International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

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Using blockchain technology to maximize supply chain and logistics management in north America

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International Journal of Science and Research Archive, 2024, 12(02), 854–863

Publication history: Received on 07 May 2024; revised on 21 June 2024; accepted on 24 June 2024

Article DOI: https://doi.org/10.30574/ijsra.2024.12.2.1096

Abstract

This study explores the application of blockchain technology in optimizing supply chain and logistics management within North America. Through qualitative thematic analysis, three key objectives were addressed: identifying benefits, examining implementation challenges, and assessing barriers to adoption. The analysis highlights significant benefits of blockchain adoption, including enhanced trust, transparency, automation, traceability, and data security, supported by findings from various studies. However, implementation challenges such as system design complexity, resistance to change, and inadequate IT staff pose obstacles to adoption. Furthermore, barriers to widespread adoption, such as the absence of a proper legal framework and the capital-intensive nature of blockchain adoption, were identified. These barriers underscore the need for collaborative efforts to address regulatory uncertainties and financial constraints. It was suggested that further studies could explore the long-term impacts of blockchain technology on supply chain resilience and sustainability, as well as investigate strategies to overcome implementation challenges and maximize the technology's potential across diverse industries and regions.

Keywords: Blockchain Technology; Supply Chain; Logistics Management; Logistics Optimization; North-America

1. Introduction

In an age defined by the relentless pursuit of efficiency and transparency, industries around the globe are constantly seeking innovative solutions to enhance their supply chain and logistics operations [10, 1, 18]. In recent years, the significance of supply chain in term of its traceability capability has surged, driven by a confluence of factors ranging from regulatory compliance, quality assurance, combating product counterfeiting, sustainability imperatives, and consumer demands for transparency and authenticity are among the key reasons fuelling the growing importance of an efficient supply chain [11, 21]. Organisations are continually looking for techniques to improve supply chain and logistics management efficiency. Among the widely identified solutions, blockchain technology has emerged as a transformative force, promising to revolutionize the way businesses manage their intricate networks of suppliers, distributors, and stakeholders.

Blockchain technology (BCT), originally conceived as the underlying framework for cryptocurrencies like Bitcoin, has transcended its origins to offer a myriad of applications across various sectors [14, 18]. At its core, blockchain is a distributed ledger system that records transactions across a network of computers in a secure and transparent manner, unlike traditional centralized databases, where information is vulnerable to manipulation and unauthorized access [2].

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Blockchain counter these manipulations by ensuring data integrity and trust through cryptographic techniques and consensus algorithms, which further ensure transparency, accuracy, and immutability across the supply chain.

Supply chain management is now more difficult than ever due to rising globalisation and market developments [2, 5, 8, 12]. The majority of the products we consume today are procured and produced in geographically distant places, and in order to efficiently manage these complicated worldwide supply chains, optimisation, digital and disruptive technologies are required [2, 9, 3, 12, 17]. In North America, just like in most other civilised countries, supply chains face a myriad of challenges stemming from geographical scale, regulatory complexities, technological advancements, labour issues, and various disruptions [1, 6]. These challenges resulted into the spurning of several businesses in the supply chain management services industry in the North America, providing services to ensure the optimisation of the the supply chain and logistics of organisations. The projected revenue in the supply chain management software market for North America is expected to reach US$11.00 billion in 2024, with an anticipated annual growth rate (CAGR 2024-2028) of 3.33% [26]. This growth trajectory is forecasted to lead to a market volume of US$12.54 billion by 2028 [26]. Despite the myriad advantages offered by blockchain technology (BCT), its application to bolster supply chain and logistics management remains relatively unexplored in most sectors around the world [2, 1, 3, 22, 4, 23, 15, 14, 7, 18], and more specifically within North America [1]. This study aims to address the under explored application of blockchain technology (BCT) in North American supply chain and logistics management. The research objectives focus on assessing stakeholders' awareness of BCT, examining perceived benefits and challenges, and identifying barriers to adoption. This study is important for understanding the readiness for BCT integration, evaluating potential impacts, and identifying areas for intervention to facilitate its uptake. This research aim to address these gaps, in line with the following research objectives:

- To explore the current level of awareness and understanding of blockchain technology among key stakeholders in the North American logistics sector.
- To investigate the perceived benefits and challenges associated with implementing blockchain technology in supply chain and logistics management within North America.
- To examine the existing barriers hindering the widespread adoption of blockchain technology in the North American logistics sector.

Undertaking this study in the light of the above objectives is important because this study serves as a vital step towards creating awareness and unlocking the full potential of blockchain technology in maximizing the efficiency and effectiveness of supply chain and logistics management within North America, ultimately contributing to enhanced transparency, traceability, and overall performance in the industry.

2. Materials and Methods

In this section, the research methodology used in this study will be examined. The research methodology employed in this study will be structured according to the research onion framework developed by Saunders, Lewis and Thornhill [25]. This framework as shown in figure 1 comprises multiple layers, each representing a different aspect of the research process, from broad philosophical assumptions to specific data collection methods. The layers include: philosophy, approach, strategy, choice of methods, time horizon, and techniques for data collection and analysis.

2.1. Philosophy

This layer involves the researcher's underlying beliefs and assumptions about the nature of reality and knowledge. In this study, the philosophical stance leans towards interpretivism philosophy. Interpretivism emphasizes the subjective interpretation of social phenomena and the construction of meaning by individuals within their social context. In the context of researching the application of blockchain technology in North American supply chain and logistics management, an interpretivist approach allows for an in-depth exploration of stakeholders' perceptions, attitudes, and experiences related to blockchain adoption.

2.2. Approach

The layer refers to the general direction of the research, guiding how data will be collected and analysed. The research approach employed in this study is deductive. A deductive approach involves testing a specific hypothesis or theory derived from existing literature or established principles. In the context of this study, the deductive approach will involve formulating hypotheses based on theoretical frameworks or research objectives of the study and then testing these hypotheses through empirical data collection and analysis.

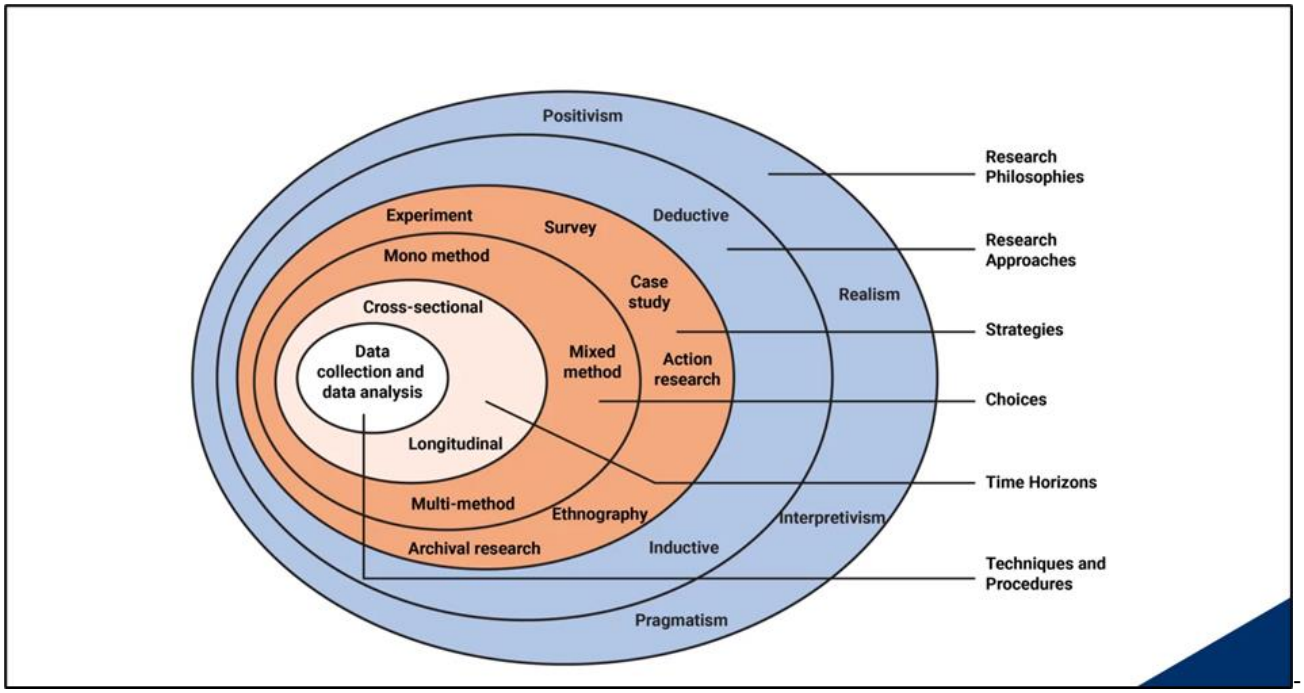

Figure 1 Saunders, Lewis and Thornhill Research Onion

2.2.1. *Strategy*

The strategy layer outlines the overall plan or approach for conducting the study. The “documentary analysis" or "documentary research" strategy was used in this study. Documentary analysis involves the systematic examination and interpretation of existing documents or texts to gain insights into a particular phenomenon or research question. In the context of this study, this strategy entails reviewing and synthesizing relevant literature, academic papers, reports, and other scholarly works that have investigated similar topics or themes related to the application of blockchain technology in supply chain and logistics management.

2.3. Choice of Methods

This layer involves selecting specific methods for data collection and analysis. Common methods include interviews, questionnaires, observations, document analysis, and experiments. The method used in this study is qualitative method through document analysis of peer review articles on the application of blockchain technology in supply chain and logistics management. This aligns with the research philosophy and strategy used in this study.

2.4. Time Horizon

The time horizon specified for this study is ten years, covering articles and publications from 2015 to 2024. This time frame aligns with the research objective of examining the various ways in which blockchain technology can be harnessed to maximize supply chain and logistics management in North America. By focusing on literature published within the past decade, the study aims to capture recent developments, trends, and insights in the field of blockchain technology and its application in supply chain management.

2.5. Techniques and Procedures for Data Collection and Analysis

The data collection process for this study entails conducting a comprehensive literature review encompassing academic papers, industry reports, case studies, and policy documents published between 2015 and 2024. Selected documents are compiled into a centralized database, categorized based on relevant themes, and systematically analysed using qualitative coding techniques. Thereafter, thematic analysis is employed to identify recurring themes, patterns, and insights across the literature, facilitating the interpretation of findings and the synthesis of meaningful conclusions. Through cross-document comparison, consistencies, contradictions, and gaps in the literature are identified, providing a nuanced understanding of the diverse applications and implications of blockchain technology in supply chain and logistics management within the North American context.

2.6. Ethical Consideration

In this study, ethical considerations were primarily focused on maintaining the integrity of the research process and upholding ethical standards in data collection and analysis. Since the data was obtained through the review of peer-reviewed articles and no direct contact was made with individuals, there were no ethical issues experienced related to participant confidentiality, informed consent, or potential harm. However, the researcher uphold ethical principles such as accurately attributing sources, ensuring the confidentiality of information obtained from published sources, and adhering to ethical guidelines and regulations governing research practices.

3. Results and Discussion

The aim of this section is to answer the primary research question: How the usage of blockchain technology maximise supply chain and logistics management in North America. For that, the section is divided into three parts. The first part includes a descriptive overview of the secondary resources selected for the study, followed by the thematic analysis of the core five articles under review. The third part deals with the discussion of findings.

3.1. Description of Secondary Resources

In this study, data collection involved the review of 45 selected publications spanning from 2015 to February 2024. Initially, the researcher identified 32 abstracts relevant to the subject area within the specified time frame. From these abstracts, only 5 articles were deemed particularly pertinent to the research objectives and were selected for further analysis. These empirical studies were chosen for their relevance and widespread acceptance within the research community, as evidenced by their citation counts, indicating their significant impact on the field of supply chain management. The following are the list of datasets selected for thematic analysis, showing the name of the author(s) and the topic of each article.

- **Dataset No. 1:** Tiwari et al.[2], “Blockchain and third-party logistics for global supply chain operations: Stakeholders’ perspectives and decision roadmap”.
- **Dataset No. 2:** Almutairi et al. [9], “Blockchain Technology Application Challenges in Renewable Energy Supply Chain Management”.
- **Dataset No. 3:** Ejairu et al. [10], “Blockchain in global supply chains: A comparative review of USA and African practices”.
- **Dataset No. 4:** Gurtu and Johnny [24], “Potential of blockchain technology in supply chain management: a literature review”.
- **Dataset No. 5:** Zhang et al. [1], “Smart supply chain management in Industry 4.0: the review, research agenda and strategies in North America”.

Table 1 Key identified benefits, challenges and barriers from the datasets

Authors	Key Identified Benefits	Key Identified Implementation Challenges	Key identified Barriers to Widespread Adoption	Page No.
Tiwari et al.	Trust, Transparency; Automation of Process; and Traceability	Lack of clear roadmap with respect to the complexity of system design; Resistance to change leading to some level of unacceptability of blochchain across supplychain network	Absence of legal framework for enforcement of contracts; Capital Intensive.	9
Almutairi et al.	Transparency; Traceability.	Resistance to change; System design complexity; Lack of IT workforce.	High Investment Cost; Absence of proper legal framework	72051
Ejairu et al.	Trust; Transparency; Traceability.	Resistance to change; Insufficient technical know-how.	Huge investment cost; No standadized protocol and established regulatory framework.	2094-2097

Gurtu and Johnny	Data Security and Traceability, Transparency; and Trust	Resistance to change; Insufficient skilled staff.	Huge investment cost; and Weak Regulatory framework.	888-892
Zhang et al.	Visibility and traceability; Automation of process; and Transparency	Resistance to change; Inadequate skilled worker.	High investment cost; and Absence of wel-defined regulatory framwork.	1103-1109

Data Extracted from the Selected Datasets with respect to the Research Objectives

The information in table 1 shows the key benefits, implementation challenges, and the barrier to the adoption of blockchain in supplychain and logistics management, as identified by the authors of each of the selected dataset.

3.2. Analysis and Discussion of Findings on the Objectives of the Study

The discussion under this section is structured around the three research objectives raised earlier in this study, while also making reference to the themes identified in table 1.

3.2.1. *Objective 1*

To explore the perceived benefits of adopting blockchain technology in supply chain and logistics management in North America.

The first research objective of the study aimed to explore the perceived benefits of adopting blockchain technology in supply chain and logistics management in North America. The frequency distribution of the identified themes on the key benefits of adopting blockchain technology in supply chain and logistics management is shown in figure 1.

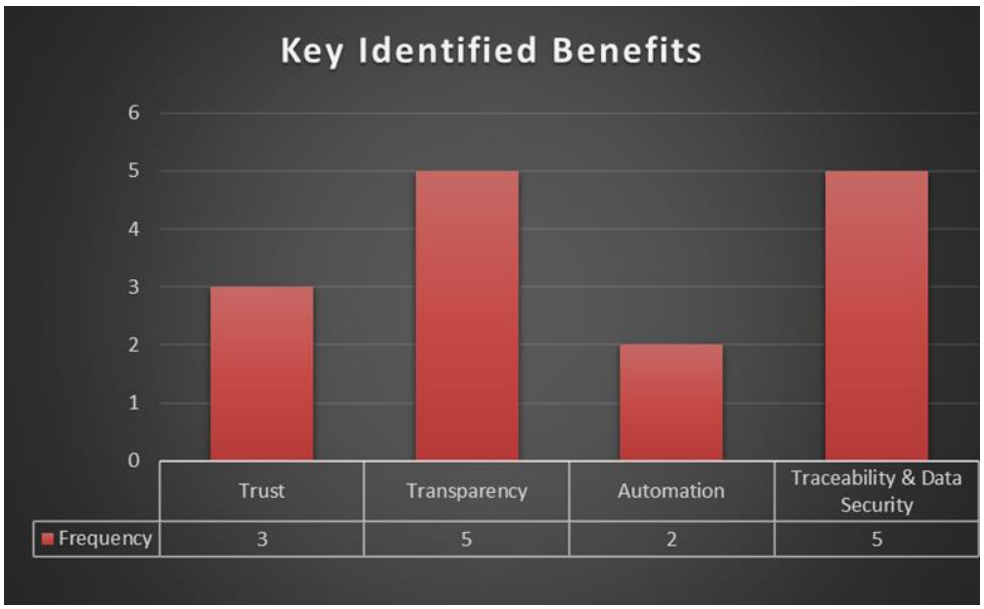

Figure 2 The frequency distribution of the key benefits identified from the datasets

The information in figure 2 shows the concise and graphical view of the key benefits identified from the datasets respectively. The analysis of the five datasets understudy revealed that the identified key benefits of blockchain technology in supply chain and logistics management suggested by the different authors of each dataset include trust, transparency, automation traceability and data security.

The information graphically illustrated in figure 2, provides insights on the number of occurrences each benefit was mentioned across the five dataset. The frequency distribution measures how significant each of the benefits are, based

on how high or low each frequency is. The analysis across the five datasets revealed that 3 of the 5 datasets considered 'trust' as one of the main benefits of adopting blockchain in supply chain and logistics management.

For instance, Zhang et al. [1] discuss how blockchain enhances trust in supply chain processes through its immutable and decentralized nature, ensuring the integrity of transactions and fostering trust among stakeholders. Tiwari et al. [2] also emphasize the importance of trust in supply chain operations facilitated by blockchain technology, highlighting its role in mitigating issues such as fraud and counterfeit products [19, 20, 21].

Transparency emerges as another significant benefit, echoed by studies such as Pesquera [3], which discusses how blockchain enables transparent and tamper-proof record-keeping, enhancing visibility and accountability throughout the supply chain. Kamble et al. [4] further elaborate on transparency, emphasizing its role in improving supply chain integration and sustainability by enabling real-time tracking and monitoring of goods.

Automation is highlighted by Difrancesco et al. [5] as a key benefit of blockchain adoption, streamlining supply chain processes and reducing manual intervention. The authors demonstrate how smart contracts and automated workflows enhance efficiency and reduce operational costs in supply chain management.

Traceability is underscored by Dhingra et al. [6], who discuss how blockchain technology enables end-to-end traceability of products, facilitating recall management and ensuring product authenticity. This aspect of traceability contributes to building consumer trust and meeting regulatory compliance requirements.

In terms of significance, the study shows that each benefit occurs at various frequency throughout the datasets. While trust and transparency emerge as major themes, with three out of five datasets citing considerable benefits, automation, traceability, and data security are also important, albeit to differing degrees among the datasets.

3.2.2. *Objective 2*

To investigate the challenges associated with implementing blockchain technology in supply chain and logistics management within North America.

The second research objective investigates the challenges associated with implementing blockchain technology in supply chain and logistics management within North America. The frequency distribution of the identified themes with respect to the key implementation challenges of adopting blockchain technology in supply chain and logistics management, is as shown in figure 3.

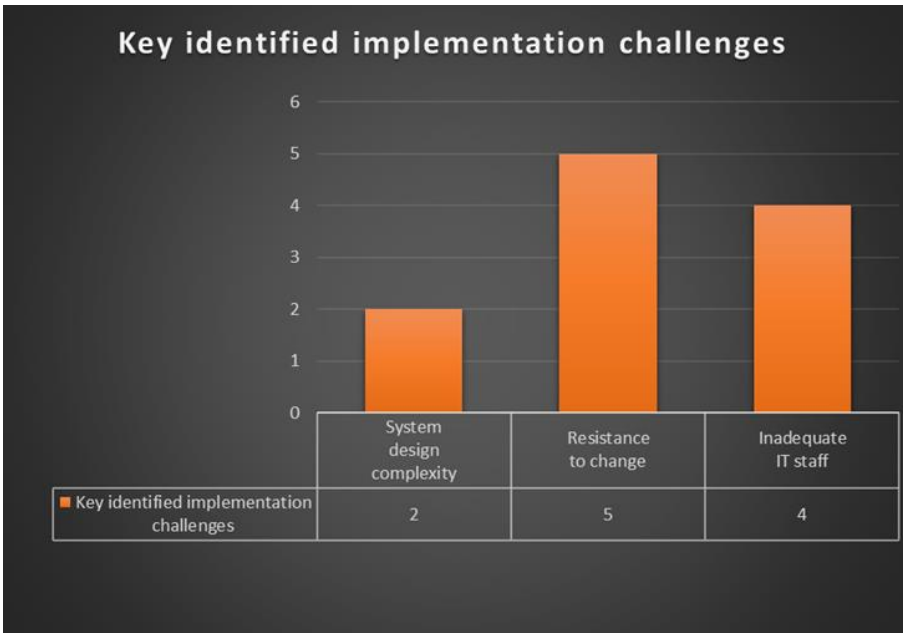

Figure 3 The frequency distribution of the key identified implementation challenges

The information in figure 3 presents the concise and graphical view of the key implementation challenges identified while analysing the datasets. The analysis revealed that three major themes emerged with respect to the challenges encountered by organisations when implementing blockchain technology into their supply chain and logistics management. The identified themes as shown in figure 3 includes system design complexity, resistance to change and inadequate IT staff.

The frequency distribution in figure 3 measure how significant each of the challenges are, based on how high or low each frequency is. The information in figure 3 shows that 'resistance to change' seems to be the most significant implementation challenges encountered by organisations when implementing blockchain technology to supply chain and logistics management. This was evident from the fact that resistant to change occurred across all the review datasets as a key implementation challenge facing organisations. The next most occurred implementation challenge with a frequency of 4, is inadequate IT staff to take change of the implementation process. While the third identified challenge is System design complexity, with an occurrence of 2 out of the 5 datasets under analysis.

System design complexity emerges as a significant challenge, as discussed by Pesquera [3] and Kamble et al. [4]. Pesquera highlights the complexity of integrating blockchain into existing logistics systems, necessitating extensive redesign and customization to ensure compatibility and functionality. Similarly, Kamble et al. emphasize the technical intricacies involved in designing blockchain-based supply chain solutions, requiring specialized expertise and resources for successful implementation.

Also, resistance to change is identified as a major challenge across all review datasets, echoing the findings of studies such as Zhang et al. [1] and Tiwari et al. [2]. These authors emphasize the organizational and cultural barriers to blockchain adoption, including reluctance to embrace new technologies, inertia towards traditional practices, and concerns about disrupting existing workflows.

Lastly, inadequate IT staff emerges as another key challenge, as highlighted by Kamble et al. [4] and Dhingra et al. [6]. The shortage of skilled personnel capable of managing blockchain implementation processes poses significant hurdles, limiting organizations' capacity to leverage the technology effectively and efficiently.

Overall, the analysis highlights the multifaceted nature of the challenges associated with implementing blockchain technology in supply chain and logistics management, emphasising the need for organisations to address organisational, technical, and human capital barriers in order to fully realise the potential of blockchain adoption.

3.2.3. *Objective 3*

To examine the existing barriers hindering the widespread adoption of blockchain technology in the North American logistics sector.

The last research objective examine the existing barriers hindering the widespread adoption of blockchain technology in the North American logistics sector. Figure 4 presents the frequency distribution of the identified themes with respect to the main barriers hindering the the widespread adoption of blockchain technology in the North American logistics sector.

The information in figure 4 shows the frequency distribtion or the number of occurrence of the identified barriers hindering the widespread adoption of blockchain technology in the North American logistics sector. The main barriers identified and common to the authors in the five datasets under review include both the absence of proper legal framework, as well as the capital intensive nature or investment required to adopt and establish a well efficient blockchain technology in the logistics sector.

The information in figure 4 revealed that 2 issues were mentioned as key barriers to the wide adoption of blochchain technology in supply chain and logistics management. These barriers include the absence of proper and widely acceptable legal framework for blockchain technology, as well as the capital intensive nature associated with the adoption of blockchain technology.

The absence of a proper legal framework is highlighted as a significant barrier by studies such as Zhang et al. [1] and Al-Khattabi [13]. These authors discuss the regulatory uncertainties surrounding blockchain technology, including issues related to data privacy, liability, and contract enforcement. The lack of standardized regulations and guidelines hampers industry-wide adoption and creates legal uncertainties for stakeholders, thereby impeding the widespread implementation of blockchain in the logistics sector.

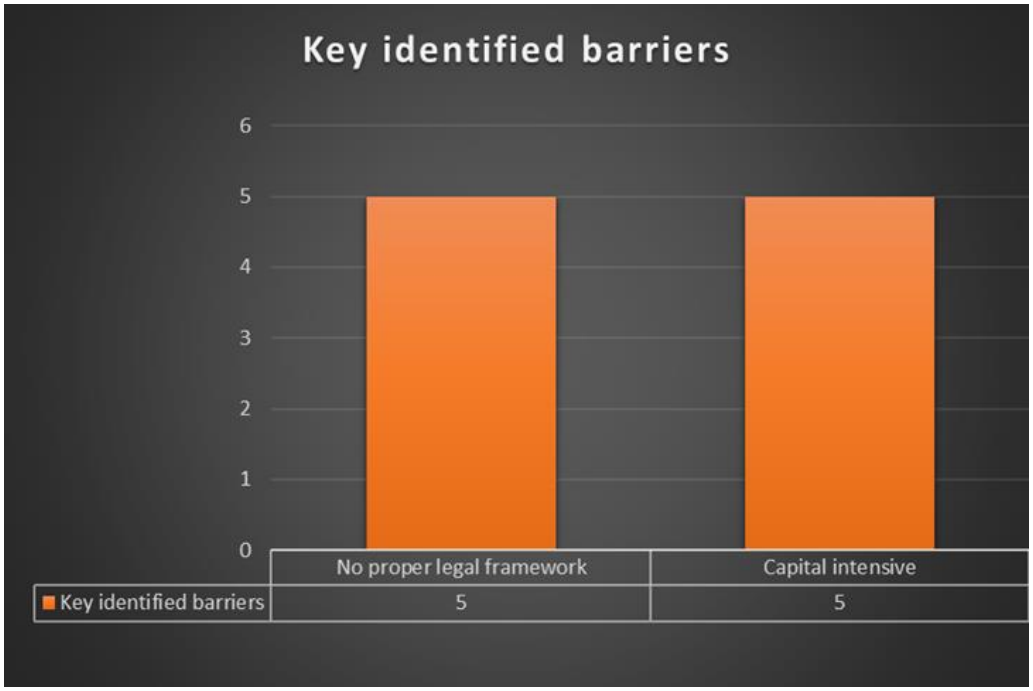

Figure 4 The frequency distribution of the key identified barriers

Furthermore, the capital-intensive nature of blockchain adoption emerges as another major barrier, as discussed by Pesquera [3] and Kamble et al. [4]. These authors emphasize the significant investment required to implement and establish efficient blockchain solutions in logistics operations. The costs associated with infrastructure development, technology integration, and talent acquisition pose financial challenges for organizations, particularly small and medium-sized enterprises (SMEs), limiting their ability to adopt blockchain technology at scale.

These constraints are significant because they have the potential to hamper the realisation of blockchain technology's transformative benefits in supply chain and logistics management. Tackling legal concerns and lowering financial barriers is critical for creating an environment conducive to innovation and investment in blockchain technologies. By overcoming these limitations, organisations may fully realise the potential of blockchain technology to improve transparency, efficiency, and trust in logistics operations, resulting in long-term growth and competitiveness in the North American logistics sector.

4. Conclusion

This study investigates the application of blockchain technology in optimizing supply chain and logistics management within North America. Through thorough investigation, it concludes that the adoption of blockchain technology in this sector has faced numerous barriers and implementation challenges over time. However, despite these obstacles, the introduction and utilization of blockchain technology have ushered in new opportunities. These include enhanced trust, transparency, automation, traceability, and data security, all of which contribute to the sector's advancement and efficiency. Among other notable areas, further studies could explore the long-term impacts of blockchain technology on supply chain resilience and sustainability, as well as investigate strategies to overcome implementation challenges and maximize the technology's potential across diverse industries and regions.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare no conflicts of interest.

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