Journal of Transport and Supply Chain Management
ISSN: (Online) 1995-5235, (Print) 2310-8789

Blockchain in the logistics sector: A systematic literature review of benefits and constraints

Authors:
Mandla Mvubu[1]
Micheline J. Naude[1]

Affiliations:
[1]School of Management, IT and Governance, Faculty of Law and Management Studies, University of KwaZulu-Natal, Pietermaritzburg, South Africa

Corresponding author:
Mandla Mvubu,
mvubum@ukzn.ac.za

Dates:
Received: 02 July 2024
Accepted: 19 July 2024
Published: 04 Sept. 2024

How to cite this article:
Mvubu, M. & Naude, M.J., 2024, 'Blockchain in the logistics sector: A systematic literature review of benefits and constraints', *Journal of Transport and Supply Chain Management* 18(1), a1068. https://doi.org/10.4102/jtscm.v18i1.1068

Background: Blockchain technology is recognised in logistics and supply chain research for its ability to enhance transparency and traceability, offering real-time tracking and authentication of goods. However, constraints persist in the implementation of blockchain technology (BCT) in the logistics industry.

Objectives: The purpose of this article is to provide insight into the benefits of BCT and the constraints hindering the logistics industry from implementing it.

Method: Data were collected through a systematic literature review. The study followed the six steps of the PRISMA framework. A total of 56 journal articles published between 2018 and 2024 were included in the study.

Results: The findings reveal seven constraints that hinder the implementation of BCT in the logistics industry. These include the following: organisational constraints; technological constraints; environmental constraints; implementation risks and costs; interoperability; supply chain fragmentation; and data issues. In addition, we highlight how the implementation of BCT could benefit the logistics industry.

Conclusion: While the logistics industry faces many constraints in blockchain implementation, this technology is a digital solution for improved communication and collaboration with suppliers in the industry.

Contribution: In addition to filling a gap in existing literature, this article serves as a valuable resource for driving BCT implementation in the logistics industry. The practical strategies presented for overcoming the identified barriers can assist stakeholders and policymakers in the adoption of BCT.

Keywords: blockchain technology; constraints; benefits; logistics industry; systematic literature review.

Introduction

Background

The Fourth Industrial Revolution (4IR) introduced various advanced technologies, enabling industries to adapt their business models. Many companies have adopted the use of emerging technologies like blockchain technology (BCT) in business-to-business (B2B) operations in an attempt to meet their organisational goals by integrating their supply chains with digital transformation (Zhang & Liu 2022). Blockchain technology has garnered significant global attention as a unique and disruptive technology of the 21st century (Marengo & Pagano 2023).

Logistics involves transporting goods from a starting point to a destination, covering services such as distribution, payment, insurance, border clearance, freight handling, and warehousing (Ahmad et al. 2021). An efficient logistics system ensures the smooth flow of information and items across different phases, expediting processes, and satisfying client needs (De Villiers, Nieman & Niemann 2017). Logistics drives competitiveness, economic growth, and export success. Inefficiencies in the logistics network can create an unfavourable business climate, hindering growth and investment while increasing trade times and costs (Ahmad et al. 2021; UNCTAD 2022).

Logistics is vital in the modern world, contributing approximately 90% of trade through international shipping yearly (UNCTAD 2022). However, logistics has become increasingly complex, facing numerous constraints such as poor communication and a lack of visibility, leading to inefficiencies in meeting customer expectations. Logistics companies that have successfully implemented BCT report improved communication and collaboration among stakeholders (Aylak 2022).

Several studies have focused on the use of BCT in the logistics industry. A 2018 World Economic Forum survey found that 10% of multinational corporations are currently implementing BCT, with another 60% planning to do so within the next 3 years (WEF 2018). Deloitte (2020) reports that 74% of logistics and transportation organisations believe BCT will positively impact their business in the next 3 years. Despite its advantages and the growing interest of industry, BCT still faces several constraints on implementation in the logistics industry. These include the absence of standards, the need for scalable solutions, and concerns about data security and privacy. Furthermore, more research is needed to determine the practical applications of BCT in logistics and to develop industry-specific regulations (Aylak 2022). Therefore, the aim of this study is to identify the benefits and constraints of BCT implementation in the logistics industry.

Problem statement

The logistics industry faces constraints because of inefficient practices, such as cyberattacks and theft, which erode trust between stakeholders. In addition, the industry struggles with complexity, tracking, and visibility issues. Thus, BCT development is required to improve processes and make them sustainable (Zhang & Liu 2022). This need is urgent in view of the global expansion of the logistics industry. While BCT has been promoted as a solution for various business constraints, its implementation has seen mixed success among logistics companies. Constraints on BCT implementation persist in both the private and public sectors, leading to hesitancy among organisations to implement BCT (Yontar 2023). Companies that have implemented BCT have encountered both positive and negative impacts, including, on the one hand, increased trust and transparency, and on the other, high implementation costs. Numerous studies have highlighted the constraints, barriers, and opportunities of BCT implementation. However, there has been limited research on the factors enabling BCT implementation in logistics and its contribution to industry performance. Because of limited information in this regard, decision-makers in the logistics industry remain doubtful about BCT's benefits, hindering its adoption and utilisation (Noor 2022).

The aim of the paper is to report on the findings of a systematic literature review (SLR) on the benefits of BCT and the constraints hindering the logistics industry from implementing it. Table 1 provides an overview of relevant existing studies conducted between 2018 and 2022.

The studies presented in Table 1 provide valuable early insights into the initial stages of blockchain implementation in logistics and the constraints and benefits identified at that time. However, by 2024, the technology landscape surrounding blockchain implementation in logistics may have evolved significantly, with new constraints emerging and existing ones being addressed through technological advancements and industry initiatives. This article, therefore, is positioned to capture the current state of blockchain implementation in the logistics industry, offering a more up-to-date and comprehensive analysis of the constraints and opportunities associated with BCT implementation.

Moreover, the time difference allows our study to benefit from a larger pool of literature and the research conducted in the intervening years, providing a more robust foundation for its analysis. The inclusion of more recent studies and developments enables the SLR study to offer insights into the latest trends, best practices, and emerging technologies shaping blockchain implementation in logistics. As such, while the studies listed earlier in the text provide a valuable historical context, this article offers a more current and comprehensive understanding of the constraints and benefits of implementing BCT in the logistics industry.

TABLE 1: An overview of relevant existing studies.

Author(s) and year	Title of research	Focus area
Ambrozie and Sorcaru (2022)	Logistics in a green era, a blockchain-based framework	This research investigated the potential of blockchain in fostering green logistics and proposes a blockchain-based framework specifically tailored for achieving sustainability in logistics, thus addressing a specific aspect of blockchain implementation related to environmental concerns and sustainability.
Ahmad et al. (2021)	Blockchain applications and architectures for port operations and logistics management	This study focused on exploring the applications and architectural frameworks of blockchain specifically in port operations and logistics management, providing insights into a niche area of blockchain implementation within the logistics sector, which may have different dynamics and constraints compared to broader logistics operations.
Ar et al. (2020)	Evaluating the feasibility of blockchain in logistics operations: A decision framework	This study evaluated the feasibility of integrating blockchain in logistics operations through a decision framework, offering practical insights and guidelines for logistics managers considering blockchain implementation, and thus providing actionable strategies for implementation.
Berneis, Bartsch and Winkler (2021)	Applications of BCT in logistics and supply chain management -insights from a systematic literature review	This study employed a systematic literature review to identify various applications of blockchain in logistics and supply chain management, offering insights into the diverse range of use cases and potential applications of BCT within the logistics sector.
Britchenko, Cherniavska and Cherniavskyi (2018)	Blockchain technology into the logistics supply chain	The study delves into the advantages of integrating BCT into logistics supply.
Da Silva and Dos Santos (2022)	Study of blockchain application in the logistics industry	This research investigated specific applications of blockchain in the logistics industry, examining its benefits in enhancing traceability, security, and efficiency and thus providing practical insights into the operational aspects of blockchain implementation.
Karakas, Acar and Kucukaltan (2021)	Blockchain implementation in logistics and supply chain: A literature review and research agenda	A literature review was conducted to identify current research trends and agendas related to blockchain implementation in logistics and supply chain management.
Tijan et al. (2019)	Blockchain technology implementation in logistics	The study offers insights into the implementation of BCT in logistics.
Valdés Figueroa, Diaz and Pérez (2021)	Blockchain implementation opportunities and constraints in the Latin American and Caribbean logistics sector	This study examined the opportunities and constraints of implementing blockchain in the logistics sector of Latin American and Caribbean regions.

BCT, blockchain technology.

Literature review

Blockchain technology

Blockchain technology originated from its use with Bitcoin and has been rapidly innovating, transforming businesses by ensuring trust in transactions and data storage (Akram et al. 2020). Blockchain was designed by Satoshi Nakamoto in 2009 when he invented Bitcoin and cryptocurrency. It was designed to address transaction issues and bottleneck crises (AlShamsi, Al-Emran & Shaalan 2022).

Ar et al. (2020) emphasised the fact that BCT's designation as a distributed ledger technology highlights its ability to enable information sharing and storage within databases, protecting this information from unauthorised modifications and corruption. Distributed ledger technology involves sharing and recording data across distributed storage units, or ledgers, which collectively manage data flow and distribute it across a network of nodes (Ar et al. 2020). Blockchain technology includes various components that support shared ledgers among users, such as businesses, software agents, and individuals, allowing participants to reach agreements without a regulatory framework (Al-Jaroodi & Mohammed 2019).

The implementation of blockchain technology

The operation of BCT allows transactions to be transmitted globally and remain immutable, ensuring consistency (Da Silva & Dos Santos 2022). Heutger and Kückelhaus (2018) found that BCT employs private and public keys to maintain privacy and confidentiality. As BCT is decentralised, transactions are distributed among all participants at various nodes, requiring any data manipulation to occur at all nodes (Santhi & Muthuswamy 2022). Pournader et al. (2020) explain that nodes function as active clients, each maintaining a copy of the blockchain and adding data to it. Furthermore, BCT records transactions secured by cryptography, eliminating the need for third-party verification. Each transaction is considered a block, with each block having a unique ID to ensure security. A transaction is initiated and then transmitted to a peer-to-peer network using algorithms (Chinnasamy et al. 2019). These transactions are verified cryptographically, forming a block that is added to the blockchain, rendering it unalterable and permanent.

Characteristics of blockchain technology

Treiblmaier (2019), from a supply chain and logistics perspective, identifies key characteristics, including immutability, which ensures that interactions between servers remain unchanged, a property particularly beneficial in financial databases (Akram et al. 2020; Chinnasamy et al. 2019; Irannezhad 2020). Smart contracts, stored within the blockchain, activate upon meeting certain conditions, enforcing mutually agreed-upon rules and reducing delivery times and costs (Irannezhad). Track and traceability, which timestamp information, enhance the ability to efficiently track transactions and verify the authenticity of transferred goods (da Silva & dos Santos 2022). Trust is bolstered by cryptography, which secures data from alteration and enhances stakeholder confidence in BCT (Tan et al. 2020; Treiblmaier 2019). Transparency is achieved as BCT transactions are decentralised, allowing users to access and view transactions (Ahmad et al. 2021; Berneis et al. 2021). Lastly, the consensus mechanism, a fundamental feature of BCT, enables participants to reach agreements on transactions through a process of voting or consensus among nodes (Santhi & Muthuswami 2022).

Logistics industry

The logistics industry involves a broad spectrum of activities essential for the movement, storage, and flow of goods and materials from the point of origin to the final destination (Rustamovich 2024). It encompasses supply chain management, transportation, warehousing, inventory management, order fulfilment, and distribution (Kim & Jeong 2023). The industry is critical for the functioning of global trade and commerce, ensuring that raw materials reach manufacturers and finished products are delivered to consumers efficiently and effectively (Lan 2024).

As the 4IR ushers in an era of technological advancement, the logistics industry must transform to remain competitive and efficient (Negueroles et al. 2024). One of the key technologies driving this transformation is BCT. Blockchain technology can revolutionise the logistics sector by providing enhanced security, transparency, and traceability across the supply chain (Wang et al. 2022). With its decentralised ledger system, blockchain ensures that all transactions are recorded in a tamper-proof manner, reducing fraud and errors (Wang et al. 2022). This is particularly important in a complex and globalised supply chain where multiple parties are involved. By adopting blockchain, logistics companies can streamline operations, improve data accuracy, and enhance collaboration among stakeholders (Li, Lee & Gharehgozli 2024).

Blockchain technology in the logistics industry

Park (2020) and Treiblmaier (2019) indicate that the logistics industry is well-positioned for BCT implementation, which is expected to enhance efficiency by 40% and competitiveness by 35% through increased visibility, dependability, and financial viability within the supply chain ecosystem. However, widespread implementation in the logistics industry requires a collective effort. The decentralised and digital nature of the logistics sector is evolving, with BCT making asset tracking 50% more transparent and 30% more efficient throughout the logistics flow (Vijay, Suriyalakshmi & Elayaraja 2021; Wang et al. 2022). Santhi and Muthuswamy (2022) emphasise that BCT addresses inefficiencies in logistics by managing transaction records, creating a transparent system, and tracking assets to provide essential documentation.

Nguyen et al. (2023) argue that modern logistics systems necessitate advanced data exchange, financial transaction

technologies, and sophisticated hardware systems. Decentralised logistics systems offer financial transparency and robust supply chain networks, with BCT-based logistics using smart contracts to track payments from logistics providers for product delivery to warehouses, improving payment accuracy by 25% (Negueroles et al. 2024). These smart contracts, monitored via radio frequency identification (RFID) devices, enable enforceable agreements between logistics providers and merchants, with termination possible by mutual consent (Pournader et al. 2020). Wang et al. (2022) contrast smart contracts with traditional contracts, noting that BCT allows public review and validation of contract results. For instance, payments can be automated upon delivery confirmation, increasing efficiency by 20%, and real-time tracking with GPS can prompt refunds without recording the location on the blockchain, enhancing transparency by 15% (Negueroles et al. 2024; Nguyen et al. 2023; Santhi & Muthuswami 2022; Wang et al. 2022).

Methodology

A descriptive, narrative review method was deemed appropriate for this study. A descriptive review examines the nature of the literature concerning a particular research objective, concept, or area. It explains the context of the literature when the review is conducted. A narrative review, the most popular descriptive review type, is less costly and time-consuming than other review types (Yontar 2023).

The SLR method employed in this study is suited for research that strictly adheres to all systematic review guidelines (Wong et al. 2013). An SLR can be defined as 'a comprehensive, protocol-based review and synthesis of research focused on a chosen topic or defined research questions' (Wong et al. 2013). It comprises six generic systematic review steps (Paré et al. 2016). These steps are dealt with in turn further in the text.

Step 1: Review plan

Following Paré et al. (2016), the review plan includes: (1) creating a review question, (2) choosing the review type and method, and (3) formulating a review protocol.

Review question: The main review question of this study is as follows: 'What are the benefits of BCT and what are the constraints hindering the logistics industry from implementing it?'

Type and method of review: A theory-building or developmental type of review was used to create a typology of constraints hindering the logistics industry in the implementation of BCT.

Review protocol: A review protocol is a detailed outline of the processes for conducting the review, enhancing the trustworthiness of findings. It includes developing a research question, guiding the data used in the search strategy, and setting inclusion and exclusion criteria. After crafting a focused question and review aim, the next stage is designing the search strategy, which is crucial for locating, choosing, analysing, and utilising information. Creating search terms and keywords involves examining key research to determine common words in the literature and ensuring search terms are aligned with the study's purpose. The review protocol also includes developing criteria for inclusion and exclusion, data extraction, and data analysis methods, ensuring consistency and minimising data ambiguity.

Step 2: Search strategy

Initially, publications were searched, sorted, acquired, and read. New keywords and concepts emerged by means of thorough reading, ensuring the focused relevance of the existing literature. The preliminary search consolidated relevant academic articles to meet research objectives, targeting peer-reviewed journals such as *Information Systems Research*, the *Journal of Management Information Systems*, *MIS Quarterly*, and the *Journal of the Association for Information Systems*. Search terms used included titles, abstracts, and keywords: ('Blockchain' or 'Logistics') and ('Constraints' or 'Benefits' or 'Logistics industry' or 'Logistics management'). Because of the evolving nature of the technology, the search focused on academic journal articles and conference papers from 2018 to 2024.

The SLR was conducted in databases like Science Direct, Research Gate, Scopus, Taylor & Francis, IEEE Xplore, and Google Scholar, focusing on relevant academic articles published between 2018 and 2024.

Step 3: Determination of inclusion and exclusion criteria

Inclusion and exclusion criteria set limits for the review, determining which research papers are relevant to the study (Stern, Jordan & McArthur 2014). These criteria help mitigate reviewer bias and ensure that studies are included based on substantiated principles rather than on personal interest. A balance between too-specific and too-broad criteria is essential to avoid excluding relevant studies or including irrelevant ones. Table 2 provides the inclusion criteria for this review.

TABLE 2: Inclusion and exclusion criteria.

Criteria	Justification
Academic papers published during the timeframe spanning from 2018 to 2024	To ensure a focus on current practices and perspectives, studies preceding 2018 were omitted from the review, reflecting the swift evolution of blockchain technologies among logistics as evidenced by a surge in research on blockchain implementation in this field.
Research articles investigating the constraints in the implementation of blockchain technologies among the logistics industry	The constraints in implementing blockchain technologies had to pertain directly to logistics and served as the central focus of the study. Studies addressing blockchain technologies implementation in industries other than logistics were excluded as they diverged from the research objectives.
Research investigating logistics processes affected by blockchain implementation	The review exclusively incorporated studies that centred on various logistics processes affected by the implementation of blockchain technologies. Studies investigating supply chain function beyond logistics were omitted.
Studies written in English	The systematic literature review comprised solely research studies published in English, as limited resources prohibited the translation and inclusion of studies in other languages.

The SLR included journal articles that pertained to or provided insights into: (1) blockchain technologies, (2) constraints in the implementation of blockchain technologies in the logistics industry, (3) the logistics processes influenced by the implementation of blockchain technologies, or (4) a combination of these aspects. For this article, the authors reviewed all article topics and abstracts; if abstracts were unavailable, the introduction was read. Articles not relevant to these four points were excluded from the review.

Step 4: The critical evaluation

For critical evaluation, the Critical Appraisal Skills Programme (CASP) qualitative checklist was used to assess research rigour and potential methodological issues affecting the validity and quality of findings. The CASP appraisal tool addressed key aspects such as the validity of the research findings, the relevance of the study, and ethical considerations through the following set of 10 questions:

- Were the research objectives clearly defined?
- Was the qualitative approach suitable for this study?
- Was the chosen research design justified by the researcher?
- Was the recruitment strategy appropriate for participant selection?
- Was the data-collection strategy justified in addressing the research problem?
- Was there consideration given to the researcher-participant relationship?
- Were ethical considerations considered by the researcher?
- Were the data analysed sufficiently?
- Are the research findings appropriately presented and discussed?
- Does the research offer meaningful contributions? (CASP International Network 2013)

Step 5: Data extraction

During data extraction, a clear framework was established within the review protocol to guide the extraction process. The authors utilised an extraction tool based on the main theme of the implementation of blockchain technologies in the logistics industry. This tool focuses on extracting information related to descriptions and characteristics of blockchain technologies, blockchain's relationship with the logistics industry, types of blockchain technologies' implementation constraints, and insights on enhancing blockchain implementation in the logistics industry. Articles meeting the inclusion criteria were carefully reviewed to ensure relevance to the study.

Step 6: Analysis and synthesis

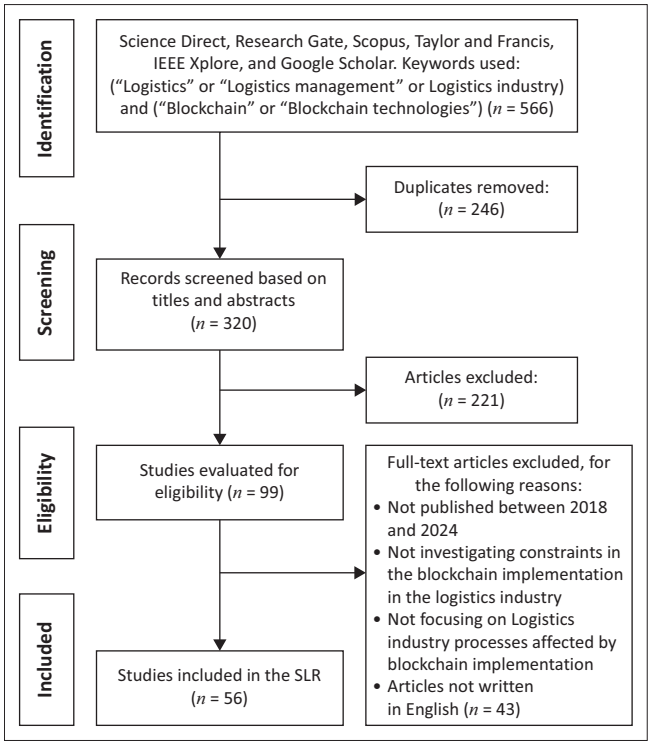
Data analysis requires becoming acquainted with the data (as outlined in steps 3 to 5), which involves categorising and summarising them before analysis. Thematic content analysis was employed in this study, aiming to identify patterns within and across texts. This method was suitable for the research as it facilitates the examination of content themes present in diverse data sources, including textbooks, journal articles, and other textual data.

Results and discussion

This section presents the findings pertaining to the primary and secondary research objectives. The data search adhered to PRISMA (Preferred Reporting Items for Systematic Review and Meta-analysis) guidelines (PRISMA 2024), utilising resources from Science Direct, Research Gate, Scopus, Taylor & Francis, IEEE Xplore, and Google Scholar. Initially, 566 articles matching the search criteria outlined in Step 2 of the generic systematic review steps were identified from a total of 566 articles. Subsequently, 246 duplicate articles were identified and removed. Following this, 320 studies were screened based on titles and abstracts, resulting in the exclusion of a further 221 articles. The remaining 99 studies underwent eligibility assessment against the inclusion criteria (see Table 2), leading to the exclusion of 43 full-text studies. Upon thorough review, 56 studies aligning with the research objectives were included in the review. A visual representation of the literature search process, following the PRISMA guidelines, is illustrated in Figure 1.

Figure 2 presents the publication timeline of the studies included in the analysis.

The timeline in Figure 2 indicates a notable surge in studies on this subject between 2021 and 2024. The surge in research studies during this period reflects the increasing interest among scholars, practitioners, and industry stakeholders in understanding the implications, constraints, and



SLR, systematic literature review.

FIGURE 1: The PRISMA (2024) flowchart illustrates the various phases of the literature search carried out in this study.

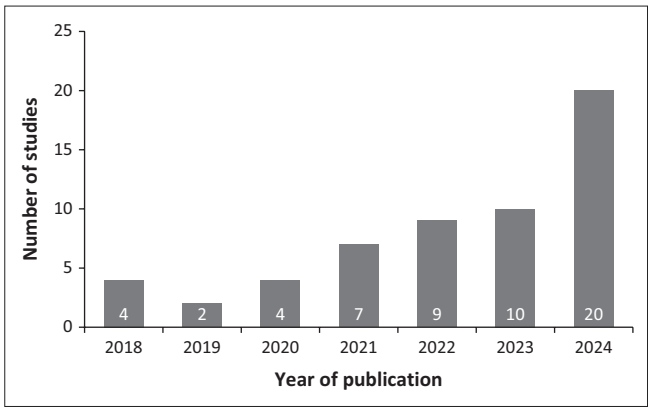


FIGURE 2: Timeline of publications of the studies included.

opportunities associated with integrating blockchain into logistics processes. This heightened focus may also be influenced by the need for innovative solutions to address longstanding issues such as supply chain visibility, transparency, and security. Furthermore, the rapid evolution and maturation of blockchain technologies during this time probably encouraged researchers to explore its applicability and effectiveness in addressing real-world logistics constraints.

For this study, all articles were reviewed and the various themes identified and categorised based on their commonalities. Among the articles meeting the primary inclusion criteria, the majority focused on exploring various aspects of BCT implementation in the logistics sector, including its applications, constraints, opportunities, and implications for supply chain management and operations.

The following section outlines the constraints hindering the implementation of BCT in the logistics industry.

Objective 1: Constraints in blockchain technology implementation in the logistics industry

Blockchain technology holds substantial promise for revolutionising traditional business processes and enhancing efficiency within the logistics industry. However, its implementation is hindered by various constraints across organisational, technological, and environmental domains. This SLR aims to analyse and discuss these constraints based on recent studies. In the study sample, seven different BCT implementation constraints in the logistics industry were identified from 30 articles, as shown in Table 3.

Organisational constraints

Organisational factors pose significant constraints to the logistics implementation of BCT. Santhi and Muthuswamy (2022) highlight the lack of top management support and business model readiness as key constraints. Catalini and Gans (2020) and Rustamovich (2024) underscore the importance of establishing BCT standards and governance models. Additionally, resistance among employees and lower management inhibit implementation (Marengo & Pagano 2023; Negueroles et al. 2024). Furthermore, organisational constraints encompass the dynamic nature of BCT networks and stakeholder loyalty, which can impede successful implementation (Singh et al. 2020 Vijay et al. 2021).

TABLE 3: Blockchain technology implementation constraints in the logistics industry.

BCT constraints	Sources
Organisational constraints	Singh, Dwivedi and Srivastava (2020); Catalini and Gans (2020); Marengo and Pagano (2023); Negueroles et al. (2024); Santhi and Muthuswamy (2022); Vijay et al. (2021)
Technological constraints	AlKubaisy and Al-Somali (2023); Adarsh et al. (2021); Görçün, Pamucar and Biswas (2023); Vijay et al. (2021); Tsolakis et al. (2021)
Environmental constraints	Aylak (2022); Chittipaka et al. (2023); Nguyen et al. (2023); Treiblmaier (2019); Zhang and Liu (2022)
Implementation risks and costs	Ganguly (2022); De Villiers, Kuruppu and Dissanayake (2021); Ambrozie and Sorcaru (2022); Tan et al. (2020)
Interoperability	Abdel-Basset, Chang and Nabeeh (2021); Tsolakis et al. (2021); Irannezhad (2020); Treiblmaier (2019)
Fragmentation of supply chain	Badhotiya et al. (2021); Ganguly (2022), Perboli, Musso and Rosano (2018); Shin et al. (2023)
Data issues	Valdés Figueroa et al. (2021); Catalini and Gans (2020); Rustamovich (2024); Tangsakul and Sureeyatanapas (2023); Yontar (2023)

Note: Please see the full reference list of the article, Mvubu, M. & Naude, M.J., 2024, 'Blockchain in the logistics sector: A systematic literature review of benefits and constraints', *Journal of Transport and Supply Chain Management* 18(1), a1068. https://doi.org/10.4102/jtscm.v18i1.1068, for more information.

BCT, blockchain technology.

Technological constraints

Technological constraints play a pivotal role in hindering BCT implementation within logistics. Adarsh et al. (2021) identify scalability as a significant issue, limiting the transactions managed by blockchain networks. Compatibility issues further compound the technological constraints (AlKubaisy & Al-Somali 2023; Tsolakis et al. 2021). Moreover, the evolving nature of BCT and the complexity of embedding it in the existing IT infrastructure present formidable hurdles (Görçün et al. 2023; Vijay et al. 2021).

Environmental constraints

Environmental factors also contribute to the constraints surrounding BCT implementation. Treiblmaier (2019) categorises these constraints into network and ecosystem readiness. The lack of guidance in BCT applications, trust issues between stakeholders, and visibility limitations add to the constraints (Chittipaka et al. 2023; Zhang & Liu 2022). Moreover, throughput and latency constraints pose additional obstacles to successful implementation (Aylak 2022; Nguyen et al. 2023).

Implementation risks and costs

Implementation risks and costs emerge as critical barriers to BCT implementation in logistics. Ganguly (2022) identifies delayed payments, inadequate standardisation, and supply chain fragmentation as significant constraints. De Villiers et al. (2021) highlight high implementation costs, usability constraints, and energy consumption as major constraints. Data, cost, and incentive issues further complicate BCT implementation within the sector (Ambrozie & Sorcaru 2022; Tan et al. 2020).

Interoperability

Interoperability concerns also impede the seamless integration of BCT into logistics operations (Abdel-Basset

et al. 2021). Treiblmaier (2019) emphasises interoperability as a technological constraint alongside scalability and security concerns. Differing applications of the data storage model pose additional difficulties (Irannezhad 2020; Tsolakis et al. 2021).

Fragmentation of supply chain and data issues

The fragmentation of supply chains and data-related constraints exacerbate the implementation constraints. Ganguly (2022) and Catalini and Gans (2020) point out that supply chain fragmentation with multiple stakeholders is a significant obstacle. Data transmission and storage issues, along with processing times, further hinder the successful implementation of BCT (Badhotiya et al. 2021; Ionescu & Diaconita 2023; Perboli et al. 2018; Shin et al. 2023; Tangsakul & Sureeyatanapas 2023; Yontar 2023).

To conclude this section, the implementation of BCT in logistics faces multifaceted constraints spanning organisational, technological, and environmental domains. To overcome these constraints, concerted efforts are needed to garner top management support, establish governance models, address scalability and compatibility issues, and tackle interoperability concerns. Moreover, strategies to mitigate implementation risks and costs, promote data standardisation, and streamline supply chain processes are imperative for unlocking the transformative potential of BCT in the logistics industry.

Objective 2: Potential benefits of blockchain technology in the logistics industry

Blockchain technology holds immense promise for revolutionising logistics operations, offering a plethora of potential benefits that can transform traditional logistics processes. In this section of the SLR, we explore the six potential benefits of implementing BCT in logistics operations, drawing insights from a range of scholarly sources. A total of six potential benefits were identified from 31 articles. Table 4 presents potential benefits of BCT in logistics.

TABLE 4: Potential benefits of blockchain technology in logistics.

BCT benefits	Sources
Enhanced transparency and traceability	Bleik (2024), da Silva and dos Santos (2022), Catalini and Gans (2020), Negueroles et al. (2024), Rabii et al. (2020).
Improved security	Abdel-Basset et al. (2021), Călinescu (2022), Park (2020), Rustamovich (2024), Wang et al. (2022)
Efficiency gains	Al-Jaroodi and Mohamed (2019), Li et al. (2024), Ar et al. (2020), Wang et al. (2022), Zhuankhan and Renken (2023)
Enhanced collaboration	Berneis et al. (2021), Lois et al. (2021), Kim and Jeong (2023), Tijan et al. (2019)
Improved compliance and governance	Aylak (2022), Ambrozie and Sorcaru (2022), Britchenko et al. (2018), Kim and Jeong (2023), Lan (2024), Septiani & Bitsy (2024)
Real-time tracking and monitoring	Ahmad, Ghani and Mahmood (2021), Aylak (2022), Ionescu and Diaconita (2023), Heutger and Kückelhaus (2018), Karakas et al. (2021), Tsolakis et al. (2021), Wamba and Queiroz (2020)

Note: Please see the full reference list of the article, Mvubu, M. & Naude, M.J., 2024, 'Blockchain in the logistics sector: A systematic literature review of benefits and constraints', *Journal of Transport and Supply Chain Management* 18(1), a1068. https://doi.org/10.4102/jtscm.v18i1.1068, for more information.

BCT, blockchain technology.

Enhanced transparency and traceability

One of the primary advantages of adopting BCT in logistics is the potential for enhanced transparency and traceability throughout the supply chain (Rabii et al. 2020). Scholars such as Catalini and Gans (2020) and Negueroles et al. (2024) emphasise the role of blockchain's immutable ledger in providing unprecedented visibility of product movements and transaction histories. This transparency not only enhances accountability but also mitigates risks associated with counterfeit products and supply chain disruptions, bolstering consumer trust and brand reputation (Bleik 2024; Da Silva & dos Santos 2022).

Improved security

Security is another critical aspect addressed by BCT implementation in logistics. Scholars like Abdel-Basset et al. (2021) and Rustamovich (2024) highlight the decentralised nature of blockchain as a key factor in ensuring data integrity and protecting against cyber threats. The immutable nature of blockchain ledgers makes it almost impossible for unauthorised parties to tamper with data, providing a high level of security for sensitive information exchanged within the logistics ecosystem (Călinescu 2022; Wang et al. 2022).

Efficiency gains

Efficiency gains emerge as a significant benefit of BCT implementation in logistics, as evidenced by studies by Wang et al. (2022) and Li et al. (2024). Through the automation of processes via smart contracts and decentralised ledgers, BCT reduces the need for manual intervention and paperwork, leading to fewer errors and delays (Al-Jaroodi & Mohamed 2019). This increased efficiency not only accelerates operations but also drives down operational costs, making logistics processes more cost-effective and competitive (Ar et al. 2020; Zhuankhan & Renken 2023).

Enhanced collaboration

The collaborative potential of BCT facilitates seamless cooperation among supply chain participants, fostering trust and cooperation. Lois et al. (2021) and Kim and Jeong (2023) emphasise the role of blockchain in enabling secure data sharing and consensus mechanisms. By providing transparent protocols and shared ledgers, BCT enhances communication and decision-making across the supply chain, leading to smoother operations and quicker responses to market changes (Berneis et al. 2021; Tijan et al. 2019).

Improved compliance and governance

In addition to operational benefits, BCT implementation in logistics enhances compliance and governance practices. Scholars like Lan (2024) and Septiani and Bitsy (2024) highlight the role of smart contracts in automating compliance procedures and ensuring adherence to regulatory standards. This automated governance framework reduces the risk of non-compliance penalties and legal disputes, providing

companies with greater confidence in their supply chain operations (Ambrozie & Sorcaru 2022; Aylak 2022; Britchenko et al. 2018; Kim & Jeong 2023).

Real-time tracking and monitoring

Finally, the implementation of BCT enables real-time tracking and monitoring capabilities, as discussed by Tsolakis et al. (2021) and Wamba and Queiroz (2020). Through blockchain-based solutions, companies can track the movement of goods, monitor environmental conditions, and receive alerts for any deviations from predefined parameters (Ahmad et al. 2021; Heutger & Kückelhaus 2018). This granular level of visibility allows for proactive issue identification and resolution, minimising the impact of disruptions and improving overall supply chain performance (Ionescu & Diaconita 2023; Karakas et al. 2021).

To sum up this section, the potential benefits of BCT in logistics are vast and multifaceted, encompassing enhanced transparency, security, efficiency, collaboration, compliance, and visibility. By leveraging BCT, logistics companies can overcome traditional constraints and unlock new opportunities for innovation and growth in the increasingly complex and interconnected global supply chain landscape.

Strategies to mitigate blockchain technology implementation constraints

The constraints hindering BCT implementation within the logistics sector encompass various dimensions, including technological immaturity, complexity, interoperability, scalability, and data transmission or storage issues. Moreover, organisational constraints such as insufficient top management support, a lack of awareness, and high implementation costs have been identified, alongside environmental constraints like navigating government policies and regulatory standards (Ganguly 2022).

Given the considerable benefits of BCT with regard to tracking of goods, compatibility enhancement, and transparency, logistics managers are urged to embrace it to achieve industry competitiveness. However, to surmount implementation constraints effectively, strategic interventions are imperative. Firstly, logistics firms can prioritise robust security measures, incorporating encryption techniques and developing permission models for BCT to ensure comprehensive data protection (Ahmad et al. 2021). Secondly, fostering collaboration among stakeholders can streamline BCT implementation by standardising processes and enhancing interoperability, thus mitigating one of the significant constraints (Ambrozie & Sorcaru 2022). Thirdly, investment in research and development (R&D) initiatives is crucial to better understand the complexities of BCT and identify optimal practices for successful implementation (Tsolakis et al. 2021). Fourthly, engaging with policymakers to establish regulatory frameworks can address data security concerns and ensure lawful BCT implementation, thereby providing a conducive environment for implementation (Irannezhad 2020). Additionally, offering hybrid BCT models that integrate technologies from both public and private domains can effectively address scalability issues, providing a versatile solution for logistics firms (Tijan et al. 2019). Lastly, promoting awareness and education within the industry can significantly enhance understanding and foster strong BCT knowledge among managers and staff, facilitating smoother implementation processes (Ahmad et al. 2021).

By implementing these strategic interventions, the logistics industry can navigate the constraints of BCT implementation more effectively and leverage its benefits to enhance operational efficiency and competitiveness.

Recommendations

The recommendations derived from the study's findings encompass various strategies aimed at addressing the constraints and maximising the benefits associated with the implementation of BCT in the logistics industry. Firstly, because the study underscores the significant advantages that BCT offers, particularly in terms of enhancing tracking and traceability within logistics operations, it is suggested that logistics managers be incentivised to acquire a fundamental understanding of this technology. Secondly, given the perennial issues confronting the industry regarding traceability, the study emphasises the critical importance of integrating BCT into logistics practices.

Moreover, the study identifies the lack of support from top management as a major constraint to BCT implementation. To overcome this constraint, logistics industry managers are encouraged to foster collaboration across various departments within their organisations, thereby garnering the necessary support for BCT initiatives. In addition, the study highlights the organisational constraint of awareness deficiency which impedes BCT implementation. To address this, communication channels such as newsletters should be established, enabling logistics stakeholders to stay abreast of global developments and the innovations pertinent to their industry. Finally, the study identifies external barriers, such as governmental policies, which hinder BCT implementation. It is recommended that governments enact stringent policies and documentation frameworks to facilitate the integration of technological innovations like BCT into the logistics sector.

Conclusion

The purpose of this article was to provide insight into the benefits of BCT and the constraints hindering the logistics industry from implementing it. In order to address these objectives, a systematic review of the literature to identify relevant studies was conducted. The literature examined the constraints hindering the implementation of BCT in logistics. Using the PRISMA framework, 56 relevant articles were identified out of the initial 566 articles. The findings revealed seven constraints hindering its implementation in logistics: organisational constraints; technological constraints;

environmental constraints; implementation risks and costs; interoperability; supply chain fragmentation; and data issues. The findings also revealed six benefits of BCT implementation: enhanced transparency and traceability; improved security; efficiency gains; enhanced collaboration, compliance and governance; and real-time tracking and monitoring. Proposed strategies to address these constraints include focusing on enhancing security and data privacy measures and fostering research and development to keep pace with technological advancements.

The logistics industry stands to gain from embracing BCT, which offers benefits like enhanced compatibility, secure data transmission and storage, and improved traceability and tracking capabilities during trade. This study aims to contribute by raising awareness within the logistics industry about the constraints to BCT implementation, proposing strategies to overcome these constraints, and advocating for governmental support in facilitating BCT implementation.

Acknowledgements

Competing interests

The authors declare that they have no financial or personal relationship(s) that may have inappropriately influenced them in writing this article.

Authors' contributions

M.M. significantly contributed to this article's inception through conceptualisation, methodology design, formal analysis, investigative efforts, original draft composition, visualisation, project administration, and data curation. M.M.'s involvement spanned various critical aspects of the research process. M.J.N. provided invaluable supervision and mentorship, overseeing the project's administrative facets, contributing to methodology refinement, validating findings, and meticulously reviewing and editing the manuscript. M.J.N.'s guidance ensured the scholarly rigour and coherence of the research, enriching its quality and impact. Together, M.M. and M.J.N. synergistically propelled the study forward, manifesting a collaborative effort of expertise and dedication across its spectrum.

Ethical considerations

Ethical clearance waiver was granted by the University of KwaZulu-Natal Research Ethics Committee (No. 00026266).

Funding information

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Data availability

Data were collected through a systematic literature review. The study followed the six steps of the PRISMA framework. A total of 56 journal articles published between 2018 and 2024 were included in the study. These articles are in the public domain.

Disclaimer

The views and opinions expressed in this article are those of the author(s) and are the product of professional research. It does not necessarily reflect the official policy or position of any affiliated institution, funder, agency, or that of the publisher. The author(s) are responsible for this article's results, findings, and content.

References

Abdel-Basset, M., Chang, V. & Nabeeh, N.A., 2021, 'An intelligent framework using disruptive technologies for COVID-19 analysis', *Technological Forecasting and Social Change* 163, 120431. https://doi.org/10.1016/j.techfore.2020.120431

Adarsh, S., Joseph, S.G., John, F., Lekshmi, M. & Asharaf, S., 2021, 'A transparent and traceable coverage analysis model for vaccine supply-chain using blockchain technology', *IT Professional* 23(4), 28–35. https://doi.org/10.1109/MITP.2021.3094194

Ahmad, R.W., Hasan, H., Jayaraman, R., Salah, K. & Omar, M., 2021, 'Blockchain applications and architectures for port operations and logistics management', *Research in Transportation Business & Management* 41, 100620. https://doi.org/10.1016/j.rtbm.2021.100620

Akram, S.V., Malik, P.K., Singh, R., Anita, G. & Tanwar, S., 2020, 'Adoption of blockchain technology in various realms: Opportunities and constraints', *Security and Privacy* 3(5), e109. https://doi.org/10.1016/j.bcra.2021.100027

Al-Jaroodi, J. & Mohamed, N., 2019, 'Industrial applications of blockchain', in *2019 IEEE 9th Annual Computing and Communication Workshop and Conference* (CCWC), Las Vegas, 7–9 January, 2019, pp. 0550–0555.

AlKubaisy, Z.M. & Al-Somali, S., 2023, 'Factors influencing blockchain technologies implementation in supply chain management and logistic sectors: Cultural compatibility of blockchain solutions as moderator', *Systems* 11(12), 574. https://doi.org/10.3390/systems11120574

AlShamsi, M., Al-Emran, M. & Shaalan, K., 2022, 'A systematic review on blockchain implementation', *Applied Sciences* 12(9), 4245. https://doi.org/10.3390/app12094245

Ambrozie, A.M. & Sorcaru, S., 2022, 'Logistics in a green era, a blockchain-based framework', *Acta Universitatis Danubius. Economica* 18(6), viewed 23 June 2024, from https://dj.univ-danubius.ro/index.php/AUDOE/article/view/2330.

Ar, I.M., Erol, I., Peker, I., Ozdemir, A.I., Medeni, T.D. & Medeni, I.T., 2020, 'Evaluating the feasibility of blockchain in logistics operations: A decision framework', *Expert Systems with Applications* 158, 113543. https://doi.org/10.1016/j.eswa.2020.113543

Aylak, B.L., 2022, 'The effects of the applications of blockchain technology on the logistics sector', *Avrupa Bilim ve Teknoloji Dergisi* 34, 148–152. https://doi.org/10.31590/ejosat.1077800

Badhotiya, G.K., Sharma, V.P., Prakash, S., Kalluri, V. & Singh, R., 2021, 'Investigation and assessment of blockchain technology adoption in the pharmaceutical supply chain', *Materials Today: Proceedings* 46(Part 20), 10776–10780. https://doi.org/10.1016/j.matpr.2021.01.673

Berneis, M., Bartsch, D. & Winkler, H., 2021, 'Applications of blockchain technology in logistics and supply chain management: Insights from a systematic literature review', *Logistics* 5(3), 43. https://doi.org/10.3390/logistics5030043

Bleik, M., 2024, 'Factors that impact the implementation of blockchain in logistics in the United Arab Emirates', *African Journal of Science, Technology, Innovation and Development* 16(3), 355–369. https://doi.org/10.1080/20421338.2024.2317640

Britchenko, I., Cherniavska, T. & Cherniavskyi, B., 2018, 'Blockchain technology into the logistics supply chain effectiveness', in I. Britchenko & Y. Polishchuk (eds.), *Development of small and medium enterprises: The EU and east-partnership countries experience: Collective monograph*, pp. 307–318, HSVCM and HSSEP, Tarnobrzeg.

Călinescu, G., 2022, 'The applications of blockchain and artificial intelligence in logistics', *Romanian Economic Journal* 25(84). https://doi.org/10.24818/REJ/2022/84/06

CASP International Network, 2013, *Critical appraisal skills programme: CASP qualitative checklist*, Public Health Resource Unit, viewed 24 June 2024, from https://casp-uk.net/casp-tools-checklists.

Catalini, C. & Gans, J.S., 2020, 'Some simple economics of the blockchain', *Communications of the ACM* 63(7), 80–90. https://doi.org/10.1145/3359552

Chinnasamy, P., Deepalakshmi, P., Praveena, V., Rajakumari, K. & Hamsagayathri, P., 2019, 'Blockchain technology: A step towards sustainable development', *International Journal of Innovative Technology and Exploring Engineering* (IJITEE) 9(2S2), 2278–3075. https://doi.org/10.35940/ijitee.B1109.1292S219

Chittipaka, V., Kumar, S., Sivarajah, U., Bowden, J.L.H. & Baral, M.M., 2023, 'Blockchain technology for supply chains operating in emerging markets: An empirical examination of technology-organization-environment (TOE) framework', *Annals of Operations Research* 327(1), 465–492. https://doi.org/10.1007/s10479-022-04801-5

Da Silva, J.O.D. & Dos Santos, D.R., 2022, 'Study of blockchain application in the logistics industry', *Theoretical Economics Letters* 12(2), 321–342. https://doi.org/10.4236/tel.2022.122017

Deloitte, 2020, *Deloitte cyber risk services: Protecting your business from cyber*, viewed 29 June 2024, from https://www2.deloitte.com/nl/nl/pages/risk/solutions/deloitte-cyber.htm.

De Villiers, C., Kuruppu, S. & Dissanayake, D., 2021, 'A (new) role for business-Promoting the United Nations' sustainable development goals through the internet- of-things and blockchain technology', *Journal of Business Research* 131, 598–609. https://doi.org/10.1016/j.jbusres.2020.11.066

De Villiers, G., Nieman, G. & Niemann, W., 2017, 'Introduction to supply chain management', in G. De Villiers, G. Nieman & W. Niemann (eds.), *Strategic logistics management: A supply chain management approach*, 2nd edn., pp. 1–18, Van Schaik Publishers, Pretoria.

Ganguly, K.K., 2022, 'Understanding the constraints of the implementation of blockchain technology in the logistics sector: The TOE framework', *Technology Analysis & Strategic Management* 36(3), 457–471. https://doi.org/10.1080/09537325.2022.2036333

Görçün, Ö.F., Pamucar, D. & Biswas, S., 2023, 'The blockchain technology selection in the logistics industry using a novel MCDM framework based on Fermatean fuzzy sets and Dombi aggregation', *Information Sciences* 635, 345–374. https://doi.org/10.1016/j.ins.2023.03.113

Heutger, M. & Kückelhaus, M., 2018, *Blockchain in logistics*, DHL, Bonn.

Ionescu, S.A. & Diaconita, V., 2023, 'Transforming financial decision-making: The interplay of AI, cloud computing and advanced data management technologies', *International Journal of Computers Communications & Control* 18(6), 5735. https://doi.org/10.15837/ijccc.2023.6.5735

Irannezhad, E., 2020, 'Is blockchain a solution for logistics and freight transportation problems?', *Transportation Research Procedia* 48, 290–306. https://doi.org/10.1016/j.trpro.2020.08.023

Karakas, S., Acar, A.Z. & Kucukaltan, B., 2021, 'Blockchain adoption in logistics and supply chain: A literature review and research agenda', *International Journal of Production Research* 1–24. https://doi.org/10.1080/00207543.2021.2012613

Kim, B. & Jeong, J., 2023, 'BA-TMS: Design and implementation of blockchain based aggregate transportation management system using smart order and electronic invoice', in *2023 International Conference on Engineering and Emerging Technologies (ICEET)*, Istanbul, Turkey, 27–28 October, 2023, pp. 1–5, https://doi.org/10.1109/ICEET60227.2023.10525900

Lan, Y., 2024, 'Exploratory study of sustainable automotive supply chain logistics process based on blockchain technology', in *Proceedings of the 4th International Conference on Economic Management and Big Data Applications*, Tianjin, China, 27–29 October, 2023. pp. 1–10.

Li, K., Lee, J.Y. & Gharehgozli, A., 2024, 'Blockchain adoption in the maritime industry: A literature review and synthesis analysis of benefits and challenges', *Maritime Economics & Logistics* 1–28. https://doi.org/10.1057/s41278-023-00280-y.

Lois, P., Drogalas, G., Karagiorgos, A., Thrassou, A. & Vrontis, D., 2021, 'Internal auditing and cyber security: Audit role and procedural contribution', *International Journal of Managerial and Financial Accounting* 13(1), 25–47. https://doi.org/10.1504/IJMFA.2021.116207

Marengo, A. & Pagano, A., 2023, 'Investigating the factors influencing the implementation of blockchain technology across different countries and industries: A systematic literature review', *Electronics* 12(14), 3006. https://doi.org/10.3390/electronics12143006

Negueroles, S.C., Simón, R.R., Julián, M., Belsa, A., Lacalle, I., S-Julián, R. et al., 2024, 'A blockchain-based digital twin for IoT deployments in logistics and transportation', *Future Generation Computer Systems* 158, 73–88. https://doi.org/10.1016/j.future.2024.04.011

Nguyen, L.T., Nguyen, D.T., Ngoc, K.N.N. & Duc, D.T.V., 2023, 'Blockchain implementation in logistics companies in Ho Chi Minh City, Vietnam', *Cogent Business & Management* 10(2), 2216436. https://doi.org/10.1080/23311975.2023.2216436

Noor, A., 2022, 'Adoption of blockchain technology facilitates a competitive edge for logistic service providers, *Sustainability* 14(23), 15543. https://doi.org/10.3390/su142315543

Paré, G., Tate, M., Johnstone, D. & Kitsiou, S., 2016, 'Contextualizing the twin concepts of systematicity and transparency in information systems literature reviews', *European Journal of Information Systems* 25(6), 493–508. https://doi.org/10.1057/s41303-016-0020-3

Park, K.O., 2020, 'A study on sustainable usage intention of blockchain in the big data era: Logistics and supply chain management companies', *Sustainability* 12(24), 10670. https://doi.org/10.3390/su122410670

Perboli, G., Musso, S. & Rosano, M., 2018, 'Blockchain in logistics and supply chain: A lean approach for designing real-world use cases', *IEEE Access* 6, 62018–62028. https://doi.org/10.1109/ACCESS.2018.2875782

Pournader, M., Shi, Y., Seuring, S. & Koh, S.L., 2020, 'Blockchain applications in supply chains, transport and logistics: A systematic review of the literature', *International Journal of Production Research* 58(7), 2063–2081. https://doi.org/10.1080/00207543.2019.1650976

PRISMA (Preferred Reporting Items for Systematic Review and Meta-analysis), 2024, *PRISMA 2020 statement*, viewed 24 June 2024, from http://www.prisma-statement.org.

Rabii, A., Assoul, S., Ouazzani Touhami, K. & Roudies, O., 2020, 'Information and cyber security maturity models: A systematic literature review', *Information & Computer Security* 28(4), 627–644. https://doi.org/10.1108/ICS-03-2019-0039

Rustamovich, E.J., 2024, 'Digital logistics: Possibilities of smart contracts in the organization of intellectual transport systems', *Raqamli iqtisodiyot (Цифровая экономика)* 6, 219–228.

Santhi, A.R. & Muthuswamy, P., 2022, 'Influence of blockchain technology in manufacturing supply chain and logistics', *Logistics* 6(1), 15. https://doi.org/10.3390/logistics6010015

Shin, S., Wang, Y., Pettit, S. & Abouarghoub, W., 2023, 'Blockchain application in maritime supply chain: A systematic literature review and conceptual framework', *Maritime Policy & Management* 1–34. https://doi.org/10.1080/03088839.2023.2234896

Singh, R., Dwivedi, A.D. & Srivastava, G., 2020, 'Internet of things based blockchain for temperature monitoring and counterfeit pharmaceutical prevention', *Sensors* 20(14), 3951. https://doi.org/10.3390/s20143951

Stern, C., Jordan, Z. & McArthur, A., 2014, 'Developing the review question and inclusion criteria: The first steps in conducting a systematic review', *American Journal of Nursing* 114(4), 53–56. https://doi.org/10.1097/01.NAJ.0000445689.67800.86

Tan, B.Q., Wang, F., Liu, J., Kang, K. & Costa, F., 2020, 'A blockchain-based framework for green logistics in supply chains', *Sustainability* 12(11), 4656. https://doi.org/10.3390/su12114656

Tangsakul, M. & Sureeyatanapas, P., 2023, 'Identification and analysis of barriers to the implementation of blockchain technology in the logistics industry', in *Proceedings of the 4th Asia Pacific Conference on Industrial Engineering and Operations Management*, IEOM Society, Ho Chi Minh City, Vietnam, 12–14 September, 2023, pp. 136–144.

Tijan, E., Aksentijević, S., Ivanić, K. & Jardas, M., 2019, 'Blockchain technology implementation in logistics', *Sustainability* 11(4), 1185. https://doi.org/10.3390/su11041185

Treiblmaier, H., 2019, 'Combining blockchain technology and the physical internet to achieve triple bottom line sustainability: A comprehensive research agenda for modern logistics and supply chain management', *Logistics* 3(1), 10. https://doi.org/10.3390/logistics3010010

Tsolakis, N., Niedenzu, D., Simonetto, M., Dora, M. & Kumar, M., 2021, 'Supply network design to address United Nations Sustainable Development Goals: A case study of blockchain implementation in Thai fish industry', *Journal of Business Research* 131, 495–519. https://doi.org/10.1016/j.jbusres.2020.08.003

United Nations Conference on Trade and Development (UNCTAD), 2022, *Global report on blockchain and its implications on trade facilitation performance*, viewed 04 May 2024, from https://unctad.org/topic/transport-and-trade-logistics/trade-facilitation/empowerment-programme.

Valdés Figueroa, L., Diaz, R.M. & Pérez, G., 2021, 'Blockchain implementation opportunities and constraints in the Latin American and Caribbean logistics sector', viewed n.d., from https://repositorio.cepal.org/server/api/core/bitstreams/5fe1bdb9-a9ef-408b-8272-561c40be2939/content.

Vijay, C., Suriyalakshmi, S.M. & Elayaraja, M., 2021, 'Blockchain technology in logistics: Opportunities and constraints', *Pacific Business Review International* 13, 147–151, viewed 21 June 2024, from http://www.pbr.co.in/2021/2021_month/January/15.pdf.

Wamba, S.F. & Queiroz, M.M., 2020, 'Blockchain in the operations and supply chain management: Benefits, challenges and future research opportunities', *International Journal of Information Management* 52, 102064. https://doi.org/10.1016/j.ijinfomgt.2019.102064

Wang, T., Hua, H., Wei, Z. & Cao, J., 2022, 'Constraints of blockchain in new generation energy systems and future outlooks', *International Journal of Electrical Power & Energy Systems* 135, 107499. https://doi.org/10.1016/j.ijepes.2021.107499

Wong, G., Greenhalgh, T., Westhorp, G., Buckingham, J. & Pawson, R., 2013, 'RAMESES publication standards: Realist syntheses', *BMC Medicine* 11(1), 21. https://doi.org/10.1186/1741-7015-11-21

World Economic Forum (WEF), 2018, *Blockchain in the logistics and transportation industry*, viewed 20 May 2024, from https://www.weforum.org/agenda/2018/09/blockchain-in-the-logistics-and-transportation-industry/.

Yontar, E., 2023, 'Constraints, threats and advantages of using blockchain technology in the framework of sustainability of the logistics sector', *Turkish Journal of Engineering* 7(3), 186–195. https://doi.org/10.31127/tuje.1094375

Zhang, Y. & Liu, N., 2022, 'Blockchain implementation in serial logistics service chain: Value and challenge', *International Journal of Production Research* 61(13), 4374–4401. https://doi.org/10.1080/00207543.2022.2132312

Zhuankhan, A. & Renken, J., 2023, 'Exploring the determinants of successful IoT implementation: The case of German manufacturing', *International Journal of Innovation and Technology Management* 20(7), 2350046. https://doi.org/10.1142/S0219877023500463