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A Systematic Review of the Adoption of Blockchain for Supply Chain Processes

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ABSTRACT

This paper systematically reviews the literature on the adoption of blockchain technology in supply chain management (SCM) processes. Using the PRISMA (preferred reporting items for systematic reviews and meta-analysis) methodology, 53 peer-reviewed research publications from five different databases (IEEE Xplore, Science Direct, Scopus, Google Scholar, and EBSCOhost) were selected and analyzed using a classification coding framework. The findings reveal that agri-food traceability, blockchain security, smart contracts, and the internet of things (IoT) were the significant identified current trends in the use of blockchain in SCM processes. The key identified challenges include high costs of transactions and a lack of trust between stakeholders. Identified solutions were blockchain traceability systems and the use of smart contracts and IoTs. In addition, this paper identified gaps in the literature that need to be addressed in future studies.

KEYWORDS

Blockchain, Challenges, Gaps, Prisma, Solutions, Supply Chain Management, Systematic Literature Review, Trends

INTRODUCTION

The primary aim of Supply chain management (SCM) is to manage a firm's stakeholder networks efficiently to maximize shareholder value and ensure customer satisfaction (Stock & Boyer, 2009). Supply chain management networks are complex due to the various components required by stakeholders in an increasingly networked and rapidly evolving digital world. Recent technological advancements associated with the Fourth Industrial Revolution (4IR) are further causing significant disruptions and compelling SCM professionals to create new business processes and models (Queiroz et al. 2019). In this paper, we systematically review research that has investigated blockchain technology as a superior 4IR technology that could unravel the increasing complexity in SCM processes while at the same time decentralizing stakeholder authority (Schniederjans et al. 2020). Specifically, the

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study seeks to explore the few studies available on the adoption of blockchain technology in SCM to identify the current trends, challenges, and proposed solutions. This paper distinguishes itself from previous systematic reviews that investigated blockchain adoption in the context of SCM, as depicted in Table 1.

Table 1. Description of previous systematic reviews on the adoption of blockchain in SCM

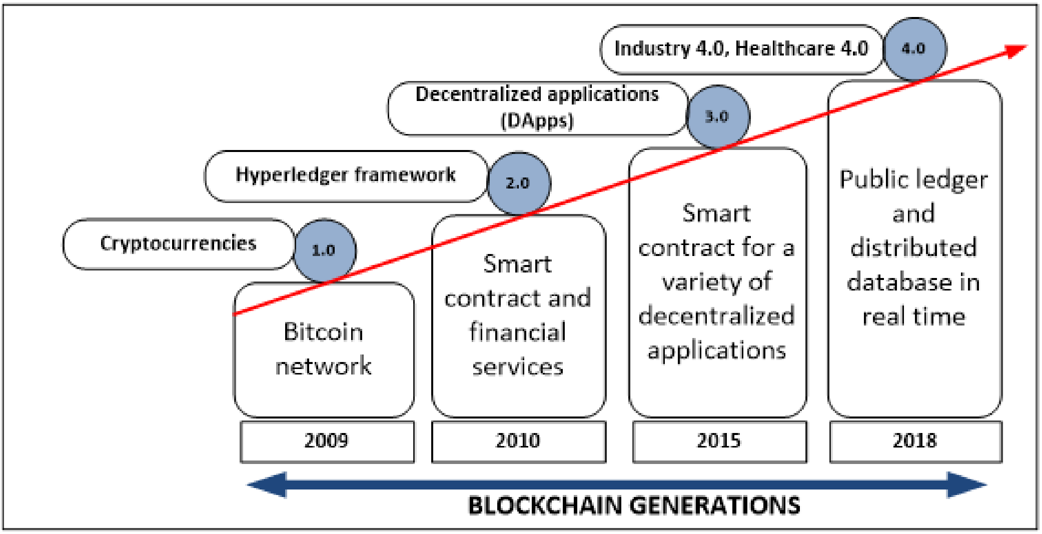
Author	Systematic Literature Review adopted methods
Surjandy et al. (2019)	Studied the current benefits, challenges, and the impact of blockchain adoption in the SCM of the pharmaceutical industry. Future research proposed in the study involved identifying current blockchain trends to improve SCM systems.
Queiroz et al. (2019)	Analysed literature on the integration of blockchain in SCM. The authors highlighted that there are very few publications that provide solutions that address issues that impede blockchain adoption in the SCM sector
Duan et al. (2020)	A content-analysis-based literature review on blockchain adoption was conducted within the food SCM. The authors recommended future studies that focus on the real-world implementation of blockchain, which provides more empirical evidence instead of just harping on theoretical concepts.
Dutta et al. (2020)	A literature search was conducted on blockchain integration in SCM operations. A future research agenda was established, thus laying a solid foundation for future research on this important emerging research area.
Chang and Chen (2020)	A literature review and an analytical review of blockchain-based SCM were conducted to elucidate the benefits and challenges of the blockchain-supply-chain paradigm. This study contributes to a broader understanding of blockchain applications in SCM and provides a blueprint for these applications.
Gonczol et al. (2020)	A survey was conducted to investigate academic studies about blockchain application in SCM and distributed ledger implementations in SCM. The benefits and drawbacks of distributed organisation and SCM presented in the study laid a foundation for practitioners and researchers to focus their future projects on improving the technology and its applications.

Source: Developed by the authors

This systematic review differs from previous systematic reviews depicted in table 1 above because it used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method to select relevant scholarly literature and used a coding framework that enables the identification of unique perspectives, including a view of which countries are engaging in SCM using blockchain technology. After considering previous systematic reviews, this paper formulated research questions to examine current blockchain trends in SCM, challenges that impede blockchain adoption in SCM, solutions to the identified challenges, and identification of gaps that require further research.

The remainder of this paper is organized as follows: The following section provides a brief overview of blockchain technology and its benefits to SCM, followed by a description of the methodology. After discussing the results using a classification and coding framework, the paper concludes by identifying the implications and limitations of the findings before making recommendations for future research.

Figure 1. Blockchain evolution (Adopted from Bodkhe et al., 2016)



Blockchain Technology and Supply Chain Management

Since the introduction of Bitcoin technology by Satoshi Nakamoto (2009), blockchain technology has, as shown in Figure 1, evolved from generation 1.0 to 4.0 (Bodkhe et al., 2016).

The cryptocurrency was the first generation of the blockchain (Bodkhe et al., 2016). The idea was to enable digital transactions to be executed over a blockchain network at a faster rate and more securely than a traditional banking system. Bitcoin is the most prominent and the first application of blockchain 1.0 (Nakamoto, 2009). Blockchain 2.0 introduced the concept of smart contracts to validate transactions through self-executable codes (i.e., without human intervention). The Ethereum platform proposed by Buterin and Wood (2013) and the Hyperledger Fabric framework of the Linux Foundation (2017) are two examples of blockchain 2.0 platforms. Ethereum and Hyperledger Fabric are both open-source, and community-driven blockchain platforms focused on developing a suite of stable frameworks, tools, and libraries for building blockchain applications. Blockchain 3.0 is related to decentralized applications (DApps) that are implemented to avoid transactions being processed through a centralized infrastructure. Blockchain 4.0 describes the solutions and approaches that make blockchain technology responsive to business demands by leveraging the foundations laid by the previous blockchain generations. Blockchain 4.0 enables organisations to navigate through the challenges posed by the 4th Industrial Revolution (4IR) since many organisations are automating traditional manufacturing, data exchange, industrial practices, and processes using smart technology. In this case, blockchain provides a secure and trusted platform for business processes and data exchange automation. Supply chain management, the Internet of Things (IoTs), and healthcare are some of the areas in which blockchain technology fulfils the 4IR demands (Bodkhe et al., 2016).

Since the mass adoption of the Internet, blockchain's potential to transform digital service delivery, data management, and value exchange has been widely considered (Chamola et al., 2020). Lately, blockchain technology has been receiving attention in providing solutions for the increasingly complex problems associated with SCM (Korpela et al., 2017). SCM consists of a sequential and complex inter-linked chain of operations occurring amongst suppliers, manufacturers, distributors, retailers, and consumers. In addition, SCM includes the coordination, preparation, and management of goods and/or services. Nevertheless, many challenges still exist within the conventional SCM processes, such as managing transactional data and information, lack of trust amongst stakeholders, and lack of transparency within supply networks (Schniederjans et al., 2020).

Traditional methods for tracing transactions in SCM have often relied on either paper methods and/or centralized databases. These two methods have often resulted in errors and data manipulation, thus affecting the integrity of supply chain records management. To track products in SCM, IoT technologies such as Radio Frequency Identification (RFID), barcodes, smart tags, and Wireless Sensor Network (WSN) were introduced (Duan et al., 2020). These technologies also aid the SCM sector in overcoming data integrity issues. Nonetheless, there are still challenges with the vulnerability of IoT devices in respect of counterfeits, cloning, fraudulent behaviours, and content modification (Rejeb et al., 2019). For example, RFID tags' security can be circumvented, thereby creating new vulnerabilities (Biswas et al., 2017).

On a global scale, SCM networks are increasingly becoming geopolitical, economic, and technological in nature (Rodrigue, 2020). The geopolitical dimensions are political insecurity, trade restrictions, terrorism, corruption, theft, illicit trade, and piracy. The economic challenges include demand shocks, price volatility, border delays, currency fluctuations, and energy shortages. Technology disruptions and infrastructure failures rank among the main global SCM challenges. Blockchain is relevant in use cases that contain any of the following features: (a) there are two or more participating stakeholders; (b) there are intermediaries that may be eliminated to enhance the system's effectiveness; (c) trust among the participating entities is required; (d) data integrity must be preserved; and (e) openness and transparency are required, and there is a need to promote trust among the collaborating stakeholders (Kouhizadeh et al., 2020). These features characterize the nature of SCM transactions. Therefore, blockchain can potentially enhance SCM processes.

Blockchains can trace products in the SCM network starting from the manufacturer all the way to the consumer (Duan et al., 2020). The blockchain concept of replicating information across all nodes in the network ensures transparency and openness (Di Francesco Maesa & Mori, 2020). The tracking and tracing feature embedded within a blockchain architecture enables SCM stakeholders, especially the consumers, to establish whether the product they are consuming has been tampered with. For example, the VeChain, a blockchain platform, was used to track COVID-19 vaccine shots and prevent counterfeiting within the Cyprus pharmaceutical SCM (VeChain, 2018). Traceability also reduces product recalls (Wang et al., 2020). Decentralization is another interesting blockchain feature in the sense that the failure of a single node on a blockchain network does not affect the status of the ledger since the information stored in the ledger is replicated across multiple nodes in the network (Gonczol et al., 2020). Self-executable smart contracts are blockchain features that enhance the enforcement of transaction agreements (Breese et al., 2019). Additionally, the immutability feature of blockchain makes it impossible to modify any records stored on the network (Gonczol et al., 2020). The following section discusses the research methodology adopted for this systematic literature review.

RESEARCH METHODOLOGY

A Systematic Literature Review methodology was adopted to examine blockchain technology as a superior 4IR technology that could unravel the increasing complexity in SCM processes while simultaneously decentralizing stakeholder authority (Chang & Chen, 2020). Specifically, the paper employed the PRISMA guidelines (Moher et al., 2009) for its rigour and popularity in multidisciplinary studies (Lage Junior and Godinho Filho, 2010). According to Moher et al. (2009), PRISMA is an evidence-based minimum set of items aimed at helping authors to report a wide array of systematic reviews and meta-analyses. Furthermore, the paper applied classification and coding framework in the analysis phase (Lage Junior and Godinho Filho, 2010).

DEFINING THE RESEARCH QUESTIONS

The following research questions were formulated:

- What are the current trends in the use of blockchain to enhance supply chain management (SCM) processes?
- What are the challenges of the adoption of blockchain to enhance the SCM processes?
- What are the proposed solutions to address issues that hamper the adoption of blockchain in the SCM sector?
- What are the existing gaps in the literature on the adoption of blockchain to enhance the SCM processes?

IDENTIFYING RELEVANT WORK

The following leading multidisciplinary academic databases were used to search for relevant research articles for the systematic literature review: Google Scholar, Scopus, IEEE Xplore, Science Direct, and EBSCOhost (Carter et al., 2017; Durach et al. 2014).

DEFINING THE SEARCH CRITERIA

The search for research articles was conducted using the search string "blockchain AND adoption AND supply chain."

SELECTION PROCESS

The selection process was conducted based on the search criteria and the PRISMA flow diagram. The PRISMA flow diagram provides 4 phases for identifying and selecting articles that fit the search criteria to answer the research questions. These phases are identification, screening, eligibility, and inclusion (see Appendix 1). A total of 919 articles were retrieved from the five databases using the search criteria in the identification phase. The retrieved articles were assessed to avoid duplicated articles in the screening phase. Thereafter, the articles were screened for relevance based using specific inclusion criteria. The first inclusion criterion entailed the selection of articles that related to both SCM processes and blockchain technology. Any paper that did not satisfy the requirements of the first inclusion was immediately discarded. The second inclusion criteria stipulated that articles that were selected for further analysis were from academia or industry. Furthermore, only articles published within the past five years (i.e., 2017-2021) were selected for further analysis. In addition, only papers published in English were considered. Table 2 is a summary of the inclusion criteria used for this study.

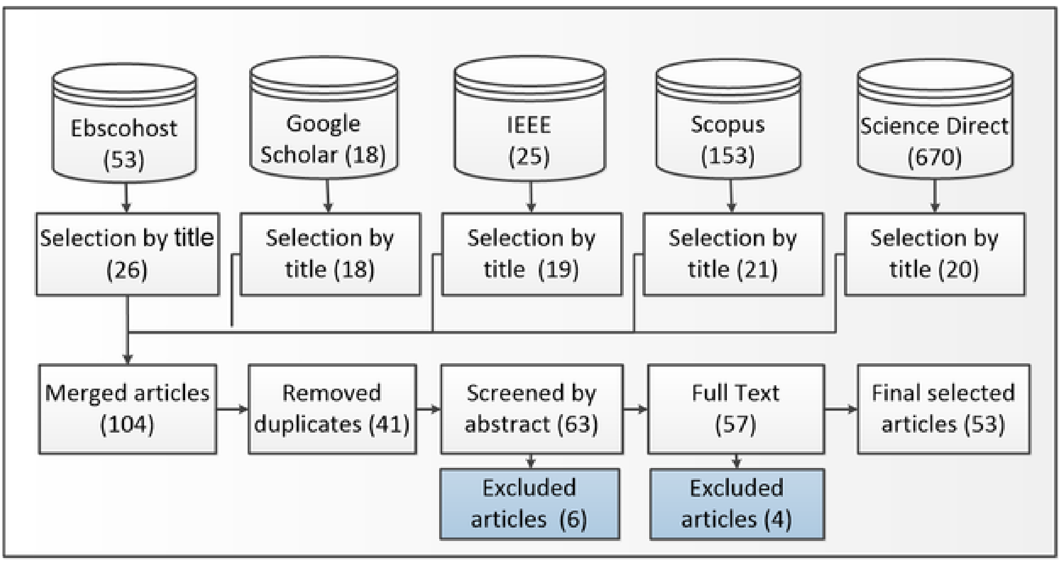
Table 2. Inclusion criteria

No	Data Item	Description
1.	Title	Articles that mentioned SCM processes and blockchain technology.
2.	Sector	Supply Chain Management and blockchain
3.	Publication Source	Academia/Industrial/ or both
4.	Year of Publication	2017 – 2021
5.	Language	English

Source: Developed by the authors

Articles that were: (1) not peer-reviewed; (2) without full-text availability; (3) duplicated; (4) not written in English; or (5) merely mentioned some of the search terms but did not focus on SCM and blockchain adoption were discarded. In the first iteration of the screening process (based on titles of the articles), 104 articles were selected, while 815 articles were excluded based on the defined inclusion/exclusion criteria. After excluding 41 duplicated articles, 63 articles remained for the next iteration of the screening process. In the second iteration of the screening process (based on the abstracts of the articles), six articles were excluded (based on the defined inclusion/exclusion criteria), meaning that 57 articles remained for the final screening iteration. In some instances, it was necessary to read the title, abstract, and conclusion to establish if an article meets the inclusion criteria to be included in the next iteration of the screening process. In the last screening iteration process, four articles were excluded based on the analysis of the full-text articles. The remaining 53 articles were found to be relevant based on the research questions of this paper. Figure 2 illustrates the selection process that was applied in this paper.

Figure 2. The process for the selection of relevant articles



CLASSIFICATION OF SELECTED ARTICLES BASED ON A CODING FRAMEWORK

A classification and coding framework (Gumbi and Twinomurinzi, 2020) was used to evaluate the 53 selected articles. Classification and coding were performed by pairing a number and a letter to produce a unique code within each specific classification (Queiroz et al., 2019). In this paper, 6 categories were chosen to aid in classifying the selected articles, namely: context (1), dimension (2), method (3), sector (4), focus (5), and origin (6) (see Table 3). A number was associated with the main category for each pair of codes, while a letter was associated with each description within a category. As shown in Table 4, the coding and classification framework developed in Table 3 was then used to classify the 53 selected articles based on the 6 main categories of the selected articles. Appendix 2, matches the publication channel of each selected article with the corresponding author(s), the source of the article, the field of application of the article, and the year of publication.

Table 3. Classification and coding framework adopted for this study (Adopted from Gumbi and Twinomurinzi, 2020)

Classification	Description	Codes
Context	Developed nations Developing nations	1A 1B
Dimension	Technical aspect Human aspect Not applicable	2A 2B 2C
Method	Qualitative Quantitative Theoretical Empirical Case studies/Interviews Survey Design Science Research	3A 3B 3C 3D 3E 3F 3G
Sector	Pharmaceutical Supply Chain Food Supply Chain Supply Chain Management Agriculture Supply Chain Operations and Supply Chain Management	4A 4B 4C 4D 4E
Focus	Current trends Challenges Solutions Gaps	5A 5B 5C 5D
Origin	North America Europe Asia Africa South America	6A 6B 6C 6D 6E

Source: Developed by the authors

Table 4. Classification and coding of the selected papers

#	Author(s)	Context	Dimension	Method	Sector	Focus	Origin
#1	Bechtsis et al. (2019)	1A	2A	3A	4B	5A	6B
#2	Duan et al. (2020)	1B	2C	3A,3C	4B	5C	6C
#3	Kamble et al. (2021)	1B	2A	3B	4C	5A	6C
#4	Ghode et al. 2020)	1B	2B	3A	4C	5B	6C
#5	Dubovitskaya et al. (2020)	1A	2A	3A,3C	4A	5B	6B
#6	Maouriyan and Krishna (2019)	1B	2A	3A	4C	5A	6C
#7	Bag et al. (2020)	1B	2A,2B	3B,3D,3F	4I	5B	6D
#8	Surjandy et al. (2019)	1B	2A	3A,3C	4B	5A	6C
#9	Di Francesco Maesa and Mori (2020)	1A	2A	3A,3D,	4C	5C	6B
#10	Queiroza and Fosso Wamba (2019)	1B	2A	3B,3D,3F	4C	5C	6A
#11	Queiroz et al. (2020)	1A	2B	3B,3D,3F	4G	5B	6B
#12	Ghode et al. (2020)	1B	2B	3B,3D,3F	4C	5B	6C
#13	Wang et al. (2021)	1B	2A	3A,3D,3E	4C	5B,5C	6C

Table 4 continued on next page

Table 4 continued

#	Author(s)	Context	Dimension	Method	Sector	Focus	Origin
#14	Queiroz et al. (2019)	1B	2C	3A,3D	4C	5A,5B,5D	6A
#15	Durach et al. (2020)	1B	2A,2B	3A,3C	4C	5A	6B
#16	Gonczol et al. (2020)	1A	2A	3A,3B,3F	4C	5C	6B
#17	Demestichas et al. (2020)	1A	2A	3A,3D	4D	5B	6B
#18	Yadav et al. (2020)	1B	2A,2B	3B,3D,3F	4D	5B	6C
#19	Breese et al. (2019)	1A	2A	3A,3C	4C	5A	6A
#20	Saurabh and Dey (2020)	1B	2A	3B	4B,4D	5A	6C
#21	Saberi et al. (2019)	1B	2A	3A	4C	5B	6A
#22	Kouhizadeh et al. (2020)	1A	2B	3A,3C	4C	5B	6A
#23	Cole et al. (2019)	1A	2B	3A,3C	4G	5D	6B
#24	Dutta et al. (2020)	1A	2A	3A	4C	5A	6C
#25	Alazab et al. (2021)	1B	2B	3B,3D	4C	5B	6C
#26	Wang et al. (2020)	1B	2A	3B	4C	5B,5C	6C
#27	Caro et al. (2018)	1A	2A	3A	4B	5A	6B
#28	Jabbar et al. (2020)	1A	2A	3A,3D,3F	4C	5B,5C,5D	6B
#29	Sheel and Nath (2019)	1B	2B	3B,3D,3F	4C	5D	6C
#30	Longo et al. (2020)	1A	2A	3B,3D,3E	4B	5A	6B
#31	Sahebi et al. (2020)	1B	2A	3B	4F	5B	6C
#32	Stranieri et al. (2021)	1A	2A	3A	4B,4D	5A	6B
#33	Choi et al. (2020)	1B	2A	3B	4C	5B	6C
#34	Coronado Mondragon et al. (2020)	1A	2A	3A,3D,3E	4I	5A,5C	6B
#35	Farooque et al. (2020)	1B	2A	3B	4C	5B	6C
#36	Shakhbulatov et al. (2020)	1A	2A	3A,3D,3F	4C	5B,5C,5D	6A
#37	Tipmontian et al. (2020)	1B	2B	3B,3F	4B	5B	6C
#38	Arumugam et al. 2018)	1B	2A	3G	4C	5A	6C
#39	Kumar et al. (2020)	1A	2A	3B	4C	5B	6A
#40	Baharmand and Comes (2019)	1A	2A	3A	4F	5B	6B
#41	Kamble et al. (2020)	1A	2B	3B	4D	5C	6B
#42	Hepp et al. (2018)	1A	2A	3A	4C	5A	6B
#43	Chod et al. (2020)	1A	2A	3B	4C	5A	6A
#44	Chen et al. (2020)	1B	2A	3B	4B	5B	6C
#45	Papathanasiou et al. (2020)	1A	2B	3A	4C	5A	6B
#46	Kim and Shin (2019)	1B	2A	3B	4C	5A	6C
#47	Fosso Wamba et al. (2020)	1A	2B	3A	4C	5B,5C	6B
#48	Francisco and Swanson (2018)	1A	2B	3A,3C	4C	5C	6A
#49	Wong et al. (2020)	1B	2C	3B	4G	5B	6C
#50	Hartley and Sawaya (2019)	1A	2B	3A,3D,3E	4C	5C	6A
#51	Hackius and Petersen (2020)	1A	2A	3A	4C	5B	6B
#52	van Hoek (2019)	1A	2B	3A	4C	5B,5C	6A
#53	Chang and Chen (2020)	1B	2A	3A	4C	5D	6C

Source: Developed by the authors

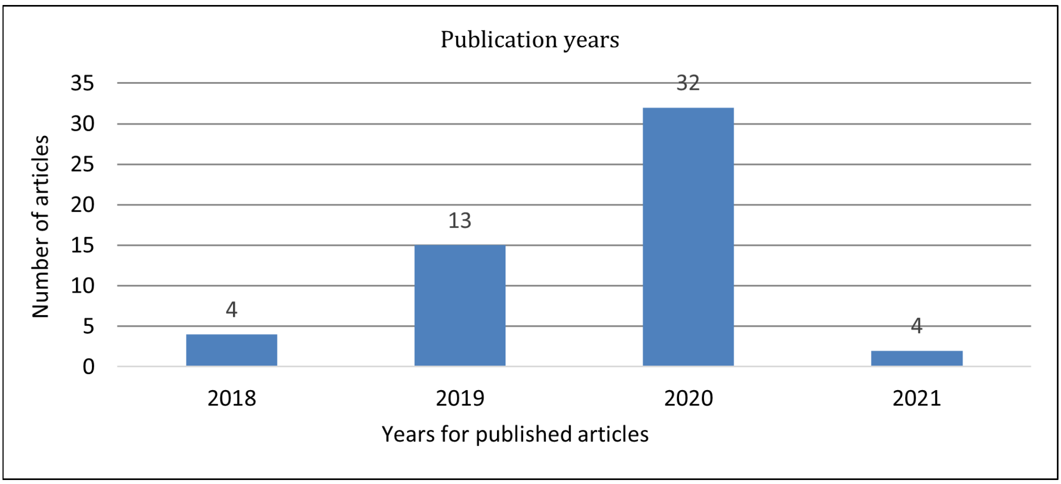
Summary of Main Findings

The initial analysis of the selected articles focused on the year of publication, the sources (academia, industrial or both), and the publication channels.

Summary of Articles by Year of Publication

Figure 3. shows the distribution of the selected articles based on the year of publication. It is important to note that there were no research articles that were retrieved for the year 2017. A comparative analysis of the number of articles published during the period 2018 to 2020 revealed a growing research interest in the application of blockchain in SCM, with the highest number of publications (thirty-two; 60% of the selected articles) being recorded for 2020. Whereas thirteen (25%) articles that passed the final selection process were recorded for 2019, only four articles were published during each year of 2018 (8% of the selected articles) and 2021 (7% of the selected articles). These findings concur with those of Queiroz et al. (2019), which established an increasing trend in the application of blockchain in SCM. The year 2018 experienced an equal and balanced distribution of the papers across the various fields (i.e., one paper each for smart contracts, IoT, and Agri-food traceability). Whereas smart contracts dominated research in 2019 and IoT (three papers each), agri-food traceability research featured prominently (six papers) in 2020 and early 2021.

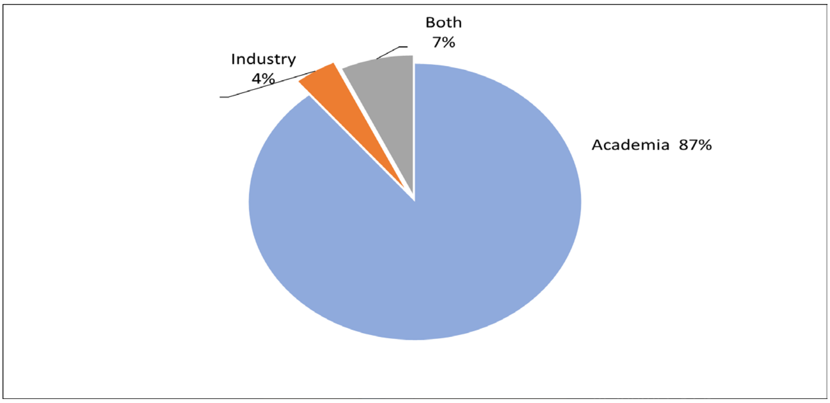
Figure 3. Distribution of the selected articles based on the year of publication



Source of Published Articles

Figure 4 shows that an overwhelming majority (87%) of the articles were published by authors affiliated with academic institutions. In contrast, while 8% of the authors of the papers that were selected were affiliated with both academic institutions and industry, a mere 5% were only affiliated with the industry. These findings, which suggest very poor academia-industry research collaboration on the blockchain and SCM, provide evidence (albeit anecdotal) of the existence of a misalignment between blockchain research conducted at academic institutions and the needs of the industry. Similar sentiments have been expressed by Saraless et al. (2017).

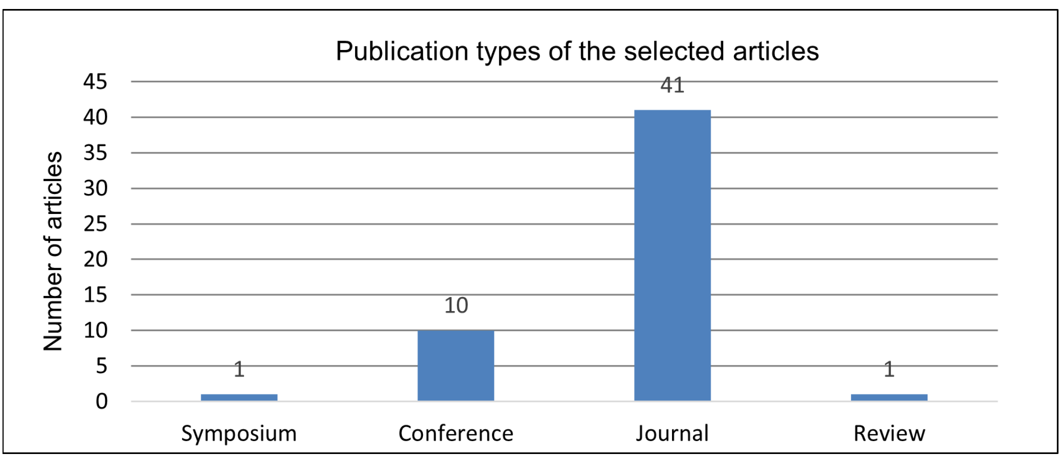
Figure 4. Affiliation of the articles' authors



Publication Channels

As shown in Figure 5, forty-one (77%) of the selected articles were published as journal articles. The balance was published as conference papers (ten; 19% of the selected articles) and symposium and reviews (one of each; 2% of the selected articles). Suffice it to say that journal articles go through a stricter and more rigorous peer-review process that ensures publication of only high-quality research (Wang, et al., 2019). Therefore, these findings suggest an acceptance of blockchain and its growing influence on SCM in mainstream academia.

Figure 5. Publication channels of the articles



Classification of Articles Based on the Context Category (developed vs undeveloped countries)

Table 5. Classification of articles based on the context category

Code	Context	Number of countries	Number of articles
1A	Developed nations	12	27 (51%)
1B	Developing nations	9	26 (49%)

Source: Developed by the authors

The analysed articles were from a total of 21 countries (see Table 5). Twelve (58%) of the screened articles were from developed countries, and the balance (nine; 49%) was from developing countries. These findings contrast sharply with those of Queiroz et al. (2019), who found that research publications from emerging economies are still sparse compared to developed countries. Interest in blockchain research in developing countries was comparable with that of developed countries.

Table 6. Continent where the study was conducted

Code	Continent	Articles per continent
6A	Asian continent	22 (42%)
6B	European continent	17 (32%)
6C	North American continent	10 (19%)
6D	South American continent	3 (6%)
6E	African continent	1 (2%)

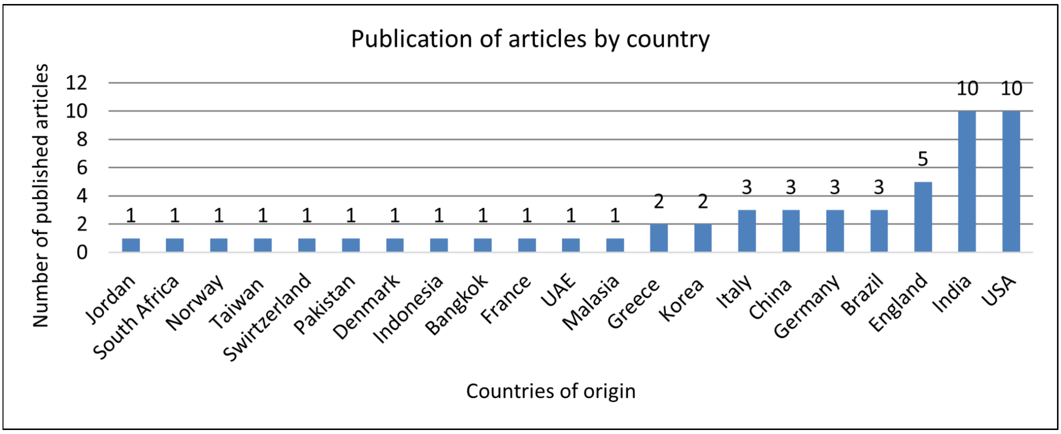
Source: Developed by the authors

Classification of Articles by the Continent from which the study was conducted

Table 6 shows that the Asian continent (42%) followed by Europe (32%) and North America (18%) are the leading continents in terms of research on the use of blockchain in SCM. South America (6%) and Africa (2%) seem to be lagging behind in this area.

Many authors have already identified the low number of published articles on the use of blockchain in SCM (Alazab et al., 2021; Bag et al., 2020; Cole et al., 2019; Fosso Wamba et al., 2020; van Hoek, 2019). Figure 6 shows that India and the USA are neck and neck with regards to the highest number of publications produced. The success of India can be ascribed to the huge investment the government has made in research and development relating to emerging technologies such as blockchain (Kumar and Pundir, 2019). Very little work has been conducted in the African continent on blockchain as part of SCM. In fact, even the single paper that South Africa published focused on SCM opportunities from India. This lack of research from Africa has the potential to further alienate the continent from the global SCM or even intra-African SCM intentions such as those of the Africa Free Trade Continental Area (AfCFTA).

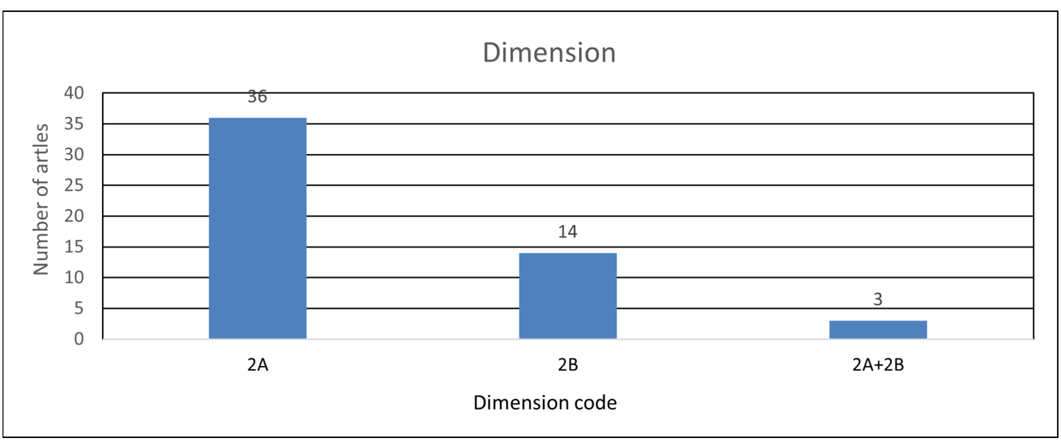
Figure 6. Analysis of articles based on the country of the affiliated authors



Classification of Articles Based on the Dimension Category

The dimension category (2) helped to categorize the selected articles based on technical aspect (2A), human aspect (2B), and both technical and human aspects (2A+2B) as observed in Figure 7. Studies that solved technical problems whereby human participation was not a requirement were classified as technical articles, while studies that required human involvement were classified as human-related articles. Thirty-six (68%) and fourteen (26%) of the articles of the selected articles accounted for technical and human-related articles, respectively. Only three (6%) of the selected articles involved both technical and human-related aspects. This implies that the maturity of blockchain as a technology has not yet peaked to allow for wider social implications of the technology.

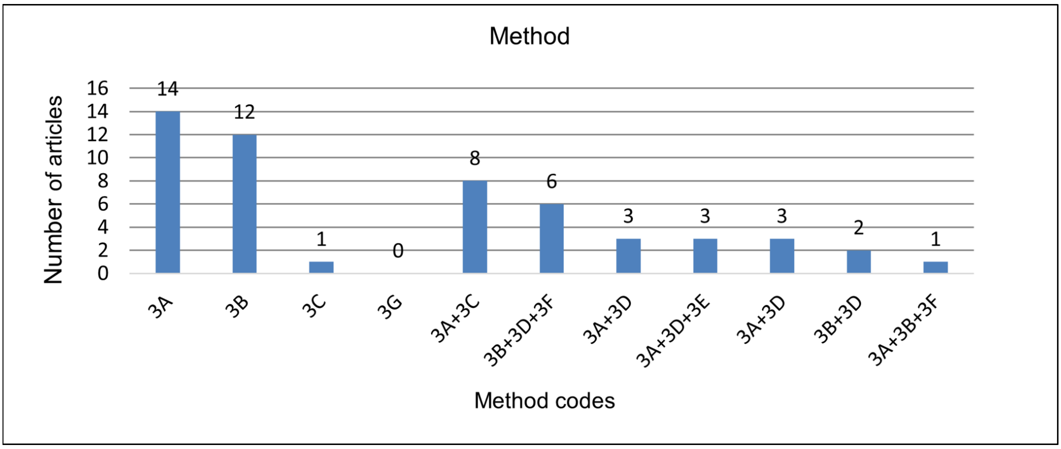
Figure 7. Classification by dimension category



Classification of Articles Based on the Research Method Category

This section reports on the type of research methods that were used in the selected papers. Figure 8 illustrates that the selected articles used the following research methods: qualitative (26%); quantitative (23%); a combination of qualitative and theoretical framework (15%); quantitative, empirical, and survey (11%); qualitative and empirical (6%); qualitative, empirical, and case study (6%); qualitative and empirical (6%); quantitative and empirical (4%); qualitative, quantitative, and survey (2%); and theory (2%). Some of the papers incorporated more than one research method. However, none of the selected articles used the design science research methodology.

Figure 8. Classification by research method(s) adopted in the selected articles

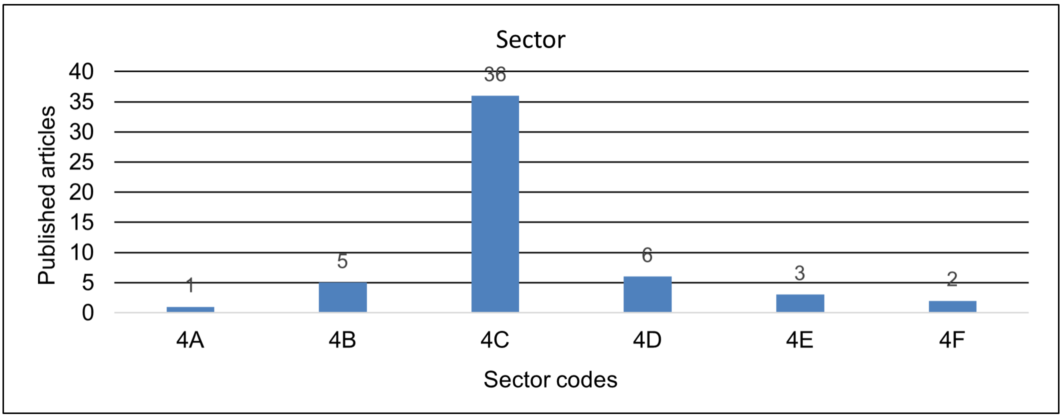


These results imply that, of the articles that were selected, none of them was aimed at developing a blockchain prototype in the context of SCM. As depicted in Figure 8, most of the selected articles were focused on blockchain adoption in SCM using qualitative and quantitative methods. Queiroz et al. (2019) argued that the application of blockchain in SCM is still at its infancy because blockchain technology is still new. Therefore, a gap still exists in the implementation of practical solutions that require developing and evaluating prototypes using the Design Science Research (DSR) methodology or similar methods (Gregor & Hevner, 2013). DSR seeks to enhance technology and science knowledge bases by creating innovative artefacts that solve problems and improve the environment in which they are instantiated (vom Brocke et al., 2020). Therefore, this paper highlights the need for research to be conducted using the DSR methodology with a view to develop and evaluate blockchain prototypes that address SCM challenges.

Classification of Articles Based on the Supply Chain Management Niche Category

The sector category (4) was used to classify articles based on their niche in the SCM sector. Figure 9 shows that most of the selected articles (68%) can be classified as general SCM (that is, without emphasis on a particular sector). The remainder of the selected articles were classified as follows: agriculture SCM (11%), food SCM (10%), humanitarian SCM (6%), operations and SCM (4%), and pharmaceutical SCM (2%). The interest in the use of blockchain technology in the food and agricultural SCM sectors is not surprising as blockchain technology has the potential to establish a shared, secure record of information flow, and thus reduce food safety risks and increase consumers' trust in food products (Longo et al., 2020). Conversely, an opportunity exists to investigate the potential use of blockchain in the pharmaceutical SCM niche because this area is currently understudied.

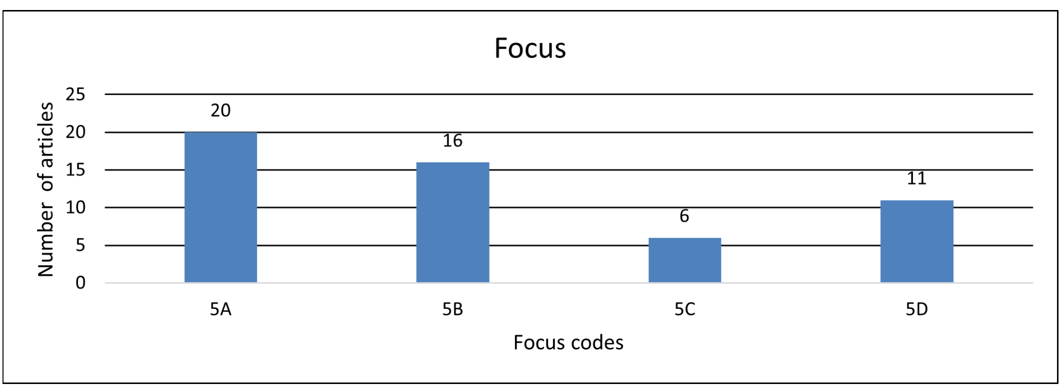
Figure 9. Classification by supply chain management category



Classification of Articles by Focus Category

As shown in Figure 10, this study was focused on: the use (trends) of blockchain to enhance the SCM processes (5A), the challenges related to adopting blockchain to enhance the SCM processes (5B), the proposed solutions to the challenges (5C), and the existing gaps in the adoption of blockchain to enhance the SCM processes (5D). Twenty (38%) of the selected articles reported on the current trends (5A) while sixteen articles (30%) discussed the challenges of the adoption of blockchain in SCM (5B). Of the articles that were selected, only six articles (11%) identified the proposed solutions (5C), and eleven articles (21%) identified gaps that exist in the literature (5D). This shows that, although most articles explored current trends within the SCM, there is limited research on proposed blockchain solutions (Queiroz, et al., 2019).

Figure 10. Classification by focus



Current Trends

Twenty articles (39% of the selected papers) portrayed the current trends in the use of blockchain to enhance the SCM processes. Appendix 2 and Table 7 classify the current trends into the themes that are covered in the selected articles such as agri-food traceability (5AA), smart contracts (5AB), IoT (5AC), and blockchain security (5AD).

Table 7. Results analysis based on the current trends (RQ1)

Code	Current trend's themes	Number of articles
5AA	Agri-food traceability	8 (15%)
5AB	Smart contracts	6 (11%)
5AC	Blockchain and Internet of Things (IoT)	4 (8%)
5AD	Blockchain Security	2 (4%)

Source: Developed by the authors

Agri-food traceability was prominently noticeable in offering the best application of blockchain in SCM. Agri-food traceability involves tracing agricultural products from source to consumer in SCM. Traceability enables better management of behavioural uncertainty among agricultural agents and the storage of transactions from-farm-to-fork. Overall, blockchain in agri-food SCM increases the quality and safety of food, enables distributed data sharing, and prevents data tampering. There is no doubt that data tampering prevention contributes to solving trust and transparency challenges Agri-food SCM.

Smart contracts facilitate the exchange of money, assets, or any valuable item in a seamless, conflict-free manner while minimizing the need for the services of intermediaries such as a financial institution, lawyer, or notary in the blockchain network (Sadiku & Musa, 2018). Smart contracts are a blockchain security feature that enables stakeholder customization. Smart contracts are automated actions that are based on scenarios developed or chosen during the overall exchange process, and they enable supplier customization thus resulting in higher levels of trust among all SCM stakeholders. Smart contracts can also automate shipping SCM processes, reduce paperwork, and increase competitiveness in the shipping industry. Although smart contracts have significant positive effects on partnership growth, they have marginal effects on partnership efficiency. Only information transparency and smart contracts (and not information immutability) have been reported to positively affect partnership efficiency (Kim and Shin, 2019). This indicates that smart contracts can improve overall SCM efficiency by providing trust and veracity, critical to the supply chain industry's future competitiveness.

The IoT is enabled by the two main pillars, namely radio frequency identification (RFID) and wireless sensor networks (WSNs). While RFID systems can identify and track devices, WSNs work together to collect and transmit data from interconnected sensors (Landaluce et al., 2020). Although IoT has recently been widely used to track goods in the SCM, however, there are security and data tampering limitations that still exist. Duan et al. (2020) proposed merging blockchain with the IoT to achieve better efficiency in the SCM processes. Smart contracts nonetheless provide the security needed for IoT implementation by enabling accountability, traceability, and liability for asset handling by the different stakeholders in SCM.

Blockchain security appears to be the least investigated aspect of blockchain in SCM. However, certain blockchain features such as the single private key were less secure. Nonetheless, some secure data sharing methodologies such as Enigma and Hawk overcome the single private key weakness. When ensured, blockchain security provides trust, secure authentication, privacy, and transparency.

Challenges With Blockchain Adoption In SCM

Sixteen (30%) of the selected articles reported the challenges that hinder the adoption of blockchain in SCM. Table 8 depicts the identified challenges that come with the adoption of blockchain in the SCM.

Table 8. Results on the analysis of the challenges of the adoption of blockchain to enhance the SCM Processes (RQ2)

Code	Challenges	Articles
5BA	Lack of blockchain awareness in SCM	5 (9%)
5BB	Lack of government rules, regulations, and legislation for blockchain	4 (8%)
5BC	Complexity of blockchain usage	3 (6%)
5BD	Scarcity of literature or publications in SCM and blockchain adoption	3 (6%)
5BE	Organisational barriers	1 (2%)

Source: Developed by the authors

There appears to be limited awareness about blockchain in SCM. Further, top-level management do not consider it as part of their strategic vision. Furthermore, cultural differences among SCM partners on the adoption of blockchain appears to be prevalent. Complex technologies such as blockchain require top-level management support and organisational readiness. Other than seeking to change the purchasing habits of consumers, consumer awareness and empowerment are also important factors in the adoption of blockchain technology. Organisational readiness and regulation were found to be the least explored factors, and these should be drastically altered for blockchain to have a broader reach and coverage.

Overall, there is a lack of government regulations, legislation, and global standard on blockchain. Suppliers in the food SCM are unable to share data or work together without uniform standards thus leading to a hinderance in the adoption of blockchain to enhance SCM processes. There is therefore a consequential lack of trust by SCM stakeholders to use blockchain.

The complexity of blockchain usage is a significant barrier to blockchain adoption in the SCM. The complexity arises from complex inter-organisational, intra-organisational, technical, and external processes. Intra-organisational processes arise from the organisation's internal activities and they require the support of top-level management for successful implementation of SCM practices. Some managers lack the long-term commitment needed to adopt new technology such as blockchain. The

inter-organisational barriers relate to a lack of solid rules for information sharing amongst SCM partners. The system-related barriers identified include new ICT tools required to implement blockchain technology and collect data for SCM. The external barriers category includes problems presented by external stakeholders, industries, institutions, and governments. The absence of suitable governmental and industry policy was also identified as a barrier to developing advanced technology-supporting mechanisms.

Owing to the scarcity of scholarly literature on blockchain adoption and SCM, blockchain technology has not been investigated sufficiently. This opens more opportunities for academics and SCM practitioners to conduct more research in this field.

Proposed Solutions to Improve the Adoption of Blockchain in SCM

Table 9 lists six (11%) of the analysed articles that propose solutions for improving the adoption of blockchain in SCM.

Table 9. Results analysis of solutions (RQ3)

Code	Solutions	No. of articles
5CA	Raising blockchain awareness to SCM stakeholders	3 (6%)
5CB	Government rules, regulations, and legislation	2 (4%)
5CC	Identification of blockchain visionary	1 (2%)

Source: Developed by the authors

The solution to this challenge was increasing collaboration, communication, and coordination in SCM, creating the requisite government regulations and legislation as well as industry standards. Whereas blockchain technologies are mature with respect to financial technology (FinTech) and cryptocurrencies, they are still in their infancy in relation of SCM. Thus, in addition to technical issues and challenges, future discussions should focus on the legislation and policies required for the integration of blockchain technologies in a fragile and sensitive sector such as agriculture.

An SCM technology champion who assists in removing the barriers to digital transformation was recommended for each organisation. Such a champion should be familiar with SCM operations, features and trends, and envision strategies for transforming SCM processes.

The Gaps on the Adoption of Blockchain in SCM

The gaps on the adoption of blockchain in SCM identified in eleven (21%) of the selected papers are listed in Table 10.

Table 10. Gap analysis results (RQ4)

Code	Existing gaps	Number of Articles
5DA	Lack of studies/publications in blockchain adoption and SCM	4 (8%)
5DB	Lack of blockchain artefacts solving SCM challenges.	3 (6%)
5DC	Lack of interoperability within blockchain systems	2 (4%)
5DD	No legal blockchain framework	1 (2%)
5DE	Lack of blockchain awareness in SCM environments	1 (2%)

Source: Developed by the authors

The lack of publications in blockchain adoption and SCM stood out as a most important challenge followed by a lack of blockchain artefacts solving SCM challenges. Lack of interoperability within blockchain systems has also not been addressed.

Even though the blockchain is still in its infancy, researchers are beginning to recognize its potential in SCM and other sectors. However, blockchain remains in the conceptualisation and exploratory phases. According to Wang et al. (2019), practical blockchain implementation is still in the early stages and no evidence of widespread adoption in the area of SCM has been observed. This shows that there is still a shortage of studies that have developed and tested blockchain artefacts in a real environment. Queiroz et al. (2019) revealed that there is a scarcity of blockchain framework developed in the SCM.

Interoperability is the ability to see and access data across multiple blockchain systems. Although blockchain adoption is growing, current blockchain solutions are developed in silos, a barrier to widespread adoption. Blockchain systems must be able to communicate in the same language and incorporate and share common capabilities and feature sets related to consensus models, transaction, and contract functionalities.

A lack of awareness and understanding of blockchain technology is a challenge for its adoption, particularly in small and medium-sized organisations. Many businesses lack general awareness of blockchain technology and its capability. Therefore, this creates a barrier for organisations to adopt blockchain technology to use it to improve the organisation's bottom line.

IMPLICATIONS

The findings reveal that agri-food traceability, blockchain security, smart contracts, and the IoT were the identified current trends in the adoption of blockchain in SCM. Blockchain, IoT, and artificial intelligence (AI) are remarkable emerging technologies expected to change the world in the coming decades (Singh & Singh, 2020). It is argued that agriculture SCM systems are critical for getting food products delivered from farmers to the consumers. Tracking and tracing in the food SCM is therefore key for food producers, logistics providers, and retailers (Li et al., 2017). Traceability has been identified as a potential blockchain feature for providing practical solutions in many sectors such as the agri-food sector, operations, and global SCM. Therefore, this paper argues that challenges such as fraud, and counterfeit drugs can be also tackled through blockchain traceability. However, the literature shows that many current existing blockchain solutions are conceptual frameworks that lack real environment evaluation. Therefore, for blockchain to be widely adopted in the SCM sector, the testing and evaluation of blockchain artifacts in a real environment is necessary. Based on this paper's results, it can be observed that research projects based on blockchain adoption and SCM are still in the early stages of development. The literature shows that there is a limited number of peer-reviewed publications in developing countries such as South Africa. Based on the gaps identified in this paper, it is argued that researchers, scholars and SCM practitioners should consider conducting more studies that portray the nexus between blockchain adoption and addressing SCM challenges such as traceability, transparency, fraud, product recalls, and counterfeit products, particularly from the perspectives of the developing countries.

From the standpoint of SCM, blockchain is still in its infancy, and its full potential remains unclear. As a result, the primary goal of this systematic review paper was to assist SCM scholars and practitioners in investigating the role of blockchain in creating value for SCM. This study sought to elucidate and gain a thorough understanding of how blockchain can be integrated into SCM and improve SCM processes. It was established that previous blockchain research had primarily focused on smart contracts, security, and the IoT.

IMPLICATIONS FOR RESEARCH

From an academic perspective, this paper offers information to researchers interested in the topic of blockchain adoption and SCM. The findings for this study indicate that most published papers focused on the developed countries with very little work on blockchain and SCM being conducted in developing countries. Therefore, a need exists to conduct research on blockchain and SCM that relates to developing countries. There is a lack of blockchain artefacts developed to address SCM challenges. In addition, not much work has been undertaken in developing theories and frameworks that can accelerate blockchain adoption in the field of SCM. Furthermore, a gap was identified in the methodologies employed by the papers used in this study. None of the selected papers adopted a Design Science Research (DSR) method to develop blockchain solutions for the SCM industry. In conclusion, an opportunity exists for the researchers to conduct studies in the context of blockchain adoption for the SCM by adopting different methodologies such as DSR to develop blockchain artefacts that meet SCM requirements and develop frameworks for the adoption of blockchain in the SCM.

IMPLICATIONS FOR PRACTICE

The findings of this research study have implications for SCM practitioners, executive management, decision-makers, and all stakeholders involved in blockchain adoption for SCM processes. Lack of studies addressing blockchain adoption in SCM, lack of blockchain awareness by SCM stakeholders, and lack of blockchain infrastructure pose serious challenges for developing countries to adopt blockchain for SCM. These challenges imply that there is a need for executive management of the SCM industry to train their staff members about the benefits of blockchain adoption in SCM. For blockchain to be widely adopted in SCM, executive management must develop strategies to improve blockchain awareness in the SCM sector. Moreover, executive management can increase their blockchain awareness and skill by attending conferences on the blockchain.

Trust also has a significant implication on SCM. For supply chain transactions, trust means an actor involved in a transaction must trust another actor for a successful transaction to take place. Blockchain enables a transparent flow of information, allowing stakeholders to develop confidence in the information shared on the SCM network. This implies that SCM professionals can rely on blockchain for trust; however, managers should monitor SCM processes to detect abnormal behaviours that can affect trust amongst stakeholders.

CONCLUSION

The main aim of this paper was to conduct a systematic literature review on the studies related to blockchain adoption in SCM. This study employed the PRISMA guidelines to systematically retrieve related articles and the coding classification framework to categorize and analyse the selected articles. The screening process used in this study produced 53 articles that were analysed to address the study's research questions.

The findings revealed that agri-food traceability, blockchain security, smart contracts, and blockchain and IoT were the identified trends. The barriers to blockchain adoption include high costs of transactions incurred by the third party, lack of trust between stakeholders, and scarcity of literature related to blockchain adoption and SCM. The key gaps identified in this paper and the associated opportunities and challenges, are summarized in Table 11. The solutions that were identified in this paper were blockchain traceability systems and the use of smart contracts and IoT.

Table 11. Key gaps, opportunities, and challenges

Key gaps	Opportunities	Challenges
Lack of published studies reporting on blockchain adoption in SCM	Investigate challenges associated with blockchain adoption in the SCM and identify the main strategies used to overcome these challenges	Not much is known about blockchain and SCM, particularly in developing countries due to the lack of published studies
Empirical studies reporting on challenges experienced by managers, practitioners, and CEOs in the SCM	Conduct analysis of qualitative studies to identify challenges faced by managers and practitioners in the SCM	Collecting data from managers and practitioners in the SCM
Lack of blockchain artefacts solving SCM challenges	Investigate existing artefacts and develop a new blockchain artefact that meets SCM requirements	Develop and evaluate a working artefact that solves SCM challenges
Lack of blockchain adoption frameworks for SCM	Develop and propose a blockchain framework for SCM	Align the objectives of the framework with the objectives of the SCM stakeholders.

Source: Developed by the authors

LIMITATIONS AND FUTURE RESEARCH

This research is subject to some limitations. One of the limitations relates to the search string used to screen the articles, and the chosen databases used to retrieve the articles. The study recognizes that important articles might have been missed out because they were not found on the selected databases. The second limitation is the period of the screened articles of five (5) years. It is acknowledged that there could have been other articles that were published outside this window period of 2017 – 2021, which were not included in this study. Nevertheless, the selected articles were relevant to this study. Therefore, it is proposed that future studies could expand on the search criteria and include more databases to further advance the discourse on the role that blockchain could play in addressing SCM challenges.

SCM processes are complex, however, future work should address several challenges such as exploring the most important guiding principles for blockchain adoption in different types of businesses. New possibilities opened by using smart contracts in SCM needs further examination. Therefore, blockchain advances should be closely monitored in the future studies. An investigation of the key implementation issues and the identification of the primary techniques employed by organisations to overcome SCM and blockchain adoption challenges need to be considered for future research. Future discussions must also focus on legislation and policies required for the integration of blockchain technologies into the SCM sector. Moreover, addressing SCM challenges through blockchain technology would require building blockchain prototypes that are geared towards the evaluation of blockchain technology under real conditions. Therefore, in conclusion, future work should look at:

- How can data security for information sharing be improved in SCM?
- How can blockchain artefacts be developed and tested?
- How can blockchain technology and artificial intelligence be combined to solve global SCM challenges?
- How can blockchain be used to improve counterfeit drug traceability in both global and local supply chains?

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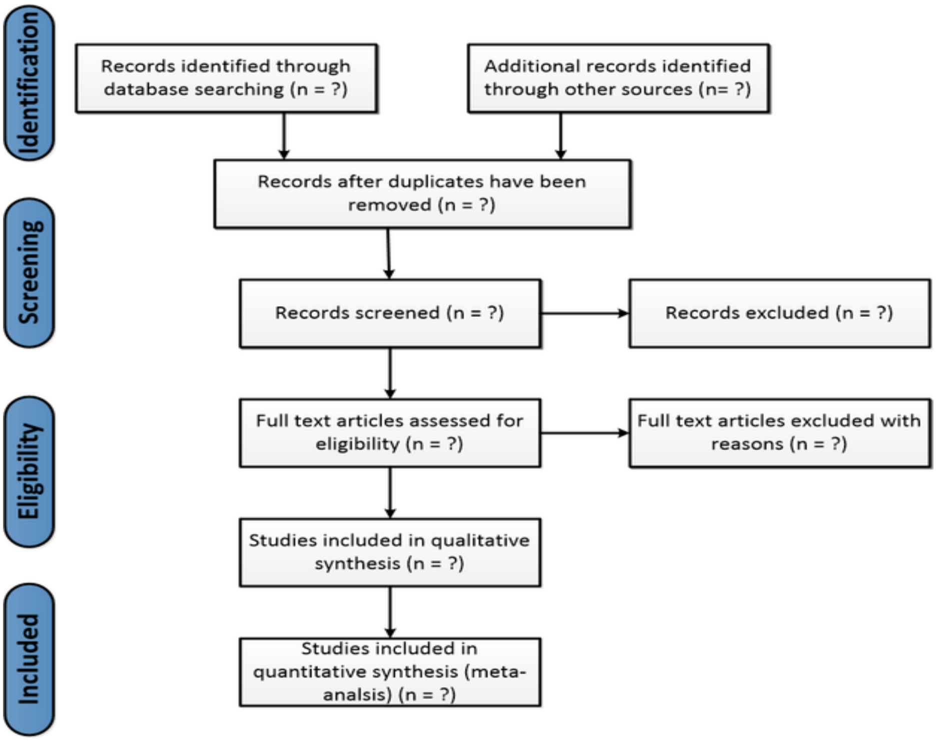
APPENDIX A

FIGURE 11 Prisma FLOW DIAGRAM



APPENDIX B

TABLE 12 ARTICLES USED IN THE SYSTEMATIC REVIEW.)

#	Publication channel	Author(s)	Source of Publication	Application	Year
#1	Symposium	(Bechtsis, Tsolakis, Bizakis, & Vlachos, 2019)	Computer-Aided Process Engineering	Food supply chain	2019
#2	Journal	(Duan, Zhang, Gong, Brown, & Li, 2020)	Environmental Research and public health	Food supply chain	2020
#3	Journal	(Kamble, Gunasekaran, Kumar, Belhadi, & Foropon, 2021)	Technological Forecasting & Social Change	Supply chain management	2021
#4	Journal	(Ghode J. J., Yadav, Jain, & Soni, 2020)	Enterprise Information Management	Supply chain management	2020
#5	Review	(Dubovitskaya, Novotny, Xu, & Wang, 2020)	Oncology and Informatics	Pharmaceutical supply chain	2020
#6	Conference	(Maouriyan & Krishna, 2019)	Computing and Communication Technologies	Supply chain management	2019
#7	Journal	(Bag, Viktorovich, Sahu, & Sahu, 2020)	Global Operations and Strategic Sourcing	Supply chain management	2020

Table 12 continued on next page

Table 12 continued

#	Publication channel	Author(s)	Source of Publication	Application	Year
#8	Journal	(Surjandy, Meyliana, Hidayanto, & Prabowo, 2019)	ICIC Express Letters	Supply chain management	2019
#9	Journal	(Di Francesco Maesa & Mori, 2020)	Parallel and Distributed Computing	Supply chain management	2020
#10	Journal	(Queiroz & Fosso Wamba, 2019)	Information Management	Supply chain management	2019
#11	Journal	(Queiroz, Fosso Wamba, De Bourmont, & Telles, 2020)	Journal of Production Research	Operations and supply chain management	2020
#12	Journal	(Ghode D., Yadav, Jain, & Soni, 2020)	Journal of Manufacturing Technology Management	Supply chain management	2020
#13	Journal	(Wang, Wu, Chen, & Evans, 2021)	Operations & Supply Chain Management an International Journal	Supply chain management	2021
#14	Journal	(Queiroz, Telles, & Bonill, 2019)	Supply Chain Management: An International Journal	Supply chain management	2019
#15	Journal	(Durach, Blesik, von During, & Bick, 2020)	Journal of Business Logistics	Supply chain management	2020
#16	Conference	(Gonczol, Katsikouli, & Hersk, 2020)	IEEE Access	Supply chain management	2020
#17	Journal	(Demestichas, Peppes, Alexakis, & Adamopoulou, 2020)	Applied sciences	Agricultural Supply chain management	2020
#18	Journal	(Yadav, Singh, Rautb, & Govindarajan, 2020)	Resources, Conservation & Recycling	Agricultural supply chain	2020
#19	Journal	(Breese, Park, & Vaidyanathan, 2019)	Information Systems	Supply chain management	2019
#20	Journal	(Saurabh & Dey, 2020)	Journal of Cleaner Production	Agri-food supply chains	2020
#21	Journal	(Saberi, Kouhizadeh, Sarkis, & Shen, 2019)	International Journal of Production Research	Supply chain management	2019
#22	Journal	(Kouhizadeh, Saberi, & Sarkis, 2020)	International Journal of Production Economics	Supply chain management	2020
#23	Journal	(Cole, Stevenson, & Aitken, 2019)	Supply Chain Management: An International Journal	Operations and supply chain management	2019
#24	Journal	(Dutta, Choi, Somani, & Butala, 2020)	Transportation Research Part E	Supply chain operations	2020
#25	Journal	(Alazab, Alhyari, Awajan, & Abdallah, 2021)	Cluster Computing	Supply chain management	2021
#26	Journal	(Wang, et al., 2020)	Automation in Construction	Supply chain management	2020
#27	Conference	(Caro, Ali, Vecchio, & Giaffreda, 2018)	IoT Vertical and Topical Summit on Agriculture	Agri-food supply chain management	2018
#28	Conference	(Jabbar, Lloyd, Hammoudeh, Adebisi, & Raza, 2020)	Multimedia Systems	Supply chain management	2020
#29	Journal	(Sheel & Nath, 2019)	Blockchain technology adoption	Supply chain management	2019
#30	Journal	(Longo, Nicoletti, & Padovano, 2020)	International Journal of Food Engineering	Food processing and supply chain	2020
#31	Journal	(Sahebi, Masoomi, & Ghorbani, 2020)	Technology in Society	Humanitarian supply chain	2020
#32	Journal	(Stranieri, Riccardi, Meuwissen, & Soregaroli, 2021)	Food Control	Agri-food supply chains	2021
#33	Journal	(Choi, Chung, Seyha, & Young, 2020)	Sustainability	Supply chain management	2020
#34	Conference	(Coronado Mondragon, Coronado Mondragon, & Coronado, 2020)	Industrial Engineering and Applications	Supply chain management	2020
#35	Journal	(Farooque, Jain, Zhang, & Li, 2020)	Computers & Industrial Engineering	Supply chain management	2020
#36	Journal	(Shakhbulatov, Medina, Don, & Rojas-Cessa, 2020)	Journal of the Computer Society	Supply chain management	2020

Table 12 continued on next page

Table 12 continued

#	Publication channel	Author(s)	Source of Publication	Application	Year
#37	Conference	(Tipmontian, Alcover, & Rajmohan, 2020)	Innovation Aviation & Aerospace Industry	Food supply chain management	2020
#38	Conference	(Arumugam, et al., 2018)	Logistics, Informatics and Service Sciences	Supply chain management	2018
#39	Journal	(Kumar, Liu, & Shan, 2020)	Journal of Decision Sciences Institute	Supply chain management	2020
#40	Conference	(Baharmand & Comes, 2019)	International Federation of Automatic Control	Humanitarian supply chain	2019
#41	Journal	(Kamble, Gunasekaran, & Sharma, 2020)	Journal of Information Management	Agricultural supply chain	2020
#42	Journal	(Hepp, Sharinghousen, Ehret, Schoenhals, & Gipp, 2018)	Information Technology	Supply chain management	2018
#43	Journal	(Chod, Trichakis, & Tsoukalas, 2020)	Operations Research Center & Sloan School of Management	Supply chain management	2020
#44	Conference	(Chen, Liu, Yan, Hu, & Shi, 2020)	Information Systems and e-Business Management	Food supply chains	2020
#45	Journal	(Papathanasiou, Cole, & Murray, 2020)	European Management Journal	Supply chain management	2020
#46	Journal	(Kim & Shin, 2019)	Sustainability	Supply chain management	2020
#47	Conference	(Fosso Wamba, Queiroz, & Trinchera, 2020)	International Federation of Automatic Control	Supply chain management	2020
#48	Journal	(Francisco & Swanson, 2018)	Logistics	Supply chain management	2018
#49	Journal	(Wong, Leong, Hew, Tan, & Ooi, 2020)	International Journal of Information Management	Supply chain management	2020
#50	Journal	(Hartley & Sawaya, 2019)	Business Horizons	Supply chain management	2019
#51	Journal	(Hackius & Petersen, 2020)	IEEE Access	Supply chain management	2020
#52	Journal	(van Hoek, 2019)	Supply Chain Management: An International Journal	Supply chain management	2019
#53	Journal	(Chang & Chen, 2020)	IEEE Access	Supply chain management	2020

Source: Developed by the authors

APPENDIX C

TABLE 13 IDENTIFIED TRENDS FOR RQ1)

#	Author	Code	Smart Contract	Internet of Things (IoT)	Agri-food traceability	Security
# 1	Bechtsis et al. (2019)	5A			X	
# 2	Duan et al. (2020)	5A	X			
# 6	Maouriyan and Krishna (2019)	5A		X		
# 8	Surjandy et al. (2019)	5A		X		
# 15	Durach et al. (2020)	5A				X
# 17	Demestichas et al. (2020)	5A			X	
# 19	Breese et al. (2019)	5A	X			
# 20	Saurabh and Dey (2020)	5A			X	
# 24	Dutta et al. (2020)	5A			X	
# 27	Caro et al. (2018)	5A			X	
# 30	Longo et al. (2020)	5A		X		
# 32	Stranieri et al. (2021)	5A			X	
# 37	Tipmontian et al. (2020)	5A			X	
# 38	Arumugam et al. 2018)	5A	X			
# 40	Baharmand and Comes (2019)	5A	X			
# 41	Kamble et al. (2020)	5A			X	
# 42	Hepp et al. (2018)	5A				X
# 43	Chod et al. (2020)	5A				X
# 45	Papathanasiou et al. (2020)	5A	X			
# 56	Kim and Shin (2019)	5A	X			

Source: Developed by the authors

APPENDIX D

TABLE 14 IDENTIFIED CHALLENGES FOR RQ2)

#	Author	Code	Lack of awareness	Lack of government rules, regulations, and legislation	Complexity of blockchain usage	Scarcity of published literature in blockchain adoption	Organisational barriers.
#4	Ghode et al. (2020	5B		X			

Table 14 continued on next page

Table 14 continued

#	Author	Code	Lack of awareness	Lack of government rules, regulations, and legislation	Complexity of blockchain usage	Scarcity of published literature in blockchain adoption	Organisational barriers.
#5	Dubovitskaya et al. (2020)	5B		X			
#7	Bag et al. (2020)	5B	X				
#18	Yadav et al. (2020)	5B		X			
#24	Dutta et al. (2020)	5B	X				
#25	Alazab et al. (2021)	5B			X		
#31	Sahebi et al. (2020)	5B				X	
#33	Choi et al. (2020)	5B	X				
#35	Farooque et al. (2020)	5B	X				
#41	Kamble et al. (2020)	5B	X				
#44	Chen et al. (2020)	5B		X			
#49	Wong et al. (2020)	5B				X	
#47	Fosso Wamba et al. (2020)	5B				X	
#51	Hackius and Petersen (2020)	5B					X
#52	van Hoek (2019)	5B	X				

Source: Developed by the authors

APPENDIX E

TABLE 15 IDENTIFIED SOLUTIONS FOR RQ3)

#	Author	Code	Blockchain awareness	Government rules, regulations, and legislation	Blockchain visionary
#17	Demestichas et al. (2020)	5C		X	
#21	Saberi et al. (2019)	5C	X		
#35	Farooque et al. (2020)	5C	X		
#39	Kumar et al. (2019)	5C	X		
#50	Hartley and Sawaya (2019)	5C			X

Source: Developed by the authors

#	Author	Code	Lack of studies	Blockchain artefacts	Lack of interoperability	No legal framework	Lack of blockchain awareness
#11	Queiroz et al. (2020)	5D		X			
#13	Wang et al. (2021)	5D		X			
#14	Queiroz et al. (2019)	5D	X				
#16	Gonczol et al. (2020)	5D			X		
#23	Cole et al. (2019)	5D	X				
#28	Jabbar et al. (2020)	5D			X		
#29	Sheel and Nath (2019)	5D				X	
#47	Fosso Wamba et al. (2020)	5D	X				
#52	van Hoek (2019)	5D	X				
#53	Chang and Chen (2020)	5D					X

Source: Developed by the authors

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