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Analyzing Potentials and Barriers in Supply Chain Management in The Promise of Blockchain

Sinniati (1)
Gede Sri Darma (2)

Universitas Pendidikan Nasional (1) (2)

sinniati@gmail.com (1)
sridarma@undiknas.ac.id (2)

ABSTRACT

This study explored the potentials and barriers to the implementation of blockchain technology in supply chain management (SCM). The purpose of the research was to determine the potential of implementing blockchain technology to enhance SCM performance, identify the challenges faced in implementing blockchain in SCM, and understand the constraints and obstacles that needed to be overcome for successful implementation. The research method applied was a Systematic Literature Review (SLR) using the PRISMA Protocol, with 73 papers collected from 2018 to June 2023. Data analysis was conducted through Meta-Synthesis. The findings provided insights into the theoretical, policy, and managerial implications of implementing blockchain technology in SCM, contributing to the advancement of knowledge in this field.

Keywords: Blockchain; Supply Chain Management; Systematic Literature Review; PRISMA Protocol

INTRODUCTION

Supply Chain Management (SCM) plays a crucial role in businesses by overseeing the flow of goods, services, and information from suppliers to end customers (Mentzer et al., 2001; Juzer and Darma, 2019; Adnyasuari and Darma, 2017; Kusuma and Darma, 2020; Putra and Darma, 2019; Bali and Darma, 2019; Ginantra et al., 2017; Darma, 2004; Wibawa and Darma, 2023; Permana and Darma, 2020; Dwisuardinata and Darma, 2023; Sanjaya and Darma, 2023; Umami and Darma, 2021; Dewi and Darma, 2022; Oyagi and Darma, 2021; Arianti and Darma, 2019; Dewi and Darma, 2016). In recent years, there has been a growing interest in utilizing blockchain technology to improve efficiency, transparency, and security in SCM.

Blockchain technology is a decentralized digital ledger system that enables secure and transparent recording of transactions (Abeyratne & Monfared, 2016). It has gained significant attention due to its potential to enhance supply chain management by providing a shared source of truth that is accessible and trusted by all parties involved.

Implementing blockchain technology in SCM offers several potential benefits (Cole et al., 2019). Firstly, it can enhance transparency and accountability by providing transparent and immutable records of all transactions along the supply chain (Zhao et al., 2019). This can help reduce fraud, counterfeiting, and illicit activities by providing a secure and reliable way to track goods and their origins. Additionally, blockchain technology can improve supply chain management efficiency by reducing the time and costs associated with traditional transaction processing methods. It streamlines documentation and verification processes, reduces paperwork and administration, and enhances the speed and accuracy of data exchange.

Several companies have already embraced blockchain technology in their supply chains. Walmart, in collaboration with IBM, developed a blockchain platform called Food Trust to track food and beverage products from manufacturers to consumers (Wang, Han, et al., 2019). Nestle has used blockchain to trace their coffee supply chain, ensuring product quality and sustainability (Sodhi & Tang, 2021). De Beers, the world's largest diamond producer, utilizes blockchain technology to track their diamond supply chain from mines to retailers, ensuring product security and sustainability (Hastig & Sodhi, 2020). Carrefour has employed blockchain technology to trace their organic food supply chain, providing more transparent and accurate information to consumers (Kamilaris et al., 2019a).

The use of blockchain technology in industries has drawn the attention of several researchers to further explore its potential. Some previous studies on blockchain have also been conducted, such as Mahyuni's research on the potential of blockchain in enhancing supply chain performance (Mahyuni et al., 2020). Additionally, there have been studies on the intention of using blockchain technology in Indonesia (Saputra & Darma, 2022).

Despite its potential benefits, the implementation of blockchain technology in SCM has been slow, primarily due to various constraints and challenges. These include technical challenges, regulatory issues, and organizational hurdles that need to be addressed before the full potential of blockchain technology can be realized. The lack of technical expertise and understanding among stakeholders poses a significant constraint. The complexity of blockchain technology can be challenging for businesses, especially those without extensive experience in the field. Additionally, the absence of regulatory frameworks and standards for blockchain technology creates uncertainty and doubt among stakeholders. Moreover, organizational challenges such as resistance to change and the need for collaboration among multiple parties can hinder implementation.

This research aims to explore the potential benefits and barriers of blockchain technology in SCM. A systematic literature review methodology will be employed to analyze existing research and provide insights into the current state of research on this topic. The research will begin with an overview of blockchain technology and SCM, followed by an exploration of the potential benefits of blockchain in supply chain management, including increased transparency, improved efficiency, and enhanced security. The study will also examine the constraints and challenges that need to be overcome for successful implementation, covering technical, regulatory, and organizational aspects. It will offer potential solutions to address these challenges.

The findings from this research are expected to provide a comprehensive understanding of the potential of blockchain technology in supply chain management and the necessary steps to overcome implementation barriers. The research will be valuable for businesses, policymakers, and researchers interested in understanding the implications of blockchain technology for SCM. It will also identify areas for future research and development, contributing to the current state of knowledge on this topic.

Blockchain

Blockchain is a revolutionary technology that has gained significant attention in recent years. It is a decentralized digital ledger system that enables secure and transparent recording of transactions (Abeyratne & Monfared, 2016). The concept of blockchain originated with the introduction of Bitcoin (Aste et al., 2017), a cryptocurrency, but its potential extends far beyond digital currencies.

What makes blockchain unique is its decentralized nature, where multiple participants (nodes) in the network maintain a copy of the ledger. Transactions are validated and added to the blockchain through a consensus mechanism, which ensures that all participants agree on the validity of the transactions. The security of blockchain is achieved through cryptographic algorithms that ensure the immutability and integrity of the recorded transactions. Once a transaction is added to the blockchain, it becomes nearly impossible to alter or tamper with (Fanning & Centers, 2016).

Blockchain technology has the potential to revolutionize various industries by providing transparency, eliminating intermediaries, enhancing security, and enabling trustless and efficient transactions. It has found applications beyond cryptocurrencies, such as supply chain management, healthcare, finance, and more. However, challenges regarding scalability, energy consumption, and regulatory frameworks still need to be addressed for widespread adoption of blockchain technology.

Characteristics of Blockchain

Blockchain technology has gained significant attention due to its unique characteristics and potential applications across various industries. In this literature review, we will explore the key characteristics of blockchain and their implications.

One of the fundamental characteristics of blockchain is decentralization (Monrat et al., 2019). Traditional centralized systems rely on a central authority to validate and record transactions. In contrast, blockchain operates as a decentralized network where multiple participants, known as nodes, maintain a copy of the distributed ledger. This decentralized structure eliminates the need for intermediaries, enhances security, and reduces the risk of single points of failure.

Blockchain maintains an immutable ledger, meaning that once a transaction is recorded on the blockchain, it cannot be altered or tampered with. Each block in the blockchain contains a hash, a unique identifier generated based on the contents of the block. This ensures the integrity of the data and prevents unauthorized modifications. The immutability of the ledger enhances transparency, trust, and auditability, making blockchain suitable for applications requiring reliable record-keeping (Ølnes et al., 2017).

Blockchain provides transparency by allowing all participants to view the transactions recorded on the blockchain. While the data remains transparent, the identity of the participants can be pseudonymous or anonymous, depending on the specific blockchain design. This transparency promotes trust among participants and enables traceability along the supply chain, making it an attractive solution for industries such as food and pharmaceuticals, where product provenance and authenticity are critical (Sunny et al., 2020).

Blockchain ensures the security of transactions through cryptographic algorithms (Miraz & Ali, 2018). Each transaction is encrypted and linked to the previous transaction using cryptographic hashes, forming a chain of blocks. This linkage makes it computationally infeasible to alter previous blocks without modifying subsequent blocks, providing a high level of security. Additionally, blockchain can employ consensus mechanisms, such as Proof of Work or Proof of Stake, to validate and agree on the order of transactions, further enhancing security (C. Zhang et al., 2020).

Smart contracts are self-executing agreements with predefined rules and conditions encoded on the blockchain (Nzuva, 2019). These contracts automate processes, eliminating the need for intermediaries and ensuring trust and transparency. Smart contracts enable the execution of transactions and the enforcement of contractual obligations without relying on third parties (Prause, 2019), reducing costs and increasing efficiency.

Interoperability refers to the ability of different blockchain networks to communicate and interact with each other (Zhang et al., 2017). Achieving interoperability is crucial for the widespread adoption of blockchain technology, as it enables seamless integration of multiple blockchain platforms and facilitates the exchange of assets and information across networks.

Supply Chain Management (SCM)

Supply Chain Management (SCM) is a critical aspect of business operations that involves the coordination and management of the flow of goods, services, and information from suppliers to end customers (Cooper et al., 1997). It encompasses the entire process of sourcing, procurement, production, logistics, and distribution. Effective supply chain management ensures that products or services are delivered to customers in a timely, cost-effective, and efficient manner (Brewer & Speh, 2000). It involves various activities such as demand forecasting, inventory management, supplier relationship management, production planning, and order fulfillment (Lee & Whang, 2000).

SCM aims to optimize the overall performance of the supply chain by minimizing costs, reducing lead times, improving customer satisfaction, and enhancing competitiveness. It requires collaboration and coordination among multiple stakeholders, including suppliers, manufacturers, distributors, retailers, and customers. The importance of SCM has grown significantly in recent years due to globalization, increasing customer demands, and advancements in technology. It plays a vital role in enhancing operational efficiency, reducing risks, and achieving a competitive edge in the marketplace. Effective supply chain management is crucial for businesses to meet customer expectations, adapt to market dynamics, and drive overall business success (Gattorna, 1998). It requires the implementation of efficient processes, effective communication, and the use of appropriate tools and technologies to optimize the flow of goods, services, and information across the supply chain. Studies on the implementation of Digital Supply Chain Management as a digital transformation effort have also been conducted (Permana & Darma, 2020).

RESEARCH METHODS

Systematic Literature Review (SLR)

The research utilizes a qualitative approach through the systematic literature review (SLR) methodology. SLR is a rigorous method that involves identifying, evaluating, and synthesizing relevant literature on a specific research question or topic (Kitchenham, 2004). It involves a comprehensive search of academic databases and other sources, followed by the evaluation and synthesis of the collected literature based on predefined criteria. The use of SLR in this study enables a comprehensive analysis of the existing literature on the potentials and barriers of implementing blockchain technology in supply chain management. It provides a reliable and comprehensive overview of the current knowledge and understanding of the topic.

PICOC Framework

Furthermore, the researcher will utilize the PICOC Framework, which is a framework used in research to formulate research questions and determine inclusion and exclusion criteria for selecting relevant studies (Booth et al., 2012). By employing the PICOC Framework, the researcher can formulate clear and focused research questions and identify inclusion and exclusion criteria in selecting relevant studies. This framework helps to focus the research on important and relevant aspects aligned with the research objectives, thereby strengthening the validity and accuracy of the research findings.

Tabel 1
PICOC Framework

Variable	Indicator
Population (P)	Studies related to the implementation of blockchain technology in supply chain management (SCM).
Intervention (I)	The utilization of blockchain technology in SCM.
Comparison (C)	Studies comparing different approaches or strategies in implementing blockchain technology in SCM.
Outcome (O)	The potentials and benefits, as well as the barriers and challenges, associated with the implementation of blockchain technology in SCM.
Context (C)	Various industries or sectors where the implementation of blockchain technology in SCM has been explored or can potentially be applied.

Table 1 showing the application of the PICOC Framework in the context of this research. By utilizing the PICOC Framework, the research will ensure a focused and systematic approach to identify and analyze relevant studies, providing valuable insights into the potentials and barriers of implementing blockchain technology in supply chain management.

PRSIMA Protocol

In addition to using the PICOC Framework, the researcher also utilizes the PRISMA Protocol. This protocol includes several crucial sections that need to be addressed in the report, such as the background, research objectives, search strategy, study selection and inclusion, data collection and analysis, and study quality assessment (Moher et al., 2015).

The PRISMA Protocol helps maintain high standards in reporting systematic reviews and meta-analyses and serves as a widely accepted guideline in the research field (Page et al., 2021). By using PRISMA, the Systematic Literature Review (SLR) within the research becomes more structured, easily understood, and trustworthy.

Data Sources

To obtain relevant data sources, this study utilized two databases or search engines: Google Scholar and ScienceDirect. Google Scholar was chosen due to its wide access to various types of academic literature, offering a diverse range of resources. ScienceDirect, on the other hand, was selected as it is a reputable publication platform managed by Elsevier, providing access to thousands of scientific journals across different disciplines. By leveraging these data sources, the study aimed to gather high-quality scholarly articles to enhance the analysis and ensure comprehensive coverage of the research topic. The combination of Google Scholar and ScienceDirect enhances the reliability and relevance of the scholarly articles used in this research.

Inclusion and Exclusion Criteria

In this study, the research method employed is Systematic Literature Review (SLR). Therefore, to ensure the quality and relevance of studies to be included in the analysis, predefined inclusion criteria will be utilized. The inclusion and exclusion criteria applied in this research are presented in Table 2 and Table 3.

Table 2
Inclusion Criteria

Criteria	Inclusion
Topic	Studies that discuss the implementation of blockchain technology in supply chain management (SCM). This includes research on the use of blockchain in various aspects of SCM such as product tracking, inventory management, product authenticity, security, or operational efficiency.
Publication Type	Articles published in scholarly journals, specifically research articles. Publications that meet scholarly standards and undergo the peer-review process will be given priority.
Publication Date	Studies published between the years 2018 and June 2023. This ensures that the utilized research is the latest and relevant to the current developments in the implementation of blockchain technology in SCM.

Criteria	Inclusion
Language	Studies written in English to facilitate understanding and accessibility for researchers.
Article Access	Articles that are fully accessible or open access.

Table 2 presents the inclusion criteria used for this study, including the topics, publication types, publication dates, language, and article accessibility.

Tabel 3
Exclusion Criteria

Criteria	Exclusion
Irrelevant Topic	Studies that are not directly related to the implementation of blockchain technology in SCM are excluded. This includes research that focuses on blockchain in general without specific emphasis on its application in SCM.
Inappropriate Publication Type	Studies published as conference proceedings, books, or other non-peer-reviewed publications are not included. The focus is on publications that have undergone the rigorous peer-review process, including research articles that meet scholarly standards.
Outdated Publication Dates	Studies published before 2018 are excluded to ensure that the analysis focuses on more recent research that is relevant to the current developments in blockchain implementation in SCM.
Unintelligible Language	Studies written in languages other than English and not readily available in easily accessible translations are excluded to ensure accurate and effective understanding.
Inaccessible Articles	Articles that are not fully accessible, for example, requiring a subscription or having broken links, will be excluded from consideration.
Duplicate Data	Duplicate articles from the search results are excluded.

Table 3 presents the exclusion criteria used for this study, including irrelevant topics, inappropriate publication types, incorrect publication dates, unfamiliar languages, inaccessible articles, and duplicate data.

Keywords

The keywords used for this research are "Blockchain Supply Chain," "Blockchain Supply Chain Integration," "Blockchain Supply Chain Potential," "Blockchain Supply Chain Challenges," "Blockchain Supply Chain Management," and "Blockchain Supply Chain Barriers."

Tabel 4
Search Results in Google Scholar and ScienceDirect

No.	Keyword	Google scholar	ScienceDirect
1.	Blockchain Supply chain	201	32
2.	Blockchain Supply Chain Integration	54	6
3.	Blockchain Supply Chain Potential	27	16
4.	Blockchain Supply Chain Challenges	15	0
5.	Blockchain Supply Chain Management	22	5
6.	Blockchain Supply Chain Barriers	29	1
	Total	348	60

Table 4 presents the search results from the Google Scholar and ScienceDirect databases on June 23, 2023, using the predefined keywords. The search on Google Scholar yielded a total of 348 articles, while the search on ScienceDirect resulted in 60 articles.

Search Strategy and Study Selection Process

On June 23, 2023, the researcher utilized the predetermined keywords on Google Scholar and ScienceDirect. The search was filtered to include articles published between 2018 and June 2023, focusing on research articles and review articles. Following this search strategy, the results were obtained shown in Table 4.

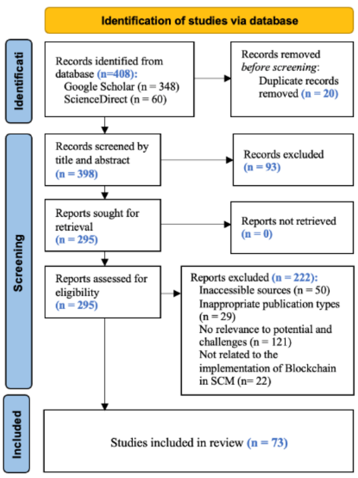

Figure 1
PRISMA Flow Diagram

Figure 1 illustrates the data collection process using the PRISMA Protocol. First, in the Identification phase, the researcher conducted a search for articles through Google Scholar, resulting in 348 articles, and through ScienceDirect, resulting in 60 articles, making a total of 408 articles. After removing duplicate data, the total number of remaining articles was 388.

Next, in the Screening phase, the researcher reviewed the titles and abstracts of the found articles. From this process, 295 articles were deemed relevant and met the inclusion criteria, while 93 articles were excluded as they did not align with the research topic. Subsequently, the researcher performed a full reading of the 295 selected articles to assess eligibility. From this stage, a total of 222 articles were excluded, with 50 articles being inaccessible, 29 articles not meeting the specified publication type, 121 articles being irrelevant as they did not discuss the potential and barriers of implementing blockchain in SCM, and 22 articles not being related to blockchain implementation in SCM. Following this assessment, 73 articles were deemed to meet the inclusion criteria.

After the identification and screening processes, a total of 73 articles were included for use in this study. These articles will serve as the basis for the analyzed data and be used in exploring the potential and barriers of implementing blockchain technology in SCM. This data selection process involved the identification phase, screening based on titles and abstracts, and an assessment of eligibility through full-text reading. By adhering to the established inclusion criteria, 73 relevant articles were selected and will be utilized in further analysis to support the exploration in this research.

Data Collection Process

The data collection process for this research followed the Systematic Literature Review (SLR) method, ensuring a rigorous and comprehensive approach. Relevant research reports were identified from databases and literature sources using specific keywords aligned with the research objectives. Each report was reviewed independently by a dedicated reviewer to maintain consistency and minimize bias. In some cases, communication with study investigators was conducted to obtain additional information or clarify findings. Automation tools, such as reference management software (EndNote 20 and Mendeley), were utilized to assist in data organization and analysis (Page et al., 2021). By adhering to established methods and protocols, the research maintains a high standard of data quality and minimizes potential biases.

Data Analysis Technique

The data analysis technique employed in this research is Meta-Synthesis. Meta-Synthesis is a comprehensive approach that integrates findings from multiple studies selected in a Systematic Literature Review. It involves a detailed analysis of individual study findings, identifying patterns and themes, and synthesizing these findings to generate a deeper understanding of the research topic. Meta-Synthesis goes beyond a simple summary and aims to develop a theoretical understanding by exploring the relationships between the findings from different studies. This approach provides a holistic perspective and enhances the overall understanding of the research area (Sandelowski & Barroso, 2007).

RESULTS

Figure 2
The Selected Papers Grouped by Year of Publication

Figure 2 shows the final outcome of the previous data collection, categorized by the year of publication. These articles cover a time range from 2018 to June 2023. Based on the data collection, the researcher found that there were 3 articles published in 2018, 12 articles in 2019, 25 articles in 2020, 14 articles in 2021, 18 articles in 2022, and 1 article in 2023.

Table 5
Journals and Number of Papers Published

Journal	Papers
Australasian Journal of Information Systems	1
Data Mining and Machine Learning	1
EasyChair: 3rd Symposium on Distributed Ledger Technology	1
Elsevier: Cleaner Logistics and Supply Chain	1
Elsevier: Computers & Industrial Engineering	2
Elsevier: Computers in Industry	1
Elsevier: Current Research in Environmental Sustainability	1
Elsevier: Digital Business	1
Elsevier: International Journal of Information Management	1
Elsevier: International Journal of Production Economics	3
Elsevier: Journal of Purchasing and Supply Management	1
Elsevier: Procedia CIRP	1
Elsevier: Procedia Computer Science	4

Journal	Papers
Elsevier: Resources, Conservation and Recycling	1
Elsevier: Technology in Society	1
Elsevier: Transportation Research Part E	2
Elsevier: Trends in Food Science & Technology	1
Emerald Insight: European Business Review	1
Emerald Insight: International Journal of Physical Distribution & Logistics Management	1
Emerald Insight: Journal of Enterprise Information Management	1
Emerald Insight: Journal of Global Operations and Strategic Sourcing	1
Emerald Insight: Journal of Manufacturing Technology Management	1
Emerald Insight: Journal of Organizational Change Management	2
Emerald Insight: Supply Chain Management - An International Journal	3
Emerald Insight: The International Journal of Logistics Management	1
GBMR: An International Journal	1
IEEE Access	3
IEEE Engineering Management Review	1
IEEE Open Journal of the Computer Society	1
IGI Global: Journal of Global Information Management	1
The IUP Journal of Supply Chain Management	1
The JBBA: The Journal of The British Blockchain Association	1
MDPI: Economies	1
MDPI: Logistics	3
MDPI: Mathematics	1
MDPI: Sustainability	5
OSCM	2
Springer Link: Annals of Operations Research	2
Springer Link: Information Systems and e-Business Management	1
Springer Link: Multimedia Systems	1
Springer Link: Soft Computing	1
Taylor & Francis: Cogent Business & Management	1
Taylor & Francis: International Journal of Construction Management	1
Taylor & Francis: International Journal of Production Research	3
Taylor & Francis: Production Planning & Control	1
Technological and Economic Development of Economy	1
Technology Innovation Management Review	1
University of Southampton Institutional Repository	1
Wiley Online Library	3

Table 5 illustrates the grouping of selected articles for analysis based on the journals they were published in. This study selected relevant articles related to the implementation of blockchain technology in SCM from various reputable journal sources. In this research, the researcher identified several journals that served as sources for the relevant articles. Some of the focused journals include Elsevier, Emerald Insight, IEEE, MDPI, Springer Link, Taylor & Francis, and Wiley Online Library. The articles chosen for analysis were collected from these journals and several others to obtain a comprehensive understanding of the potential and barriers of implementing blockchain technology in SCM.

Potential Implementation of Blockchain in SCM

Organizational Level

The implementation of blockchain technology in Supply Chain Management (SCM) offers several potential benefits that can revolutionize the way supply chains operate. One of the key advantages is traceability, which allows for the tracking and documentation of products or components throughout the supply chain. By utilizing blockchain, information related to the movement of products can be recorded in a secure, decentralized, and immutable manner (Gurtu & Johny, 2019). This enhances transparency and accountability while enabling stakeholders to verify the authenticity and sustainability of products.

Transparency is another significant benefit of implementing blockchain in SCM. Every transaction and change on the blockchain can be observed by all parties involved, ensuring that information is accessible and cannot be manipulated by unauthorized entities (Abeyratne & Monfared, 2016). This transparency improves reliability and minimizes errors or data inconsistencies, providing stakeholders with real-time access to relevant information.

Efficiency is a crucial aspect of SCM, and blockchain technology has the potential to streamline processes and reduce time (Li et al., 2021) and intermediaries (Kamilaris et al., 2019b). Blockchain enables automatic and real-time validation and processing of transactions, eliminating the need for time-consuming manual processes and reducing reliance on intermediaries. This results in improved efficiency (Queiroz et al., 2019) and faster completion of SCM activities.

Trust is a fundamental element in SCM relationships, and blockchain technology contributes to enhancing trust (Qian & Papadonikolaki, 2021) by securely recording all transactions and changes in the supply chain. The immutable nature of blockchain ensures that recorded information cannot be altered or manipulated (Gururaj et al., 2020), providing high levels of evidence and reliability (Nair & Dorai, 2021). This helps build stronger relationships among stakeholders.

Digitization is facilitated by implementing blockchain in SCM, allowing for the transformation of manual processes into more automated and connected forms (Parviainen et al., 2017). This reduces human errors (Rogerson & Parry, 2020), improves accuracy, and enhances overall efficiency in supply chain operations.

Quality management is essential in SCM, and blockchain technology can assist in risk management (Giudici, 2018) and inventory management (Mondol, 2021). By optimizing stock management and enabling real-time inventory monitoring, blockchain helps improve quality control and continuous improvement efforts.

Anti-counterfeiting measures can be significantly enhanced by implementing blockchain in SCM (Shen et al., 2021). The ability to record and trace the origin of products throughout the supply chain helps combat counterfeiting and ensures the integrity of the supply chain (Xu et al., 2021).

Security is a critical concern in SCM, and blockchain's decentralized model (Wright & De Filippi, 2015) enhances data security (Patel et al., 2023). As data is distributed across multiple nodes, there is no single point of failure that can be attacked or accessed by unauthorized entities. This ensures the integrity and security of supply chain data. Cost reduction is another potential benefit of implementing blockchain technology in SCM. Administrative costs can be reduced through automation (X. Zhang et al., 2020) and the execution of processes by smart contracts. This eliminates the need for human intervention in many SCM administrative tasks, resulting in cost savings.

Industrial Level

Implementing blockchain technology in Supply Chain Management (SCM) has the potential to support sustainability (Esmaeilian et al., 2020) by providing high transparency (Centobelli et al., 2022) and enabling the monitoring of sustainability practices (Saberi et al., 2018). Transparent information encourages responsible practices and supports the adoption of more sustainable approaches in the supply chain. Waste management can be improved through blockchain's ability to accurately record and trace every step in waste management processes (Park & Li, 2021), leading to more efficient and effective waste reduction and disposal. Furthermore, blockchain implementation in SCM can enhance compliance with industry standards (Kopyto et al., 2020) by enabling accurate tracking and auditing of standard compliance (Dai & Vasarhelyi, 2017). This facilitates tracking, verification, and auditing by authorized parties, promoting adherence to established standards.

The Barriers in Implementing Blockchain in SCM

Technological Barriers

Blockchain technology shows significant potential for improving supply chain management (SCM) through its unique characteristics. However, there are several technological barriers that need to be considered when implementing blockchain in SCM.

First, the immaturity of blockchain technology poses challenges (Alkhudary et al., 2020; Cole et al., 2019). Blockchain is still in the development stage and lacks mature standards,

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interoperability, and performance. Integration with existing SCM infrastructure can be difficult (Öztürk & Yildizbaşi, 2020), requiring further research and development efforts to enhance maturity and compatibility.

Second, the complexity of blockchain technology presents challenges. Its design, architecture, and algorithms require a deep understanding and expertise. Organizations may struggle to grasp and manage the technical complexities of blockchain (Yadav et al., 2020), necessitating proper training and expert consultation.

Security is another concern. While blockchain is designed to provide strong security through decentralization (Singh et al., 2022) and cryptography, there are still cybersecurity risks to address (Aslam et al., 2021). Protection against attacks, including potential quantum computer attacks, is essential for maintaining the integrity of supply chain data stored on the blockchain.

Privacy is a challenge due to the transparent and permanent nature of blockchain. Protecting sensitive data while maintaining transparency requires careful management and control of privacy settings (Sahebi et al., 2020).

Scalability is critical in SCM (Sahebi et al., 2020), where millions of daily transactions occur. Blockchain must handle increasing data, transactions, and participants without sacrificing performance. Transaction delays, slow speeds, and increased costs can hinder scalability (Monrat et al., 2019).

Immutability, a core feature of blockchain, can be a double-edged sword. While it ensures data integrity, it also means that errors or inaccuracies become permanent (Howson, 2020). Maintaining data accuracy and quality is crucial to avoid issues in SCM processes.

Interoperability is essential for integrating blockchain with existing SCM infrastructure. Challenges arise from differences in data formats, communication protocols, and smart contracts across blockchain platforms (Belchior et al., 2021).

System speed is crucial for SCM efficiency. Slow blockchain systems can cause delays in transaction processing and decision-making (Duan et al., 2020). Issues related to data storage and transaction latency can affect the overall speed of the system (Kamilaris et al., 2019b).

Organizational Barriers

Organizational barriers in implementing blockchain technology in supply chain management (SCM) include lack of knowledge about blockchain , lack of incentives for adoption, lack of trust in blockchain, higher costs, lack of resources or expertise, lack of organizational policies, lack of management support, cultural challenges, partner resistance, information sharing and disclosure challenges, and collaboration, communication, and coordination challenges.

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The lack of knowledge about blockchain can hinder adoption as organizations may not fully understand its concepts and potential (Kouhizadeh et al., 2021). The lack of incentives stems from a lack of early adopters (Balci & Surucu-Balci, 2021) and successful use cases (Santhi & Muthuswamy, 2022), making organizations hesitant to invest in blockchain technology. Lack of trust can result from concerns about criminal activities (Bryans, 2014) or negative perceptions toward technology (Wang, Singgih, et al., 2019).

Higher costs associated with blockchain implementation (Korpela et al., 2017; Öztürk & Yildizbaşi, 2020) and maintenance (Chavalala et al., 2022) can pose financial barriers for organizations. The lack of resources or expertise (Wong et al., 2020) in terms of computing capacity (Kouhizadeh et al., 2021; Wamba & Queiroz, 2020) and dedicated research and development units can also impede implementation (Rejeb et al., 2022). The absence of organizational policies (Saberi et al., 2018) and management support (Kouhizadeh et al., 2021) for blockchain usage reflects unpreparedness for adopting changes and investing in the technology. Cultural challenges (Saberi et al., 2018) and partner resistance (Hastig & Sodhi, 2020; Sternberg et al., 2020) may arise due to organizational habits and resistance to change.

Information sharing and disclosure challenges can arise from concerns about data confidentiality and business privacy (Kouhizadeh et al., 2021; Saberi et al., 2019; Sudiwedani and Darma, 2020). Collaboration, communication, and coordination challenges involve trust and data confidentiality (Kopyto et al., 2020), coordination and communication difficulties, leadership and decision-making complexities, and the need to change established organizational culture and habits (Etemadi et al., 2021).

Environmental Barriers

Environmental barriers to implementing blockchain technology in supply chain management (SCM) include the lack of government regulation, market competition and uncertainty, lack of industry acceptance, and high costs for sustainability.

The lack of government regulation (Balci & Surucu-Balci, 2021; Yadav et al., 2020) creates uncertainty and challenges in adopting blockchain technology in SCM (Malik et al., 2021). Without clear regulations, organizations may be hesitant to implement blockchain due to legal uncertainties, concerns about consumer protection (Paliwal et al., 2020), security, privacy (Gordon & Catalini, 2018), and the absence of industry standards. Government regulations are necessary to provide guidance and establish a supportive environment for blockchain adoption (Caldarelli et al., 2021).

Market competition and uncertainty can hinder blockchain implementation. Intense competition in SCM can make organizations resistant to change and reluctant to invest in new technologies (Gray, 2002). Rapidly changing business environments and market uncertainty can also discourage organizations from adopting blockchain, especially if the long-term benefits and impact are unclear.

Lack of industry acceptance is another challenge. Many industry stakeholders may have limited awareness and understanding of blockchain technology and its potential in SCM (Mathivathanan et al., 2021). Uncertainty about the benefits and return on investment, as well as compatibility issues with existing infrastructure and systems, can further hinder industry acceptance.

High costs for sustainability pose challenges for organizations. Blockchain technology, particularly in public networks, consumes substantial energy (Andoni et al., 2019) and contributes to material resource depletion (Rana et al., 2019). The high energy consumption and material requirements can result in increased costs and environmental impacts, making it difficult for organizations to maintain operational sustainability while adopting blockchain.

DISCUSSIONS

Implementing blockchain in Supply Chain Management (SCM) faces challenges that are closely tied to the relationship between blockchain characteristics and technological, organizational, and environmental barriers. The discussion of research findings focuses on the constraints and challenges that need to be addressed in the implementation of blockchain technology in Supply Chain Management (SCM). With a deep understanding of these constraints and effective collaboration among stakeholders, appropriate solutions can be developed to harness the potential of blockchain in enhancing security, transparency, and efficiency in SCM.

Technological Barriers

Blockchain's unique characteristics present technological challenges that need to be overcome for effective SCM implementation. The decentralized nature of blockchain can hinder scalability, especially when dealing with a large volume of transactions. The consensus mechanisms used in blockchain require agreement among multiple nodes, leading to potential bottlenecks. Scalability solutions, such as sharding and off-chain transactions, can help address this challenge.

Integrating blockchain with existing systems and achieving interoperability across different blockchain networks is crucial. The lack of standardization and compatibility between various blockchain platforms can hinder seamless data exchange and collaboration. Developing interoperability protocols and standards is essential to enable effective integration and interaction among different blockchain networks.

Blockchain transactions can have slower processing times compared to traditional centralized systems. The time required to reach consensus and record transactions on the blockchain can impact real-time SCM operations. Enhancing the performance and speed of blockchain networks through optimization techniques and advancements in consensus algorithms is vital for SCM implementation.

Organizational Barriers

Organizational barriers relate to challenges in implementing blockchain within the organizational context and fostering collaboration among stakeholders. Implementing blockchain technology requires a shift in organizational processes and mindset. Resistance to change from employees and stakeholders can hinder adoption. Effective change management strategies, including communication, training, and stakeholder involvement, are necessary to address this challenge.

SCM involves multiple stakeholders, each with their own interests and requirements. Establishing collaboration mechanisms and governance models that foster trust and enable decision-making is crucial. Developing consensus among stakeholders, defining roles and responsibilities, and establishing protocols for data sharing and access are key components of effective governance.

Blockchain technology requires specialized skills and knowledge that may not be readily available within organizations. Building internal expertise or partnering with external consultants or technology providers can help address this challenge. Training programs and capacity-building initiatives should be implemented to equip employees with the necessary skills to work with blockchain technology.

Environmental Barriers

Environmental barriers pertain to the impact of blockchain implementation on energy consumption and sustainability. Some blockchain networks, particularly those based on Proof of Work consensus algorithms, consume substantial amounts of energy. This high energy consumption can have environmental implications. Exploring alternative consensus mechanisms, such as Proof of Stake, and adopting energy-efficient hardware and infrastructure can help mitigate this challenge.

Organizations must consider the environmental impact of blockchain implementation in SCM. This includes responsible sourcing of energy, minimizing e-waste, and ensuring adherence to sustainability practices throughout the blockchain lifecycle. Integrating sustainability criteria into the design and selection of blockchain networks can help mitigate negative environmental effects.

To address these challenges, organizations and stakeholders should take the following actions:

Collaboration and Partnerships

Collaboration among industry players, technology providers, and regulators is essential to overcome technological barriers and develop interoperable and scalable blockchain solutions. By working together, organizations can share knowledge, resources, and best practices to advance blockchain adoption in SCM.

Regulatory Frameworks and Standards

The development of clear regulatory frameworks and industry standards for blockchain implementation in SCM is crucial. Governments and regulatory bodies should collaborate with industry stakeholders to establish guidelines that address legal and compliance aspects, data privacy, and interoperability standards.

Pilot Projects and Proof of Concepts

Conducting pilot projects and proof of concepts can help organizations identify and address technological, organizational, and environmental challenges in a controlled environment. These initiatives allow for testing, learning, and refining blockchain solutions before full-scale implementation.

Education and Training

Investing in education and training programs can enhance the technical expertise of SCM professionals and stakeholders. This includes providing training on blockchain fundamentals, smart contract development, data privacy, and cybersecurity. Educational institutions, professional organizations, and technology providers can collaborate to offer specialized courses and certifications.

In conclusion, implementing blockchain in SCM faces technological, organizational, and environmental barriers. Overcoming these challenges requires collaboration, investment in technical expertise, the development of regulatory frameworks, and sustainable practices. By addressing these barriers, organizations can harness the potential of blockchain technology to enhance transparency, efficiency, and security in supply chain management.

CONCLUSION

In this research, an in-depth analysis has been conducted on the potential and barriers of adopting blockchain technology in SCM. Based on the findings obtained, it can be concluded that blockchain technology offers significant potential in enhancing efficiency, transparency, security, and reliability in the supply chain.

However, there are several barriers that need to be overcome for successful implementation of blockchain in SCM. These barriers include technological constraints such as the immaturity of blockchain, complexity, security, privacy, scalability, immutability, and interoperability. Additionally, there are organizational barriers such as lack of knowledge about blockchain, lack of incentives for adoption, lack of trust, high costs, lack of resources or expertise, lack of organizational policies, lack of management support, cultural challenges, resistance from business partners, information sharing challenges, and collaboration, communication, and coordination challenges. Furthermore, there are environmental barriers such as lack of government regulations, market competition, uncertainty, lack of industry acceptance, and high costs towards sustainability.

To address these barriers, potential solutions have been proposed that can serve as guidelines for companies and stakeholders in implementing blockchain in SCM. These solutions involve efforts to enhance understanding and knowledge about blockchain, build collaborations among stakeholders, overcome trust and cultural barriers, and encourage supportive regulations for blockchain implementation.

Thus, this research provides a significant contribution to the understanding of the potential and barriers of implementing blockchain technology in SCM. The findings and potential solutions derived from this research can guide companies and stakeholders in tackling the challenges of adopting blockchain technology. In the future, it is hoped that this research will further drive the development and implementation of blockchain technology in SCM, thereby enhancing overall efficiency and sustainability in the supply chain.

Although this study attempts to comprehensively investigate the potential and barriers of implementing blockchain technology in Supply Chain Management (SCM), there are several limitations that need to be acknowledged. Firstly, the study relied on a single reviewer to review the validity and reliability of the findings. While steps have been taken to ensure the accuracy and precision of the analysis, a broader perspective from multiple reviewers could have provided valuable additional insights.

Another limitation is the constraint in the types of publications used as data sources. This research relied on scholarly publications such as research articles and peer-reviewed articles, which may limit access to important information that could be available in non-academic publications or internal company reports. As a result, there is a potential that some relevant resources and findings may not have been included in the analysis.

Furthermore, despite efforts made to present a comprehensive overview of the potential and barriers of implementing blockchain technology in SCM, rapid changes in technology and the business environment can render some findings outdated. Therefore, this research only reflects the conditions and understanding at the time the study was conducted.

Finally, time and resource limitations can also impact the depth and breadth of this research. Due to these constraints, there may be certain aspects that were not covered in-depth or areas that were not fully explored. Nevertheless, this study provides a solid foundation for further research and expands the understanding of the potential and barriers of implementing blockchain technology in SCM.

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