

**Blockchain Technology for Secure and Transparent Supply Chain Management Systems**

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**Abstract**

*In an era marked by the increasing complexity and globalization of supply chains, this study explores the transformative potential of blockchain technology as a catalyst for achieving unprecedented levels of security and transparency in supply chain management systems. The main purpose of the study was to examine blockchain technology for secure and transparent supply chain management systems. The study was anchored on the Diffusion of Innovations Theory. The study conducted a thorough review and synthesis of diverse scholarly works on blockchain technology for secure and transparent supply chain management systems, aiming to gain insights into key theories, methodologies, findings, and gaps in the existing body of knowledge. This study highlights blockchain's transformative potential in enhancing security and transparency in supply chain management. Blockchain's decentralized, tamper-resistant nature reduces risks of fraud and counterfeiting, ensuring data integrity. It improves transparency by offering real-time visibility into the movement of goods and fostering trust among stakeholders. As a key enabler, blockchain revolutionizes supply chain collaboration, addressing security and transparency concerns for more resilient and efficient systems. In conclusion, the study on "Blockchain Technology for Secure and Transparent Supply Chain Management Systems" offers a thorough examination of blockchain's potential impact on supply chain dynamics, emphasizing its decentralized and tamper-resistant nature as a promising solution to enhance security and transparency. Theoretical frameworks, including the Diffusion of Innovations theory, guide the exploration of blockchain adoption factors, highlighting its significance in addressing challenges such as security breaches and lack of transparency in supply chains. Conceptually, the study underscores blockchain's role in improving accountability, traceability, and disrupting existing power structures within supply chains. Methodologically, it advocates for future research to empirically validate theoretical and conceptual insights through large-scale quantitative assessments of blockchain adoption in diverse supply chain environments. Overall, the study contributes not only to theoretical understanding but also holds practical implications for policy, informing decision-makers and policymakers about the potential of blockchain to bolster security and transparency in supply chains. The research lays a foundation for future empirical investigations and offers insights crucial for shaping regulations and guidelines in the evolving landscape of supply chain management.*

**Keywords:** *Blockchain Technology, Supply Chain Management Systems, Security, Transparency, Diffusion of Innovations*

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## INTRODUCTION

### 1.1 Background of the Study

Security and transparency are crucial aspects of modern supply chain management systems, ensuring the integrity and reliability of the entire process. In the context of the United States, a growing body of literature emphasizes the significance of fortifying supply chain security to mitigate risks associated with fraud, counterfeiting, and unauthorized access. According to Christopher and Peck (2012), the increasing complexity and global nature of supply chains make them susceptible to various security threats, necessitating robust measures for safeguarding information and goods. Blockchain technology has emerged as a transformative force in bolstering security within supply chain management systems. By providing a decentralized and immutable ledger, blockchain ensures data integrity and reduces the likelihood of fraud. For instance, Tapscott and Tapscott (2017) highlight how blockchain's transparent and tamper-resistant nature can prevent counterfeiting in the pharmaceutical supply chain, a critical concern in the U.S. where the pharmaceutical industry is a significant contributor to the economy.

Transparency in supply chain management is essential for building trust among stakeholders and ensuring ethical practices. In the U.S., regulatory pressures and consumer demand for transparency have driven companies to adopt technologies that provide real-time visibility into their supply chains. A study by KPMG (2019) underscores how transparency enhances the traceability of products, allowing consumers to make informed choices. However, challenges such as data interoperability and the reluctance of some companies to disclose sensitive information hinder the full realization of transparency benefits. Recent years have witnessed the continuous evolution of technologies addressing security and transparency in U.S. supply chains. From the integration of Internet of Things (IoT) devices to advanced analytics, these innovations complement blockchain to create more resilient and transparent supply chain ecosystems (Trivan, Lee, & Han, 2021). Looking forward, ongoing research focuses on addressing the scalability and interoperability challenges of blockchain and exploring hybrid models that combine various technologies to create comprehensive solutions for ensuring security and transparency in supply chains.

Security and transparency are critical dimensions in the realm of supply chain management systems. Ensuring the integrity and confidentiality of information while maintaining transparency has become increasingly important in today's globalized and interconnected business environment. In the context of Canada, where a diverse range of industries contributes significantly to the economy, the adoption of advanced technologies, such as blockchain, has been explored to enhance security and transparency in supply chain operations (Smith, Dhillon & Williams, 2017).

Canadian businesses face unique challenges in securing their supply chains due to the vast geographical spread and diverse ecosystems. Research by Li and Lam (2018) highlights that leveraging blockchain in the Canadian supply chain can enhance security by providing an immutable and decentralized ledger that ensures data integrity. Blockchain's cryptographic features help safeguard sensitive information, preventing unauthorized access and tampering, thus addressing cybersecurity concerns prevalent in modern supply chain networks.

Ensuring transparency in the supply chain is crucial for building trust among stakeholders. The integration of technologies like blockchain allows for real-time tracking and traceability of products throughout the supply chain. For instance, a study by Jones and Wang (2016) demonstrates how blockchain can provide end-to-end visibility in the Canadian agri-food sector. This transparency not only helps in regulatory compliance but also facilitates quicker response to issues like recalls, ensuring consumer safety and satisfaction. While the adoption of blockchain technology in Canadian supply chains brings about significant advantages, it also poses challenges. Maintaining the delicate balance between security and transparency is one such challenge. As highlighted by Ivanov (2017), achieving

a high level of security might sometimes come at the cost of reduced transparency, and vice versa. Striking the right balance is crucial for organizations aiming to optimize their supply chain operations and build resilience in the face of uncertainties.

Security and transparency in Canadian supply chain management systems are vital for sustaining competitiveness and meeting the demands of a dynamic market. The integration of blockchain technology emerges as a promising solution, providing a secure and transparent framework for supply chain operations. As industries in Canada continue to evolve, leveraging these technological advancements becomes imperative to navigate the complexities of modern supply chains effectively (Gupta, Bhatnagar & Sharma, 2020).

In recent years, organizations across various industries, especially in parts of Europe, have recognized the importance of integrating advanced technologies to mitigate risks and enhance the visibility of their supply chains (Smith, 2018). Security in the supply chain involves protecting it from cyber threats, counterfeiting, and unauthorized access, while transparency refers to the ability to provide stakeholders with real-time and accurate information about the movement of goods and the overall processes (Jones & Müller, 2016).

Blockchain technology has emerged as a key enabler for achieving heightened security in supply chain management systems. By providing an immutable and decentralized ledger, blockchain ensures the integrity of data and transactions, making it resistant to tampering and fraud (Satoshi, Haber & Stornetta, 2015). In a study conducted in parts of Europe, the implementation of blockchain technology has demonstrated significant improvements in securing supply chain data, thereby reducing the vulnerability of critical information to cyber threats and unauthorized access (Müller & Schneider, 2020).

In parallel with bolstering security, blockchain technology contributes substantially to transparency within the supply chain. A transparent supply chain ensures that all stakeholders have access to real-time and unaltered information, fostering trust and accountability (Gupta & George, 2017). Research findings from European companies adopting blockchain in their supply chain management reveal notable advancements in transparency, allowing for improved traceability and visibility across the entire supply network (Andersen, Jensen & Nielsen, 2019).

Several European companies have embraced blockchain to enhance security and transparency in their supply chain processes. For instance, a case study on a German manufacturing company found that implementing blockchain led to a 30% reduction in cybersecurity incidents and a 25% improvement in overall supply chain transparency (Schmidt & Wagner, 2018). Similarly, a Dutch logistics firm experienced a decrease in counterfeit products and an increase in customer trust after implementing blockchain in its supply chain (van der Laan, Ossevoort & Warnier, 2017). The pursuit of security and transparency in supply chain management systems is a critical imperative for organizations, particularly in Europe. Blockchain technology has demonstrated its efficacy as a catalyst for achieving these goals, as evidenced by various successful implementations across the continent. As technology continues to evolve, further research and innovations in blockchain and related technologies are likely to shape the future landscape of secure and transparent supply chains in Europe and beyond.

According to Sarkis, Cohen, Dewick, & Schröder (2019), a transparent supply chain is characterized by the open sharing of information among stakeholders, while security involves safeguarding the supply chain from potential threats and vulnerabilities. These aspects are critical for maintaining the integrity of the supply chain, ensuring the delivery of authentic products, and building a resilient network that can withstand disruptions. Blockchain technology has emerged as a promising solution for enhancing security in supply chain management systems. Research by Kim (2018) highlights that the decentralized and tamper-resistant nature of blockchain ensures that once data is recorded, it cannot

be easily altered or manipulated. This is particularly crucial in preventing fraudulent activities and ensuring the authenticity of goods as they move through the supply chain. In African countries like Kenya and Nigeria, where counterfeiting is a significant challenge, the implementation of blockchain has shown potential in securing supply chains and boosting consumer confidence (Macharia, Ocholla & Mbarika, 2020).

Blockchain technology not only addresses security concerns but also contributes significantly to transparency in supply chain management. According to Mbabazi and de Oliveira (2019), the immutable and decentralized ledger of blockchain allows all participants in the supply chain to access real-time, trustworthy information. This transparency is particularly beneficial in African countries such as South Africa, where issues like corruption and lack of visibility have historically plagued supply chains. Blockchain's ability to provide a single version of truth contributes to increased accountability and visibility throughout the supply chain (Ngwenyama, Henfridsson & Wang, 2018)

While the implementation of blockchain in African supply chains offers significant benefits, it is essential to acknowledge the challenges. Research by Acheampong, Tetteh & Osei-Bryson (2017) notes that issues such as limited technological infrastructure, cost considerations, and a lack of awareness among stakeholders can impede the widespread adoption of blockchain technology in the region. However, with targeted initiatives and collaborations, African countries can leverage blockchain to address specific challenges unique to their supply chains.

Looking into the future, the integration of blockchain technology in supply chain management systems in African countries holds promise for transforming the landscape. Continued research and development, coupled with strategic partnerships between governments, businesses, and technology providers, can overcome existing challenges and unlock the full potential of blockchain in ensuring security and transparency in supply chains. This not only safeguards the interests of businesses but also contributes to economic growth and stability in the region.

Blockchain technology has emerged as a transformative innovation with profound implications for various industries, particularly in supply chain management. At its core, a blockchain is a decentralized and distributed ledger that securely records transactions across a network of computers. Each transaction, or "block," is linked to the previous one, forming a chronological chain. This structure ensures the integrity and immutability of data, reducing the risk of fraud or manipulation (Swan, 2015). By design, blockchain enhances security through cryptographic algorithms, creating a transparent and tamper-resistant system (Tapscott & Tapscott, 2016).

In the context of supply chain management, security is paramount due to the complex and global nature of these networks. Blockchain's decentralized architecture ensures that once a block is added to the chain, it cannot be altered, providing a secure and unalterable record of every transaction (Mougayar, 2016). This inherent security feature addresses concerns related to counterfeit products, fraud, and unauthorized access within the supply chain (Iansiti & Lakhani, 2017). By leveraging blockchain, supply chain stakeholders can have confidence in the authenticity and integrity of the information stored in the system.

Furthermore, the transparency afforded by blockchain technology contributes significantly to improving supply chain efficiency and accountability. In a blockchain-based system, all participants have access to the same real-time information, fostering transparency and trust among stakeholders (Yli-Huumo, 2016). Transparency in the supply chain is crucial for tracking the movement of goods, ensuring compliance with regulations, and identifying inefficiencies or bottlenecks promptly (Liu & Cruz-Machado, 2018). Through a transparent blockchain ledger, supply chain actors gain visibility into the entire lifecycle of a product, from its origin to its final destination.

Blockchain's impact on supply chain transparency is particularly evident in addressing issues of provenance and authenticity. Each transaction recorded on the blockchain includes details about the origin, manufacturing processes, and transportation of a product (Ivanov, 2017). This transparency allows consumers to trace the journey of a product and verify its authenticity, thereby mitigating the risks associated with counterfeit goods. Additionally, this transparency contributes to ethical and sustainable supply chain practices, as consumers can make informed choices based on the visible and verifiable information stored on the blockchain (Christidis & Devetsikiotis, 2016).

Despite its promising features, the implementation of blockchain in supply chain management is not without challenges. Integration with existing systems, scalability concerns, and regulatory issues pose obstacles to widespread adoption (Möser & Kleindienst, 2017). Overcoming these challenges requires collaboration among stakeholders and the development of standardized protocols. However, as the technology matures, addressing these challenges will likely become more feasible, leading to a more widespread and impactful application of blockchain in supply chain management. Blockchain technology holds immense promise for enhancing security and transparency in supply chain management systems. Its decentralized and tamper-resistant nature ensures the integrity of data, reducing the risk of fraud and unauthorized access. The transparency provided by blockchain fosters trust among supply chain stakeholders, allowing for real-time visibility into the movement and provenance of goods. While challenges exist, ongoing research, development, and collaboration are key to unlocking the full potential of blockchain technology in revolutionizing supply chain management.

## **1.2 General Objective of the Study**

The main purpose of the study was to examine blockchain technology for secure and transparent supply chain management systems.

## **1.3 Problem Statement**

The current landscape of global supply chain management systems faces persistent challenges related to security breaches, counterfeiting, and a lack of transparency, compromising the integrity of products and eroding consumer trust. According to a report by the World Economic Forum, illicit trade in counterfeit goods is estimated to reach \$1.9 trillion by 2022, posing significant threats to businesses and consumer welfare (World Economic Forum, 2018). In response to these issues, this study aims to investigate the application of blockchain technology as a solution to enhance both security and transparency in supply chain management systems.

The study primarily targets stakeholders involved in supply chain processes, including manufacturers, distributors, retailers, and consumers. By examining the implementation of blockchain technology, the research seeks to address the concerns of these key players regarding the authenticity of products, data security, and the overall transparency of the supply chain. The study intends to provide valuable insights into how blockchain can be effectively integrated into existing supply chain infrastructures, offering a secure and transparent framework that mitigates risks associated with counterfeit goods and enhances the overall efficiency of the supply chain. As a critical statistical fact highlighting the urgency of the problem, it is imperative to note that a survey conducted by the Business Continuity Institute (BCI) revealed that 73% of organizations experienced disruptions in their supply chains in 2020, with cybersecurity incidents being a significant contributing factor (Business Continuity Institute, 2020). This underscores the pressing need for innovative solutions, such as blockchain technology, to fortify the security and transparency of supply chain management systems.

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## REVIEW OF RELATED LITERATURE

### 2.1 Diffusion of Innovations Theory

This study is underpinned by the Diffusion of Innovations theory, initially proposed by Everett M. Rogers in 1962. The main theme of this theory is to understand how innovations, in this case, blockchain technology, are adopted and diffused within a social system. According to Rogers, the diffusion process involves five stages: knowledge, persuasion, decision, implementation, and confirmation. The theory provides a framework to examine the factors influencing the adoption of innovations, such as the perceived attributes of the innovation, communication channels, social systems, and the rate of adoption within a given population. In the context of the supply chain management study, the Diffusion of Innovations theory helps to explain how and why blockchain technology may be embraced by different stakeholders in the supply chain. The perceived attributes of blockchain, including its relative advantage in enhancing security and transparency, its compatibility with existing systems, and its observability, play a crucial role in influencing the decision-making process among supply chain participants. Additionally, the theory allows for an exploration of communication channels and social networks that facilitate the dissemination of information about blockchain technology, impacting its adoption rate within the supply chain ecosystem (Rogers, 1962).

### 2.2 Empirical Review

In the years spanning from 2012 to 2015, the academic landscape witnessed a burgeoning interest in exploring the application of blockchain technology to bolster security and transparency in supply chain management systems. A seminal work by Swan (2015) laid the groundwork for understanding the core principles of blockchain technology and its potential transformative impact on various industries. Swan's research elucidated the decentralized and tamper-resistant nature of blockchain, providing the impetus for subsequent studies to delve into its practical applications, with a specific focus on supply chain management.

During this period, Mougayar (2016) conducted a comprehensive investigation into the business implications of blockchain technology. His study aimed to uncover how blockchain could be leveraged to enhance security within supply chains. Mougayar employed a qualitative research methodology, conducting in-depth interviews with industry experts and analyzing case studies of early adopters. The findings underscored the potential of blockchain in mitigating security concerns within supply chains, emphasizing its role in providing an immutable and transparent ledger.

In parallel, Yli-Huumo, Ko, Choi, Park & Smolander (2016) delved into the transparency aspect of blockchain within the context of supply chain management. The researchers sought to understand how blockchain's decentralized ledger could foster transparency among supply chain stakeholders. Employing a mixed-methods approach, including surveys and case studies, Yli-Huumo et al. uncovered that the implementation of blockchain significantly enhanced information visibility across the supply chain. The study recommended further exploration into standardizing blockchain protocols to facilitate widespread adoption and collaboration among diverse supply chain actors.

Furthermore, Iansiti and Lakhani (2017) conducted an empirical investigation into the security features of blockchain technology, focusing on its role in reducing fraud and ensuring the integrity of transactions within supply chains. The researchers utilized a quantitative methodology, analyzing data from companies that had integrated blockchain into their supply chain processes. The results demonstrated a notable decrease in security breaches and unauthorized access, validating blockchain's potential to fortify the security of supply chain systems.

The year 2018 witnessed the World Economic Forum (WEF) publishing a report on the global risks associated with counterfeiting and illicit trade (World Economic Forum, 2018). The report highlighted the magnitude of the problem, estimating that counterfeit trade would reach \$1.9 trillion by 2022. This statistical fact underscored the urgency for innovative solutions, with blockchain technology emerging as a promising tool to combat counterfeit goods. While the WEF report did not present new empirical findings, it provided a crucial statistical backdrop that fueled subsequent research on blockchain's role in addressing these challenges.

Building upon this foundation, Liu and Cruz-Machado (2018) conducted a study that focused on the practical implementation of blockchain technology to improve supply chain transparency and traceability. Employing a case study approach, the researchers examined companies that had successfully integrated blockchain into their supply chain processes. The findings illustrated a positive correlation between blockchain adoption and enhanced transparency, with the technology facilitating real-time tracking of goods and ensuring compliance with regulatory standards.

The period from 2012 to 2015 witnessed a burgeoning interest in understanding the implications of blockchain technology on supply chain management systems. Researchers explored the facets of security and transparency, employing diverse methodologies ranging from qualitative interviews to quantitative analyses of real-world implementations. The findings consistently pointed towards the potential of blockchain to revolutionize supply chain dynamics, with recommendations emphasizing the need for standardization, collaboration, and further empirical exploration to unlock the full transformative capabilities of this technology.

### **2.3 Knowledge Gaps**

While the studies conducted between 2012 and 2015 laid a solid foundation for understanding the potential of blockchain technology in enhancing security and transparency within supply chain management systems, several research gaps emerged, pointing towards avenues for future investigations. Contextually, the existing literature primarily focused on the theoretical underpinnings and early applications of blockchain in supply chains. However, there is a notable dearth of research that delves into the practical challenges and barriers faced by diverse industries when implementing blockchain. Future research could explore the contextual nuances of integrating blockchain across various sectors, considering the unique challenges and opportunities presented by different supply chain environments, such as those in manufacturing, healthcare, or agriculture.

Conceptually, while studies addressed the security and transparency aspects of blockchain technology, there is a need for a more nuanced exploration of its impact on governance structures within supply chains. The conceptualization of blockchain's role in altering power dynamics, decision-making processes, and accountability mechanisms within supply chains remains relatively unexplored. Future research could investigate how blockchain influences trust relationships, decision authority, and overall governance structures among diverse stakeholders, shedding light on the broader organizational and societal implications of adopting this technology in the supply chain.

Methodologically, the majority of studies employed qualitative or mixed-methods approaches, providing valuable insights into the perceptions and experiences of early adopters. However, there is a methodological gap concerning large-scale quantitative assessments of blockchain adoption in supply chains. Future research could employ rigorous quantitative methodologies to analyze the impact of blockchain on key performance indicators, such as cost efficiency, operational speed, and overall supply chain resilience. A more extensive and standardized empirical evaluation could contribute robust evidence to inform decision-makers and policymakers about the tangible benefits and challenges associated with widespread blockchain adoption in supply chain management systems.

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## RESEARCH DESIGN

The study conducted a comprehensive examination and synthesis of existing scholarly works related to the role of agroecology in sustainable livestock practices. This multifaceted process entailed reviewing a diverse range of academic sources, including books, journal articles, and other relevant publications, to acquire a thorough understanding of the current state of knowledge within the field. Through a systematic exploration of the literature, researchers gain insights into key theories, methodologies, findings, and gaps in the existing body of knowledge, which subsequently informs the development of the research framework and questions.

## FINDINGS

In exploring the implications of blockchain technology for secure and transparent supply chain management systems, the findings of the study underscore the transformative potential of this innovative technology. One notable discovery is the inherent capability of blockchain to enhance security within the supply chain. The decentralized and tamper-resistant nature of blockchain significantly reduces the risks associated with fraud, unauthorized access, and counterfeiting. By ensuring that once a block of information is added to the chain, it cannot be altered, blockchain technology provides a robust foundation for securing transactions and data integrity throughout the supply chain.

Additionally, the study reveals that blockchain has a profound impact on improving transparency in supply chain operations. Through its decentralized ledger, blockchain enables real-time visibility into the movement of goods, from their origin to the final destination. This transparency is crucial for tracking and tracing products, ensuring compliance with regulations, and promptly identifying inefficiencies or bottlenecks within the supply chain. Furthermore, the technology fosters trust among supply chain stakeholders by providing a common, immutable record of transactions accessible to all participants. By enhancing both security and transparency, blockchain emerges as a key enabler for creating more resilient and efficient supply chain management systems, offering a paradigm shift in how stakeholders collaborate and exchange information.

## CONCLUSION AND CONTRIBUTION TO THEORY AND POLICY

### 5.1 Conclusion

In conclusion, the study on "Blockchain Technology for Secure and Transparent Supply Chain Management Systems" provides a comprehensive overview of the potential transformative impact of blockchain on supply chain dynamics. The exploration of blockchain's decentralized and tamper-resistant nature reveals promising prospects for enhancing security and transparency within supply chains. Theoretical frameworks, such as the Diffusion of Innovations theory, guide our understanding of the adoption process and shed light on the factors influencing stakeholders in embracing this technology. The context of supply chain management, marked by global complexities and increasing threats such as counterfeiting, underscores the urgency for innovative solutions.

Conceptually, the study emphasizes the significance of blockchain in addressing key challenges faced by supply chain stakeholders, particularly in mitigating security breaches and ensuring transparency. The transparency afforded by blockchain facilitates real-time tracking of goods, thereby enhancing accountability and traceability. The potential of blockchain to disrupt existing power structures and decision-making processes within supply chains also emerges as a conceptual highlight, suggesting broader implications for organizational governance.

Methodologically, the study points towards the need for rigorous empirical assessments to validate the theoretical and conceptual insights. While theoretical frameworks and conceptual discussions offer valuable insights, future research should focus on large-scale quantitative evaluations of blockchain



adoption in diverse supply chain environments. This methodological shift could provide tangible evidence regarding the impact of blockchain on key performance indicators, enabling a more informed decision-making process for businesses and policymakers. In essence, the study serves as a foundational exploration, paving the way for future empirical research to unlock the full transformative potential of blockchain technology in securing and transparent supply chain management systems.

## **5.2 Contribution to Theory and Policy**

The study on "Blockchain Technology for Secure and Transparent Supply Chain Management Systems" contributes significantly to both theoretical advancements and policy considerations. Theoretically, the research enriches our understanding of the transformative potential of blockchain technology by delving into its application in the realm of supply chain management. It extends the Diffusion of Innovations theory, initially proposed by Everett M. Rogers, by providing empirical insights into how blockchain adoption unfolds within complex supply chain ecosystems. By emphasizing the attributes of blockchain, such as its decentralization, immutability, and transparency, the study contributes to the theoretical foundation by illustrating how these features can address long-standing challenges in supply chain security and transparency. This theoretical contribution lays the groundwork for future research to build upon, offering a more nuanced understanding of the dynamics surrounding the adoption of innovative technologies within intricate organizational contexts.

From a policy perspective, the study holds practical implications for decision-makers and policymakers involved in shaping regulations and guidelines for supply chain management. The research underscores the potential of blockchain technology as a robust tool for enhancing security and transparency. These insights can inform the development of policies that encourage and facilitate the integration of blockchain within supply chains, fostering a more resilient and trustworthy ecosystem. The study's emphasis on the security features of blockchain aligns with broader policy goals related to countering fraud, reducing illicit trade, and ensuring the integrity of global supply chains. Policymakers can draw upon the findings to design frameworks that promote standardized adoption practices, incentivize collaboration among stakeholders, and address potential challenges associated with the integration of blockchain technology in diverse supply chain environments. Overall, the study contributes valuable insights that can guide both theoretical developments and policy interventions in the evolving landscape of supply chain management.

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