially during disruptions like the COVID-19 pandemic. The period from 2021 to 2024 saw exponential growth in research, peaking at 318 publications in 2024. This surge reflects rapid AI adoption, increased regulatory pressures for accountability, and industry demand for greater transparency, as highlighted by the transformative role of AI and blockchain integration in enabling real-time tracking and fraud detection (Ofodile *et al.*, 2024). The 2025 data indicate a decline to 21 publications; however, this is due to the dataset being limited to January 2025, rather than reflecting a true decrease in research output. Research in this area continues to evolve, with AI-driven solutions for SCM, such as predictive analytics, real-time visibility, and ethical AI practices, remaining at the forefront of both scholarly and practical advancements (Abhulimen & Ejike, 2024; Pal, 2023).

These trends underscore the critical role of AI in addressing challenges such as transparency and sustainability, while driving innovative solutions for resilient global supply chains. Nevertheless, this exponential growth in publications also reveals an important paradox: while technological solutions have advanced rapidly, academic research remains largely technology-centric, often overlooking organizational readiness, ethical implications, and regulatory complexities that are essential for real-world implementation. This disconnect highlights a growing need for future research to bridge the gap between technological innovation and managerial or governance practices, and to foster more holistic frameworks for deploying AI within transparent and accountable supply chain ecosystems.

4.2 Geographical Contributions to AI-Driven Supply Chain Research: A Country Analysis

4.2.1 Country-Level Analysis: Leading Nations and Collaborative Hubs

As illustrated in Figure 3, the analysis of country contributions reveals a polarized yet dynamic distribution of research output in AI and supply chain transparency. India leads the field with 147 documents, reflecting its growing prominence in global supply chains and its robust academic and technological ecosystem. China follows with 68 documents, underscoring its role as a global manufacturing powerhouse and a frontrunner in adopting AI-driven solutions. The United Kingdom (53 documents) and the United States (44 documents) also emerge as significant

contributors, highlighting their strong focus on technological innovation and academic leadership. European countries such as Germany (22 documents), Italy (18 documents), and France (14 documents) demonstrate a collaborative emphasis on sustainable and efficient supply chain practices, reinforcing their reputation as key players in global research networks. Meanwhile, emerging contributors like Malaysia (20 documents), Pakistan (19 documents), and Saudi Arabia (18 documents) demonstrate the increasing interest of developing economies in utilizing AI for supply chain optimization. North African nations, including Morocco (14 documents), Egypt (7 documents), and Tunisia (7 documents); show promising engagement in addressing regional supply chain challenges, while Southeast Asian countries such as Indonesia (7 documents) and Thailand (6 documents) represent incremental progress in the field. To further underscore the global nature of these efforts, the network visualization in Figure 3 underscores the interconnectedness of research efforts, with India, China, the United Kingdom, and the United States acting as central hubs of collaboration. Their high total link strengths emphasize their influence in shaping global research trends and fostering interdisciplinary partnerships.

However, this geographical distribution also highlights important imbalances in global research production, with a clear dominance of Asian and Western countries, while African and several Southeast Asian regions remain significantly underrepresented. This disparity suggests that, despite increasing global attention, the development and implementation of AI-driven supply chain solutions may risk perpetuating existing technological divides. Therefore, future research should prioritize greater inclusivity, cross-regional collaboration, and capacity-building initiatives to ensure that the benefits of AI adoption in supply chains are distributed equitably across both developed and emerging economies.

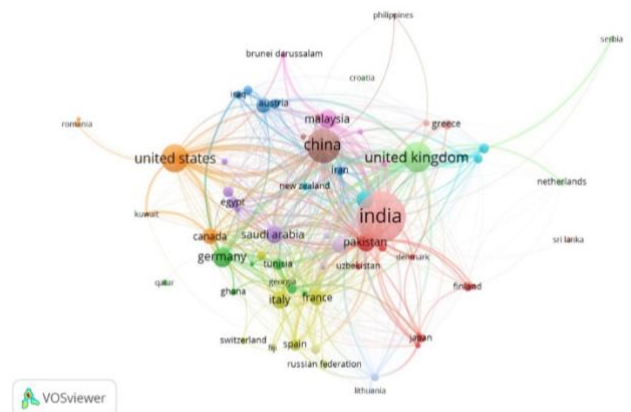


Figure 3 Global collaboration and country contributions in AI-driven supply chain research.

4.2.2 Insights and Trends from Emerging Economies

The inclusion of an emerging economies filter reveals both encouraging progress and persistent disparities in the global landscape of AI-driven supply chain research. For instance, India has demonstrated a significant increase in scholarly output, reflecting national strategies aimed at modernizing supply chains and increased investments in research and development (Tiwari *et al.*, 2023). Similarly,

Malaysia and Saudi Arabia have shown notable growth in AI-related supply chain publications, indicating a regional emphasis on technological advancement in logistics and SCM (Alquraish, 2025; Zaman *et al.*, 2025). In North Africa, Morocco has actively engaged in research to enhance its supply chain capabilities, with studies highlighting the country's efforts in integrating AI technologies (Riad *et al.*, 2024). Pakistan, while still developing its research infrastructure, has begun to contribute to the field, focusing on the application of AI in optimizing supply chain processes (Velarde *et al.*, 2024; Koo, 2025). Despite these gains, the overall field remains largely led and shaped by mature economies, including the United States, China, and the United Kingdom, which continue to dominate in both publication volume and collaborative networks.

In contrast, papers authored within emerging economies show a greater emphasis on context-specific challenges, such as integrating affordable AI solutions in resource-constrained settings, addressing local regulatory frameworks, and enhancing supply chain resilience to region-specific disruptions. Thematic mapping and keyword analysis highlight that topics such as “supply chain visibility,” “traceability,” and “digital inclusion” are especially prominent in these regions, and there is a growing focus on applied, solution-oriented research often conducted in partnership with local industries or government agencies. Nevertheless, despite notable engagement from Morocco, Egypt, Indonesia, and Thailand, African and Southeast Asian countries continue to demonstrate comparatively low research output. This imbalance can be attributed to several factors, including limited research funding, lack of established academic-industry partnerships, lower levels of digital infrastructure, and barriers to publishing in high-impact international journals. For instance, Rossoni *et al.* (2023) identify limited financial resources and weak university–industry collaboration as significant obstacles to research development in these regions. Additionally, challenges such as high publication fees and language barriers hinder researchers from publishing in prestigious journals, further limiting their global visibility (Elgamri *et al.*, 2023). The digital divide, characterized by inadequate infrastructure and limited access to advanced technologies, also impedes research progress in these areas (Nadeem *et al.*, 2023). Moreover, systemic issues like the dominance of Western-centric research agendas and evaluation metrics contribute to the underrepresentation of scholars from developing countries in high-impact publications (Elgamri *et al.*, 2023). Overall, while mature economies continue to lead discussions and set the research agenda, often analyzing or proposing solutions for emerging economies, there is an unmistakable trend of rising contributions, innovation, and local adaptation from within the developing world itself. To achieve greater inclusivity and relevance in global AI supply chain research, future initiatives should prioritize supporting research capacity, fostering cross-regional collaborations, and promoting equitable access to funding and publication opportunities in underrepresented regions.

4.3 Scholarly Impact and Contributions: A Journal Analysis of AI in Supply Chain

As illustrated in Table 1, the analysis of the top 10 journals contributing to AI and supply chain research reveals

a diverse and interdisciplinary focus, highlighting the convergence of technology, sustainability, and logistics. Notably, *Sustainability* emerges as the leading journal, with 27 documents and 646 citations, underscoring the increasing scholarly emphasis on integrating sustainable practices within global supply chains. This trend reflects growing academic engagement with environmental and social responsibility challenges.

Technological advancements are prominently represented by journals such as *IEEE Internet of Things Journal* (8 documents, 439 citations) and *Sensors* (7 documents, 305 citations), which showcase significant contributions related to IoT applications and real-time monitoring for enhancing transparency and traceability. Additionally, journals like *Logistics* (5 documents, 150 citations) and *Scientific Reports* (5 documents, 16 citations) emphasize practical approaches to improving supply chain efficiency, resilience, and operational performance. Collectively, these contributions reflect a concerted effort across multiple disciplines to position AI as a key enabler of innovation and sustainability in global supply chains. However, this distribution of research output also reveals a notable fragmentation: technological, sustainability, and logistics-oriented studies often develop in parallel rather than in an integrated manner. This fragmentation highlights an important gap in current research, the need to develop more comprehensive and interdisciplinary frameworks that connect technological innovation with managerial practices, ethical considerations, and sustainability imperatives within supply chain ecosystems.

Table 1 Top 10 journals in AI and supply chain research.

Source	Documents	Citations
Sustainability	27	646
Lecture Notes in Networks and Systems	19	4
IEEE Access	11	58
IEEE Internet of Things Journal	8	439
ACM International Conference Proceedings	7	5
Sensors	7	305
IFAC Papers Online	6	5
Logistics	5	150
Food Chemistry	5	5
Scientific Reports	5	16

4.4 Key Themes and Trends in AI-Driven Supply Chain Research: A Keyword Analysis

The keyword analysis, as depicted in Figure 4, highlights the centrality of *accountability* (298 occurrences), underscoring its critical role in ensuring ethical governance, traceability, and trust within *supply chain management* (155 occurrences), which serves as the core context of this study. Additionally, *artificial intelligence* (185 occurrences) and *machine learning* (119 occurrences) emerge as foundational technologies driving innovation in predictive analytics and decision-making frameworks. *Blockchain* (138 occurrences) and *smart contracts* (50 occurrences) play a significant role in enabling enhanced *transparency* (87 occurrences) and *traceability* (69 occurrences) through secure and automated processes. The adoption of *Internet of Things (IoT)* (85 occurrences) and *Industry 4.0* (45 occurrences) supports real-time monitoring and interconnected systems for operational efficiency and

resilience. *Sustainability* (58 occurrences) further reflects the growing shift toward environmentally and socially responsible practices, facilitated by these technological advancements.

Collectively, these findings demonstrate the transformative potential of advanced technologies in shaping transparent and accountable supply chains. However, the keyword landscape also reveals an important imbalance: the dominance of technology-oriented terms, such as

blockchain, AI, and IoT, contrasts with the relative underrepresentation of concepts related to governance models, stakeholder engagement, and regulatory frameworks. This thematic gap suggests that future research should move beyond a purely technology-driven narrative and place greater emphasis on *the human, organizational, and ethical dimensions* critical to the effective implementation of AI in real-world supply chain contexts.

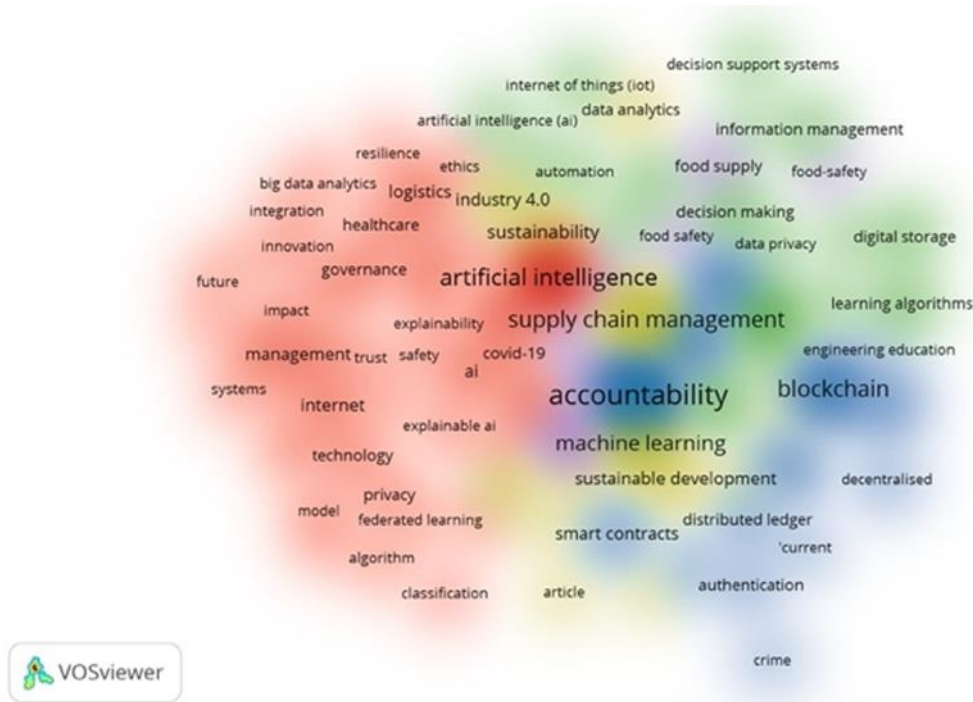


Figure 4. Keyword co-occurrence network: Highlighting core themes in AI-driven supply chain research.

4.5 Thematic Clustering of AI in Supply Chain Research: Key Areas and Insights

Thematic clustering in this study was empirically derived using a keyword co-occurrence network analysis conducted with VOSviewer.

As visualized in Figure 4, keywords were grouped into four main clusters, each represented by a distinct color: red, green, blue, and yellow. These clusters correspond to the core thematic areas discussed below and are further detailed in Table 2.

Table 2 Key components and labels for thematic clusters in AI and supply chain research.

Cluster	Key Component	Cluster Labeling
Cluster 1 (Red)	Accountability, Algorithm, Artificial Intelligence, Big Data, Big Data Analytics, Blockchain Technology, Challenges, Classification, COVID-19, Digital Technologies, Digital Transformation, Explainability, Framework, Future, Governance, Healthcare, Impact, Information, Innovation, Internet, Logistics, Management, Model, Performance, Prediction, Privacy, Resilience, Security, Supply Chain, System, Systematic Literature Review, Technology, Trust	Core Concepts and Foundations for Accountability and AI in Supply Chains
Cluster 2 (Green)	Artificial Intelligence, Automation, Chain Management, Data Privacy, Decision Making, Decision Support Systems, Deep Learning, Digital Storage, Efficiency, Information Management, Learning Algorithms, Learning Systems, Machine Learning, Network Security, Predictive Analytics, Supply Chain Management, Supply Chains, Smart Contract	AI-Driven Accountability and Decision Support in Supply Chains
Cluster 3 (Blue)	AI, Authentication, Blockchain, Crime, Decentralized, Distributed Ledger, Ethereum, IoT, Smart Contract, Smart Contracts, Traceability, Transparency	Blockchain and AI: Enhancing Accountability and Transparency in Supply Chains
Cluster 4 (Yellow)	Agriculture, Artificial Intelligence (AI), Circular Economy, Data Analytics, Human, Industry 4.0, Internet of Things (IoT), Sustainability, Sustainable Development	AI and IoT for Accountability and Sustainability in Circular Supply Chains

4.5.1 Cluster 1: Core Concepts and Foundations for Accountability and AI in Supply Chains

Cluster 1, represented in red in Figure 4 and described in Table 2, focuses on the foundational technologies and frameworks critical to integrating AI into SCM. Central to this cluster is the interplay between blockchain, big data analytics, advanced algorithms, and digital transformation, all of which serve as key pillars of technological innovation in the field. Several influential studies exemplify this trend. For example, Ofodile *et al.* (2024) demonstrate how the combination of AI and blockchain can significantly enhance transparency, traceability, and fraud detection across supply chains, while simultaneously improving compliance and ethical practices. This integration of technologies is echoed in the work of Abhulimen and Ejike (2024), who underscore the importance of AI-driven big data analytics for optimizing inventory management and demand forecasting. Their findings suggest that leveraging these analytics not only enhances visibility but also improves decision-making and operational efficiency (Abhulimen & Ejike, 2024).

The significance of advanced AI algorithms is further highlighted by Mathur (2024), who show that neural networks and LSTM models are driving the development of predictive analytics and logistics optimization, which in turn reduces inefficiencies and strengthens supply chain agility. Expanding on the theme of technological convergence, Sharma *et al.* (2023) explore how the integration of AI, IoT, and blockchain fosters smarter decision-making and supports the resilience of supply chains in increasingly complex environments. Governance and data integrity are also prominent topics within this cluster. Bist *et al.* (2022) make a compelling case for the role of blockchain-enabled governance frameworks, particularly in agricultural supply chains, where ensuring data integrity and regulatory compliance is critical. Despite these advancements, several challenges persist. For instance, Chen *et al.* (2024) discuss persistent issues such as data privacy and integration complexity, especially when decentralized systems are implemented that must balance transparency and confidentiality. Collectively, these foundational studies underscore the pivotal role of integrating *blockchain, big data, and advanced algorithms* in creating AI-driven supply chains that are not only more efficient and transparent, but also more adaptable to modern challenges. By addressing integration complexities and leveraging robust governance frameworks, this cluster of technologies offers some of the most promising solutions for enhancing global supply chain resilience and driving future innovation.

4.5.2 Cluster 2: AI-Driven Accountability and Decision Support in Supply Chains

As indicated by the green cluster in Figure 4 and summarized in Table 2, Cluster 2 focuses on AI-driven decision support, automation, and predictive analytics, all of which play pivotal roles in optimizing modern SCM. This cluster is characterized by the integration of machine learning, deep learning, and automation technologies, which are reshaping the supply chain landscape by enabling smarter decision-making, greater efficiency, and improved security. Several recent studies exemplify these developments. For instance, Eyo-Udo (2024) highlights how the application of AI in supply chain optimization not only enhances efficiency

through predictive analytics, demand forecasting, and logistics management but also provides organizations with the tools needed to respond proactively to market fluctuations. This emphasis on adaptability and resilience is further reinforced by Sodiya *et al.* (2024), who underscore the role of AI and machine learning in fostering agility. Their work demonstrates that accurate demand forecasting and risk management, enabled by advanced AI algorithms, allow supply chains to better withstand market volatility.

The expanding role of deep learning is particularly noteworthy within this cluster. As Lima *et al.* (2024) observe, machine learning algorithms (especially neural networks) are increasingly harnessed for deep learning applications, which reveal hidden patterns in large datasets and facilitate enhanced decision-making and operational efficiency. Building on this, Pournader *et al.* (2021) provide a comprehensive taxonomy of AI in SCM, categorizing AI methods into sensing, learning, and decision-making functions. These classifications collectively illustrate how AI supports both operational efficiency and supply chain resilience. Risk management, another critical dimension in this cluster, is exemplified by Belhadi *et al.* (2021), who propose a multi-criteria decision-making framework powered by fuzzy logic and machine learning. This approach helps organizations mitigate disruptions and build more resilient supply chains by systematically assessing and responding to risks. Considered together, the studies within Cluster 2 clearly illustrate that the integration of automation, machine learning, and predictive analytics is not only optimizing supply chain operations, but also enhancing adaptability and risk management in increasingly dynamic environments. These AI-driven technologies enable organizations to anticipate disruptions, streamline decision-making, and quickly respond to market shifts. As a result, AI is evolving from a support tool into a strategic asset, empowering firms to build more resilient and responsive supply chains capable of meeting both present and future challenges.

4.5.3 Cluster 3: Blockchain and AI: Enhancing Accountability and Transparency in Supply Chains

As depicted in Figure 4 (Blue cluster) and detailed in Table 2, Cluster 3 explores how the integration of *blockchain* and *AI* is revolutionizing SCM by enhancing decentralization, traceability, and transparency. At the heart of this transformation is blockchain's decentralized ledger, which provides an immutable and secure framework for managing transactions, thereby improving accountability and reducing fraud throughout the supply chain. The practical benefits of this approach are evident in several recent studies. For instance, Wang *et al.* (2019) proposed a blockchain-based traceability system utilizing smart contracts to combat data tampering and ensure the authenticity of supply chain records. Their work highlights not only improved data integrity, but also the ability of such systems to streamline dispute resolution and foster greater trust among supply chain participants. Kouhizadeh *et al.* (2020) further emphasized blockchain's capacity to address inefficiencies and promote sustainability in global supply chains, reinforcing its role in building transparent and trustworthy networks across multiple stakeholders.

The role of *smart contracts* is another recurring theme within this cluster. Agrawal *et al.* (2022) developed a

blockchain-based framework for resource sharing, demonstrating how smart contracts automate processes, improve data authenticity, and boost operational efficiency by reducing human error. Similarly, Kumar *et al.* (2024) showed that the application of smart contracts can significantly enhance vendor management and increase transparency in supply chain operations. Moreover, decentralization emerges as a key mechanism for strengthening supply chain resilience. Shahzad *et al.* (2021) proposed a decentralized blockchain-based monitoring solution designed to improve scalability, security, and traceability, particularly in trustless supply chains where traditional oversight may be lacking. The synergistic integration of blockchain and AI also opens new avenues for advanced predictive analytics and fraud detection. As demonstrated by Oriekhoe *et al.* (2024), these combined technologies can optimize inventory management and logistics while simultaneously ensuring robust fraud prevention measures. Despite these advances, widespread industry adoption remains constrained by issues of interoperability and regulatory uncertainty. Overall, these studies illustrate that the adoption of blockchain and AI in SCM addresses persistent challenges such as inefficiencies, fraud, and lack of transparency. To fully realize the transformative potential of these technologies, future research should prioritize overcoming scalability and regulatory challenges, paving the way for their broader implementation and integration across diverse supply chain contexts.

4.5.4 Cluster 4: AI and IoT for Accountability and Sustainability in Circular Supply Chains

Based on the empirical clustering in Figure 4 (yellow) and the summary in Table 2, Cluster 4 examines how the integration of advanced technologies, particularly *AI*, *IoT*, and *Industry 4.0*, with circular economy principles is revolutionizing sustainability practices across industries. By enabling resource optimization, waste reduction, and greener operations, these technological advancements are at the forefront of the transformation toward sustainable supply chains. A growing body of research highlights the pivotal role of the IoT in this transformation. For instance, Sun and Wang (2022) demonstrate how IoT-driven Industry 4.0 technologies enhance real-time monitoring, operational efficiency, and green manufacturing, thereby improving recycling and remanufacturing processes with positive effects on both economic and environmental performance. Building upon these IoT advancements, AI provides predictive analytics and robust decision-making frameworks that further sustainability goals. As shown by Abir (2024), the integration of AI with IoT facilitates resource-efficient manufacturing, directly reducing material and energy waste.

Industry 4.0 is also recognized as a foundational enabler of circular economy practices, especially in transforming traditional production systems into sustainable, data-driven operations. De Sousa Jabbour *et al.* (2018) proposed a roadmap outlining how Industry 4.0 technologies can unlock circular business models, enabling the recycling and reuse of resources. This technological synergy is not limited to manufacturing; in agriculture, IoT and AI have enabled precision farming and sustainable resource

management. For example, Baharin *et al.* (2024) explore how the integration of IoT and big data analytics with circular economy principles enhances agricultural productivity while addressing environmental challenges. Despite these significant advancements, challenges such as high implementation costs and the need for robust regulatory frameworks continue to impede widespread adoption. Ali *et al.* (2024) emphasize the importance of hybrid frameworks and government incentives to overcome these barriers, arguing that such support is essential to ensure long-term sustainability.

Viewed holistically, the convergence of advanced digital technologies and circular economy principles is creating unprecedented opportunities to transform both industries and agriculture into more sustainable, resilient, and circular systems. These integrated approaches not only drive greater resource efficiency and waste minimization, but also support organizations in meeting stricter regulatory requirements and societal expectations for responsible business practices. Furthermore, by leveraging real-time data, predictive analytics, and closed-loop production models, companies can enhance their adaptability to market disruptions and environmental pressures. Ultimately, these developments are pivotal in advancing global sustainability goals, fostering a new era in which economic growth and environmental stewardship are mutually reinforcing priorities.

4.6 Bridging the Gap Between Theoretical Frameworks and Practical AI Development in Supply Chain Transparency

While the bibliometric analysis conducted in this study offers valuable insights into the evolution of AI-driven research within the domain of supply chain transparency, the findings underscore a persistent and critical gap between theoretical advancements and practical implementations. A predominant share of the literature, as revealed by the thematic cluster analysis, remains heavily technology-centric (Jia *et al.*, 2024; Modgil *et al.*, 2021). Considerable emphasis is placed on technical constructs such as artificial intelligence, blockchain, IoT, predictive analytics, and smart contracts, all of which have collectively advanced the understanding of how emerging technologies can enhance traceability, transparency, and operational performance in supply chains (Ofodile *et al.*, 2024; Ejjami & Boussalham, 2024).

However, this technological orientation frequently occurs in isolation from organizational realities and contextual complexities (Chettiar, 2024; Ofodile *et al.*, 2023). Theoretical models, though often innovative, tend to focus on the potential of technology itself, while comparatively limited attention is given to how these advances interact with managerial practices, regulatory frameworks, or ethical and social considerations across diverse supply chain environments (Hasan & Habib, 2023). As a result, a significant disconnect emerges between technological innovation and the operational, governance, and institutional infrastructures required for successful, scalable implementation (Singh *et al.*, 2023). This disconnect is further highlighted in our geographical and journal analyses. Although emerging economies have become increasingly active contributors to the literature, a

substantial proportion of published studies still lack context-specific insights that address the unique challenges faced by resource-constrained or institutionally fragmented environments (Zhang, 2024). The risk, therefore, is the continued proliferation of technologically sophisticated, but practically unfeasible or socially exclusive, solutions (Vinay *et al.*, 2024).

To quantify the extent of this gap, we classified the analyzed articles by their primary research focus: theoretical development, practical implementation, or a mixed approach. As illustrated in Figure 5, two-thirds (66%) of the articles are focused on theoretical development, whereas only 23% address practical implementation, and 11% adopt a mixed-methods perspective. This finding aligns with previous bibliometric research that underscores the dominance of conceptual or technology-oriented research in the field (Culot *et al.*, 2024).

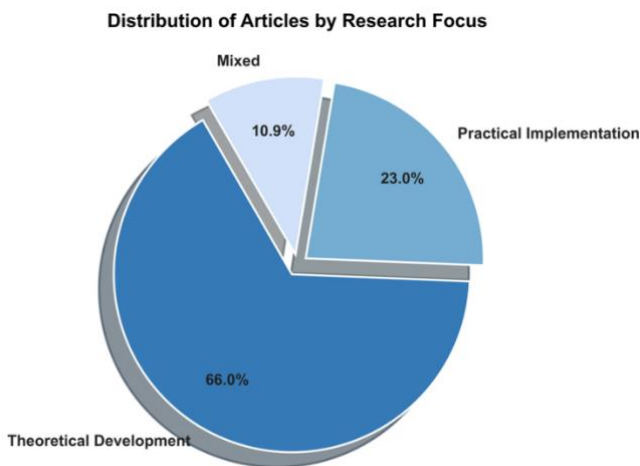


Figure 5 Distribution of articles by research focus.

This distribution highlights the need for the field to move beyond technology-centric narratives and foster more integrated, interdisciplinary research frameworks (Belhadi *et al.*, 2021; Pournader *et al.*, 2021). Future investigations should explore how AI-driven solutions can be effectively adapted to institutional, cultural, and regulatory contexts, particularly in emerging economies (Abir, 2024; Baharin *et al.*, 2024), as well as examine the organizational capabilities necessary to operationalize these technologies for transparent, resilient supply chains (Vandana *et al.*, 2024). Additionally, there is a pressing need to investigate how governance frameworks can effectively balance technological efficiency with ethical principles, regulatory compliance, and stakeholder engagement. By addressing these challenges, the literature can progress towards delivering research that is not only technologically robust, but also socially responsible, contextually relevant, and operationally viable for diverse global supply chain ecosystems.

4.7 Practical Implications & Future Directions

The results of this study provide actionable insights for supply chain managers, technology leaders, and policymakers aiming to harness artificial intelligence for greater accountability and transparency. While advanced technologies such as blockchain, IoT, and predictive analytics offer transformative opportunities, their effective

deployment relies equally on organizational readiness, cross-functional collaboration, and regulatory alignment. To ensure successful and responsible AI implementation, practitioners should embed principles of transparency, explainability, and ethical oversight within their operational and governance frameworks.

Despite recent advancements, the field is still characterized by a gap between conceptual innovation and real-world practice, particularly in resource-constrained and institutionally fragmented environments. Future research should therefore prioritize empirical investigations in diverse contexts, especially in emerging economies, to better understand operational challenges and contextual specificities. Further, the development and validation of integrative frameworks that bridge technological innovation with governance structures and stakeholder engagement will be critical for advancing both theoretical and practical understanding. Finally, fostering interdisciplinary collaboration among technology experts, supply chain professionals, ethicists, and policymakers will be essential to ensure that AI adoption is not only technically robust, but also socially responsible, contextually relevant, and sustainable.

5. CONCLUSION

This study set out to address the pressing question of how artificial intelligence is transforming accountability and transparency in global supply chains, with a special focus on the dynamics emerging in both advanced and developing economies. Motivated by the proliferation of digital technologies and evolving global standards for ethical governance, we recognized a critical need to systematically map the research landscape and highlight both achievements and persistent challenges. By conducting a comprehensive bibliometric analysis of 421 peer-reviewed articles published between 1998 and January 2025, we identified and characterized the intellectual structure and thematic evolution of the field. Our results identify four dominant clusters: foundational technologies, decision support and automation, blockchain and decentralization, and the integration of AI with sustainability and circular economy principles. We also document significant trends in publication growth, geographical distribution, and the key journals driving research in this area.

Notably, the analysis revealed a persistent dominance of technology-centric approaches, with theoretical and technical development comprising the majority of published work. This imbalance points to a continuing gap between conceptual advances and practical implementation, especially in the context of emerging economies, where resource constraints, regulatory uncertainty, and limited digital infrastructure remain significant barriers. Our findings reinforce the importance of bridging this gap through research that not only advances technical capabilities, but also addresses organizational, regulatory, and ethical dimensions. In response, we emphasize the need for integrative, interdisciplinary frameworks that align AI innovation with practical, context-sensitive governance. Embedding responsible AI principles, ensuring transparency, and fostering cross-sectoral collaboration will be essential to translate technological promise into meaningful progress across diverse supply chain

environments. Our synthesis also offers actionable guidance for managers, policymakers, and practitioners aiming to foster inclusive, effective, and ethically grounded AI adoption. Ultimately, this study provides a robust foundation for future research by clarifying the current state of knowledge and articulating critical directions for further exploration. By consolidating implications and recommendations within the results and discussion section, we hope to inspire the development of resilient, transparent, and socially responsible supply chains, ensuring that the transformative potential of AI is realized not only in technical terms, but also in alignment with broader organizational and societal values.

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CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript. The research was conducted independently, without any financial or personal relationships that could be viewed as influencing the results or interpretations reported in this study.

DATA AVAILABILITY STATEMENTS

The data used in this study were extracted from Scopus and Web of Science databases for bibliometric analysis. Access to these databases is subject to institutional or individual subscriptions and restrictions. Therefore, the raw data cannot be shared publicly. However, the processed data supporting the findings of this study are available from the corresponding author upon reasonable request.

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Boutayna Elghomri is a joint PhD researcher between the National School of Applied Sciences at Sidi Mohamed Ben Abdellah University (USMBA), Morocco, and the University of Artois, France. She is affiliated with the Laboratory of Artificial Intelligence, Data Science, and Emerging Systems (LIASSE) at USMBA and the Laboratory of Computer Engineering and Automation of Artois (LGI2A) in France. Her research centers on collaborative forecasting for sustainable supply chains, leveraging artificial intelligence to enhance demand forecasting, transparency, and the digital transformation of global logistics networks. Email: boutayna.elghomri@usmba.ac.ma

Fayçal Messaoudi is an accredited professor at the National School of Business and Management, Sidi Mohamed Ben Abdellah University (USMBA), Fez, Morocco. He plays a leading role in both the Research Laboratory in Management, Finance and Audit of Organizations, and the Laboratory of Artificial Intelligence, Data Science, and Emerging Systems (LIASSE). His academic work bridges business, data analytics, and emerging technologies, focusing on how artificial intelligence and data-driven decision-making transform organizations and markets. Email: faycal.messaoudi@usmba.ac.ma

Nihal Touti is a PhD researcher at the National School of Business and Management, Sidi Mohamed Ben Abdellah University (USMBA), Fez, Morocco. She is affiliated with the Laboratory of Research and Studies in Management, Entrepreneurship and Finance (LAREMEF). Her research explores the applications of artificial intelligence in economics and organizational systems, with a particular focus on leveraging data-driven methods to enhance decision-making, transparency, and accountability across various domains. Email: nihal.touti@usmba.ac.ma