University of Tehran Press

Industrial Management Journal

Online ISSN: 3115 - 7386

Homepage: https://imj.ut.ac.ir

Blockchain-Driven Supply Chain Management: A Systematic Literature Review and Research Agenda

Akbar Pourfatemi [1], Amir Khodakhah [2], Narges Ghadiri [3], Hero Isavi[4], Reza Rostamzadeh ✉ [5]

1. Ph.D. Candidate, Department of Management, Ur. C., Islamic Azad University, Urmia, Iran. E-mail: fatemia69@gmail.com
2. Assistant Prof., Sociology- Economic Development, Ro. C., Islamic Azad University, Roudehen, Iran. E-mail: amirkhodakhah555@gmail.com
3. Master of Science (M.Sc.) Candidate in Executive Business Administration, Istanbul Arel University, Istanbul, Turkey. E-mail: nargesghadiri25@istanbularel.edu.tr
4. Assistant Prof., Department of Management, Ur. C., Islamic Azad University, Urmia, Iran. E-mail: hero.isavi@iau.ac.ir
5. Corresponding author, Associate Prof., Department of Management, Ur. C., Islamic Azad University, Urmia, Iran. E-mail: reza.rostamzadeh@iau.ac.ir

Article Info

Article type:
Research Article

Article history:
Received March 09, 2026
Received in revised form April 18, 2026
Accepted June 08, 2026
Available online July 01, 2026

Keywords:
Blockchain, systematic review, smart contract, digitization, sustainability.

ABSTRACT

Objective: The objective of this research is to systematically investigate and analyze the connection between technology management and blockchain technology (BT) by exploring research trends and identifying gaps within the scientific literature.

Methodology: To fulfill this objective, a qualitative research methodology is employed, utilizing a comprehensive review system that encompasses bibliometric analysis and thematic analysis. Data for the research were sourced from the esteemed Web of Science and Scopus databases, with the timeframe from 2019 to 2025 being considered for article selection. Search terms such as "blockchain", "chain management", and "smart contract" were utilized.

Results: The findings of the research indicate that blockchain significantly contributes to the transformation of management, particularly in domains such as transparency technology, traceability, fostering trust among stakeholders, environmental sustainability, and process digitization. The co-occurrence of terms and the analysis of authors' contributions reveal that research in this field is growing at an accelerating rate; however, notable gaps exist in areas such as practical implementation, rights determination, and economic assessment.

Conclusion: The outcomes of international analyses, interdisciplinary studies, and supportive policies from governmental and research institutions are crucial for the adoption of blockchain technologies in machine chains. This study, by outlining executive policies at three levels organizational, governmental, and research ultimately advocates for the utilization of blockchain to enhance efficiency and sustainability.

Cite this article: Pourfatemi, A., Khodakhah, A., Ghadiri, N., Isavi, H., & Rostamzadeh, R. (2026). Blockchain-driven supply chain management: A systematic literature review and research agenda, ***Industrial Management Journal***, 18(3), 221-257. https://doi.org/10.22059/imj.2026.412325.1008302

Publisher: University of Tehran Press.

DOI: https://doi.org/10.22059/imj.2026.412325.1008302

Introduction

Blockchain technology (BT) has garnered significant interest from researchers and industry professionals due to its characteristics, including transparency, decentralization, and the immutability of data. Supply chain management (SCM), particularly in intricate and global contexts, encounters issues such as insufficient information transparency and a lack of trust among stakeholders, resulting in diminished efficiency and heightened costs (Saberi et al., 2019). By offering a distributed ledger that facilitates the recording of unchangeable information, blockchain has effectively mitigated these challenges and contributed to the enhancement of supply chain (SC) operations (Wang et al., 2020b). A primary application of blockchain within the SC is its capacity to monitor products from their origin to their final destination. This functionality has been especially recognized in sectors such as food and pharmaceuticals, where the quality and safety of products are paramount (Kamble et al., 2020). For instance, the implementation of blockchain in the food sector has allowed consumers to access the complete history of products via transparent platforms, thereby fostering increased consumer trust (Salah et al., 2019). Furthermore, in the pharmaceutical sector, blockchain has played a crucial role in preventing the distribution of counterfeit medications and enhancing SC traceability (Li et al., 2023). Nevertheless, the integration of BT into the SC has not been without challenges. One significant barrier is the substantial cost associated with the implementation and maintenance of this technology, which has hindered many organizations, particularly small and medium-sized enterprises, from adopting it on a broader scale (Queiroz et al., 2020; Ali et al., 2024). Furthermore, the disparity between current information systems and BT represents a significant obstacle that has hindered its adoption across various sectors (Chang and Chen, 2020). Concurrently, numerous studies have indicated that blockchain can effectively enhance the sustainability of SCs. By facilitating precise tracking and monitoring of product manufacturing and distribution, this technology can contribute to waste reduction and improved resource efficiency (Centobelli et al., 2022). Moreover, the capability to monitor the carbon footprint of the SC via blockchain enables companies to progress towards their environmental objectives (Zhang et al., 2020). Unlike previous review studies, the present research develops its conceptual framework directly from bibliometric clustering and thematic synthesis of the literature structure.

The implementation of blockchain can also foster enhanced collaboration among SC participants. The transparency inherent in BT promotes trust among partners, allowing for accurate and real-time data exchange (De Giovanni, 2020). This transparent and efficient collaboration can result in cost savings, heightened efficiency, and an overall enhancement of SC performance (Dubey et al., 2020). Recent evaluations further reveal that BT holds significant promise for managing SC risks. Through the utilization of smart contracts and transparent processes, this technology can mitigate risks related to supply delays and fluctuations in demand (Chowdhury et

al., 2022). Additionally, the capacity to track information on blockchain facilitates quicker and more effective problem identification, which is vital for sensitive sectors such as pharmaceuticals (Lai et al., 2021). This study aims to fill the existing gaps in the utilization of BT within SCM through a thorough review of prior research. By employing scientometric techniques and thematic analysis, the research identifies significant themes and anticipates future trends (Chein et al., 2024). A primary goal of this study is to establish an analytical framework that enhances the understanding of the factors influencing the adoption of this technology, while also offering recommendations for future investigations. This framework is designed to assist both researchers and managers in making informed decisions regarding the implementation of blockchain in SCs.

Literature Background

A SC is defined as a network comprising various processes and institutions, which encompasses manufacturers, suppliers, distributors, retailers, and end customers. The primary goal of an SC is to deliver products and services that are of high quality, cost-effective, and timely to customers (Saberi et al., 2019). SCM represents a holistic approach to coordinating the flow of information, materials, and capital across the chain, to enhance overall performance and generate additional value for all stakeholders (Helo and Hao, 2019). In recent years, traditional SCs have encountered obstacles such as insufficient transparency, restricted information sharing, and a lack of trust among stakeholders. These challenges diminish efficiency and elevate risks within the SC (Kshetri, 2018). To mitigate these issues, digital technologies, including blockchain, the Internet of Things (IoT), cloud computing, and big data, have been implemented, each contributing uniquely to the enhancement of SC performance (Sangari and Mashatan, 2022). Blockchain technology, initially introduced by Nakamoto in 2008 within the realm of digital currencies, functions as a distributed ledger that securely, transparently, and immutably stores and manages information (Saberi et al., 2019). The key characteristics of this technology include:

1. Transparency: All information recorded in the blockchain is accessible to all authorized members.
2. Decentralization: The blockchain is not controlled by a central entity, and all network members play a role in its management (Wang et al., 2020b).
3. Traceability: It is possible to track and observe all transactions and processes from origin to destination (Salah et al., 2019).
4. Security: The use of advanced cryptography and consensus mechanisms makes blockchain information secure against fraud and manipulation (Chang and Chen, 2020).

Blockchain Applications in SCM

BT has been extensively utilized in SCM, particularly in sectors where transparency and trust are crucial. The applications of blockchain in this context include the following:

- Traceability and Transparency: Blockchain enhances the traceability and transparency of material and information flows within the SC. This feature is particularly significant in industries such as food and pharmaceuticals (Li et al., 2023).
- Risk Mitigation: The use of smart contracts within blockchain facilitates improved management of risks related to supply delays or demand fluctuations (Chowdhury et al., 2022).
- Environmental Sustainability: Blockchain contributes to achieving environmental sustainability objectives by enhancing the recycling and reuse of materials (Centobelli et al., 2022).
- Financial Process Acceleration: Implementing blockchain in SC finance promotes transparency, lowers costs, and streamlines financial operations (Guo et al., 2022). The advantages of blockchain in the SC stem from its capacity to enhance transparency, security, and efficiency: 1. Enhanced Trust: The transparency of data and the ability to independently verify information foster increased trust among partners (De Giovanni, 2020). 2. Cost Reduction: The removal of intermediaries and the optimization of processes lead to decreased operational expenses (Dubey et al., 2020). 3. Improved Resource Management: Accurate tracking of products and information enables optimal resource utilization (Gupta et al., 2025). However, despite the significant potential of blockchain, several challenges hinder its adoption, including:
- High Implementation Costs: The expenses associated with the implementation and maintenance of blockchain can be prohibitive for many organizations (Queiroz et al., 2020).
- System Incompatibility: The mismatch between existing systems and BT can impede its adoption (Chang and Chen, 2020).
- Shortage of Expertise: Numerous organizations face a lack of skilled personnel capable of designing and managing blockchain systems (Shoaib et al., 2023).

A brief review of articles in the field of BT and SCM

A crucial step in establishing theoretical foundations and pinpointing research avenues involves reviewing prior studies and scrutinizing the existing literature pertinent to the field of inquiry. In recent years, BT has garnered significant interest from numerous researchers within the domain of

SCM, leading to the publication of various review articles on the subject. These articles have sought to identify and evaluate the challenges, advantages, and applications of BT in SCs through a thorough examination of the scientific literature. The table presented below summarizes these review studies, categorizing the articles and analyzing their content (Iseri et al, 2025). Serving as a reference tool, this table aids in more effectively identifying existing research gaps and outlining potential future directions for researchers.

Table 1. Background review of BT and SCM

Title	Authors	Year investigated	Research content
Understanding BT for Future SCs: A Systematic Review and Research Agenda	Wang, Han, and Beynon-Davies	2008–2018	1. Identification of drivers and barriers to blockchain adoption in supply chains 2. Exploration of areas where blockchain adds value to supply chain operations 3. Development of a future research agenda
The Potential of BT in SCM: A Literature Review	Gurtu and Johny	2015–2018	1. Descriptive analysis of literature (year, journal, keywords, author) 2. Evaluation of the suitability of blockchain adoption in supply chain management
Blockchain Integration and SCM: A Systematic Literature Review	Queiroz, Telles, and Bonilla	2008–2018	1. Descriptive analysis (country, year, journal) 2. Review of blockchain applications and challenges in supply chains 3. Discussion of future developments
When Blockchain Meets SC: A Systematic Review of Current Developments and Potential Applications	Chang and Chen	2016–2020	1. Descriptive analysis (year and journal) 2. Identification of key research topics and their evolution 3. Analysis of research methods 4. Citation analysis
Blockchain in SCM: A Review, Bibliography, and Network Analysis	Moosavi et al.	2010–2019	1. Bibliometric analysis (authors, institutions, countries, keywords) 2. Citation and co-citation network analysis
An Overview of BT Applications in SCs: A Comprehensive Analysis of Topics, Methods, and Industries	Lim et al.	2017–2020	1. Descriptive analysis (year, journal, country) 2. Supply chain topics addressed 3. Research methodologies 4. Industry applications 5. Identification of future opportunities
A Systematic Review of Blockchain Adoption for SC Processes	Buthelezi et al.	2017–2021	1. Descriptive analysis (publication year and source) 2. Classification of studies by context, dimension, methodology, and focus
A Data-Driven and Comparative Review of Academic Literature and News Media on Blockchain-Based SCM	Sangari and Mashatan	Before 2021	1. Classification of scientific and news articles related to blockchain in SCM 2. Comparison of academic research with practical business trends
Improving SC Flows through Blockchain: A Comprehensive Literature Review	Peng et al.	Before 2022	1. Bibliometric analysis (year, journal, citations, keywords) 2. Thematic analysis of logistics, information, and financial flows
A Bibliometric Study on Blockchain-Based SCs	Shoaib, Zhang, and Ali	2017–2022	1. Bibliometric analysis (keywords, journals, authors, institutions, countries) 2.

			Identification of research topics, methodologies, and industrial applications
Artificial Intelligence Applications for Information Management in Sustainable SCM: A Systematic Review	Yadav, Garg, and Sachdeva	2024	1. Systematic review of AI applications in sustainable supply chains 2. Identification of data management and decision-support capabilities
Blockchain Application for Transparency and Security in E-commerce Supply Chains	Unknown Author(s)	2024	1. Examination of blockchain-based transparency and security in e-commerce supply chains 2. Evaluation of traceability and transaction reliability
Weaving a Greener Future: Impact of Green HR and Green SCM on Sustainability	Ali et al.	2024	1. Investigation of sustainability practices in green supply chains 2. Analysis of the relationship between environmental management and supply chain performance
Green Production Planning for Circular Supply Chain and Resource Management	Chien et al.	2024	1. Analysis of production planning within circular supply chains 2. Resource optimization and sustainability strategies
Blockchain in Healthcare Logistics: Enhancing Transparency and Traceability	Gupta, Kumar, and Dutta	Before 2025	1. Application of blockchain in healthcare logistics 2. Improvement of transparency, traceability, and security of medical supply chains
AI-Based Predictive Analytics for Enhancing Data-Driven Supply Chain Optimization	Iseri et al.	2025	1. Application of AI-based predictive analytics in supply chain optimization 2. Development of data-driven decision models
Smart and AI-Based Food Packaging: Blockchain's Role	Kolikipogu et al.	2025	1. Integration of blockchain with smart food packaging systems 2. Enhancement of traceability, food safety, and monitoring
Auditing in the Blockchain: A Literature Review	Zhang, Ma, and Meng	2025	1. Review of blockchain-based auditing mechanisms 2. Evaluation of transparency, accountability, and verification in digital transactions

The research summarized in Table 1 demonstrates the growing scholarly interest in the application of blockchain technology (BT) within supply chain management (SCM). Early studies primarily concentrated on conceptualizing the potential of blockchain and identifying its possible benefits and challenges within supply chains. These investigations emphasized key themes such as traceability, transparency, trust building, information sharing, and risk reduction in supply chain operations (Wang et al., 2018; Gurtu & Johny, 2019; Queiroz et al., 2020). In addition, several systematic and bibliometric reviews were conducted to map the evolution of research topics, identify influential authors and journals, and highlight emerging trends in blockchain-based supply chains (Moosavi et al., 2021; Lim et al., 2021; Shoaib et al., 2023). Over time, the scope of research has expanded significantly. More recent studies have begun to integrate blockchain with broader digital transformation initiatives in supply chains. For example, artificial intelligence and advanced data analytics are increasingly considered complementary technologies that enhance the effectiveness of blockchain-based systems by improving data management, forecasting, and

decision-making capabilities (Yadav et al., 2024; Iseri et al., 2025). The convergence of these technologies enables more intelligent and data-driven supply chain systems capable of responding to complex operational challenges.

Another important trend in the literature is the growing emphasis on sustainability and green supply chain practices. Recent studies highlight how digital technologies, including blockchain, can support environmentally responsible supply chain operations by increasing transparency, improving resource efficiency, and facilitating sustainable production and distribution processes (Ali et al., 2024; Chien et al., 2024; Yıldırım et al., 2025). These studies demonstrate that blockchain can contribute not only to operational efficiency but also to broader sustainability objectives within supply chains. Furthermore, recent research increasingly focuses on industry-specific applications of blockchain. For instance, blockchain has been explored in healthcare logistics to enhance traceability and ensure the authenticity and safety of medical products (Gupta et al., 2025). Similarly, applications in food supply chains and smart packaging systems emphasize the importance of real-time monitoring, product tracking, and food safety assurance (Kolikipogu et al., 2025). In addition, blockchain solutions have been proposed to enhance transparency and security in e-commerce supply chains, where reliable transaction records and trust between stakeholders are essential (Unknown Author(s), 2024). Another emerging area of research involves governance, auditing, and regulatory aspects of blockchain systems. Blockchain-based auditing mechanisms are being explored as tools for improving accountability, verification, and trust in digital supply chain transactions (Zhang et al., 2025). These developments indicate that blockchain research is gradually evolving from conceptual discussions toward more practical and interdisciplinary applications. Despite the significant progress made in the literature, several research gaps remain. A considerable portion of existing studies still focuses on descriptive analyses, bibliometric reviews, or conceptual discussions rather than empirical investigations. Consequently, there is a need for more quantitative studies, analytical models, and practical implementation frameworks that evaluate the real impact of blockchain technology on supply chain performance. Additionally, the integration of blockchain with other emerging technologies such as artificial intelligence, the Internet of Things (IoT), and advanced data analytics requires further exploration. Industry-specific investigations that consider the unique operational and regulatory conditions of different sectors are also relatively limited.

Therefore, future research should aim to develop comprehensive analytical frameworks and empirical models that can assess the practical implications of blockchain adoption in supply chains. Investigating the combined application of blockchain with other digital technologies, as well as exploring its role in specific industries and sustainability initiatives, could provide valuable insights for both researchers and practitioners. The present study seeks to address these gaps by

systematically reviewing the existing literature and proposing new directions for future research in blockchain-enabled supply chain management.

Linking Blockchain to Established SCM Theories

While the technical functionalities of blockchain are well documented, a deeper theoretical grounding is necessary to understand *why* and *under what conditions* blockchain adoption influences supply chain performance and governance. This section synthesizes the blockchain-SCM nexus through the lens of three established theoretical frameworks: Transaction Cost Economics (TCE), the Resource-Based View (RBV), and Institutional Theory.

Transaction Cost Economics (TCE)

Transaction Cost Economics, as articulated by Williamson (1975, 1985), posits that the governance structure of an economic exchange is determined by the imperative to minimize transaction costs—namely, the costs of searching, negotiating, monitoring, and enforcing contracts. These costs are exacerbated by two behavioral assumptions: bounded rationality and, critically, opportunism (self-interest seeking with guile). In complex, global supply chains characterized by information asymmetry and geographically dispersed actors, the potential for opportunistic behavior—such as quality shading, delivery delays, or falsified certifications—substantially inflates monitoring and enforcement costs. Blockchain technology directly addresses these TCE concerns through two primary mechanisms. First, by providing a shared, immutable, and time-stamped ledger, blockchain reduces information asymmetry among transacting parties. All authorized stakeholders possess an identical, verifiable record of transactions, order statuses, and custody transfers, thereby diminishing the monitoring costs associated with verifying counterparty compliance. Second, smart contracts automate contract execution: pre-agreed conditions (e.g., confirmation of IoT-verified delivery) trigger automatic payment release, effectively reducing enforcement costs to near zero and curtailing the scope for opportunistic post-contract renegotiation. From a TCE perspective, blockchain can therefore be conceptualized as an institutional technology that shifts the efficient boundary of governance, making market-based or hybrid (networked) governance structures more viable for transactions previously requiring costly hierarchical (vertically integrated) controls.

Resource-Based View (RBV)

The Resource-Based View (Barney, 1991) explains competitive advantage through the possession of resources and capabilities that are Valuable, Rare, Inimitable, and Non-substitutable, and that the firm is Organized to exploit (VRIO framework). While blockchain technology itself is a general-purpose technology and thus not inherently rare or inimitable, its specific implementation

and the unique, high-integrity data ecosystem it generates can constitute a source of sustained competitive advantage. The capability for real-time, end-to-end supply chain traceability—generating verifiable provenance data that is costly for competitors to replicate without comparable network-wide adoption—can become a VRIO resource, particularly in industries where trust, authenticity, and sustainability credentials command a market premium (e.g., organic food, luxury goods, pharmaceuticals). Furthermore, the transparent and immutable record of a firm's ethical sourcing and environmental stewardship creates a credible reputational asset. Unlike self-reported sustainability claims, blockchain-verified data provides a path-dependent, causally ambiguous, and socially complex resource that competitors cannot easily duplicate. Thus, through the RBV lens, blockchain is not merely a cost-reduction tool but an enabler of product and brand differentiation grounded in verifiable trust.

Institutional Theory

Institutional Theory (DiMaggio & Powell, 1983) explains how organizational practices diffuse through fields not solely due to efficiency imperatives but also due to institutional pressures. Three isomorphic forces are relevant to blockchain adoption in SCM. *Coercive pressures* arise from regulatory mandates and powerful trading partners: for instance, government regulations requiring pharmaceutical serialization (e.g., the Drug Supply Chain Security Act in the U.S.) or sustainability reporting mandates (e.g., the EU Deforestation Regulation) may compel firms to adopt blockchain for compliance. *Mimetic pressures* emerge under conditions of uncertainty: as leading firms and competitors successfully implement blockchain for supply chain visibility, others imitate these practices to avoid perceived competitive disadvantage. *Normative pressures* stem from professionalization and industry standards: the establishment of blockchain standards (e.g., by GS1 or ISO) and its endorsement by consulting firms and industry bodies create a normative expectation that a "legitimate" modern supply chain should leverage such technology. Institutional Theory thus complements TCE and RBV by explaining blockchain adoption as not only an efficiency-driven or resource-seeking choice but also a response to the broader institutional environment in which supply chains are embedded.

Materials and Methods

This research employs a qualitative methodology utilizing a systematic review approach to investigate and analyze the connection between SCM and blockchain technology. This methodology incorporates a blend of bibliometric analysis and thematic analysis to identify and scrutinize research trends and gaps within this domain. In this research, pertinent and credible articles were sourced and analyzed from trustworthy databases. Initially, relevant articles were identified and selected through the Web of Science and Scopus databases. This database was selected as the primary source for the research due to its reliability and comprehensive coverage.

The search was executed using keywords such as "blockchain", "supply chain management", and "smart contract". Additionally, a timeframe from 2019 to 2025 was established for the collection of articles. In the subsequent phase, the inclusion and exclusion criteria were meticulously defined. These criteria are presented in Table 2.

Table 2. Article inclusion and exclusion criteria

Criteria	Explanation
Entry criteria	Articles published in reputable journals focusing on blockchain and SCM
Exit criteria	•Purely review articles (e.g., narrative, systematic, or meta-analysis reviews) •Non-peer-reviewed materials such as editorials, notes, short communications, and extended abstracts •Conference papers published in non-indexed proceedings lack rigorous peer review •Articles without full text or content unrelated to the topic

For the purpose of data analysis, VOSviewer software was employed to conduct a bibliometric analysis and to pinpoint highly cited authors and articles. This analysis encompassed the examination of publication time trends, the geographical distribution of research, and the identification of commonly used keywords and topics. Additionally, selected articles underwent a qualitative review for thematic analysis to extract the most significant research topics and patterns. This analysis is divided into three primary sections: the application of BT in the supply chain, the factors influencing the adoption of this technology, and the anticipated future trends in this domain. The inclusion of highly cited indexed proceedings was intended to capture emerging technological developments and interdisciplinary innovations frequently disseminated through conference-oriented publication channels in rapidly evolving digital technology domains. Figure 1 illustrates the process of reviewing studies.

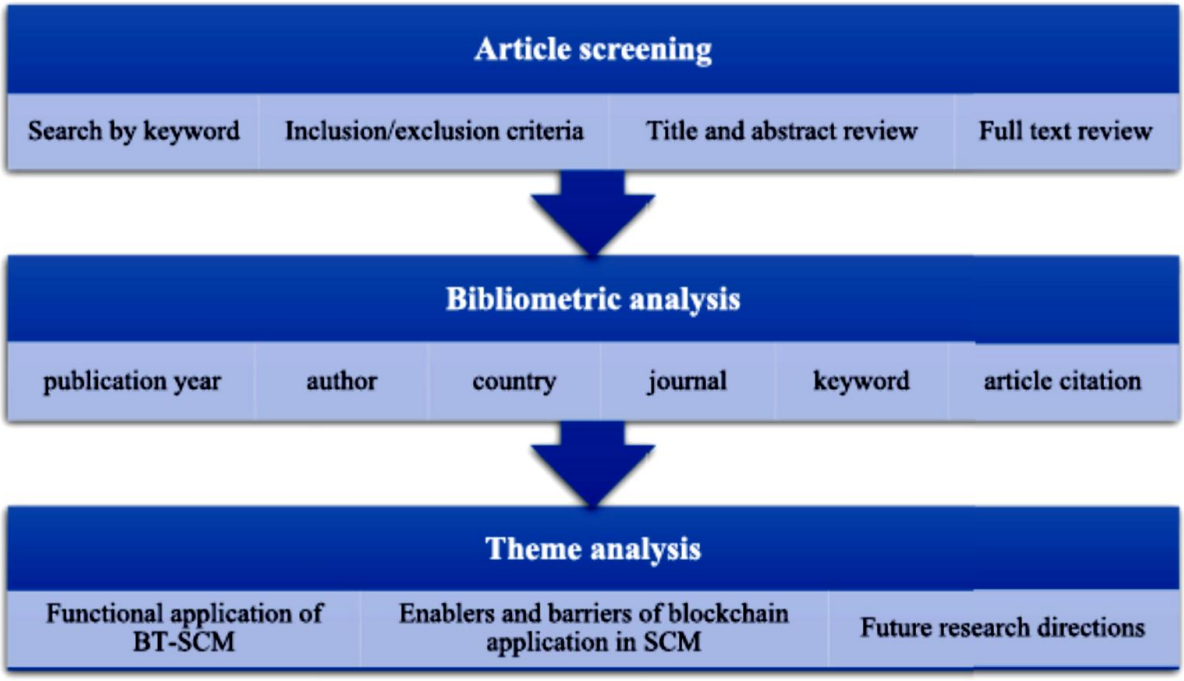

Figure 1. Review process

Article Screening

The Web of Science (WoS), Scopus, and Google Scholar are recognized as some of the most significant and authoritative databases for citation evaluation. Among these, WoS is regarded as the most authoritative due to its provision of comprehensive interdisciplinary research data alongside its coverage of high-quality articles (Lim et al. 2021). This database is also distinguished by its sophisticated search functionalities, high credibility, and extensive coverage (Sangari and Mashatan 2022; Nematian et al.,2025). Consequently, this research utilized the WoS core database for the purpose of searching and gathering articles, with the search period spanning from 2019 to 2025. The article screening procedure in this research was conducted in four phases: (1) Keyword search: To locate pertinent articles, a variety of terms related to blockchain were employed, such as "blockchain", "distributed management", and "smart contract". Additionally, terms like "supply chain management", "supply chain integration, "supply chain collaboration", and "supply chain coordination" were utilized to delineate SCM. (2) Inclusion and exclusion criteria: Non-peer-reviewed conference abstracts, editorials, notes, and short communications were excluded. However, indexed conference proceedings published in recognized scholarly series such as Procedia and LNCS were retained due to their significant citation impact and relevance within the blockchain-SCM research domain. (3) Title and abstract review: Articles lacking keywords pertinent to blockchain and SCM in their titles and abstracts were eliminated. (4) Full-text review: Articles that did not pertain to the subject of blockchain-SCM or that consisted of reviews and case

studies were excluded from consideration. Ultimately, 800 articles were selected for further analysis.

Search Strategy

The literature search was conducted in January 2025 across two databases: Web of Science Core Collection and Scopus. The following Boolean search string was applied to the title, abstract, and keyword fields:

("blockchain" OR "distributed ledger" OR "smart contract*")

AND

("supply chain management" OR "supply chain integration" OR "supply chain collaboration" OR "supply chain coordination" OR "SCM")

The search was limited to English-language articles and indexed proceedings published between 2019 and 2025. In Web of Science, document types were filtered to "Article" and "Proceedings Paper." In Scopus, document types were limited to "Article" and "Conference Paper." No subject category filters were applied to avoid excluding interdisciplinary work.

To manage database overlap, all retrieved records were exported into a reference management tool. Duplicate identification followed a two-step protocol: first, records with identical DOIs were automatically merged; second, records sharing identical titles and first-author surnames were manually inspected and removed if confirmed as duplicates. The number of duplicates identified and removed is reported in the PRISMA flow diagram (Figure 1).

Bibliometric Analysis

It is a quantitative approach employed to assess and scrutinize scientific publications. This approach aids in identifying authors and keywords, and it can uncover emerging research domains. Bibliometric analysis typically concentrates on elements such as publication year, author, country, keywords, journal, and citation analysis of articles (Moosavi et al. 2021; Azzavi et al., 2025). VOSviewer software is utilized to analyze data obtained from articles. This software is an open-source application that facilitates the exploration and examination of scientific literature sourced from various databases. Its comprehensive search capabilities, strong compatibility with scientific databases, and user-friendliness have rendered this software a favored tool among researchers (Eck and Waltman 2010). Owing to these attributes, this article employs VOSviewer for the visual analysis of literature data.

Theme Analysis

A bibliometric analysis of the current literature fails to deliver a complete and thorough overview of the research landscape. To achieve a more profound comprehension of the research status within the domain of BT and SCM (BT-SCM), it is essential to perform in-depth qualitative surveys across various themes. Theme analysis serves as a qualitative research technique employed to examine a substantial number of scholarly articles and evaluate the advancement of research in this domain (Sangari and Mashatan 2022). This approach is also extensively utilized to pinpoint research deficiencies and emerging trends within the BT-SCM sector. In this study, the theme analysis is organized into three primary sections: the functional applications of BT in SCM, the facilitators and obstacles to the adoption of this technology in SCM, and prospective research directions in this field.

Conceptual Model Development Process

The conceptual framework proposed in this study was not developed independently of the bibliometric analysis. Instead, it emerged through an interpretive synthesis of the dominant thematic clusters identified via keyword co-occurrence analysis using VOSviewer. Initially, 1,454 keywords extracted from the selected publications were analyzed and grouped into thematic clusters based on co-occurrence frequency and relational proximity. Subsequently, the major clusters were interpreted and consolidated into broader conceptual dimensions representing the main intellectual structure of blockchain-enabled supply chain management research. This process enabled the transformation of bibliometric findings into a coherent conceptual framework grounded in the empirical structure of the literature.

Table 3. Transformation of Bibliometric Clusters into Conceptual Dimensions

Bibliometric Cluster	Representative Keywords	Derived Conceptual Dimension
Cluster 1	transparency, traceability, trust, security	Transparency and Trust Mechanisms
Cluster 2	IoT, AI, Industry 4.0, smart contracts	Smart Technology Integration
Cluster 3	sustainability, green supply chain, circular economy	Sustainability-Oriented SCM
Cluster 4	governance, regulation, decentralization	Governance and Regulatory Framework
Cluster 5	efficiency, optimization, performance	Operational Optimization

Thematic Interpretation and Cluster Synthesis

The present study did not employ a conventional qualitative thematic analysis based on interview transcripts or narrative datasets. Instead, thematic interpretation was conducted through bibliometric cluster synthesis using keyword co-occurrence analysis in VOSviewer. The extracted keywords were grouped into thematic clusters according to frequency, relational proximity, and

network association. Subsequently, these clusters were interpretively analyzed and consolidated into broader thematic dimensions representing the dominant intellectual structure of blockchain-enabled supply chain management research. Therefore, the conceptual model emerged from an interpretive synthesis of bibliometric patterns rather than from classical qualitative coding procedures.

Table 4. Bibliometric Themes and Conceptual Interpretation

Cluster	Main Keywords	Interpreted Theme
Cluster 1	transparency, traceability	Trust and Transparency
Cluster 2	IoT, AI, smart contracts	Technology Convergence
Cluster 3	sustainability, green SCM	Sustainable Supply Chains

As shown in Table 4, the thematic dimensions of the proposed conceptual framework were derived through an interpretive synthesis of the bibliometric clusters identified in the keyword co-occurrence analysis. The clustering process enabled the identification of dominant research streams and conceptual relationships within the literature. Subsequently, related keywords within each cluster were consolidated into broader thematic categories representing the major intellectual domains of blockchain-enabled supply chain management research. This process provided the analytical foundation for developing the final conceptual model presented in the study.

Results

In order to investigate the research trends pertaining to the integration of BT-SCM, a bibliometric analysis was performed on 800 chosen articles sourced from the Web of Science and Scopus databases covering the period from 2019 to 2025. This analysis utilized VOS viewer software along with additional tools, examining indicators such as the number of sources, the number of authors, the extent of international collaborations, average citations, and annual growth.

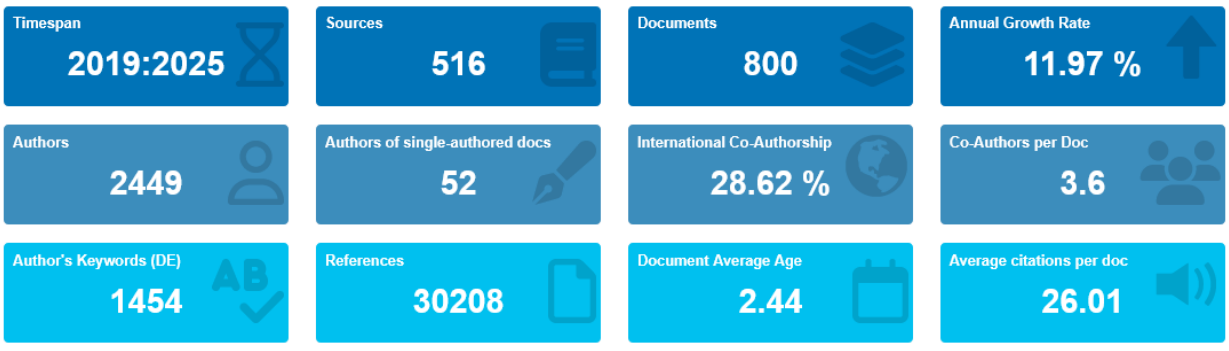

Figure 2. Bibliometric indices of selected articles in the field of blockchain and SCM

Figure 2 illustrates a collection of essential bibliometric indicators derived from the examination of 800 selected scientific articles published between 2019 and 2025. Throughout this

timeframe, the annual growth rate of article production reached 11.97%, signifying a rising trend in researchers' engagement with the integration of BT into SCM. Furthermore, the total number of active authors in this domain was recorded at 2,449, with only 52 of them publishing articles independently. This suggests a robust team-oriented and interdisciplinary collaboration within this research area. Among the total articles, 28.62% resulted from international collaborations, highlighting the global significance of the subject of blockchain in SCM. Additionally, the cumulative number of cited sources stands at 30,208, with an average citation count of 26.01 per article, reflecting the relative impact of this research across related fields. The average age of the documents was reported to be 2.44 years, indicating the novelty and contemporary relevance of the literature utilized in this study. Moreover, with an average of 3.6 authors per article, it can be inferred that scientific collaboration in this field is conducted in a collective and organized manner. The thematic diversity of the research is further evidenced by the presence of 1,454 distinct keywords from the authors, which underscores the extensive range of approaches and subfields explored within the realm of blockchain applications in SCM.

Considering the quantitative analysis depicted in Figure 2, which provides an overarching view of the current state of research in blockchain and SCM, a more thorough investigation into the structure of scientific collaboration among authors appears warranted. In this context, Figure 3 presents the cumulative distribution of the degree of author collaboration, which aids in gaining a clearer understanding of the influence and roles of key researchers within this field.

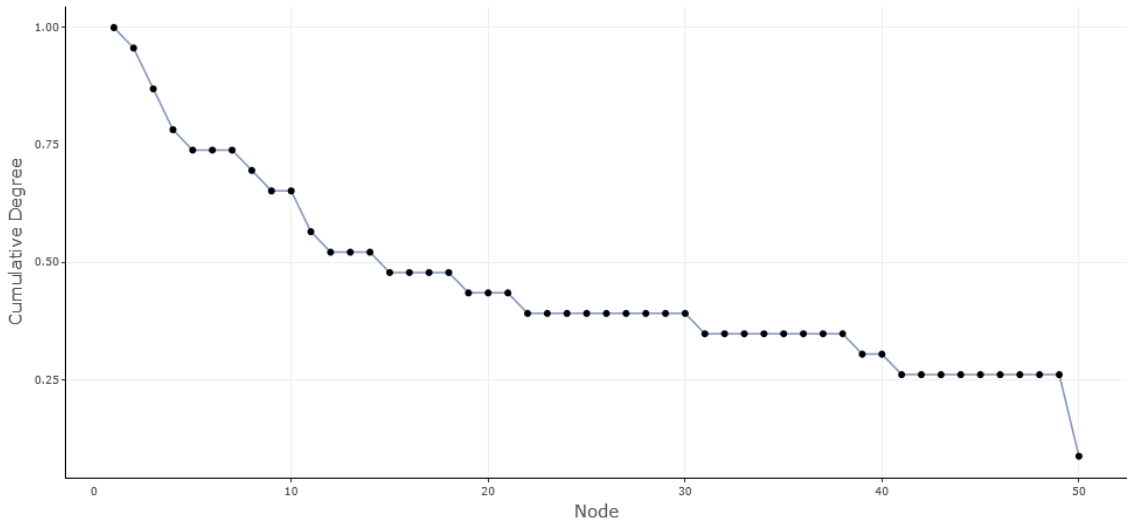

Figure 3. Cumulative Degree Distribution Chart of Author Contributions

Figure 3 illustrates the authors' contributions as depicted by the cumulative degree distribution. The horizontal axis represents the number of nodes or authors (Nodes), while the vertical axis indicates their cumulative degree of contribution. The graph clearly demonstrates that initially, a limited number of authors contribute significantly to article production, thereby commanding a

substantial portion of scientific interactions and knowledge generation. Over time, as the number of nodes increases, the overall contribution diminishes, leading to a continued decline in the curve. This trend is frequently observed in scientific networks and research collaborations, mirroring the power-law distribution; specifically, a small group of individuals plays a central and influential role in scientific production, while numerous other contributors operate on the periphery. Consequently, this graph reveals that the author network structure within the domain of blockchain and SCM is characterized by an imbalance and a central focus, where certain key researchers have made notable contributions to the creation and direction of knowledge flow.

Analysis of Publication Trends in Selected Scientific Journals

To gain a deeper insight into the significance and status of scientific journals in the evolution of research literature concerning the use of BT in SCM, an analysis was conducted on the cumulative publication trends of articles in six leading scientific journals from 2019 to 2025. The journals examined include IEEE Access, Sustainability (Switzerland), Procedia Computer Science, Lecture Notes in Networks and Systems, AIP Conference Proceedings, and Lecture Notes in Computer Science. By analyzing these trends, researchers can pinpoint the most impactful journals for their studies and future publications.

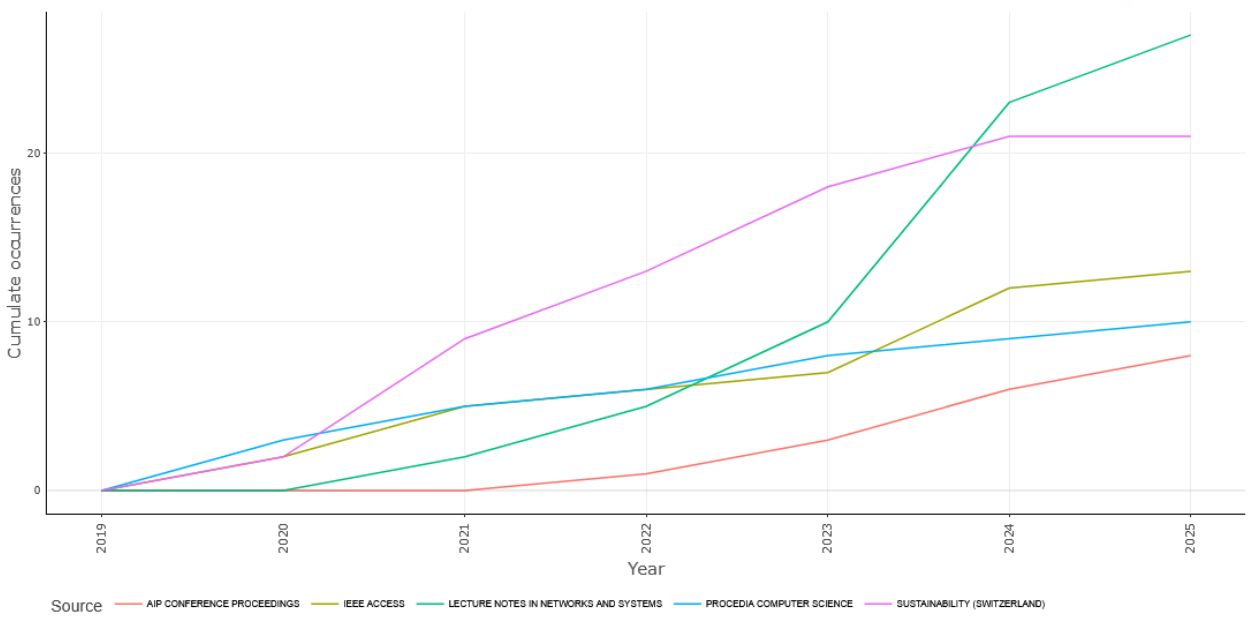

Figure 4. Cumulative trend of publication of articles in selected scientific sources

"The publication trajectory presented in Figure 4 reveals a significant thematic evolution within the field. The early dominance and rapid growth of Sustainability (Switzerland) from 2020 to 2023 can be theoretically interpreted as reflecting the field's initial conceptual phase, wherein

blockchain was predominantly framed as an enabler of environmental and social sustainability goals—a narrative strongly aligned with the scope of that journal. However, the subsequent plateau and the concurrent sharp rise of Lecture Notes in Networks and Systems from 2022 onwards signal a disciplinary maturation and a shift toward engineering-oriented, application-specific research. This transition suggests that the scholarly community has moved beyond proving blockchain's potential for sustainability toward the technical challenges of implementation, including system architecture, network design, and integration with Industry 4.0 technologies. The growth of IEEE Access, a multidisciplinary open-access journal, further corroborates this trend, indicating a broadening of the research base and an increasing emphasis on technical feasibility and cross-disciplinary engineering solutions."

International Collaboration Network in the Field of Blockchain and SC

The global network of scientific collaboration serves as a crucial metric for assessing the dynamism and scientific advancement within a research domain. To illustrate this, a network depicting the scientific collaborations among nations in the area of BT applied to SCM has been created. In this representation, each node symbolizes a country, while each link signifies a scientific collaboration (co-authorship of articles) between nations. Furthermore, the size of each node is proportional to the volume of scientific outputs produced by the respective countries.

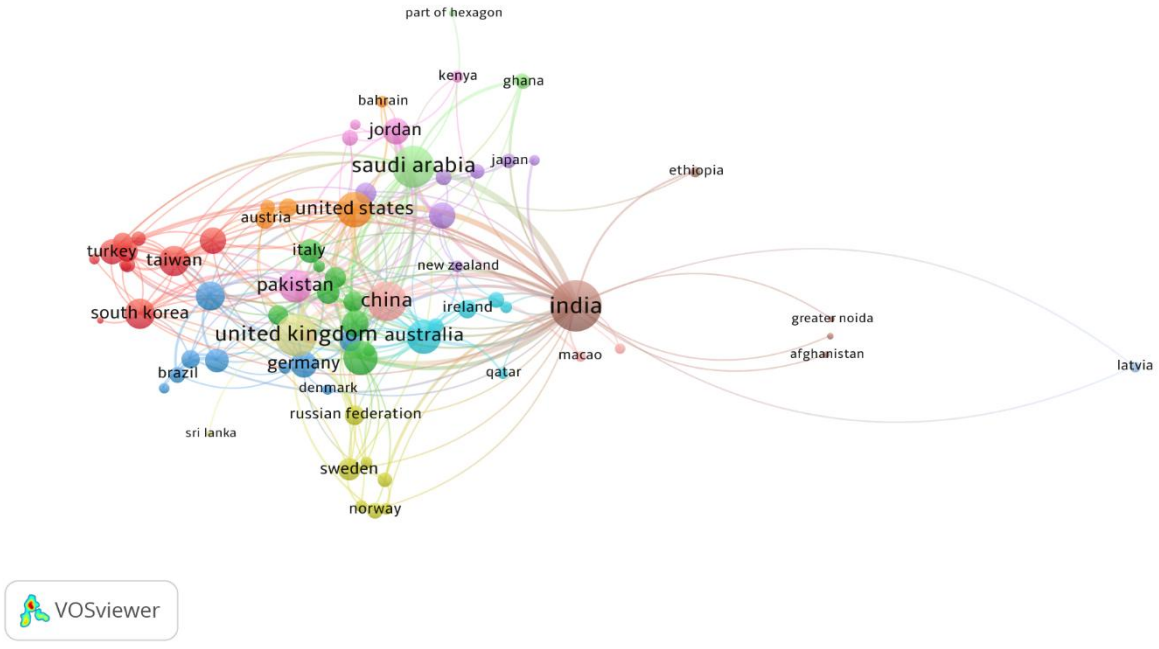

Figure 5. Network of scientific cooperation between countries in the field of blockchain and SC

The findings indicate that India exhibits the highest degree of scientific collaboration in this domain, significantly surpassing other nations, and serves as the pivotal hub of the network. This nation maintains the most extensive connections with various countries, including the United States, Saudi Arabia, China, the United Kingdom, and Australia. Following India, nations such as China, Pakistan, the United Kingdom, Germany, and the United States also occupy relatively central and influential roles. Furthermore, countries like Afghanistan, Latvia, Macau, and Ethiopia, despite their lower levels of scientific engagement, remain connected to the global cooperation network in some capacity. The cluster structure depicted in the graph further illustrates the emergence of groups of countries that engage in closer collaboration, potentially reflecting regional or linguistic ties in scientific production. For instance, a cluster focused on East Asian nations and another involving Western European countries are distinctly identifiable.

Keyword Co-occurrence Analysis in the Field of SC and Blockchain

This analysis is the result of a bibliometric study and shows the clustering of topics based on the co-occurrence of words in abstracts or keywords. The size of the circles indicates the frequency of use of words, and the colors represent different topic clusters.

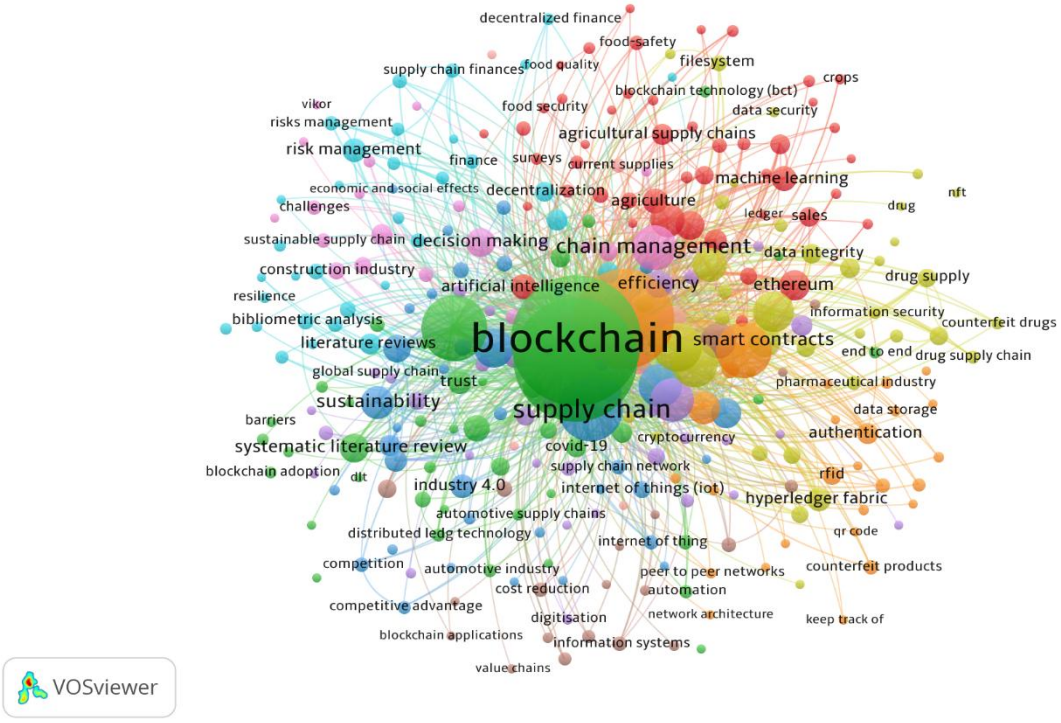

Figure 6. Co-occurrence map of keywords in the field of SCM and blockchain

"The keyword co-occurrence network in Figure 6 reveals the intellectual structure of the field, which can be interpreted through the lens of three distinct yet interconnected research streams. First, the red cluster, centered on 'blockchain', 'supply chain', and 'smart contracts', constitutes the **core foundational stream**—it represents research focused on the intrinsic functionalities of the technology itself, namely trust, transparency, and automation. Second, the green cluster, featuring 'sustainability' and 'circular economy', signifies a **normative and impact-oriented stream**, where blockchain is conceptualized not merely as an efficiency tool but as a governance mechanism for achieving environmental and social objectives. Third, the blue cluster, linking 'IoT' and 'artificial intelligence', embodies the **technological convergence stream**, highlighting a research agenda that transcends blockchain in isolation and explores its synergistic integration with other pillars of the Fourth Industrial Revolution. The conceptual distance between the 'foundational' and 'convergence' clusters on the map is particularly noteworthy, as it visually suggests that significant intellectual and empirical work remains to be done in bridging theoretical blockchain promises with complex, multi-technology implementation realities."

Figure 7. Keyword cloud in the field of SC and blockchain technology

In these illustrations, commonly appearing keywords like "blockchain", "supply chain", "smart contracts", "trust", "efficiency", and "sustainability" are represented by larger circles. The connections between terms are depicted by lines that signify their co-occurrence across various documents. Additionally, thematic color coding highlights the categorization of related concepts in fields such as agriculture, data security, the automotive sector, pharmaceuticals, and emerging technologies (including the IoT and artificial intelligence (AI).

Time trend analysis of research in the field of SC and blockchain

Figure 7 illustrates the evolution of research emphasis on keywords associated with "supply chain management and blockchain technology" throughout the years. The various colors depicted on this map represent the average publication year of articles about each term; purple denotes older articles (2021), while yellow signifies more recent articles (2024).

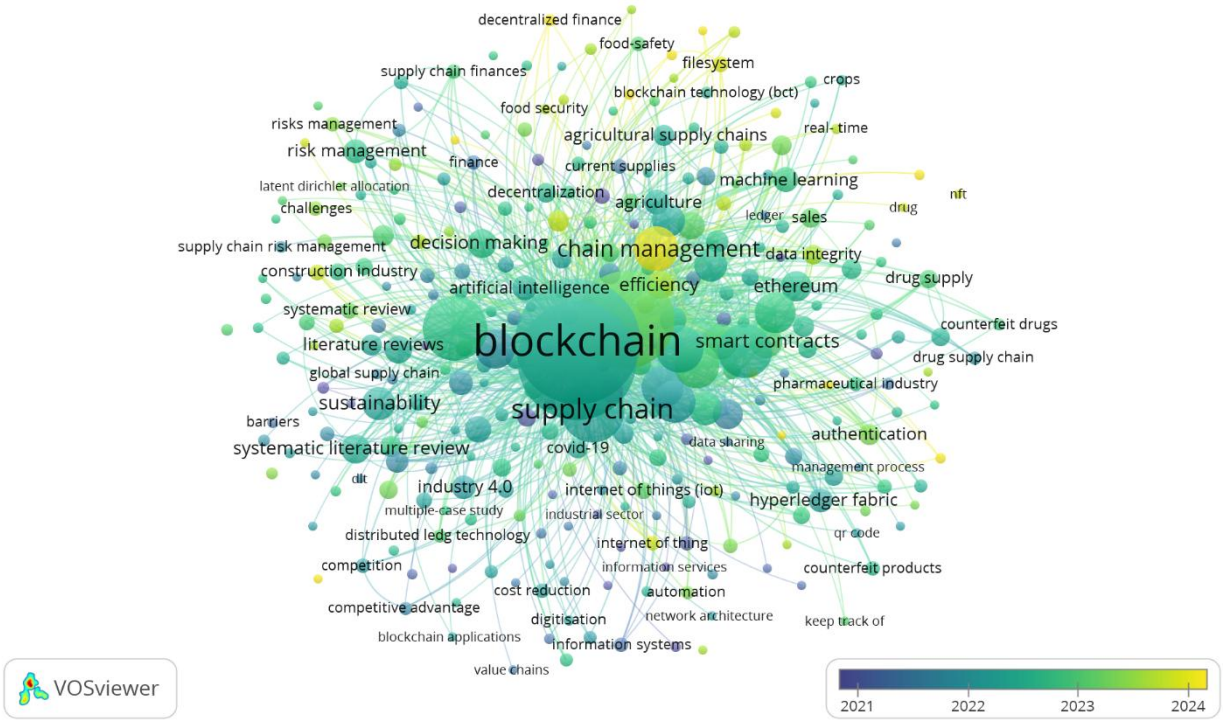

Figure 8. Timeline of keywords in the field of SCM and blockchain

"The temporal overlay visualization in Figure 8 maps the evolutionary trajectory of research frontiers. The transition from foundational, purple-coded terms such as 'blockchain' and 'traceability' (average publication year ~2021) to the emergence of bright-yellow, cutting-edge concepts like 'machine learning', 'authentication', and 'NFT' (average publication year ~2024) signifies a crucial paradigm shift. This shift can be interpreted as a move from passive tracking to intelligent, predictive, and tokenized supply chains. The recent surge in 'machine learning' indicates that the research frontier is increasingly concerned with leveraging blockchain's immutable data as a trustworthy input for AI-driven predictive analytics and autonomous decision-making. Simultaneously, the appearance of 'NFT' (Non-Fungible Token) suggests an early-stage exploration of tokenization as a mechanism for representing unique physical assets digitally on a blockchain, potentially revolutionizing provenance tracking, ownership transfer, and anti-counterfeiting for high-value goods. This temporal analysis reveals that the field is not static; it is rapidly absorbing adjacent digital innovations."

Time trend and co-occurrence of key concepts in the field of “supply chain management” and “blockchain technology”

The chart presented below illustrates a scientometric analysis of significant terms utilized in scholarly articles concerning SCM and BT from 2019 to 2025. In this graph, the vertical axis represents the terms (frequent terms), while the horizontal axis denotes the time periods during which these terms were active in scientific literature. The dimensions of the circles reflect the frequency or relative significance of each term in the year it first appeared.

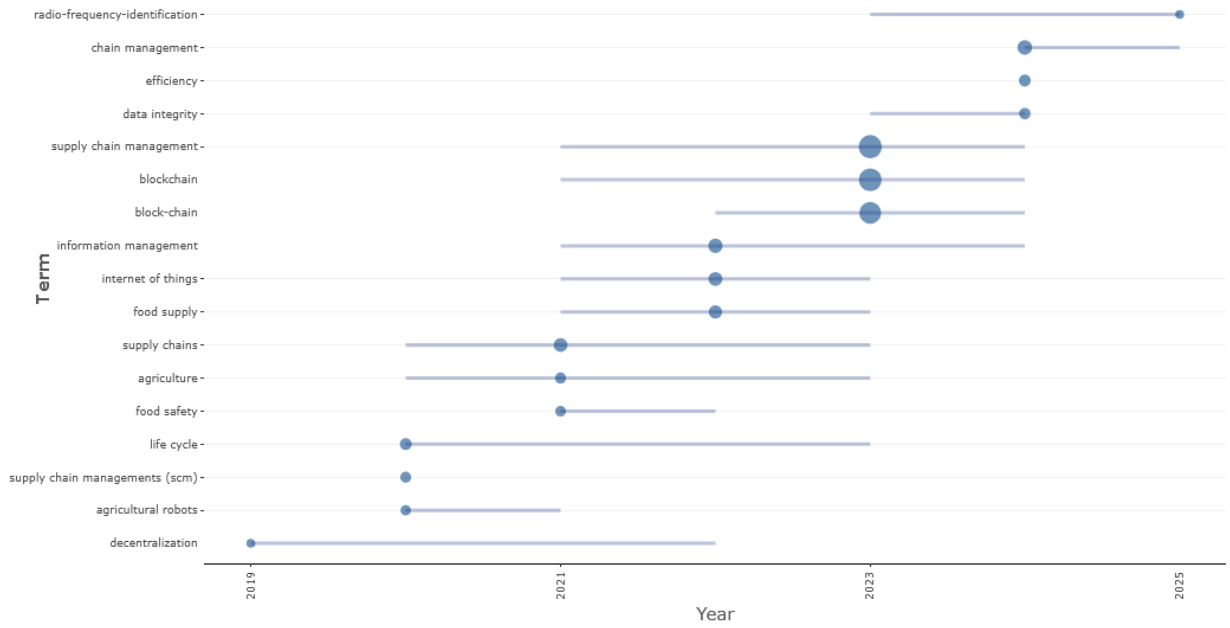

Figure 9. Timeline and co-occurrence of key concepts in the fields of "SCM" and "BT"

Figure 8 illustrates that since 2021, the predominant emphasis of scientific inquiry has been on the integration of the principles of "supply chain management" and "blockchain technology". Terms such as "blockchain", "block-chain", and "supply chain management" exhibit the highest frequency and temporal range, signifying the escalating growth of research in this domain. Concurrently, concepts like "data integrity", "information management", and "internet of things" have also been incorporated, suggesting an expansion of the research scope to encompass additional emerging technologies. Furthermore, the focus on efficiency, data security, and information management highlights the emphasis of scholarly articles on the practical advantages of blockchain in enhancing SC performance. Simultaneously, terms associated with agriculture and food safety, including "food supply", "agriculture", "food safety", and "agricultural robots", are also evident in this analysis, reflecting the application of blockchain in the tracking and management of agricultural and food resources. Concepts such as "radio-frequency-identification" and "decentralization", which have surfaced in recent years (from 2023 onwards), signify a novel research trend towards the adoption of decentralized frameworks and intelligent tracking technologies within the SC. In summary, this analysis indicates that the convergence of BT and

SCM is persistently evolving, and with the emergence of new concepts, fresh avenues for research and practical implementation have been established.

Co-authorship network of researchers in the field of "SCM and BT"

The illustration below depicts the co-authorship network among scholars who have engaged in the integration of SCM and blockchain technology. Each node symbolizes an author, with its size reflecting the quantity of citations or published works. The connections between the nodes signify collaboration and co-authorship among the authors. The various colors denote distinct clusters of researchers who share a more robust scientific relationship within each cluster.

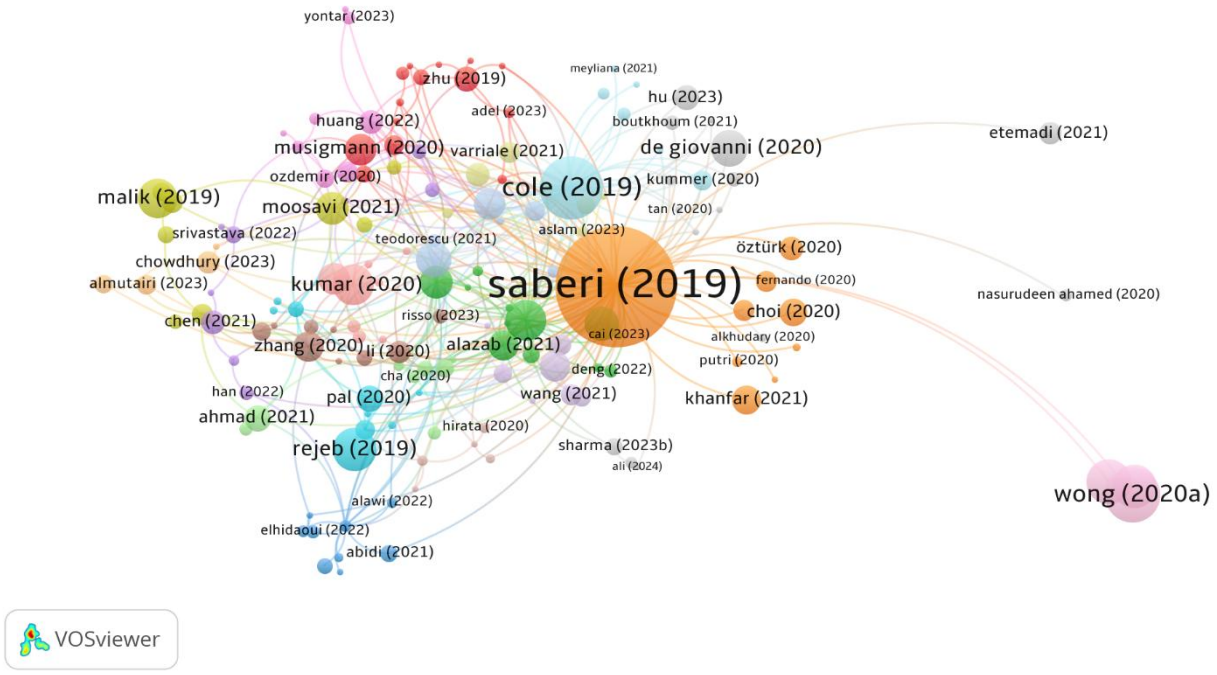

Figure 10. Co-authorship network of researchers in the field of "SCM and BT"

According to the image, the researcher "Saberi (2019)" occupies a central position within the network and is acknowledged as the most cited and influential figure in this domain. The substantial size of Saberi's node, along with the extensive number of connections to other researchers, underscores his pivotal role in advancing and directing research concerning the integration of BT with SCM. Additionally, other scholars such as "Cole (2019)", "De Giovanni (2020)", and "Kumar (2020)" also hold central roles within the network, serving as intermediaries in the dissemination of knowledge across various clusters. Conversely, in another segment of the network, authors like

"Wong (2020a)" and "Nasurudeen Ahamed (2020)" are identified; despite their considerable research output, they exhibit limited connections with their peers, suggesting a tendency towards independent or less collaborative research endeavors. Furthermore, the network is characterized by distinct colored clusters, including the orange cluster (led by Choi and Khanfar), the blue cluster (led by Rejeb), and the green cluster (led by Kumar and Alazab), which signify the emergence of various research streams, each pursuing a unique approach or thematic focus.

Analysis of Barriers and Challenges in the Reviewed Literature

To assess the extent to which the reviewed literature addresses the implementation challenges identified in the Introduction, a targeted analysis of barrier-related keywords was conducted. Terms such as "cost," "implementation barrier," "system incompatibility," "scalability," "regulatory uncertainty," and "lack of expertise" were mapped within the keyword co-occurrence network. The analysis reveals that while "cost" and "scalability" appear as moderately frequent nodes, they are predominantly situated within conceptual and review-oriented publications. Empirical studies that quantitatively measure implementation costs or systematically compare the total cost of ownership of blockchain-based versus traditional supply chain systems remain scarce, representing a significant gap. Similarly, "system incompatibility" and "integration challenge" appear as peripheral nodes in the network, indicating that, despite being frequently cited as barriers in introductory and theoretical discussions, these topics have not yet coalesced into a sustained, empirically driven research stream. This disconnect between the frequency with which barriers are invoked and the depth with which they are investigated constitutes one of the key findings of this review.

The most prolific authors in the field of SCM and blockchain

Table 5 presents a compilation of authors who have contributed the highest volume of articles in the domain of integrating BT with SCM. The "Articles" column reflects the cumulative number of articles attributed to each author, whereas the "Articles Fractionalized" column assesses the number of articles according to the actual contributions made (indicating the relative input of each author to the respective article).

Table 5. The most prolific authors in the field of SCM and blockchain

Authors	Articles	Articles Fractionalized
KUMAR A	9	2.28
SHARMA A	7	1.62
ZHANG X	7	1.26
LIU Y	6	1.69
PAL K	6	5.50
SHARMA S	6	1.62
SINGH S	6	1.13
WANG X	6	1.17
WANG Y	6	1.52
GUPTA M	5	1.95

In this table, the author Kumar A is acknowledged as the most prolific researcher in this domain, having published 9 articles. However, his actual contribution to these articles, when calculated using the fractional model, amounts to 2.28. Conversely, Pal K, who has authored only 6 articles, demonstrates the highest actual contribution to article writing, with a fractional contribution coefficient of 5.50. This suggests that Pal plays a more significant role in generating scientific content compared to other researchers who have published a greater number of articles. Additionally, researchers such as Zhang X, Sharma A, and Gupta M are also noted as frequent authors; however, their actual contribution coefficients are comparatively lower than those of Pal or even Kumar. The disparity between the quantity of articles and the actual contribution rates may imply that certain authors engage in more extensive collaborations with other researchers or have their names included in collaborative works. Consequently, analyzing both the absolute and fractional counts of articles concurrently offers a more precise insight into the scientific productivity of each author.

Authors with the highest local impact based on the H-index

Figure 10 illustrates the prominent authors within the domain of blockchain-based SCM, evaluated through the H-index, which serves as a metric for concurrently measuring both the volume and quality of scholarly output. A greater H-index value for an author indicates a more significant influence of their publications in the academic literature and the frequency of their citations.

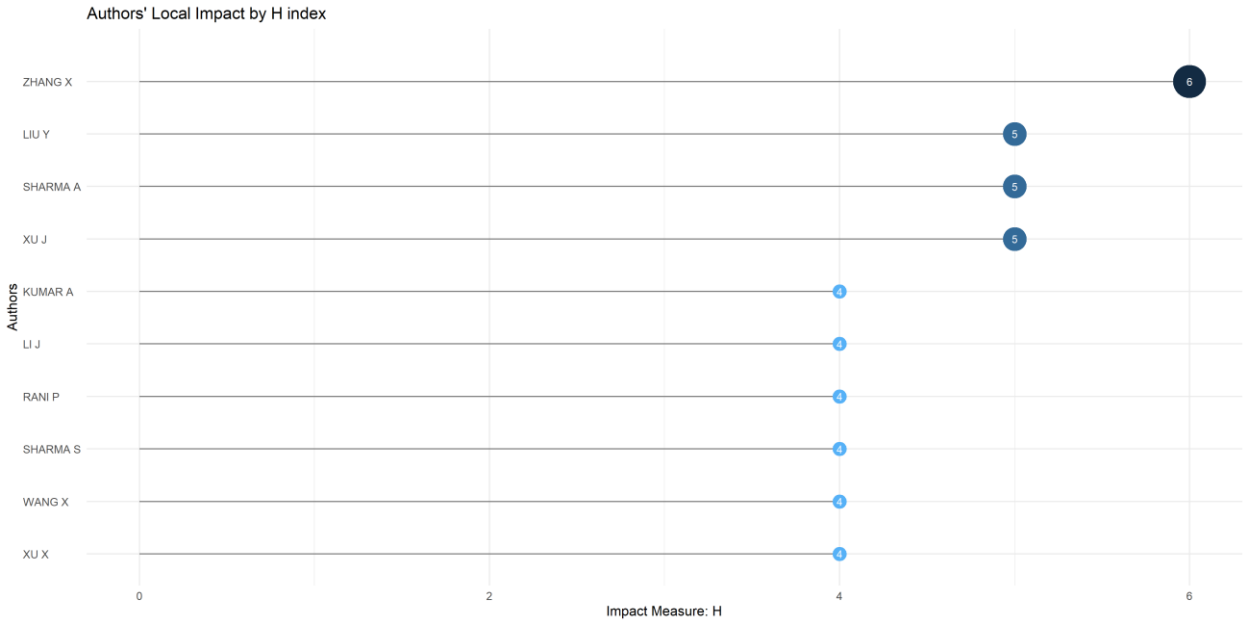

Figure 11. Authors with the highest local impact based on H-index

According to the chart, ZHANG X holds the highest local impact in this domain, boasting an H index of 6, thereby securing the top position. Following him, authors such as LIU Y, SHARMA A, and XU J occupy the second position with an H index of 5. This indicates that the scholarly contributions of these authors are not only abundant but have also garnered recognition from the scientific community in terms of citations.

"Figure 11 displays the local H-index of the most impactful authors, calculated exclusively within the 800-article dataset (2019–2025) based on citations indexed in the combined WoS-Scopus corpus of this study. These values are dataset-specific and should not be interpreted as the authors' global H-indices."

Discussion

Recent systematic bibliometric investigations reveal a pronounced and accelerating scholarly trajectory in blockchain technology (BT) applications within supply chain management (SCM), characterized by both quantitative expansion and qualitative differentiation across global research networks. Nishant et al. conducted a comprehensive meta-analysis of 1,069 peer-reviewed publications spanning the 2019–2025 interval, demonstrating substantial research momentum in this interdisciplinary domain. Shoaib et al. empirically classify this publication growth pattern as “exponential,” underscoring the field’s rapid maturation from nascent exploration to systematic investigation. Collaborative intensity metrics further illuminate the collective nature of knowledge production: the calculated mean authorship stands at 2.75 authors per manuscript, while the Collaboration Index approximates 2.89, signaling the emergence of multi-institutional research

consortia and cross-disciplinary academic partnerships addressing complex blockchain-SCM integration challenges. Geographically, the research landscape exhibits a stratified distribution dominated by four principal contributors: China, the United States, India, and the United Kingdom. Collectively, China and the United States account for approximately 45% of global output, with China contributing 128 articles and the United States 65 publications, followed by India (60 articles) and the United Kingdom (53 articles). However, citation impact analysis reveals critical qualitative asymmetries: publications originating from the United States and the United Kingdom command significantly higher citation frequencies and impact metrics, indicating superior scientific influence and theoretical rigor relative to China's volumetric dominance. This divergence between publication volume and scholarly impact underscores the imperative of evaluating both quantitative productivity and qualitative contribution. Furthermore, the international collaboration architecture reflects a convergent paradigm wherein advanced industrialized economies and rapidly emerging markets forge transnational research alliances, amplifying knowledge diffusion and methodological innovation. Journal-level analysis unveils pronounced thematic specialization within the publication ecosystem. Among the top-tier outlets, the International Journal of Production Research has disseminated 24 blockchain-SCM studies, the Sustainability Journal (MDPI) has published 37 articles, and IEEE Access has contributed 26 papers. This distribution indicates that blockchain-SCM scholarship gravitates toward journals emphasizing operations research, environmental sustainability, and applied technology innovation. The heterogeneity of publication venues, spanning engineering, operations management, information systems, accounting, and strategic management, attests to the cross-disciplinary resonance of blockchain within SCM, engaging diverse epistemic communities and catalyzing multidisciplinary discourse. Keyword co-occurrence network analysis further delineates the conceptual architecture underpinning the research domain and provides the analytical foundation for the proposed conceptual framework. Rather than developing the conceptual model independently, the framework emerged through an interpretive synthesis of the dominant bibliometric clusters identified via VOSviewer analysis. The 1,454 extracted keywords were systematically grouped according to co-occurrence frequency, relational proximity, and thematic association, enabling the identification of major intellectual domains within blockchain-enabled SCM research. Specifically, clusters centered on "Blockchain," "Supply Chain," "Transparency", "Traceability" and "Trust" were consolidated into the conceptual dimension of transparency and trust mechanisms. Similarly, keywords such as "IoT", "Artificial Intelligence," "Smart Contract," and "Big Data Analytics" formed the technological convergence dimension, while sustainability-oriented keywords, including "Sustainability," "Green Supply Chain," and "Circular Economy," contributed to the sustainability integration dimension. Governance-related terminologies, including "Regulation," "Decentralization," and "Security," were synthesized into governance and digital trust architecture

themes. This interpretive thematic synthesis strengthened the traceability and logical consistency between the bibliometric findings and the final conceptual model.

Beyond macro-thematic clusters, emergent application domains are discernible. Blockchain has been posited as a critical enabler for ensuring food safety and agricultural traceability, mitigating risks of contamination and fraud in perishable goods supply chains. Similarly, in the pharmaceutical sector, blockchain-based authentication mechanisms are being deployed to combat counterfeit drug proliferation and ensure patient safety. The integration of blockchain with complementary digital technologies, notably the Internet of Things (IoT), Artificial Intelligence (AI), and Big Data Analytics, represents a transformative convergence. Empirical evidence suggests that blockchain-IoT amalgamation facilitates real-time asset tracking, automated verification, and predictive analytics, thereby augmenting operational efficiency, security robustness, and decision-making intelligence across complex, multi-tier supply networks. Thematic interpretation of the bibliometric clusters additionally indicates a temporal evolution in research priorities. Earlier studies predominantly emphasized transparency enhancement, traceability, and trust-building mechanisms, whereas more recent research streams increasingly focus on intelligent automation, decentralized governance, cybersecurity resilience, ESG compliance, and predictive analytics integration. This thematic transition reflects the broader maturation of blockchain-SCM research from exploratory conceptualization toward application-oriented and data-driven innovation ecosystems. Co-authorship network topology exhibits pronounced asymmetry, with J. Sarkis emerging as the most influential scholar, evidenced by the highest Total Link Strength (TLS) value of 983.30, followed by A. Gunasekaran and T.M. Choi. Institutionally, the Hong Kong Polytechnic University and other research-intensive universities dominate citation rankings. Notably, while Saberi et al. (2019) contributed seminal foundational work, their declining prominence in recent citation networks suggests an evolutionary shift in research leadership toward specialized, newer research clusters. This temporal evolution reflects the field’s maturation from exploratory frameworks to empirically grounded, application-specific investigations.

The quality-quantity dichotomy merits deeper scrutiny. Despite China’s volumetric supremacy, the aggregate citation impact of U.S. and U.K. publications substantially exceeds that of Chinese contributions, indicating superior theoretical rigor, methodological sophistication, and policy relevance. Conversely, nations such as India and Iran, while prolific in publication output, demonstrate lower international collaboration indices (TLS), suggesting limited global research integration. This pattern underscores that raw publication counts are insufficient proxies for scientific impact; rather, collaboration network density, citation frequency, and H-index metrics provide more robust indicators of scholarly influence. To further refine quality assessment, H-index benchmarks have been incorporated. For instance, J. Sarkis possesses an H-index exceeding

60 (per BIBLIOMETRIX and Google Scholar), corroborating his sustained, high-impact contributions. Such metrics underscore the necessity of triangulating quantitative productivity measures with qualitative impact indicators, including citation counts, H-index, co-citation strength, and collaborative breadth, to achieve a holistic evaluation of scholarly contributions.

Temporal keyword trend analysis reveals an emergent research frontier centered on data security, privacy, and digital trust architectures. Recent investigations increasingly emphasize IoT-blockchain synergy and smart contract automation as next-generation SCM enablers. Citation trajectories further indicate that blockchain's decentralized, immutable ledger architecture enhances data integrity, auditability, and resilience against cyber threats, aligning with the escalating security imperatives of Industry 4.0 and digitalized supply ecosystems. This growing emphasis on cybersecurity and environmental sustainability reflects the dual challenges confronting modern supply chains: operational digitization and regulatory compliance with ESG (Environmental, Social, Governance) standards. Empirical case studies substantiate blockchain's pragmatic value proposition. Moosavi et al. document that blockchain deployment significantly elevates SC transparency and traceability, mitigating information asymmetries. Hughes et al. demonstrate that disintermediation via smart contracts reduces transaction costs, accelerates settlement processes, and fortifies contractual trust, thereby enhancing inter-organizational efficiency. Moreover, blockchain-IoT integration optimizes resource allocation, reduces waste, and strengthens circular economy initiatives, reinforcing the environmental and sustainability imperatives of contemporary SCM. The strategic importance of international collaboration is unequivocally evident. Collaboration network cartography positions Australia, China, Canada, and the United Kingdom as central nodes with dense transnational linkages. The identification of 63 active nations organized into 8 research clusters underscores a positive correlation between scientific output volume and international partnership intensity. This polycentric collaboration architecture facilitates cross-border knowledge exchange, methodological pluralism, and innovation diffusion, illustrating how collaborative networks function as critical enablers of global research advancement. Finally, research gap identification delineates future inquiry pathways. The bibliometric thematic synthesis reveals that, despite substantial conceptual advancement, empirical implementation studies remain limited across real-world industrial contexts. Existing research is heavily concentrated on conceptual and simulation-based approaches, while longitudinal field investigations, cross-sector comparative analyses, and ROI-oriented evaluation frameworks remain underdeveloped.

Policy and Managerial Implications

Companies ought to allocate resources towards blockchain infrastructure to establish a platform that facilitates transparent recording and exchange of information within the SC, thereby enhancing trust between suppliers and customers. The implementation of blockchain-based traceability systems can guarantee the authenticity of products, the provenance of raw materials, and adherence to quality standards; this is particularly crucial in sensitive sectors such as food, pharmaceuticals, and export commodities. The utilization of smart contracts in supplier interactions can streamline, expedite, and enforce procurement, payment, and delivery processes without errors. Organizations should establish dedicated units to oversee the environmental sustainability of their SCs, leveraging BT to transparently publish data concerning energy consumption, carbon emissions, and the origins of goods. Governments can facilitate the legal and effective application of this technology across industries by formulating legal frameworks, standardizing data, and establishing rules for blockchain-based information exchange. Endorsing national pilot initiatives in SC digitization through blockchain can provide a template for other sectors. Ministries and development agencies should offer financial and credit incentives to companies that pursue transparency, traceability, and sustainability within their SCs. Governments can establish a framework for collaboration in SCs among small, medium, and large enterprises by developing joint inter-industry or regional blockchain platforms. Universities and research institutions should prioritize interdisciplinary research on the utilization of blockchain in sectors such as logistics, agriculture, tourism, and healthcare. Promoting research focused on the adaptation of BT within the cultural, legal, and economic frameworks of developing nations can enhance the effective application of this technology. Scholars should perform economic evaluations of the return on investment (ROI) associated with BT in SCs to elucidate its implementation strategies for businesses. The establishment of international databases and collaborative scientific efforts among universities to disseminate research findings in this domain can accelerate the generation of knowledge. A summary of policy and management recommendations is presented in Table 6.

Table 6. Summary of policies and management recommendations for implementing blockchain in SCM

Policy-making level	Key field	Practical and managerial suggestions
Organizational (Companies)	Information transparency	Implementing blockchain-based information recording systems to increase trust among stakeholders
	Traceability	Designing processes for tracking products from origin to consumption using blockchain
	Digitalization of processes	Using smart contracts to automate supplier and customer interactions
	Sustainability and the environment	Monitoring SC environmental indicators and transparently recording them on the blockchain platform
Government (policymaking)	Legal and regulatory framework	Developing rules for data exchange and digital ownership in blockchain projects

	Financial and technological support	Providing financial facilities and incentives for SC digitization with an emphasis on transparency and sustainability
	Infrastructure and synergy	Creating common blockchain platforms for small and medium-sized industries to increase productivity and collaboration
Research and academic	Interdisciplinary studies	Implementing research projects in the field of blockchain with a focus on logistics, agriculture, health, and tourism
	Technology localization	Research on adapting blockchain to the country's economic and cultural structures
	Economic analysis of applications	Investigating the economic efficiency and competitive advantages of blockchain in optimizing the SC
	International scientific collaborations	Developing scientific networks for exchanging data and research results at the regional and global levels

Conclusion

This study set out to systematically map and synthesize the scientific literature at the intersection of blockchain technology and supply chain management from 2019 to 2025. Through a dual-method approach combining bibliometric analysis of 800 selected publications and thematic cluster synthesis, the research provides an empirically grounded account of the field's intellectual structure, evolutionary trajectory, and persistent gaps. The bibliometric findings document an accelerating research interest in blockchain-enabled SCM, evidenced by an annual publication growth rate of 11.97% and a progressively expanding international collaboration network spanning 63 countries. The keyword co-occurrence and temporal trend analyses reveal that the field has undergone a discernible thematic evolution. The initial research agenda, concentrated on foundational concepts such as transparency, traceability, and trust, has progressively absorbed adjacent concerns including sustainability, circular economy principles, and—more recently—technological convergence with IoT, artificial intelligence, and machine learning. This trajectory, derived directly from the temporal overlay visualization (Figure 8), indicates a maturing research domain moving from conceptual advocacy toward the investigation of multi-technology, data-driven supply chain architectures. Thematic cluster synthesis, interpreted through the theoretical lenses of Transaction Cost Economics, the Resource-Based View, and Institutional Theory, illuminates the underlying logic of this research landscape. The persistent prominence of transparency and trust themes corresponds to blockchain's theorized capacity to reduce inter-organizational transaction costs. The growing sustainability cluster reflects an emerging recognition of blockchain-verified provenance as a potential source of VRIO resources and competitive differentiation. Meanwhile, the observed international collaboration asymmetries and geographic concentration of research output suggest the formative influence of institutional and policy-driven forces—rather than purely scientific curiosity—in shaping the direction and volume of national research efforts.

However, the findings also foreground three significant gaps that temper the optimistic narratives prevalent in the literature. First, despite abundant conceptual and simulation-based studies, the volume of empirical, real-world implementation research remains limited, creating a disconnect between theoretical propositions and operational evidence. Second, sector-specific investigations are unevenly distributed, with food and pharmaceutical supply chains receiving disproportionate attention relative to other critical sectors. Third, the thematic emphasis on technical functionality has not been matched by commensurate attention to economic viability, governance mechanisms, or the legal determination of rights and liabilities in blockchain-based supply networks. These gaps, identified through the analysis of what the literature systematically does not address, constitute a data-grounded research agenda for future scholarship. The managerial and policy implications derived from this synthesis are presented across three levels—organizational, governmental, and research-institutional—and are summarized in Table 4. At the organizational level, firms are advised to move beyond proof-of-concept experimentation toward the operational integration of blockchain with complementary digital infrastructure, particularly IoT and data analytics, for specific, high-value use cases such as automated compliance verification and product provenance authentication. At the governmental level, the findings suggest that policy interventions—including regulatory clarity, standardization of data exchange protocols, and financial incentives for small and medium-sized enterprise adoption—are essential to move blockchain from isolated pilot projects to network-level implementation. At the research level, the identified gaps call for interdisciplinary, empirically rigorous studies that evaluate blockchain's actual operational and economic performance, rather than its assumed potential.

Several limitations qualify the conclusions of this study. The reliance on Web of Science and Scopus databases, while ensuring source quality, excludes potentially relevant grey literature and industry reports. The inclusion of indexed conference proceedings, methodologically justified by the rapid evolution of the field, introduces some heterogeneity in publication formats. Furthermore, the bibliometric analysis did not incorporate advanced network diagnostics such as centrality, density, and modularity metrics, limiting the formal quantitative validation of cluster structures. These limitations, however, do not undermine the study's primary contribution: a conceptually grounded, empirically derived synthesis of a fragmented and rapidly expanding research domain, accompanied by a transparent account of its remaining blind spots.

In conclusion, the trajectory mapped by this study suggests that blockchain in supply chain management has moved beyond the stage of technological promise into a phase of structured, albeit uneven, scholarly investigation. Its future contribution to supply chain practice will depend less on further affirmation of its theoretical potential and more on the capacity of the research community to address the operational, economic, and governance questions that the present systematic review has empirically identified as unresolved. One methodological consideration of this study involves

the inclusion of indexed conference proceedings (e.g., LNCS, Procedia) alongside journal articles. While this approach broadens the dataset and captures timely research, it may introduce a slight heterogeneity in terms of publication format and review depth. To mitigate this, only proceedings from reputable series with documented rigorous peer review were included, and non-peer-reviewed abstracts were strictly excluded. Future research could conduct a comparative analysis to isolate the impact of conference versus journal publications on bibliometric trends in this field.

A second methodological consideration pertains to the depth of the bibliometric network analysis. While this study employed co-occurrence and co-authorship network mapping to identify thematic clusters and key contributors, it did not compute advanced network metrics such as centrality measures (degree, betweenness, and closeness centrality), network density, or modularity scores for formal cluster validation. The interpretation of cluster structures and node importance was therefore based on visual inspection and relational proximity rather than on formal quantitative network diagnostics. This analytical choice was shaped by the study's primary objective: to provide a comprehensive thematic synthesis and conceptual framework grounded in the literature's intellectual structure, rather than to conduct a purely computational network analysis. Nonetheless, the absence of these metrics limits the formal statistical validation of the identified research clusters and the precise quantification of influential nodes within the collaboration and keyword networks. Future studies are encouraged to complement the thematic synthesis approach adopted here with formal social network analysis (SNA) metrics, including centrality, density, and modularity, to quantitatively validate cluster cohesion and to apply sensitivity analyses that test the robustness of cluster assignments under varying resolution parameters.

Author Contributions

All authors contributed equally to the conceptualization of the article and writing of the original and subsequent drafts.

Data Availability Statement

Not applicable.

Acknowledgements

The authors would like to thank all participants of the present study.

Ethical considerations

The authors avoided data fabrication, falsification, and plagiarism, and any form of misconduct.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest

The authors declare no conflict of interest.

References

Agrawal, Divyansh, Sachin Minocha, Suyel Namasudra, and Amir H. Gandomi. 2022. "A Robust Drug Recall Supply Chain Management System Using Hyperledger Blockchain Ecosystem." *Computers in Biology and Medicine* 140 (January): 105100. https://doi.org/10.1016/j.compbiomed.2021. 105100.

Alazab, Moutaz, Salah Alhyari, Albara Awajan, and Ayman Bahjat Abdallah. 2021. "Blockchain Technology in Supply Chain Management: An Empirical Study of the Factors Affecting User Adoption/Acceptance." *Cluster Computing: the Journal of Networks Software Tools and Applications* 24 (1): 83–101. https://doi.org/10.1007/s10586-02003200-4.

Ali, S. R., A. Al-Masud, M. A. Hossain, et al. 2024. "Weaving a Greener Future: Impact of Green HR and Green Supply Chain Management on Sustainability." Cleaner Logistics and Supply Chain 12 (1): 101–123. https://doi.org/10.1016/j.clscn.2024.100143.

Azzavi, M., A. Foukerdi, A. Altuğ Biçer, and S. Ghorbani. 2025. "Green Efficiency of an Energy Supply Chain: A Multi-Stage Network DEA Application to Iranian Petrochemicals." *Industrial Management Journal 17 (4)*: 1-39. https://doi.org/10.22059/imj.2025.400690.1008260

Centobelli, Piera, Roberto Cerchione, Pasquale Del Vecchio, Eugenio Oropallo, and Giustina Secundo. 2022. "Blockchain Technology for Bridging Trust, Traceability and Transparency in Circular Supply Chain." *Information & Management* 59 (7): 103508. https://doi.org/10.1016/j.im.2021. 103508.

Chang, Shuchih E., and Yichian Chen. 2020. "When Blockchain Meets Supply Chain: A Systematic Literature Review on Current Development and Potential Applications." *IEEE Access* 8: 62478–62494. https://doi.org/10.1109/ACCESS.2020. 2983601.

Chien, C.-F., P.-C. Kuo, P.-C. Sun, et al. 2024. "Green Production Planning for Circular Supply Chain and Resource Management." Resources, Conservation & Recycling 178: 107–125. https://doi.org/10.1016/j.resconrec.2024.107499.

Chittipaka, Venkataiah, Satish Kumar, Uthayasankar Sivarajah, Jana Lay-Hwa Bowden, and Manish Mohan Baral. 2022. "Blockchain Technology for Supply Chains Operating in Emerging Markets: An Empirical Examination of Technology-Organization-Environment (TOE) Framework." *Annals of Operations Research*. Accessed October 20, https://doi.org/10.1007/s10479-022-04801-5.

Choi, Tsan-Ming. 2020. "Supply Chain Financing Using Blockchain: Impacts on Supply Chains Selling Fashionable Products." *Annals of Operations Research*. Accessed October 19, https://doi.org/10.1007/s10479-020-03615-7.

Chowdhury, Soumyadeb, Oscar Rodriguez-Espindola, Prasanta Dey, and Pawan Budhwar. 2022. "Blockchain Technology Adoption for Managing Risks in Operations and Supply Chain Management: Evidence from the UK."*Annals of Operations Research*. January, https://doi.org/10.1007/s10479 -021-04487-1.

De Giovanni, Pietro. 2020. "Blockchain and Smart Contracts in Supply Chain Management: A Game Theoretic Model." *International Journal of Production Economics* 228 (October): 107855. https://doi.org/10.1016/j.ijpe.2020.107855.

Dubey, Rameshwar, Angappa Gunasekaran, David J. Bryde, Yogesh K. Dwivedi, and Thanos Papadopoulos. 2020. "Blockchain Technology for Enhancing Swift-Trust, Collaboration and Resilience Within a Humanitarian Supply Chain Setting." *International Journal of Production Research* 58 (11): 3381–3398. https://doi.org/10.1080/00207543.2020. 1722860.

Elhidaoui, Sana, Khalid Benhida, Said El Fezazi, Srinivas Kota, and Ahmed Lamalem. 2022. "Critical Success Factors of Blockchain Adoption InGreen Supply Chain Management: Contribution Through an Interpretive Structural Model." *Production and Manufacturing Research-an Open Access Journal* 10(1):1–23.https://doi.org/10.1080/21693277.2021.

Gao, Zhimin, Lei Xu, Lin Chen, Xi Zhao, Yang Lu, and Weidong Shi. 2018. "CoC: A Unified Distributed Ledger-Based Supply Chain Management System." *Journal of Computer Science and Technology* 33 (2): 237–248. https://doi.org/10.1007/ s11390-018-1816-5.

Guo, Lingling, Jingjing Chen, Shihan Li, Yafei Li, and Jinzhi Lu. 2022. "A Blockchain and IoT-Based Lightweight Framework for Enabling Information Transparency in Supply Chain Finance." *Digital Communications and Networks* 8 (4): 576–587. https://doi.org/10.1016/j.dcan.2022.03.020.

Gupta, V., R. Kumar, and P. Dutta. 2025. "Blockchain in Healthcare Logistics: Enhancing Transparency and Traceability." Journal of Healthcare Engineering 12 (3): Article ID 1234567. https://doi.org/10.1155/2025/1234567.

Gurtu, Amulya, andJestinJohny. 2019. "Potential of Blockchain Technology in Supply Chain Management: A Literature Review." *International Journal of Physical Distribution & Logistics Management* 49 (9): 881–900. https://doi.org/ 10.1108/IJPDLM-11-2018-0371.

Helo, Petri, and Yuqiuge Hao. 2019. "Blockchains in Operations and Supply Chains: A Model and Reference Implementation." *Computers & Industrial Engineering* 136 (October): 242–251. https://doi.org/10.1016/j.cie.2019.07. 023.

Iseri, F., E. Iakovou, E. N. Pistikopoulos, et al. 2025. "AI-Based Predictive Analytics for Enhancing Data-Driven Supply Chain Optimization." Journal of Global Optimization 45 (4): 332–357. https://doi.org/10.1007/s10898-025-01509-1.

Kalyani, Dasari, Putta Srivani, and S. Pradeep. 2022. "Secured Information Sharing in Supply Chain Management: Modified Data Sanitization with Optimal Key Generation via Hybrid

Algorithm." *Advances in Engineering Software* 173 (November): 103194. https://doi.org/10.1016/j.advengsoft. 2022.103194.

Kamble, Sachin S., Angappa Gunasekaran, and Rohit Sharma. 2020. "Modeling the Blockchain Enabled Traceability in Agriculture Supply Chain." *International Journal of InformationManagement* 52(June):101967.https://doi.org/10.1016/ j.ijinfomgt.2019.05.023.

Khanfar, Ahmad A. A., Mohammad Iranmanesh, Morteza Ghobakhloo, Madugoda Gunaratnege Senali, and Masood Fathi. 2021. "Applications of Blockchain Technology in Sustainable Manufacturing and Supply Chain Management: A Systematic Review." *Sustainability* 13 (14): 7870. https://doi.org/10.3390/su13147870.

Kolikipogu, S., et al. 2025. "Smart and AI-Based Food Packaging: Blockchain's Role." Frontiers in Food Science and Technology 6 (2): 45–69. https://doi.org/10.3389/frfst.2025.1665055.

Kshetri, Nir. 2021. "Blockchain and Sustainable Supply Chain Management in Developing Countries." *International Journal of Information Management* 60 (October): 102376. https://doi.org/10.1016/j.ijinfomgt.2021.102376.

Kumar Bhardwaj, Amit, Arunesh Garg, and Yuvraj Gajpal. 2021. "Determinants of Blockchain Technology Adoption in Supply Chains by Small and Medium Enterprises (SMEs) in India." *Mathematical Problems in Engineering* 2021 (June): 5537395. https://doi.org/10.1155/2021/5537395.

Lee, Chung-Hong, Hsin-Chang Yang, Yu-Chen Wei, and WenKai Hsu. 2021. "Enabling Blockchain-Based SCM Systems with a Real-Time Event Monitoring Function for Preemptive Risk Management." *Applied Sciences-Basel* 11 (11): 4811. https://doi.org/10.3390/app11114811.

Li, Jian, Shichao Zhu, Wen Zhang, and Lean Yu. 2020. "Blockchain-Driven Supply Chain Finance Solution for Small and Medium Enterprises." *Frontiers of Engineering Management* 7 (4): 500–511. https://doi.org/10.1007/s42524 -020-0124-2.

Liu, He, Biao Yang, Xuanrui Xiong, Shuaiqi Zhu, Boyu Chen, Amr Tolba, and Xingguo Zhang. 2023. "A Financial Management Platform Based on the Integration of Blockchain and Supply Chain." *Sensors* 23 (3): 1497. https://doi.org/10.3390/s23031497.

Liu, Jiongbin, Gingsun Yeoh, Longxiang Gao, Shang Gao, and Ojelanki Ngwenyama. 2022c. "Designing a Secure Blockchain-Based Supply Chain Management Framework." *Journal of Computer Information Systems* 63 (1): 1–16. https://doi.org/10.1080/08874417.2022.2089774.

Liu, Pan, Yue Long, Hai-Cao Song, and Yan-Dong He. 2020. "Investment Decision and Coordination of Green Agri-Food Supply Chain Considering Information Service Based on Blockchain and Big Data." *Journal of Cleaner Production* 277 (December): 123646. https://doi.org/10.1016/j.jclepro.2020. 123646.

Moosavi, Javid, Leila M. Naeni, Amir M. Fathollahi-Fard, and Ugo Fiore. 2021. "Blockchain in Supply Chain Management: A Review, Bibliometric, and Network Analysis." *Environmental Science and Pollution Research*." February, https://doi.org/10.1007/s11356-021-13094-3.

Nematian, J., Stanimirović, P. S., Ghorbani, S., Karabašević, D., & Brzaković, P. (2025). A Maximal Covering Location Problem Under Uncertainty Through Possibility Theory. *Mathematics*, 13(22), 3653. https://doi.org/10.3390/math13223653

Pattanayak, Sirsha, Ramkumar M. Arputham, Mohit Goswami, and Nripendra P. Rana. 2023. "Blockchain Technology and Its Relationship With Supply Chain Resilience: A Dynamic Capability Perspective." *IEEE Transactions on Engineering Management*, 1–15. https://doi.org/10.1109/TEM.2023. 3235771.

Queiroz, Maciel M, and Samuel Fosso Wamba.2019."Blockchain adoption challenges in supply chain: An empirical investigation of the main drivers in India and the USA." *International Journal of Information Management* 46: 70–82. http://dx.doi.org/10.1016/j.ijinfomgt.2018.11.

Queiroz, Maciel M., Renato Telles, and Silvia H. Bonilla. 2020. "Blockchain and Supply Chain Management Integration: A Systematic Review of the Literature." *Supply Chain Management: An International Journal* 25 (2): 241–254. https://doi.org/10.1108/SCM-03-2018-0143.

Queiroz, Maciel M., Samuel Fosso Wamba, Marc DeBourmont, and Renato Telles. 2021. "Blockchain Adoption in Operations and Supply Chain Management: Empirical Evidence from an Emerging Economy." *International Journal of ProductionResearch*59(20):6087–6103.https://doi.org/10.1080/ 00207543.2020.1803511.

Saberi, Sara, Mahtab Kouhizadeh, Joseph Sarkis, and Lejia Shen. 2019. "Blockchain Technology and Its Relationships to Sustainable Supply Chain Management." *International Journal of Production Research* 57 (7): 2117–2135. https://doi.org/10.1080/00207543.2018.1533261.

Salah, Khaled, Nishara Nizamuddin, Raja Jayaraman, and Mohammad Omar. 2019."Blockchain-Based Soybean Traceability in Agricultural Supply Chain." *IEEE Access* 7: 73295 –73305. https://doi.org/10.1109/ACCESS.2019.2918000.

Sangari, Mohamad Sadegh, and Atefeh Mashatan. 2022. "A Data-Driven, Comparative Review of the Academic Literature and News Media on Blockchain-Enabled Supply Chain Management: Trends, Gaps, and Research Needs." *Computers in Industry* 143 (December): 103769. https://doi.org/ 10.1016/j.compind.2022.103769.

Shoaib, Muhammad, Shengzhong Zhang, and Hassan Ali. 2023. "A Bibliometric Study on Blockchain-Based Supply Chain: A Theme Analysis, Adopted Methodologies, and Future Research Agenda." *Environmental Science and Pollution Research* 30 (6): 14029–14049. https://doi.org/10.1007/ s11356-022-24844-2.

Singh, Rajani, Ashutosh Dhar Dwivedi, and Gautam Srivastava. 2020. "Internet of Things-Based Blockchain for Temperature Monitoring and Counterfeit Pharmaceutical Prevention." *Sensors* 20 (14): 3951. https://doi.org/10.3390/s20143951.

Unknown Author(s). 2024. "Blockchain Application for Transparency and Security in E-Commerce Supply Chains." World Journal of Advanced Research and Reviews 24 (2): 45–62. https://doi.org/10.30574/wjarr.2024.24.2.3593.

Wang, Bill, Zhiyu Lin, Michael Wang, Fangyi Wang, Peng Xiangli, and Zhi Li. 2022b. "Applying Blockchain Technology to Ensure Compliance with Sustainability Standards in the PPE Multi-

Tier Supply Chain." *International Journal of Production Research* 61 (1): 1–17.https://doi.org/10.1080/00207543. 2022.2025944.

Wong, Lai-Wan, Garry Wei-Han Tan, Voon-Hsien Lee, KengBoon Ooi, and Amrik Sohal. 2020b. "Unearthing the Determinants of Blockchain Adoption in Supply Chain Management." *International Journal of Production Research* 58 (7): 2100–2123.https://doi.org/10.1080/00207543.2020.1730463.

Wong, Lai-Wan, Lai-Ying Leong, Jun-Jie Hew, Garry Wei-Han Tan, and Keng-Boon Ooi. 2020a. "Time to Seize the Digital Evolution: Adoption of Blockchain in Operations and Supply Chain Management among Malaysian SMEs." *International Journal of Information Management* 52 (June): 101997. https://doi.org/10.1016/j.ijinfomgt.2019.08.005.

Wu, Yue, and Yingfeng Zhang. 2022. "An Integrated Framework for Blockchain-Enabled Supply Chain Trust Management Towards Smart Manufacturing." *AdvancedEngineering Informatics* 51 (January): 101522. https://doi.org/10.1016/ j.aei.2021.101522.

Yadav, A., R. K. Garg, and A. Sachdeva. 2024. "Artificial Intelligence Applications for Information Management in Sustainable Supply Chain Management: A Systematic Review." *International Journal of Information Management Data Insights* 9 (1): 20–50. https://doi.org/10.1016/j.ijid.2024.100292.

Yıldırım, F., E. I. Develi, I. Meidute-Kavaliauskiene, R. Rostamzadeh, and S. Ghorbani. 2025. "*Symmetric Encryption and Cryptography Algorithms in Internet of Things*." Pesquisa Operacional 45: e295986. https://doi.org/10.1590/0101-7438.2025.045.00295986

Zhang, Abraham, Ray Y. Zhong, Muhammad Farooque, Kai Kang, and V. G. Venkatesh. 2020. "Blockchain-Based Life Cycle Assessment: An Implementation Framework and System Architecture." *Resources Conservation and Recycling* 152 (January): 104512. https://doi.org/10.1016/j.resconrec. 2019.104512.

Zhang, Y., Z. Ma, and J. Meng. 2025. "Auditing in the Blockchain: A Literature Review." Frontiers in Blockchain 3 (5): 1–19. https://doi.org/10.3389/fbloc.2025.1549729