


Article

Blockchain-Enabled Supply Chain Finance: A Bibliometric Review and Research Agenda

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Abstract: The COVID-19 pandemic has revealed weaknesses in traditional supply chain finance systems, highlighting the need for digital change. Blockchain technology, with its ability to create secure and transparent records of transactions, offers a potential solution. This study uses bibliometric analysis and a literature review to examine research on blockchain-enabled supply chain finance, drawing on a database of 446 articles from ScienceDirect and Scopus. The findings show a growing interest in how blockchain can improve transparency, efficiency, and security in supply chain finance, addressing challenges like information asymmetry. This study suggests future research should focus on real-world applications of blockchain, how it can be used with other technologies, regulations and governance, and the social and environmental impacts of blockchain-based supply chain finance. This research also highlights the different priorities of the Global North and South in blockchain-enabled supply chain finance. The North focuses on efficiency and traceability, while the South emphasizes adding value and transparency. A lack of research on fair pricing, especially in the Global South, points to a critical gap that future research needs to address to ensure fairness in global trade.

Keywords: efficiency; fair price; sustainable; transparency; traceability



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1. Introduction

The COVID-19 pandemic has served as an unambiguous reminder of the vulnerabilities inherent in traditional supply chain finance (SCF) systems. The reliance on paper-based documentation and manual processes, long-standing features of the industry, proved particularly susceptible to disruption amidst lockdowns, travel restrictions, and workforce shortages (Ioannou and Demirel 2022). These challenges led to significant delays, operational inefficiencies, and a heightened risk of fraud, further exacerbating the already substantial financing gap in international trade, which is now estimated to be over USD 4 trillion (IFC 2021). The pandemic, in essence, has exposed the urgent need for a digital transformation of SCF, pushing the industry towards innovative solutions capable of navigating the complexities of a globalized and increasingly volatile business landscape.

In this context, blockchain technology has emerged as a beacon of transformative potential. Its ability to create a secure, transparent, and immutable record of transactions has captured the attention of various sectors, and supply chain management is no exception (Wuttke et al. 2013). The decentralized nature of blockchain, coupled with the automation capabilities of smart contracts, offers a compelling vision for a future where SCF is not only more efficient but also more accessible and resilient. The convergence of the pandemic's challenges and blockchain's promise has thus ignited a wave of interest in blockchain-enabled SCF solutions, with both academics and industry leaders actively exploring its potential to revolutionize the financial supply chain (Hanafizadeh and Alipour 2024; Tandon et al. 2021).

Early research on blockchain was primarily focused on its applications in financial transactions (Urquhart 2016) and cryptocurrency, particularly Bitcoin (Bariviera 2017; Corbet et al. 2018), given its initial prominence in these areas. However, a shift in focus is evident post-2016, with studies increasingly exploring blockchain's potential beyond cryptocurrency (Miau and Yang 2018; Yli-Huumo et al. 2016). Additionally, recent research on blockchain applications in business and management has progressed from conceptual and exploratory studies (Frizzo-Barker et al. 2020) to a growing focus on theory-driven investigations (Schmidt and Wagner 2019). Early studies explored blockchain's potential in various domains such as supply chain management (Chen et al. 2021), healthcare (Siyal et al. 2019), banking (Guo and Liang 2016), and education (Chen et al. 2018). As blockchain technology matures, researchers are increasingly utilizing theories to understand its adoption, implementation, and impact (Frizzo-Barker et al. 2020). This trend is also reflected in the domain of SCF, where blockchain's capacity to enhance transparency, efficiency, and security has garnered significant interest.

Various systematic literature reviews (SLRs) have attempted to map this evolving research landscape. While some SLRs offer a broad overview of blockchain applications across various domains (Jaoude and Saade 2019), others delve into specific sectors like healthcare (Agbo et al. 2019; Hölbl et al. 2018; Tandon et al. 2020) or analyze design trade-offs and vulnerabilities within blockchain systems (O'Donoghue et al. 2019). However, a comprehensive understanding of the broader context of blockchain applications, particularly in SCF, remains elusive. The existing SLRs either provide a cross-sectoral overview or focus narrowly on specific sectors, leaving a gap in the identification of emerging themes, focal areas, and future potential within the broader business and management context (Miau and Yang 2018). However, the necessitates a more holistic approach to fully grasp the evolving landscape of blockchain research and its implications for SCF are needed.

Our study addresses the current gap in research on blockchain applications within the business sector, particularly in SCF, a relatively unexplored area compared to fields like SCF in agriculture commodities. While previous studies have primarily focused on financial transactions and cryptocurrencies, we take a broader perspective, examining blockchain applications beyond these traditional domains. To achieve this, we have formulated three research questions: RQ1: What is the current state of research on blockchain applications and SCF in the business sector? This question aims to assess the existing research landscape, identifying prominent trends, gaps, and opportunities for further investigation. RQ2: What research contexts and themes have been explored in the existing literature on blockchain-enabled SCF in the business sector? This question seeks to uncover key themes and areas of focus within the current research, highlighting the most prevalent applications and challenges. RQ3: What themes can be addressed in future research on blockchain-enabled SCF in business sectors? This question aims to propose new research directions and potential areas for further exploration, based on the identified gaps and emerging trends in the field.

We adopt a two-level methodological approach to address these questions, combining bibliometric analysis to map the evolution and knowledge structure of blockchain research in management with a comprehensive literature review to delve deeper into specific themes and applications. This approach allows for us to gain a holistic understanding of the current state of research while identifying promising avenues for future inquiry in this rapidly evolving field.

The following sections of this paper are organized as follows: Section 2 provides a concise overview of blockchain and SCF applications in various sectors, while Section 3 introduces the concept of bibliometric analysis and details the methods employed, including data collection and analysis techniques, and presents descriptive statistics. In Section 4, the results of the bibliometric analysis are discussed, revealing key trends and patterns in the literature. Section 5 offers an in-depth discussion of the findings, highlighting their implications for theory and practice, and proposes potential avenues for future research. Finally, Section 6 summarizes this study's contributions and acknowledges its limitations.

2. Blockchain-Enabled Supply Chain Finance

2.1. Blockchain Technology

Blockchain technology, a peer-to-peer distributed ledger system, offers significant advantages for enhancing supply chain efficiency and product quality (Zheng et al. 2017; Usman et al. 2021; Arkeman et al. 2023). By enabling transparent tracking of all supply chain events, from small producers to consumers, blockchain fosters trust and accountability. Its decentralized nature empowers authorized entities to directly verify information, eliminating intermediaries. Cryptographic security measures ensure the integrity of transaction records and data verification. Furthermore, the interoperability of blockchains allows for seamless integration across national borders, facilitating global supply chain collaboration.

The blockchain supply chain business model streamlines the marketing value chain by integrating systems and reducing intermediaries, focusing on retailers as the primary point of contact. This model utilizes a distributed system to manage value chain information from procurement to consumers, ensuring data integrity and accessibility. A key advantage of this model is its adherence to the 3T principles of Trusted, Transparent, and Traceable information (Iansiti and Lakhani 2017).

- **Transparent:** All transaction records (blocks) undergo validation by network members (peers) before storage, ensuring visibility and accountability for all involved entities.
- **Trusted:** Each record is securely linked to previous and subsequent records (forming a chain) and protected by robust cryptography, making it tamper-proof and irreversible.
- **Traceable:** The structured nature of the blockchain (blocks and chains) enables effortless backward and forward traceability of transaction records, enhancing transparency and accountability.

Blockchain technology, a chain of immutable data blocks linked chronologically through cryptography (Naughton 2016; Swan 2015), forms a secure, distributed ledger of transactions. Its key characteristics include the following:

- **Immutability:** Changes to transactions are easily detectable due to the interconnected nature of blocks and cryptographic hash algorithms (Wang et al. 2019; Sultan et al. 2018), enhancing system security and traceability (Sachdev 2019).
- **Decentralization:** Unlike traditional databases, blockchain's distributed architecture improves scalability and data security (Wang et al. 2020; Drescher 2017). This structure promotes data sharing across organizational networks like supply chains (Cole et al. 2019).
- **Smart Contracts:** These self-executing digital protocols within the blockchain automate processes based on predefined conditions (Gatteschi et al. 2018; Wang et al. 2019), streamlining transactions and enhancing efficiency (Bottoni et al. 2022).

Integrating cryptography, smart contracts, peer-to-peer networks, consensus, and market mechanisms, blockchain enables secure inter-institutional data sharing (Mendling et al. 2018). Its applications have evolved from cryptocurrency (Blockchain 1.0) to economic contracts (Blockchain 2.0) and now encompass diverse fields like art, education, and government (Blockchain 3.0) (Swan 2015).

Blockchain technology, with its unique characteristics of immutability, decentralization, and smart contracts, has sparked significant interest across various sectors. Despite growing interest in blockchain across sectors like supply chains (Kamble et al. 2019), healthcare (Casado-Vara and Corchado 2019), and banking (Guo and Liang 2016), extant research primarily focuses on technical aspects (Tandon et al. 2020; Mamoshina et al. 2018; Quaini et al. 2018). Non-technical, management-oriented research remains limited and fragmented (Risius and Spohrer 2017; Yli-Huumo et al. 2016). A more holistic and strategic approach is needed to address the diverse contexts and challenges of blockchain adoption (Tandon et al. 2020). Thus, this study utilizes bibliometric analysis to streamline existing research, identify gaps, and outline future research directions in this rapidly evolving field. This limitation hinders a comprehensive grasp of emerging research themes, focal areas, and future potential, especially in relatively unexplored areas like supply chain finance (SCF).

2.2. Supply Chain Finance

The concept of supply chain finance (SCF) was first introduced by [Stemmler \(2002\)](#), who defined it as the integration of financial processes into supply chain operations to optimize working capital and liquidity management in supply chain processes and transactions. The evolution of SCF has been driven by the continuous development and adoption of new technologies. In recent years, there has been a surge of interest in blockchain technology as a potential tool to revolutionize SCF ([Ioannou and Demirel 2022](#)).

Moreover, SCF represents an evolution in traditional trade finance, offering organizations the means to optimize their working capital management by providing access to financing at more advantageous interest rates ([Templar et al. 2020](#)). The benefits of SCF extend to both buyers and suppliers within the supply chain ([Rogers et al. 2020](#)). Buyers can leverage SCF to provide financial support to their suppliers on favorable terms, thereby bolstering the resilience of their supply network. On the other hand, suppliers can utilize SCF to mitigate the risks associated with outstanding receivables, ensuring a more predictable cash flow. The diverse range of SCF practices encompasses solutions tailored to various financial needs, including accounts payable solutions (such as reverse factoring and dynamic discounting), inventory solutions (like on- and off-balance sheet inventory financing), and accounts receivable solutions (including trade receivables solutions and factoring).

The core idea behind blockchain-enabled SCF is to leverage the technology's capabilities, such as immutability, transparency, and smart contracts, to address the inherent challenges of traditional SCF processes. The authors highlight the potential of blockchain to streamline information flow, synchronize material, information, and financial flows, and enhance trust and collaboration among supply chain participants ([Ioannou and Demirel 2022](#)). Blockchain-enabled SCF aims to create a more efficient, secure, and transparent financial ecosystem within supply chains. It promises to streamline processes, reduce costs, and enhance trust among participants, ultimately facilitating greater access to finance and improving overall supply chain performance ([Ioannou and Demirel 2022](#)).

In addition to the definition provided by [Ioannou and Demirel \(2022\)](#), SCF can also be understood as a strategic approach employed by two or more organizations to jointly create value by planning, steering, and controlling the flow of financial resources at an inter-organizational level ([Hofmann 2005](#)). It represents the integration of financing processes to enhance the value proposition for all participating companies ([Pfohl and Gomm 2009](#)). From an operational perspective, SCF solutions are geared towards increasing visibility and availability of cash while reducing its cost for all supply chain partners ([Gelsomino et al. 2019](#); [Grosse-Ruyken et al. 2011](#)). Blockchain-based SCF platforms can provide easier access to financing for small and medium-sized enterprises (SMEs) in the supply chain. By leveraging the transparency and trust provided by blockchain, these platforms can offer financing solutions to SMEs that may have difficulty accessing traditional financing options.

Moreover, the lack of visibility across the supply chain is a major barrier in SCF. It hinders trust, collaboration, and coordination, leading to inefficiencies and increased risks. The research on West Java's specialty coffee could highlight how blockchain can address this issue by providing end-to-end visibility into the coffee supply chain, from bean to cup. This transparency can enable stakeholders to track the movement of coffee, verify its origin and quality, and ensure fair price practices. In addition, blockchain-enabled SCF can mitigate fraud in the coffee supply chain by creating an immutable record of transactions and product information. This can help ensure the quality and origin of specialty coffee, enhancing its value and protecting consumers from counterfeit products. Lastly, a blockchain-enabled SCF model can foster collaboration among various stakeholders in the industry, including farmers, cooperatives, exporters, and financial institutions. It could also explore the potential for co-opetition, where competitors collaborate on certain aspects of the supply chain while competing in others.

3. Method

The bibliometric analysis, introduced by Pritchard (1969), is a scientific method that objectively examines a research field's temporal evolution and knowledge structure (Bhatt et al. 2020; Cavaggioli and Ughetto 2019). It employs mathematical and statistical techniques to uncover relationships within the literature, eliminating subjective biases inherent in manual selection processes. By identifying influential authors, research frontiers, and potential new directions (Xu et al. 2018), bibliometric analysis has proven instrumental in various fields (Zhu et al. 2022). To ensure procedural consistency with the previous literature (Capobianco-Uriarte et al. 2019), this research followed the five-step approach shown in Figure 1.

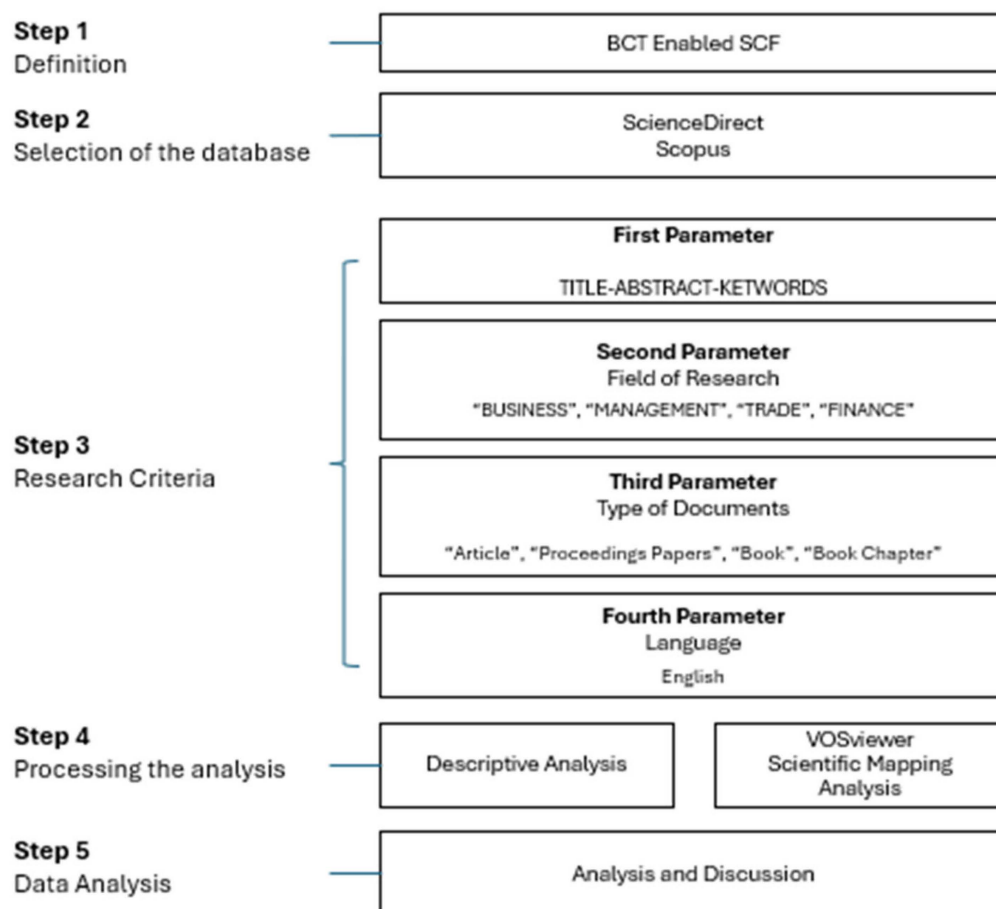


Figure 1. Five steps in bibliometric analysis.

A comprehensive bibliometric analysis of blockchain technology-enabled supply chain finance (BCT-enabled SCF) research necessitates a systematic approach encompassing five key steps. The first step, a precise definition of the research topic, "BCT-enabled SCF", establishes the focus for subsequent analysis. The selection of appropriate databases, such as ScienceDirect and Scopus, follows, contingent upon research requirements and accessibility. Crucially, research criteria are meticulously defined to refine the search and ensure data relevance. Parameters encompass TITLE, ABSTRACT, and KEYWORDS, while the "Field of Research" is delimited to "BUSINESS", "MANAGEMENT", "TRADE", and "FINANCE". "Type of Documents" includes "Article", "Proceedings Papers", "Book", and "Book Chapter", with "English" as the exclusive language.

Subsequently, the collected data undergo processing and analysis utilizing descriptive analysis and scientific mapping analysis facilitated by VOSviewer software version 1.6.19. VOSviewer, a software tool created by Van Eck and Waltman (2010), provides a powerful means to visually represent and analyze relationships within bibliographic data. By utiliz-

ing techniques like bibliographic coupling, co-citations, co-authorship, and co-occurrence of author keywords, VOSviewer generates graphical maps that illuminate connections between various entities such as countries, institutions, journals, authors, and keywords. This comprehensive visualization approach, as noted by [Cobo et al. \(2011\)](#), significantly enhances researchers' ability to understand and interpret complex interactions and patterns within the scholarly landscape. This enables both basic statistical analysis and intricate visualization of relationships within the data. The final step entails interpreting the results through comprehensive analysis and discussion. This culminates in the extraction of meaningful insights, identification of key trends, detection of research gaps, and the proposition of potential future research directions in the dynamic field of BCT-enabled SCF.

Moreover, in this study, we leverage bibliometric techniques, such as co-citation, co-word, and network analysis, to understand the evolution of blockchain research in management and related areas. Co-citation analysis reveals correlations between papers based on shared citations, helping identify research hotspots ([Xue et al. 2018](#)). Co-word analysis, on the other hand, examines relationships between keywords, illuminating connections between different topics.

This study aims to understand the evolution of research on blockchain-enabled supply chain finance (SCF) and related areas. To achieve this, we conducted a comprehensive search of relevant articles in the Scopus database, selected for its extensive coverage of peer-reviewed research ([Caviggioli and Ughetto 2019](#)). Our search strategy involved a two-step approach. Initially, we conducted a preliminary literature review using Google Scholar, focusing on the keyword "blockchain". By analyzing the top 50 results, we identified additional relevant terms like "smart contract" and "transparency". Based on this analysis, we refined our search query to include "blockchain OR blockchain technology" OR "blockchain OR transparency" OR "blockchain OR smart contracts" AND "supply chain finance". This refined search string was applied to the Scopus database on 1 August 2024, ensuring a thorough and targeted collection of relevant articles for subsequent analysis and review.

To ensure a focused and relevant dataset for our study, we applied specific inclusion criteria to the Scopus database search. We limited our analysis to articles published in peer-reviewed journals within the categories of business, management and accounting, social sciences, economics, econometrics and finance, decision sciences, energy, and environmental science. This allowed for us to specifically target research on blockchain applications in operation, business and management, and related areas, excluding other domains like engineering and law.

Additionally, we restricted our search to articles published in English and did not impose any limitations on the publication year, ensuring that all relevant studies since the introduction of the term blockchain and supply chain finance to encompass all relevant research, including influential early publications. We used four distinct search strings incorporating the terms "blockchain", "supply chain finance", "smart contracts", and "transparency" to capture a broad range of the relevant literature. After applying these criteria, we compiled a comprehensive database of 446 articles, which were then exported in both RIS and CSV formats. This final dataset, complete with citation and bibliographic information, served as the foundation for our subsequent bibliometric analysis and literature review, enabling a thorough investigation of blockchain applications in the business sector.

4. Results

4.1. Descriptive Analysis

The descriptive analysis of scientific productivity, based on 446 contributions sourced from Scopus and filtered according to established criteria, reveals a burgeoning interest in the intersection of blockchain and supply chain finance. As illustrated in the accompanying [Figure 2](#), the earliest relevant contribution was published in 2016, marking the inception of scholarly inquiry into this nascent field. However, it was not until 2020 that research output began to gain significant traction, with a notable surge in publications observed in

subsequent years. This upswing in research activity underscores the growing recognition of blockchain's transformative potential within supply chain finance, as researchers and practitioners alike seek to harness its capabilities to address longstanding challenges and inefficiencies.

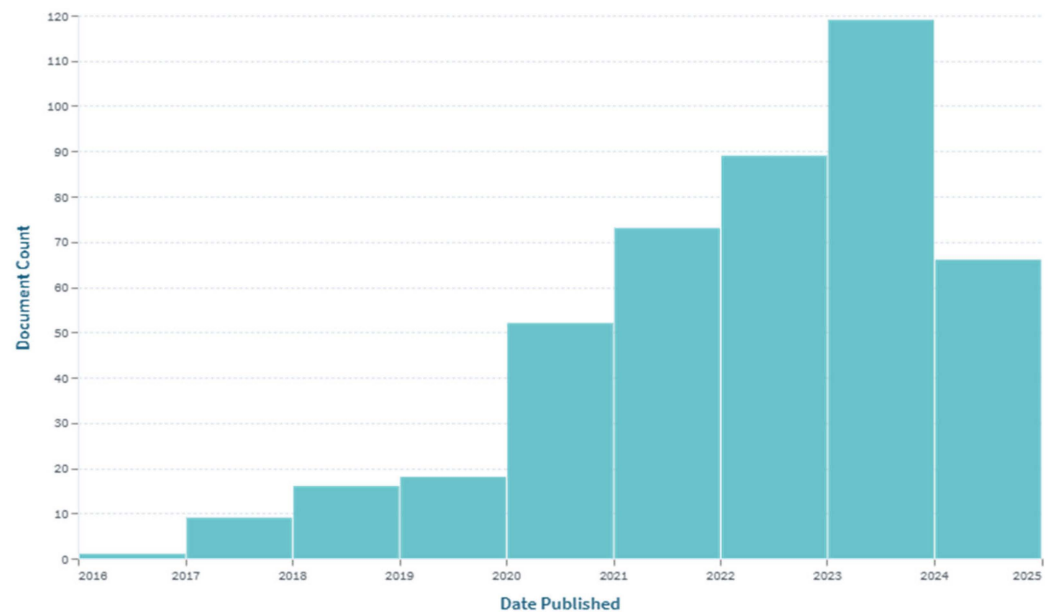


Figure 2. Number of publications and citations 2016–August 2024.

The distribution of document types reveals a clear dominance of journal articles as shown in Figure 3, accounting for 293 out of 314 documents, or 93.3% of the total. This highlights the significance of journals as the primary platform for disseminating research findings in the field of blockchain and supply chain finance. Notably, a substantial portion of these journal articles, 69 in total (24.3%), are classified as “Early Access”. This indicates a trend towards making research available before formal publication, facilitating timely dissemination and discussion within the academic community. While journal articles constitute the majority, other document types also contribute to the overall corpus. Conference proceedings represent 4.9% of the total, with six conferences recorded before 2021 and eight after. These proceedings likely capture a diverse range of research and discussions presented at various conferences, with topics spanning business, computer science, information systems, management, engineering, and economics. Finally, book chapters comprise a relatively small fraction, accounting for 1.8% of the total, with five chapters documented. This suggests that while books may play a role in the field, journal articles remain the predominant medium for scholarly communication.

The leading publication outlets for research on blockchain and supply chain finance showcase a diverse range of interests within the field, as shown in Figure 4. The most prolific journal, *Sustainability*, boasts 11 publications, reflecting a strong emphasis on exploring the environmental and social impacts of blockchain technology within supply chain operations. This is followed by *IEEE Transactions on Engineering Management* and *Annals of Operations Research*, each with seven publications, indicating a significant interest in the technological and operational aspects of blockchain implementation. Notably, several journals share the fourth position with six publications each, including *Frontiers in Engineering Management*, *Supply Chain Forum: An International Journal*, and *Business Process Management Journal*. This clustering suggests a broad exploration of blockchain's potential across various facets of supply chain management, encompassing engineering, strategic decision-making, and process optimization. The remaining top 10 journals further underscore this diversity, covering areas such as electronic commerce research, theoretical and applied electronics, and operations management. Overall, the distribution of publications across these journals paints a picture of a vibrant and rapidly evolving field, where researchers are

actively investigating the multifaceted implications of blockchain technology for enhancing sustainability, efficiency, and transparency within supply chains.

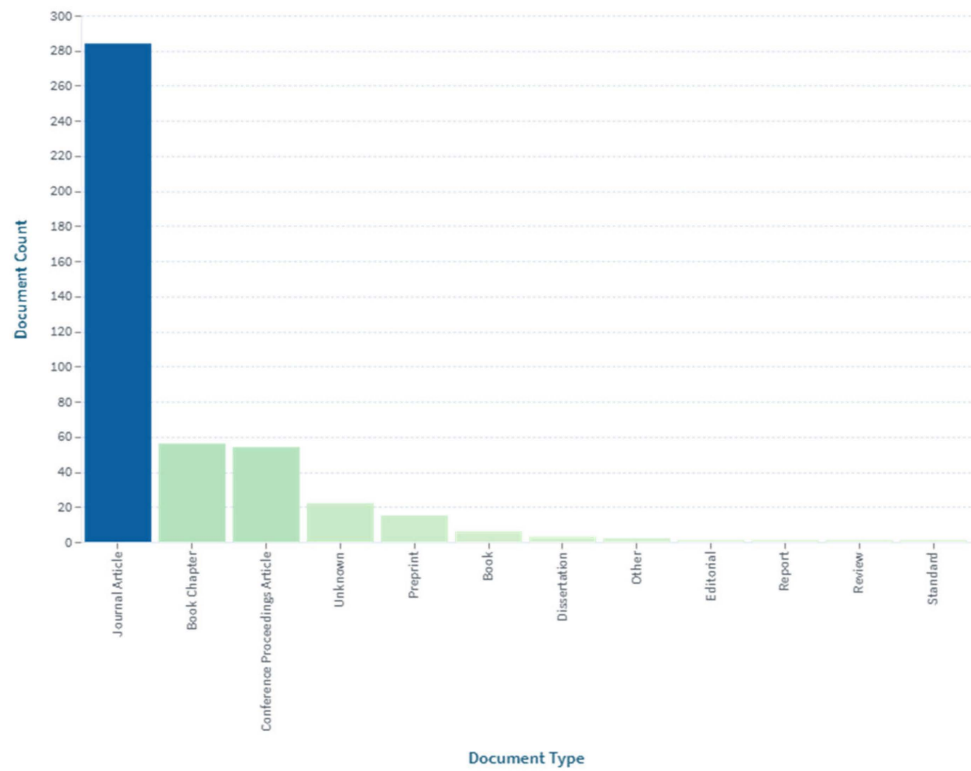


Figure 3. Number of types of documents.

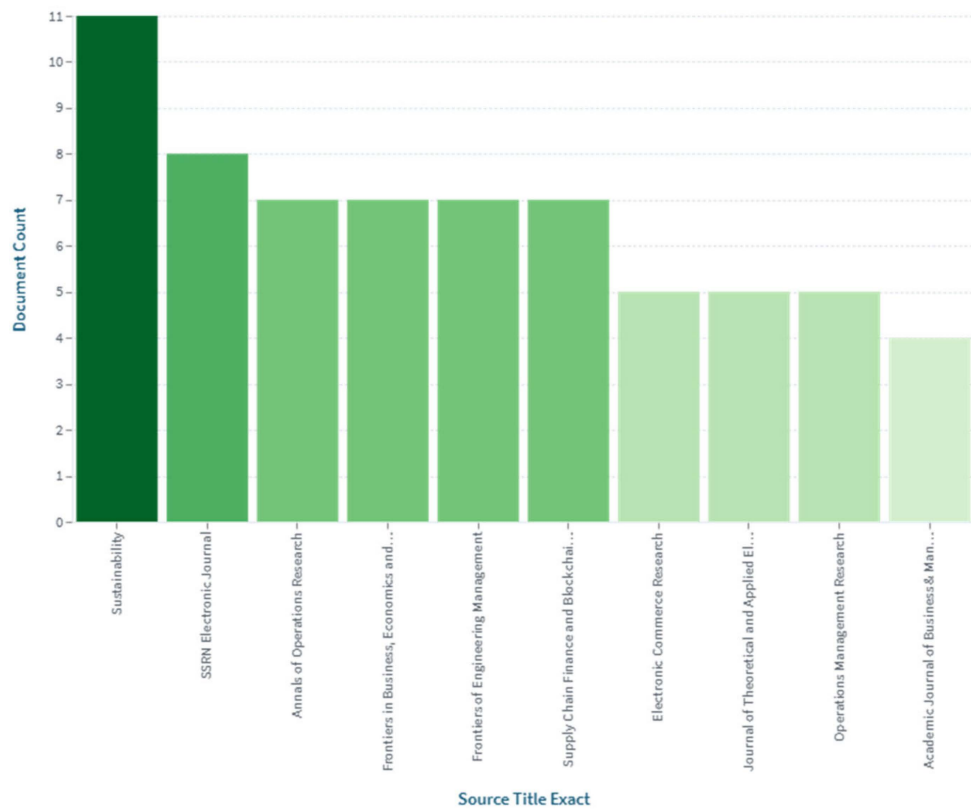


Figure 4. Top 10 journals and publication count.

The analysis of the top 10 most prolific countries in blockchain and supply chain finance research reveals China as the clear leader with 162 publications, boasting a substantial lead in publication volume, as shown in Figure 5.

The United States secures the second position with 28 publications, followed by India and the United Kingdom. These four countries collectively account for a significant majority of the total publications in this field during the examined period. Further down the ranking, Australia, Switzerland, Canada, Taiwan, and Hong Kong also demonstrate notable contributions. The presence of South Korea at the tenth position underscores the global interest and engagement in this emerging research area. These data highlight the dominance of certain countries, particularly China, in shaping the global research landscape of blockchain and supply chain finance (Figure 5).

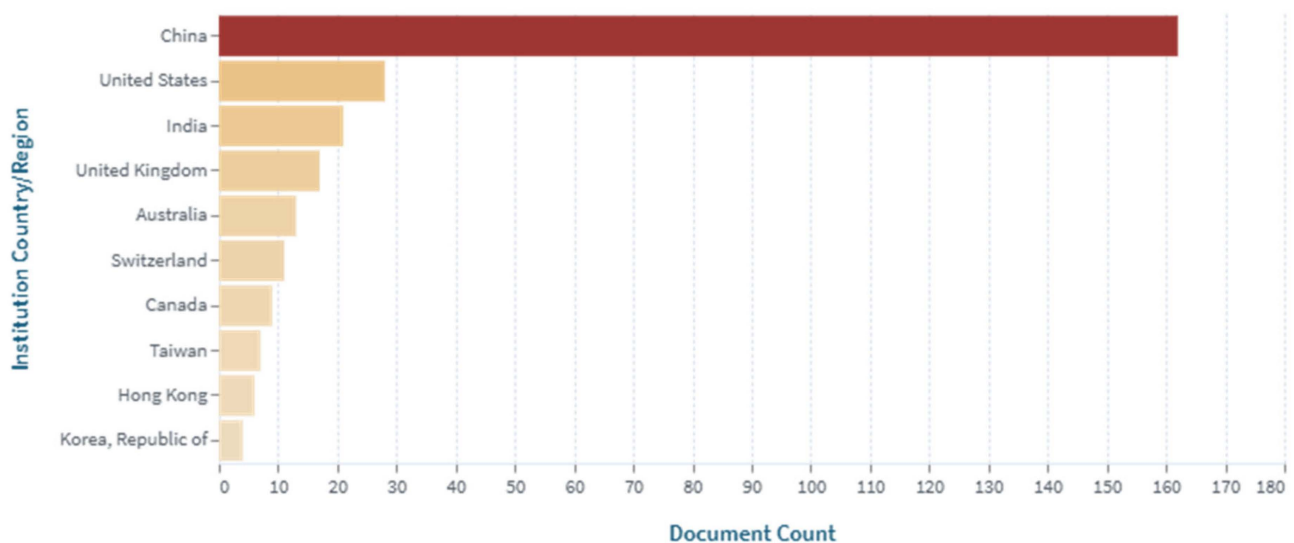


Figure 5. Top 10 of the most productive countries.

4.2. Bibliographic Analysis

To gain insights into the interrelations among different research topics in the field of blockchain and supply chain finance, network visualizations and density maps were generated using VOSviewer. These visualizations represent the current state of research in this domain. In these maps, items are depicted as multicolored dots, with the size of each dot corresponding to the frequency of its occurrence in the documents. The larger the dot, the more frequently the associated term appears. Furthermore, the color of each dot signifies its membership in a particular thematic or social cluster.

The bibliographic analysis was carried out using VOSviewer software, which allows for precise investigation of large datasets and provides various data visualization options (Fahimnia et al. 2015). Publication network analysis was also performed through citation analysis, co-citation, and keyword clustering data using VOSviewer. VOSviewer automatically forms clusters by assigning each node (publication, author, etc.) to a cluster using the normalization strength and visualization of similarities (VOS) mapping technique (Van Eck and Waltman 2014). The number of clusters can be affected by resolution; hence, the optimal resolution for each network analysis is determined based on the clarity of clusters emerging during the analysis.

Bibliometric and citation analyses have been conducted using various software packages, including Bibexcel (Fahimnia et al. 2015), Gephi (Xu et al. 2018), VOSviewer (Caviggioli and Ughetto 2019), Pajek (Persson et al. 2009), and CiteSpace (Li et al. 2018). In our study, we utilized the VOSviewer platform, drawing on its extensive capabilities for data analysis and visualization, as well as referring to relevant manuals and prior studies (Bastian et al. 2009; Fahimnia et al. 2015; Caviggioli and Ughetto 2019). VOSviewer was chosen for its

ability to efficiently handle large datasets and offer diverse visualization options (Fahimnia et al. 2015).

We employed bibliographic coupling through VOSviewer to examine relationships between publications and conducted network analysis, including citation, co-citation, and topical clustering. The software's ability to automatically create clusters and visualize similarities using association strength normalization and VOS mapping techniques facilitated our analysis.

To optimize the visualization and interpretation of results, we adjusted the resolution parameter within VOSviewer to ensure the prominence and clarity of emerging clusters. The generated outputs, including network, density, and overlay visualization maps, enabled us to characterize relationships between elements and identify patterns. Furthermore, we set a threshold of nine occurrences for keywords to be included in the analysis. By leveraging VOSviewer's capabilities, our study aims to enhance the investigation of research trends in the application of blockchain technology in the management sector and related areas. The initial phase involved assessing the total link strength (TLS) of institutions and countries, a metric used to gauge the interconnectedness of researchers and articles within the field (Vallaster et al. 2019). This analysis highlighted significant contributions from 175 authors out of a total of 1284, with a notable concentration in developed countries such as the China, USA, UK, and Germany. However, developing nations like India also emerged as active participants in this research landscape.

A co-occurrence analysis of author keywords further revealed the core intellectual themes underpinning this research. Predictably, "bitcoin" and "cryptocurrency" emerged as dominant keywords due to blockchain's origins as a cryptocurrency dissemination mechanism (Nakamoto 2008). However, the analysis also illuminated the growing prominence of other key combinations, such as "blockchain-smart contracts", "blockchain-SCF", and "blockchain-transparency". These linkages underscore the expanding applications of blockchain beyond its financial roots, particularly in areas like supply chain management.

The visualization generated by VOSviewer, as depicted in the Figure 6, offers a more nuanced understanding of these interrelationships. The network visualization portrays items as multicolored dots, with size indicating frequency of occurrence and color denoting cluster membership. Notably, the most frequent terms, "blockchain", "smart contracts", and "supply chain finance", cluster together, signifying their interconnectedness and central role in ongoing research. Moreover, the presence of other clusters highlighting "finance", "risk management", and "information asymmetry" underscores the multifaceted nature of blockchain's impact on the management domain.

In essence, this comprehensive analysis provides a visual and quantitative representation of the complex network of themes and concepts shaping the research landscape of blockchain application in management. It reveals not only the dominance of established terms like "bitcoin" and "cryptocurrency" but also the emergence of new focal points like "smart contracts" and "supply chain finance". These insights pave the way for a deeper understanding of the field's trajectory and potential avenues for future research.

Figure 6 shows the image appear to be network visualizations generated by VOSviewer. These visualizations represent a bibliometric analysis of keywords in scientific publications. In Figure 6, "blockchain" is the most prominent node, indicating its central role in the literature analyzed. It is connected to many other terms, such as "SCF", "smart contracts", "supply chain", and "finance", indicating that these are key topics associated with blockchain research. The VOSviewer analysis of supply chain finance (SCF) research reveals a multifaceted landscape with interconnected themes.

The most prominent cluster in Figure 6, highlighted in red, revolves around the transformative potential of blockchain technology in SCF. Terms such as smart contracts, decentralized finance (DeFi), and cryptocurrency emphasize the growing interest in leveraging blockchain's transparency, security, and efficiency to revolutionize traditional SCF processes. Next, in green, a cluster focusing on the financial dimension of SCF emerges, encompassing risk management, investments, and financial performance. This empha-

sizes the increasing need for sophisticated risk mitigation strategies and the integration of financial considerations into supply chain management. The blue cluster highlights the rising concern for sustainability in SCF, incorporating terms like sustainable development, environmental impact, and social responsibility. This suggests a growing recognition of the importance of integrating environmental and social considerations into financial decision-making within supply chains. The yellow cluster represents the broader financial context of SCF, connecting it to fintech, financial services, and investments. This signifies the increasing integration of SCF into the wider financial ecosystem and its growing relevance in the financial sector. Finally, the purple cluster focuses on the diverse stakeholders involved in SCF, including SMEs, commercial banks, and suppliers. This underscores the importance of developing solutions that cater to the specific needs of these different actors in the SCF ecosystem. The VOSviewer analysis paints a comprehensive picture of the SCF landscape, showcasing the interplay between technology, finance, sustainability, and the diverse stakeholders involved. This analysis provides valuable insights into the current state of SCF research and highlights potential areas for future exploration.

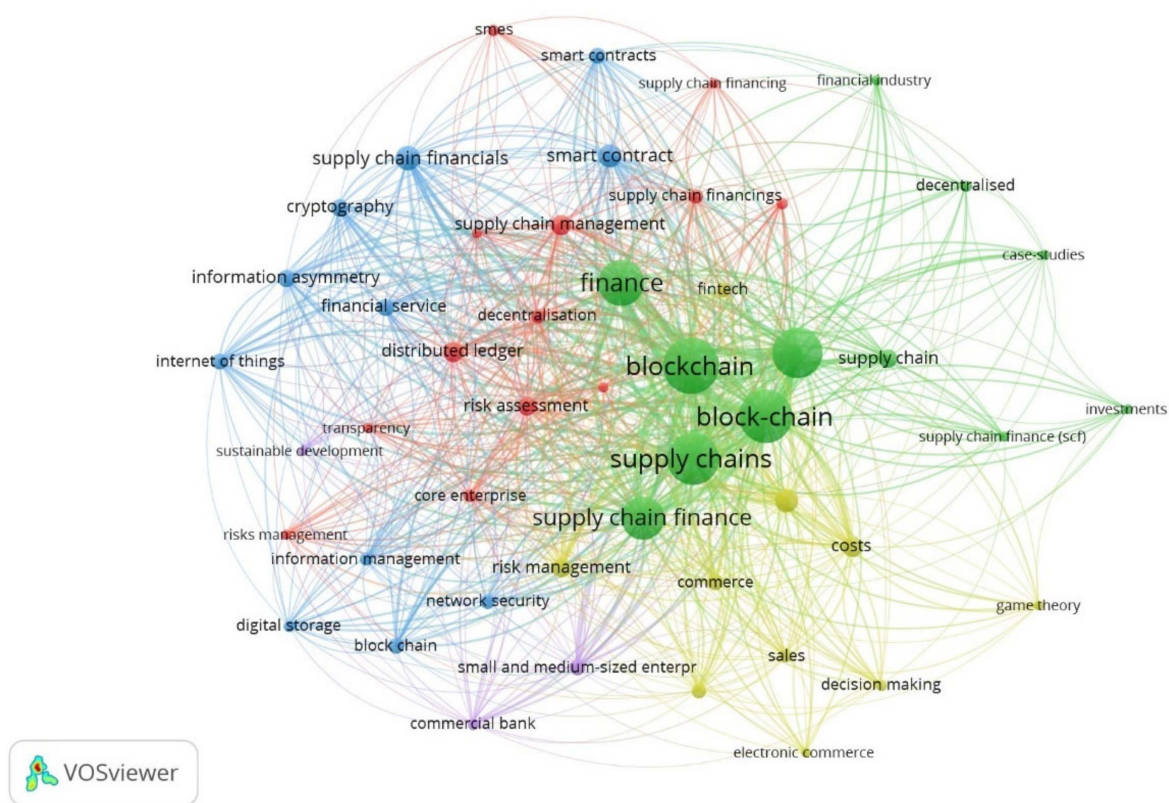


Figure 6. Network visualization map—VOSviewer output.

The VOSviewer overlay visualization map effectively illustrates the evolution of research areas in Blockchain and SCF research (Figure 6). By analyzing the color of items in the map, we can gain valuable insights into the chronological development of various research topics. Blue items represent older research areas, while yellow signifies more recent ones. This color-coding scheme allows for us to trace the trajectory of research interests over time, identifying emerging trends and potential future directions. The overlay map reveals a dynamic landscape of research activity in BCT-enabled SCF. Early research focused on traditional areas such as risk management, financial performance, and investment analysis. These topics are still relevant today, but they have been joined by a growing body of research on emerging trends such as blockchain technology, sustainable development, and the integration of SCF with broader financial concepts like fintech and decentralized finance (DeFi).

The overlay map also highlights the increasing interconnectedness of research topics in SCF shows in Figure 7. Terms that were once isolated are now linked by lines, indicating the growing awareness of the complex relationships between different aspects of SCF. This interconnectedness suggests a more holistic approach to SCF research, one that considers the interplay of technology, finance, sustainability, and stakeholder interests. By analyzing the color and connectivity of terms, we can gain insights into the past, present, and future of this dynamic field. This information can be used to inform research agendas, identify emerging trends, and ultimately contribute to the advancement of knowledge in SCF. Apparently, additional insights that can be gleaned from the VOSviewer overlay visualization map;

- (1) The growing popularity of blockchain technology in SCF research is evident in the emergence of a prominent cluster of yellow terms related to this topic.
- (2) The increasing focus on sustainability in SCF is reflected in the presence of a blue cluster of terms related to this area.
- (3) The integration of SCF with broader financial concepts is highlighted by the presence of a yellow cluster of terms related to fintech and DeFi.
- (4) The interconnectedness of research topics in SCF is evident in the presence of numerous lines connecting terms across different clusters.

The VOSviewer density visualization map illustrates in Figure 8 is the thematic landscape of research in BCT-enabled SCF. The map's color gradient, ranging from blue to yellow, indicates varying densities of research terms. A prominent yellow area dominates the center, highlighting a high concentration of research around "blockchain". Closely linked are terms like "smart contracts", "decentralized", "cryptography", and "distributed ledger", underscoring the significant focus on blockchain technology and its potential applications in SCF. This central cluster extends to include terms like "supply chain", "supply chains", and "supply chain finance", indicating a strong emphasis on the integration of blockchain within supply chain management and financial processes.

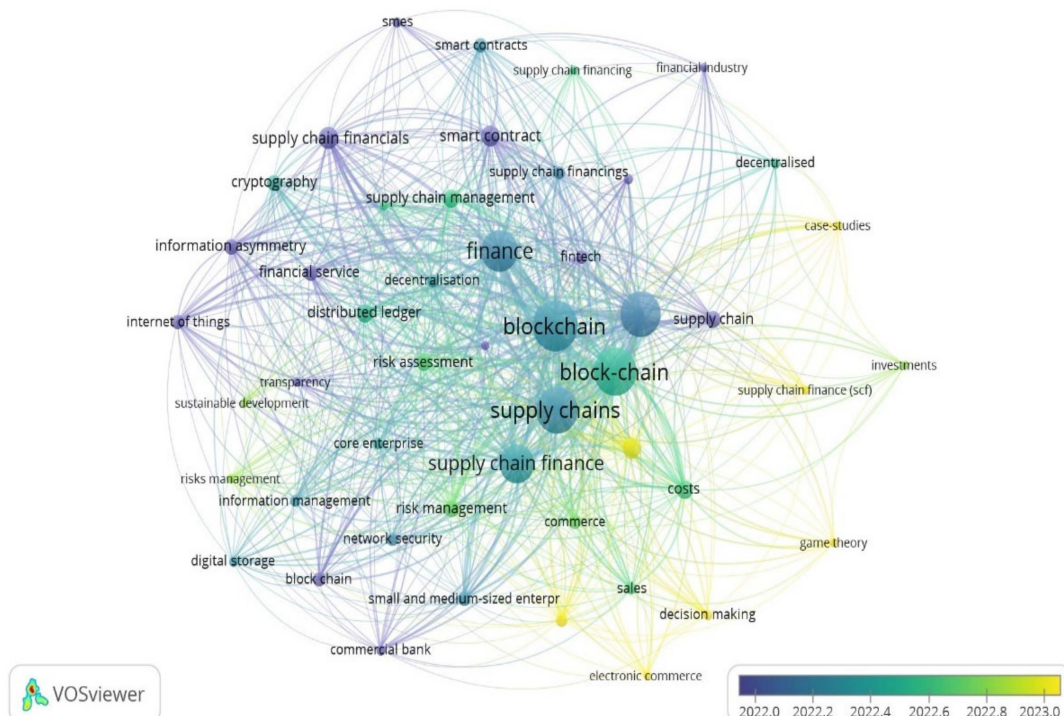


Figure 7. Overlay visualization map—VOSviewer output.

Surrounding this core, a green region emerges, indicating a moderately dense research area. This area includes terms like "risk assessment", "risk management", "information asymmetry", and "finance". This suggests a substantial interest in understanding and

addressing the financial and risk-related aspects of SCF. The map's edges, colored blue, represent areas with lower research density. These areas encompass diverse terms like "sustainable development", "Internet of things", "small and medium-sized enterprises", "commercial bank", and "financial service". While research in these areas may be less concentrated than in the central cluster, they remain important and interconnected with the broader SCF landscape. Thus, the VOSviewer density map reveals a dynamic and evolving research landscape in SCF. The strong focus on blockchain technology indicates its transformative potential in the field. At the same time, the map highlights the ongoing exploration of various financial, risk-related, and sustainability aspects of SCF, demonstrating the complexity and multidimensionality of this research domain.

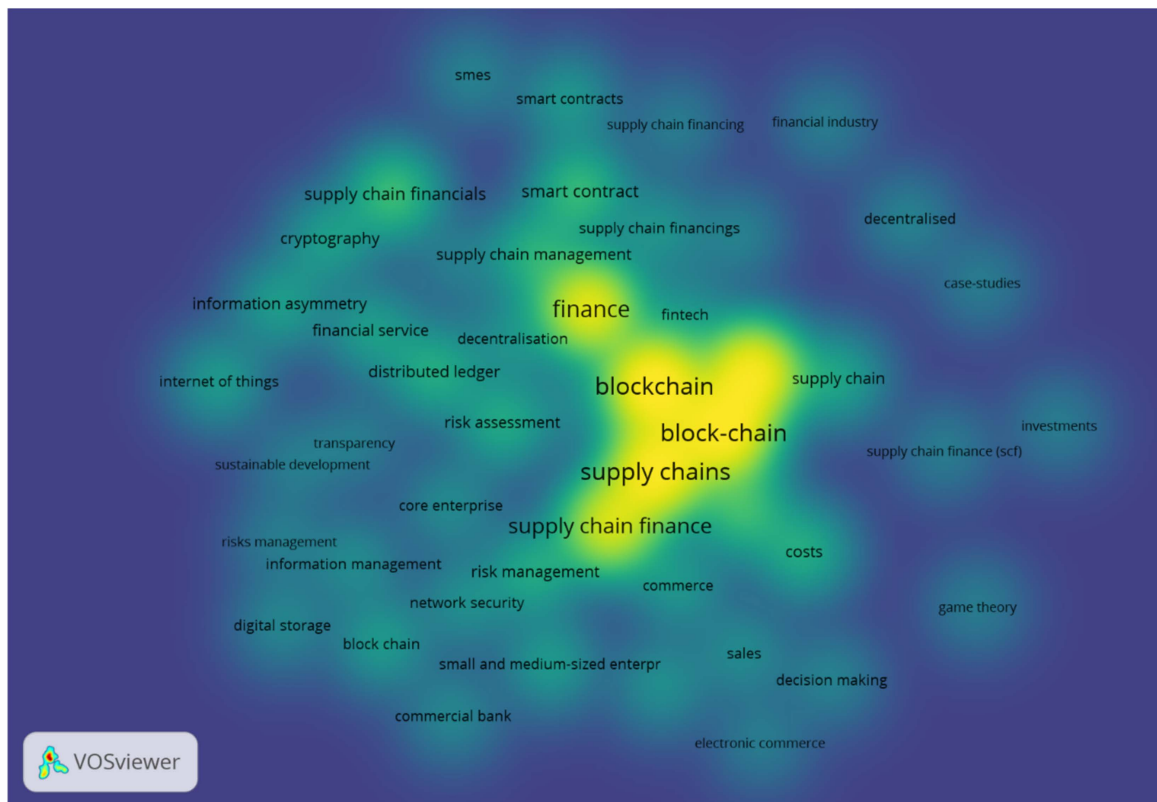


Figure 8. Items density visualization map—VOSviewer output.

5. Discussion

5.1. Future Direction and Implication of Blockchain in SCF

The implications of blockchain technology for supply chain finance (SCF) are both vast and profound. Theoretically, blockchain offers a decentralized, transparent, and immutable ledger that can streamline and secure financial transactions across complex supply chains (Hofmann et al. 2017). This has the potential to reduce costs, increase efficiency, and enhance trust between stakeholders. In practice, blockchain-based SCF solutions are already being implemented, with promising results (Chod et al. 2019). For example, several platforms leverage smart contracts to automate invoice financing, purchase order financing, and other SCF processes. These platforms offer improved transparency, faster settlement times, and reduced risk of fraud, providing tangible benefits for both buyers and suppliers (Wuttke et al. 2020).

From a theoretical perspective, blockchain can address many of the challenges that have traditionally plagued SCF, such as information asymmetry, lack of trust, and high transaction costs (Hofmann et al. 2017). By providing a shared, tamper-proof record of transactions, blockchain can create a more transparent and efficient SCF ecosystem. Practically, this can translate into greater access to finance for small and medium-sized

enterprises (SMEs) (Wuttke et al. 2020), reduced risk of fraud (Chod et al. 2019), and improved liquidity for all supply chain participants. Blockchain technology has long been touted as a potential game-changer for SCF, promising to enhance efficiency and transparency. Empirical studies and case examples provide compelling evidence that blockchain is delivering on this promise. For instance, research by Chod et al. (2019) demonstrates that blockchain can significantly reduce the time and cost of SCF transactions, while also improving visibility and traceability throughout the supply chain.

The research landscape of blockchain in SCF has evolved significantly in recent years. Early research was primarily theoretical, focusing on the potential benefits and challenges of blockchain technology for SCF (Hofmann et al. 2017). However, as the technology has matured and more practical applications have emerged, the focus of research has shifted towards empirical studies and real-world implementations (Chod et al. 2019; Wuttke et al. 2020).

This shift is reflected in the increasing number of publications that examine the use of blockchain in specific SCF use cases, such as invoice financing, trade finance, and supply chain traceability (Wuttke et al. 2020). These studies provide valuable insights into the practical challenges and opportunities of implementing blockchain-based SCF solutions. Additionally, there is a growing body of research that explores the impact of blockchain on SCF performance, efficiency, and risk management (Chod et al. 2019).

In the realm of blockchain-enabled SCF networks, the dynamics of collaboration and co-opetition play a pivotal role. Collaboration, facilitated by the shared ledger and smart contracts, fosters trust and transparency among stakeholders, leading to more efficient and secure transactions (Wuttke et al. 2020). However, the inherent competition among financial institutions and fintech companies necessitates a delicate balance between cooperation and competition, known as co-opetition. Game theory provides a valuable framework for understanding this complex interplay. By modeling the strategic interactions of stakeholders, game theory can help identify optimal strategies for collaboration and competition in blockchain-enabled SCF networks (Chod et al. 2019). For instance, cooperative game theory can be used to analyze how stakeholders can collaborate to maximize the overall value created by the network, while non-cooperative game theory can shed light on how competition can drive innovation and efficiency.

Network formation models offer another lens through which to examine the dynamics of collaboration and co-opetition. These models can help explain how blockchain-enabled SCF networks emerge and evolve, as well as the factors that influence their success (Hofmann et al. 2017). For example, network formation models can help identify the key players in the network, the relationships between them, and the potential for new entrants to disrupt the market. Furthermore, blockchain-based SCF platforms have been shown to improve access to finance for small and medium-sized enterprises (SMEs) (Wuttke et al. 2020). By reducing the need for intermediaries and automating many of the manual processes involved in SCF, blockchain can lower the barriers to entry for SMEs, enabling them to participate more fully in global trade.

The transparency afforded by blockchain also has the potential to mitigate risk in SCF (Hofmann et al. 2017). By providing a shared, immutable record of transactions, blockchain can help to reduce the risk of fraud and errors. This can lead to more accurate risk assessments and improved credit decisions, ultimately benefiting all stakeholders in the supply chain. However, it is important to note that the full impact of blockchain on SCF efficiency and transparency is still unfolding. As the technology continues to mature and adoption increases, we can expect to see even more significant improvements in these areas driven by factors such as capabilities, infrastructure, finance, risk perception, and market demands (Fauziana et al. 2023).

5.2. Research Agenda: Transparency and Traceability Crossroad

Future research at the intersection of blockchain and supply chain finance (SCF) should prioritize investigating how this technology can bolster transparency in commodity trade

between the Global North (developed countries) and the Global South (developing and least-developed countries). More specifically, the Global North consists of the world's developed countries, whereas the Global South consists of the world's developing and least-developed countries (UNCTAD 2023). This research agenda focus could shed light on how blockchain can address the information asymmetries and power imbalances that often characterize trade relationships between these regions, potentially leading to fairer and more equitable outcomes for all stakeholders as shown in Table 1.

Table 1. BCT-enabled SCF publications in Global North and Global South.

Country	No of Publications	%	Country	No of Publications	%
Global North			Global South		
United States	28	24.6	China	162	78.6
United Kingdom	17	14.9	India	21	10.2
Australia	13	11.4	Indonesia	3	1.5
Switzerland	11	9.6	Malaysia	3	1.5
Canada	9	7.9	Mexico	2	1.0
Taiwan	7	6.1	Saudi Arabia	2	1.0
Hong Kong	6	5.3	Colombia	1	0.5
Republic of Korea	4	3.5	Croatia	1	0.5
Netherlands	3	2.6	Ecuador	1	0.5
France	2	1.8	Iran	1	0.5
Germany	2	1.8	Jordan	1	0.5
Portugal	2	1.8	Macau	1	0.5
Singapore	2	1.8	Morocco	1	0.5
Italy	2	1.8	Pakistan	1	0.5
Japan	2	1.8	Philippines	1	0.5
Greece	1	0.9	Poland	1	0.5
Norway	1	0.9	Qatar	1	0.5
Spain	1	0.9	Russia	1	0.5
Sweden	1	0.9	Serbia	1	0.5
Total	114		Total	206	

Table 1 illustrates a stark disparity in the distribution of publications BCT-enabled SCF between the Global North and South. The Global South is led overwhelmingly by China, which accounts for 78.6% of Global South-originating publications, while the United States has the leading contribution of 24.6% to Global North-originating publications.

The contrasting priorities of the Global North and South in blockchain-enabled supply chain finance (SCF) reveal distinct yet complementary goals. The Global North, as highlighted by Ioannou and Demirel (2022), seeks enhanced efficiency, ethical and sustainable practices, and robust traceability in their supply chains. In contrast, the Global South, as emphasized by Wang et al. (2022), prioritizes value addition, transparency, and fair pricing within SCF frameworks. However, both regions converge on common goals of standardization and risk mitigation, as underscored by Zheng et al. (2022) and Rijanto (2021). This convergence suggests a potential for blockchain to act as a unifying force, fostering cooperation and shared benefits across diverse geographies. By leveraging blockchain's immutability and transparency, both regions can achieve streamlined processes (Yang et al. 2023), bolster trust, and mitigate risks (Guo et al. 2022). The challenge lies in tailoring blockchain solutions that cater to the unique priorities of each region while simultaneously promoting global standards and risk management practices. Such an approach would not only unlock the full potential of blockchain in SCF but also contribute to a more inclusive and equitable global trade ecosystem.

The analysis of BCT-enabled SCF publications reveals a distinct bifurcation in research priorities between the Global North and South, as shown in Table 2. The Global South demonstrates a pronounced focus on reliable financial transactions, particularly risk mitigation, likely driven by a desire to alleviate vulnerabilities in their financial systems

(Ioannou and Demirel 2022). Conversely, the Global North displays a keen interest in economic benefits, particularly efficiency, aligning with their focus on optimizing existing SCF processes. This divergence underscores the varied motivations and challenges faced by different regions in adopting blockchain technology for supply chain finance (Guo et al. 2022).

Table 2. Distribution of publications on BCT-enabled SCF by category.

Category *	No of Publications		
	Total	Global North	Global South
Cluster I: Reliable financial transactions			
Risk mitigation	49	15	34
Transparency	24	18	6
Cluster II: Economic benefits			
Value addition	39	10	29
Efficiency	27	18	9
Standardization	19	9	10
Cluster III: Responsible sourcing			
Ethics and Sustainability	37	25	12
Traceability	30	18	12
Fair price	0	0	0

* Research agenda categories of BCT-enabled supply chain finance publications.

Furthermore, the Global North's emphasis on responsible sourcing, specifically ethical and sustainability concerns, highlights a greater awareness of environmental and social impacts in their business practices. This could be attributed to stricter regulations or increased consumer demand for ethically sourced products in these regions. In contrast, the Global South's focus on value addition and efficiency may be driven by the need for economic growth and competitiveness (Wang et al. 2022).

The absence of research on "Fair Price", despite its potential importance, especially for the Global South, presents a critical gap in the existing literature. This highlights a potential area for future research, as ensuring equitable outcomes in global trade facilitated by BCT is essential for sustainable and inclusive development. Bridging this research gap could contribute to a more balanced understanding of BCT's impact on SCF and inform the development of fairer and more equitable trade practices. This involves addressing the distinct needs of each region, with the Global North seeking product traceability and the Global South demanding transparency in financial transactions. Blockchain's immutable ledger presents a promising solution for the Global North, providing a verifiable record of a commodity's journey from origin to destination (Hofmann et al. 2017). This traceability can ensure ethical sourcing, verify sustainability claims, and mitigate risks associated with counterfeit products. Future research should investigate the specific data points necessary for comprehensive traceability and effective communication of this information to consumers.

A key area for future research is to investigate the feasibility and effectiveness of integrating blockchain with existing traceability systems and standards, such as those used for organic or fairtrade certification. Furthermore, research should explore the potential of blockchain to empower small-scale farmers and producers in the Global South by giving them greater visibility and control over their products' journey through the supply chain. This could lead to fairer prices, improved access to markets, and increased economic empowerment for these communities. Simultaneously, blockchain's transparency can empower producers and suppliers in the Global South by offering greater visibility into financial transactions (Wuttke et al. 2020). This can ensure fair payment terms, reduce the risk of fraud, and increase access to finance. Research should explore how blockchain can facilitate equitable financial arrangements, potentially through smart contracts that automate payments upon fulfilment of agreed-upon conditions. To fully realize these bene-

fits, future research should focus on developing standardized frameworks and protocols for blockchain implementation in commodity trade (Chod et al. 2019). These frameworks should define data elements, stakeholder roles, and verification mechanisms, taking into account the diverse needs of both regions. Moreover, successful implementation hinges on building trust and collaboration among stakeholders, including governments, businesses, NGOs, and consumers (Hofmann et al. 2017).

Future research should prioritize investigating the practical implementation and impact of blockchain-enabled SCF solutions, particularly in the context of commodity trade between the Global South and North. This entails a focus on developing standardized frameworks and protocols that address the diverse needs of both regions, ensuring both product traceability for the Global North and financial transparency for the Global South. Additionally, future studies should delve into the integration of blockchain with existing traceability systems and standards, explore its potential to empower small-scale producers, and examine the factors that contribute to trust and collaboration in blockchain-based SCF networks. By addressing these research gaps, we can unlock the full potential of blockchain technology to create a more equitable, efficient, and sustainable global trade ecosystem.

6. Conclusions

This study provides a comprehensive overview of the current state of research on blockchain applications in supply chain finance (SCF). Our analysis of 446 research articles reveals key trends and knowledge gaps in this rapidly evolving domain. We identified a growing focus on the practical implications of blockchain in SCF, including the use of smart contracts, decentralized finance, and risk management. While the field is transitioning from theoretical exploration to practical implementation, gaps remain in empirical studies on real-world impact, integration with other emerging technologies like IoT and AI, and the development of appropriate regulatory frameworks. Critically, we highlight the lack of research on “fair price” and its implications for equitable outcomes in global trade, particularly for the Global South.

Blockchain technology holds immense potential for democratizing access to finance, enhancing transparency, and fostering greater collaboration within supply chains. Future research should prioritize addressing the identified gaps, including (1) conducting empirical studies to measure the tangible benefits of blockchain adoption, (2) exploring innovative integrations with other technologies, and (3) developing standardized frameworks and protocols for blockchain implementation in commodity trade that address the diverse needs of the Global North and South. This includes ensuring product traceability for the North and financial transparency for the South, empowering small-scale producers, and fostering trust and collaboration among stakeholders. By addressing these research priorities, we can unlock blockchain’s full potential to create a more equitable, efficient, and sustainable global trade ecosystem. As the technology matures and adoption increases, it is crucial to establish clear guidelines and standards to ensure the security, transparency, and ethical use of blockchain in SCF. Finally, future research should examine the social and environmental implications of blockchain-enabled SCF. While the technology has the potential to create significant economic benefits, it is important to ensure that it is used in a way that promotes sustainability and social responsibility.

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