Evaluating Blockchain Adoption in Indonesia's Supply Chain Management Sector

Satrya Fajri Pratama[1], Priyo Agung Prastyo[2]

[1]Department of Computer Science, School of Physics, Engineering and Computer Science, University of Hertfordshire, Hatfield AL10 9AB, United Kingdom

[2]Magister of Computer Science, Computer Science Faculty, Universitas Amikom Purwokerto, Indonesia

ABSTRACT

This research evaluated the adoption of blockchain technology in the supply chain management sector, focusing on the factors that influence the intention to use blockchain, including perceived usefulness, security, facilitating conditions, cost, regulatory support, and trust. Data were collected through a cross-sectional survey distributed to 315 individuals actively involved in supply chain management, of which 309 valid responses were obtained after a validation process that included screening questions such as prior use of blockchain technology. The study employed structural equation modeling (SEM) for data analysis. The findings highlighted that trust played a significant mediating role between perceived usefulness, security, and intention to use blockchain technology. Perceived usefulness and security were found to significantly enhance trust, which in turn positively influenced the intention to adopt blockchain. Regulatory support also had a strong positive impact on adoption intentions, underscoring the importance of clear and supportive regulatory frameworks. Cost was identified as a barrier to adoption, reflecting the need for organizations to address financial concerns associated with blockchain implementation. The results contributed to the theoretical understanding of blockchain adoption by integrating trust as a key mediator in the Technology Acceptance Model and offered practical implications for supply chain management professionals and policymakers.

Keywords blockchain adoption; supply chain management; trust; perceived usefulness; regulatory support

INTRODUCTION

Blockchain technology had emerged as one of the most significant technological advancements of the 21st century, revolutionizing the way data was managed and transactions were conducted across various sectors. Originating as the underlying technology for cryptocurrencies like Bitcoin, blockchain had transcended its initial application, finding relevance in industries such as finance, healthcare, real estate, and supply chain management. Its decentralized and immutable nature provided a robust framework for enhancing transparency, security, and efficiency in numerous business processes. Blockchain technology is increasingly recognized for its transformative potential across various sectors due to its unique characteristics, such as decentralization, transparency, and security. This technology enables trustless systems where transactions can be verified and recorded without the need for centralized authorities, attracting significant interest from organizations aiming to streamline operations and reduce costs associated with intermediaries [1], [2], [3]. The integration of smart contracts within blockchain platforms further enhances its utility by automating and enforcing contractual agreements,

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Corresponding author
Satrya Fajri Pratama,
s.f.pratama@herts.ac.uk

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minimizing human error, and increasing operational efficiency. Blockchain's capability to provide immutable records significantly improves traceability and accountability, particularly in supply chain management, where it can revolutionize traditional practices [4]. However, realizing the full potential of blockchain depends on overcoming challenges such as regulatory hurdles, privacy concerns, and technical complexities [5], [6], [7]. Collaborative efforts among regulators, industry leaders, and academics are crucial in addressing these barriers and promoting broader adoption [7]. As blockchain technology continues to evolve, its integration into various applications is expected to drive significant advancements in operational efficiency and innovation across multiple domains [8], [9].

In the context of supply chain management, blockchain technology has demonstrated significant potential in addressing longstanding challenges related to transparency, traceability, and security. Traditional supply chains often suffer from fragmented and opaque processes, resulting in inefficiencies, increased costs, and vulnerabilities to fraud and counterfeit products. Blockchain offers a decentralized ledger system that allows real-time data sharing among all stakeholders, enhancing visibility and accountability throughout the supply chain [10], [11]. For example, companies like Walmart have successfully implemented blockchain for food traceability, reducing traceability times from weeks to mere seconds, thereby ensuring the integrity and safety of food products [12], [13]. Implementing blockchain in supply chain operations also enhanced security by providing an immutable record of transactions, thereby reducing the risk of data tampering and unauthorized access. This level of protection was particularly critical in industries such as pharmaceuticals and food, where product authenticity and safety were paramount. Furthermore, blockchain-enabled supply chains facilitated improved coordination among stakeholders, streamlined documentation processes, and enabled more responsive and resilient operational frameworks capable of adapting to dynamic market demands.

Previous studies on blockchain adoption had predominantly focused on examining individual factors, such as perceived usefulness and security, in isolation. These studies provided valuable insights into the specific attributes that influenced users' attitudes towards blockchain technology. However, they often needed a comprehensive approach that integrated multiple critical variables into a cohesive model. This gap limited the understanding of how various factors might interact to collectively shape the intention to use blockchain technology, especially in complex and multifaceted sectors like supply chain management. Moreover, while the literature had increasingly acknowledged the potential of blockchain to revolutionize supply chain processes, there needed to be more empirical research exploring the simultaneous impact of these variables on the adoption process. Studies had typically examined factors like security or cost separately, without considering the broader ecosystem of influences that could affect a decision-maker's intention to implement blockchain technology. As a result, there was a clear need for a study that not only investigated these factors together but also examined the mediating role of trust in this context.

This research aimed to address the identified gaps by developing and validating an integrated model that encompassed multiple factors influencing the intention

to use blockchain technology within the supply chain management sector. The primary objective was to understand how perceived usefulness (PU), security (SC), facilitating conditions (FC), cost (C), regulatory support (RS), and trust (TR) interacted to shape the overall intention to adopt blockchain technology (IU). By creating a comprehensive model that considered these relationships, the study sought to provide a more holistic understanding of the dynamics at play in the decision-making process surrounding blockchain adoption. The study specifically focused on evaluating how TR mediated the relationship between the perceived usefulness and security of blockchain technology and the intention to use it. Additionally, the research explored the direct effects of FC, C, and RS on the intention to adopt blockchain. This approach aimed to capture the complexity of the adoption process in a sector where TR, usability, SC, and external support are critical factors. The research sought to answer several key questions that were critical to understanding the adoption of blockchain technology in supply chain management. The primary research questions included: What were the effects of PU, SC, FC, C, and RS on the intention to use blockchain technology (IU)? Additionally, how did TR mediate the relationships between these factors and the intention to use?

Literature Review

Understanding the Value of Perceived Usefulness in Blockchain Adoption

Perceived usefulness was defined as the degree to which a person believed that using a particular system would enhance their job performance. In the context of blockchain technology, perceived usefulness had been recognized as a critical determinant influencing the intention to adopt the technology across various sectors. The underlying principle was that users were more likely to embrace blockchain solutions if they believed these systems could improve their efficiency, SC, and overall operational effectiveness. This concept was deeply rooted in the Technology Acceptance Model (TAM), which posited that perceived usefulness was a primary driver of users' behavioral intentions. Previous research consistently highlighted the strong correlation between perceived usefulness and the IU blockchain technology. For instance, [14] emphasized that the perceived usefulness of blockchain technology was closely tied to its capabilities in securely filtering, sorting, and storing data, as well as enhancing communication among stakeholders. This increased transparency and accountability within systems were pivotal in bolstering users' intentions to adopt blockchain, particularly in supply chain management. Similarly, [15] found that in the context of private blockchain-based collaborations, perceived usefulness played a pivotal role in influencing users' behavioral intentions. The study suggested that users were more inclined to adopt technologies that they perceived as beneficial to their operations, reinforcing the importance of perceived usefulness in technology adoption. Furthermore, studies employing the extended Technology Acceptance Model (TAM) provided additional evidence of the importance of perceived usefulness. Research by [16] found that perceived usefulness emerged as a strong predictor of the IU blockchain in business processes. Their research indicated that understanding the perceived benefits of blockchain—such as cost reduction and enhanced efficiency—was essential in influencing users' decisions to adopt this technology. In another study, [17] examined the adoption of blockchain-based games. Similarly, it

concluded that users' behavioral intentions were significantly influenced by their perceptions of the benefits associated with blockchain technology. Moreover, the relationship between perceived usefulness and technology adoption was further supported by [18], who highlighted that perceived usefulness, along with perceived ease of use, directly affected users' attitudes toward technology. This, in turn, influenced their behavioral intentions to adopt blockchain. The study underscored the necessity for organizations to effectively communicate the practical advantages of blockchain technology to enhance user acceptance. In summary, the body of literature consistently supported the assertion that perceived usefulness was a fundamental factor influencing the IU blockchain technology. Demonstrating the tangible benefits of blockchain was crucial for organizations aiming to foster greater acceptance and facilitate the integration of this transformative technology across various sectors.

The Role of Security in Building Trust for Blockchain Integration

Security (SC) referred to the degree to which a system was perceived to be free from unauthorized access and manipulation. In the context of blockchain technology, SC was often highlighted as a cornerstone that significantly influenced users' trust in the system. Blockchain's design inherently aimed to provide a secure environment where data could be stored and transactions could be processed without the risk of tampering or unauthorized access. This robust SC framework was essential not only for maintaining data integrity but also for protecting against fraud and cyber threats, making it a critical factor in the decision to adopt blockchain technology. Previous research consistently underscored the importance of SC in fostering TR in blockchain systems, which, in turn, influenced users' intentions to adopt and utilize these technologies. Research by [19] emphasized that users' perceptions of SC in blockchain transactions were crucial in shaping their TR in the technology. They argued that in environments lacking standardized interfaces, users often relied on intrinsic TR, which was heavily influenced by how secure they perceived their transactions to be. This intrinsic TR acted as a key heuristic, guiding users' decisions and reinforcing their confidence in blockchain systems. The study highlighted that users who felt secure about their transactions were more likely to TR the blockchain system, thereby increasing their intention to use it. Further supporting this relationship, [20] demonstrated that the transparency and SC provided by blockchain technology positively contributed to building trust within supply chains. Their empirical analysis revealed that as firms recognized the SC advantages of blockchain, they were more inclined to adopt the technology, thereby enhancing TR among customers and suppliers. This finding underscored the critical role of SC in fostering the TR necessary for the successful implementation of blockchain in various sectors.

Moreover, [21] found that TR in blockchain technology was a significant predictor of users' intentions to engage with platforms utilizing the technology. Their research indicated that TR in the underlying blockchain infrastructure directly influenced users' TR in the platform itself, highlighting the cascading effect of SC on TR and, consequently, on the intention to adopt blockchain solutions. This reinforced the notion that robust SC measures within blockchain systems were essential for building the TR needed to drive adoption. Study by [22] also illustrated that blockchain's inherent SC features, such as cryptographic protocols and consensus mechanisms, played a crucial role in

establishing TR in distributed systems. The authors argued that these SC attributes not only enhanced user confidence but also facilitated the broader adoption of blockchain technologies across various applications. Their findings emphasized that the SC provided by blockchain was fundamental to overcoming the skepticism that often accompanied new technological solutions. Additionally, [23] pointed to the role of blockchain in enhancing TR through secure data management and transaction verification. Their study highlighted how blockchain's transparent and immutable record-keeping capabilities helped mitigate risks associated with fraud and data breaches, thereby fostering TR among users and stakeholders. This further reinforced the idea that SC was not just a technical requirement but a critical enabler of TR and adoption.

Facilitating Conditions: Enabling Blockchain Success in Supply Chains

Facilitating conditions (FC) encompassed the extent to which an individual believed that the necessary organizational and technical infrastructure was in place to support the use of a system. In the context of blockchain technology adoption, FC referred to the availability of resources, infrastructure, and support systems that enabled users to engage with blockchain applications effectively. These conditions were critical as they determined whether users felt supported in their efforts to adopt new technologies. When users perceived that they had access to the required tools, knowledge, and assistance, their confidence in using blockchain technology increased, which in turn positively influenced their intention to adopt it Previous research had consistently highlighted the importance of FC in the successful implementation of new technologies. Study by [24] conducted an empirical study within the supply chain management sector in Australia, demonstrating that FC significantly influenced users' intentions to adopt blockchain technology. Their study revealed that when users perceived that the necessary technological and organizational infrastructure, along with network and human support, was adequately provided, their confidence in using blockchain technology grew, leading to a higher likelihood of adoption. This finding underscored the necessity for organizations to invest in and maintain robust infrastructure and support systems to foster a conducive environment for blockchain adoption.

Similarly, [25] found that FC, along with TR and performance expectancy, were significant predictors of blockchain adoption in agri-food supply chain management. Their research emphasized the need for organizations to ensure that users had access to the tools and support necessary to facilitate effective use of blockchain technology. The study aligned with broader literature, which suggested that organizations must proactively address the FC encountered by users to promote the adoption of new technologies. This approach was critical in sectors like supply chain management, where the successful implementation of blockchain technology could lead to significant improvements in efficiency and transparency. Further evidence of the importance of FC was provided by [26] in the context of mobile banking. Their study demonstrated that FC had a significant impact on users' behavioral intentions to adopt blockchain technology. The research revealed that when FC were favorable, users were more likely to engage with blockchain systems, thereby explaining a substantial portion of the variation in blockchain usage behavior. This finding highlighted the critical role of banks and financial institutions in investing in the necessary

infrastructure and resources to support blockchain adoption, thereby creating a more favorable environment for users. In addition, [27] reinforced the notion that FC, along with performance expectancy and TR, played a significant role in influencing the behavioral intention of healthcare professionals to adopt blockchain technology. The study indicated that when healthcare practitioners perceived that they had the necessary support and resources, their intention to utilize blockchain solutions increased. This, in turn, enhanced the overall effectiveness of healthcare delivery by ensuring that blockchain technology was successfully integrated into healthcare operations.

Balancing Cost and Benefits of Blockchain

Cost (C) referred to the perceived financial implications associated with adopting blockchain technology, encompassing both initial investments and ongoing operational expenses. In the context of blockchain adoption, cost considerations were particularly significant, as they often influenced the decision-making process of organizations. The adoption of new technology typically required substantial financial outlays for implementation, infrastructure, training, and maintenance. These expenses could be daunting, especially in industries where the return on investment was not immediately clear. As such, understanding the impact of cost on the IU blockchain technology was crucial for assessing the feasibility and attractiveness of blockchain solutions. Previous research had consistently identified cost as a significant barrier to the adoption of blockchain technology. Study by [28] highlighted the anticipated benefits of cost reduction as a motivating factor for adopting blockchain, particularly within the accounting and auditing professions. The study suggested that when users perceived blockchain as a tool for enhancing SC, reducing error rates, and decreasing fraud levels, they were more likely to accept the technology. These perceived benefits were directly tied to the cost-effectiveness of blockchain solutions, underscoring the importance of demonstrating potential savings to encourage user adoption.

Similarly, [14] emphasized the role of perceived usefulness, which included cost considerations, in influencing the intention to adopt blockchain technology in supply chain management. Their findings indicated that when users recognized the potential for cost savings and efficiency improvements through blockchain, their intention to adopt the technology increased. This insight highlighted the necessity for organizations to effectively communicate the financial advantages of blockchain to enhance user acceptance, particularly in sectors where operational efficiency and cost management were critical concerns. In the retail industry, [29] discussed the volatility of blockchain and the associated costs as factors that could impact user intentions. The study suggested that high operational costs might deter potential users, particularly if the perceived financial risks outweighed the benefits. This finding emphasized the need for a balanced approach that considered both the potential advantages and the financial implications of implementing blockchain technology. Organizations were encouraged to conduct thorough cost analyses to assess the viability of blockchain adoption, ensuring that the perceived benefits justified the expenses. Study by [30] further addressed the issue of cost by highlighting concerns about the high costs of implementing blockchain technology. Their research suggested that organizations might resist adopting blockchain due to uncertainties surrounding the financial outlays required. Understanding these

cost dynamics was essential for organizations to mitigate resistance and increase the likelihood of adoption. The study implied that by offering clear cost-benefit analyses and demonstrating the long-term financial advantages of blockchain, organizations could overcome initial reservations.

Additionally, [31] pointed out that FC, including cost-related factors, played a significant role in influencing users' intentions to adopt blockchain technology. The study indicated that when organizations provided the necessary resources and support to offset costs, users were more inclined to engage with blockchain solutions. This finding reinforced the importance of addressing cost concerns as part of a broader strategy to promote blockchain adoption. Moreover, [32] emphasized the importance of conducting a thorough cost-benefit analysis before adopting blockchain technology. The study argued that organizations needed to carefully weigh the potential cost savings against the initial investment required for implementation. Such analyses were crucial for decision-makers to justify the adoption of blockchain solutions, particularly in sectors where budget constraints and financial scrutiny were prevalent.

Regulatory Support on Legal Landscape of Blockchain

Regulatory Support (RS) referred to the extent to which government policies and regulations facilitated the adoption of blockchain technology. In the realm of blockchain adoption, regulatory frameworks played a pivotal role in shaping the environment in which blockchain technology could be implemented and utilized. A supportive regulatory environment not only provided legal clarity but also helped to mitigate risks associated with adopting new technologies. By establishing clear guidelines and legal protections, RS could enhance user confidence, thereby encouraging the adoption of blockchain solutions across various sectors. Previous research highlighted the critical importance of RS in promoting TR and facilitating the widespread adoption of blockchain technology. Study by [33] conducted a study on blockchain adoption within the apparel supply chain sector, finding that while RS was acknowledged as a positive influence, its impact on adoption was statistically insignificant. This suggested that, although regulatory frameworks were recognized, other factors might have played a more significant role in driving adoption decisions. The study underscored the need for clearer and more robust regulations to enhance the effectiveness of blockchain adoption initiatives.

Contrastingly, [34] emphasized the critical role that regulatory measures played in facilitating the adoption of cryptocurrency, a technology closely related to blockchain. Their research identified government regulatory bodies as significant barriers to the widespread adoption of blockchain, indicating that effective regulation could help mitigate these barriers and promote greater user engagement. This highlighted the importance of regulatory clarity and enforcement in creating an environment conducive to blockchain adoption, particularly in sectors where regulatory uncertainty might hinder technological innovation. Study by [17] further supported the notion that RS was essential for building user TR in blockchain applications, particularly in the context of blockchain-based games. Their findings indicated that when users perceived a supportive regulatory environment, their intention to engage with blockchain technology increased significantly. This underscored the necessity for developers and service providers to ensure that users were aware of the legal frameworks that supported their use of blockchain applications, thereby

fostering greater confidence in the technology. In the context of small and medium enterprises (SMEs) in India, [35] found that while RS was important, it did not significantly influence the intention to adopt blockchain technology. Instead, other factors, such as relative advantage and technology compatibility, played a more prominent role in driving adoption. This finding suggested that, although RS was necessary, it might only sometimes be the primary driver of adoption in some contexts. The study implied that regulatory frameworks should be complemented by other factors that directly addressed the specific needs and concerns of potential adopters.

Study by [36] discussed the importance of establishing a supportive regulatory framework that clarified legal aspects related to blockchain, ensuring its legality and promoting innovation. The study highlighted the role of regulatory clarity in fostering user confidence and encouraging the adoption of blockchain technologies. The findings emphasized that a well-structured regulatory environment could help alleviate concerns related to legal risks and uncertainties, thereby making blockchain technology more appealing to potential users. Study by [37] conducted a quantitative study on blockchain adoption in Italy, revealing strong positive correlations between blockchain adoption and RS. The study's findings suggested that organizations were more likely to adopt blockchain solutions when they perceived a favorable regulatory environment. This reinforced the idea that clear and supportive regulatory frameworks could significantly influence user intentions and facilitate the successful integration of blockchain solutions across various sectors.

Trust as a Catalyst for Blockchain Adoption

Trust (TR) was defined as the belief in the reliability and integrity of a technology. In the context of blockchain, TR was particularly crucial due to the decentralized and often complex nature of the technology. Blockchain’s reliance on cryptographic methods and distributed ledger systems required users to TR that the technology would function as intended, without the need for intermediaries. This TR was not just in the technology itself but also in its ability to protect data, ensure transparency, and maintain operational integrity. TR played a pivotal role in shaping users' perceptions of blockchain and their willingness to adopt it. It acted as a key mediator between other influential factors such as perceived usefulness and SC. Previous research consistently identified TR as a critical mediator that linked perceived usefulness and SC with the IU blockchain technology. Study by [38] emphasized that key characteristics of blockchain, such as tamper-proofing and immutability, were fundamental in establishing TR among users. The study highlighted that when users recognized the robust SC features of blockchain, their TR in the technology naturally increased, which in turn enhanced their intention to adopt it. This relationship underscored the importance of SC as a foundational element that supported TR, which then mediated the link between the perceived usefulness of blockchain and users' adoption intentions. Supporting this perspective, [19] discussed how users often relied on TR heuristics when interacting with blockchain services. Given the complexity of blockchain systems, users tend to depend on their TR in the technology to navigate their perceptions of SC and usefulness. This reliance on TR indicated that improving users' perceptions of blockchain's SC features could significantly boost their TR in the technology, thereby increasing their likelihood of adoption. The study suggested that TR

was not merely a byproduct of perceived usefulness and SC but a critical factor that bridged these perceptions with actual behavioral intentions to use blockchain.

Research by [39] further explored the role of TR in user adaptations and constraints within blockchain media. Their findings indicated that users' judgments about blockchain technology were heavily influenced by their TR in the system's SC mechanisms. This suggested that perceived SC not only contributed to overall TR but also played a mediating role in the relationship between perceived usefulness and the IU blockchain. In other words, users were more likely to adopt blockchain if they trusted that the technology was secure and valuable, reinforcing the integral role of TR in the adoption process. Study by [21] provided empirical evidence supporting the notion that TR in blockchain platforms was a significant predictor of users' intentions to engage with these technologies. Their research demonstrated that TR served as a mediator between perceived usefulness and the IU blockchain, reinforcing the idea that when users found blockchain both useful and secure, their TR in the technology increased, leading to a higher likelihood of adoption. This finding emphasized that building TR was essential for encouraging widespread adoption of blockchain solutions. Moreover, [40] highlighted the importance of TR in collaborative environments, such as healthcare data management, where SC concerns were particularly acute. Their findings suggested that a strong TR model, supported by perceived SC, was crucial in enhancing users' intentions to adopt blockchain solutions in these sensitive contexts. This study underscored the role of TR as a mediator in environments where the integrity and SC of data were paramount, further illustrating the multifaceted impact of TR on the adoption of blockchain technology.

Method

Research Design and Data Collection

The research adopted a cross-sectional survey design to explore the factors influencing the adoption of blockchain technology within the supply chain management sector. This design was selected due to its effectiveness in capturing data from a large sample at a single point in time, allowing for the analysis of relationships between variables. The survey approach was deemed appropriate for this study as it facilitated the collection of quantitative data that could be analyzed using structural equation modeling (SEM), a method suitable for testing complex relationships among multiple constructs. A convenience sampling method was employed to gather data from individuals who were actively involved in supply chain management. This non-probability sampling technique was selected due to its practicality and ease of access to the target population, although it was recognized that this approach could limit the generalizability of the findings. Initially, 315 questionnaires were distributed, but after the validation process, 309 were deemed valid for analysis. Validation included a screening question, such as asking whether the respondent had ever used blockchain technology, to ensure relevance and accuracy of the data collected. The final sample size of 309 respondents was considered sufficient to achieve reliable results in the SEM analysis. This sample size was determined based on established guidelines for structural equation modeling, ensuring that the model could be adequately tested with the available data. The validated sample allowed for robust analysis while accounting for the intricacies

of blockchain adoption in the supply chain management sector.

The target population for this study consisted of professionals and stakeholders in the supply chain management sector, including managers, logistics coordinators, and IT specialists. These individuals were selected because of their direct involvement in decision-making processes related to technology adoption within their organizations. The diversity within this population provided a comprehensive view of the factors influencing blockchain adoption across different roles and perspectives within the supply chain sector. Data collection was conducted using an online survey distributed via Google Forms in March 2024. The survey was designed to be user-friendly and accessible, ensuring a high response rate from participants. Respondents were invited to participate through professional networks, industry associations, and social media platforms relevant to supply chain management. The survey included questions designed to measure the constructs outlined in the research model, such as Perceived Usefulness, SC, FC, C, RS, TR, and IU. Both original and standardized indicator data were collected to ensure consistency and accuracy in the analysis. To facilitate the analysis, settings for both the inner model (structural model) and the outer model (measurement model) were established prior to data collection. These settings were carefully designed to align with the hypotheses and theoretical framework of the study, ensuring that the collected data could be effectively analyzed using SEM. The indicator data were processed and standardized to prepare for subsequent analyses, including reliability and validity tests, as well as hypothesis testing using the SEM approach. This rigorous methodological approach was intended to provide robust insights into the factors driving blockchain adoption in the supply chain management sector.

Research Model and Hypothesis Development

The research model for this study was designed to examine the factors influencing the adoption of blockchain technology in the supply chain management sector. The model integrated key constructs identified in the literature, namely PU, SC, FC, C, RS, TR, and IU. The relationships between these constructs were hypothesized based on established theoretical foundations and previous empirical findings, providing a robust framework for understanding the drivers of blockchain adoption. The first hypothesized relationship (H1) proposed that PU positively influenced TR in blockchain technology. This hypothesis was grounded in the Technology Acceptance Model (TAM) and supported by studies like those of [38], which emphasized that users' TR in a technology increases when they perceive it as useful, particularly due to its features like immutability and tamper-proofing. The second hypothesis (H2) suggested that SC positively influenced TR. This relationship was supported by research from [19], which found that users' TR in blockchain systems was closely tied to their perceptions of the technology’s security features.

The third hypothesis (H3) stated that TR positively influenced the IU blockchain technology. This hypothesis was based on the understanding that TR is a critical mediator between perceived benefits and the actual decision to adopt new technology, as evidenced by [21], who showed that TR significantly predicts users’ intentions to engage with blockchain platforms. The fourth hypothesis (H4) posited that RS positively influenced the IU blockchain technology. This

was grounded in the literature, including research by [37], which emphasized that clear and supportive regulatory frameworks reduce perceived risks and foster a favorable environment for blockchain adoption. The fifth hypothesized relationship (H5) suggested that FC positively influenced the IU blockchain technology. This hypothesis was derived from the Unified Theory of Acceptance and Use of Technology (UTAUT) and supported by studies like those of [24], which highlighted the importance of organizational and technical infrastructure in supporting technology adoption. Finally, the sixth hypothesis (H6) proposed that C negatively influenced the IU blockchain technology. This hypothesis was based on findings from [30], who noted that high costs are a significant barrier to adopting new technologies, especially in sectors where financial constraints are a major concern. To visually represent these hypothesized relationships, a research framework diagram was developed. Figure 1 provided a graphical overview of the model, illustrating the connections between PU, SC, FC, C, RS, TR, and IU. The diagram served as a visual guide for the analysis, helping to clarify the direct and mediated paths that were tested in the study. This comprehensive framework laid the groundwork for the subsequent empirical analysis, which aimed to validate the proposed relationships and contribute to the broader understanding of blockchain adoption in the supply chain management sector.

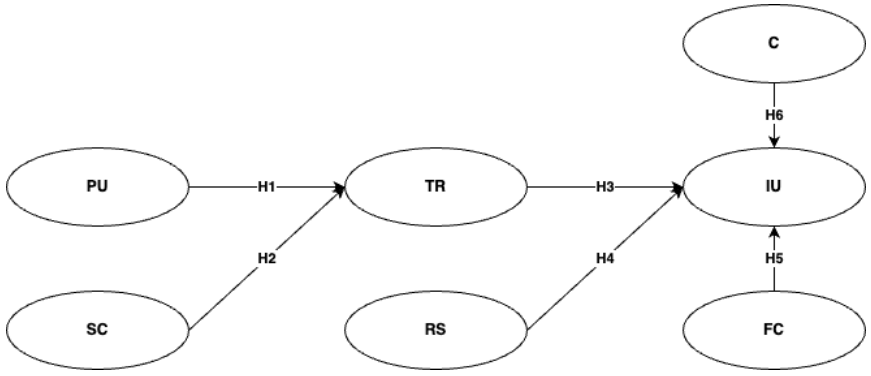

Figure 1 Research Method Flowchart

Measurement Instruments

Scales were carefully developed or adapted from existing literature to measure each of the key variables in this study. The process involved selecting validated instruments from previous research to ensure the reliability and validity of the constructs being examined. This approach was crucial in maintaining the integrity of the research findings and ensuring that the measures accurately reflected the theoretical constructs. PU was measured using three indicators adapted from previous studies such as those by [14] and [38], which focused on how users perceive the benefits of blockchain technology in enhancing operational efficiency. The indicators included items that assessed the extent to which respondents believed blockchain technology would improve their work performance and streamline supply chain processes. SC was assessed using three indicators, drawing on the work of [19], who emphasized the importance of SC in fostering TR in blockchain technology. The indicators measured respondents' perceptions of the SC features of blockchain, including data integrity, protection against fraud, and the robustness of the technology against unauthorized access. FC were measured with three indicators adapted from the

Unified Theory of Acceptance and Use of Technology (UTAUT) and further supported by the studies of [24]. These indicators focused on the availability of organizational and technical infrastructure to support blockchain adoption, including the presence of necessary resources, training, and support systems within the respondents' organizations.

C was measured using three indicators based on research by [30] and [29], which examined the financial implications of adopting blockchain technology. The indicators captured respondents' perceptions of the initial investment required, ongoing operational costs, and the overall cost-effectiveness of implementing blockchain solutions. RS was assessed through three indicators derived from the studies of [37] and [36], which highlighted the role of government policies and regulations in facilitating blockchain adoption. The indicators measured respondents' views on the clarity, adequacy, and supportiveness of the regulatory environment surrounding blockchain technology. TR was measured using three indicators adapted from the research of [21] and [39]. These indicators focused on the respondents' confidence in the reliability, integrity, and overall trustworthiness of blockchain technology as a secure and effective tool for managing supply chain activities. IU was measured with three indicators based on the work of [40] and [17], which explored the factors influencing the likelihood of adopting blockchain technology. The indicators assessed respondents' intentions to implement blockchain in their supply chain operations, including their willingness to recommend its use to others in their industry. To provide a clear and organized view of the measurement instruments used in the study, Table 1 was included. This table listed all the items used to measure each construct. Each item was designed to capture the essence of the corresponding construct, allowing for a thorough analysis of the factors influencing blockchain adoption in the supply chain management sector.

Table 1. Item Questionnaire

Variable	Item	Questionnaire	References
PU	PU1	Using blockchain improves the efficiency of supply chain operations.	[14]
	PU2	Blockchain technology enhances the overall performance of supply chain management.	
	PU3	I find blockchain technology useful for my work in supply chain management.	
SC	SC1	Blockchain provides secure transactions within the supply chain.	[19]
	SC2	I believe that blockchain technology protects against unauthorized access to data.	
	SC3	Blockchain enhances data integrity in supply chain processes.	
FC	FC1	My organization has the necessary resources to support the use of blockchain technology.	[24]
	FC2	Adequate technical support is available for implementing blockchain in supply chain management.	

Variable	Item	Questionnaire	References
	FC3	There is sufficient infrastructure in place to facilitate the adoption of blockchain.	
C	C1	The initial cost of adopting blockchain is high.	[30]
	C2	The ongoing operational costs of blockchain are a significant concern.	
	C3	I am concerned about the cost-effectiveness of implementing blockchain technology.	
RS	RS1	Government regulations support the adoption of blockchain technology in supply chains.	[37]
	RS2	There are clear legal guidelines for using blockchain in supply chain management.	,
	RS3	Regulatory frameworks facilitate the use of blockchain technology in my sector.	
TR	TR1	I trust the reliability of blockchain technology in managing supply chain processes.	[21]
	TR2	I believe that blockchain technology operates with integrity.	
	TR3	My confidence in blockchain technology influences my intention to use it in supply chains.	
IU	IU1	I intend to use blockchain technology for managing supply chain operations.	[40]
	IU2	I am likely to recommend the use of blockchain technology to others in the supply chain sector.	,
	IU3	I plan to incorporate blockchain technology into my supply chain management practices.	

Data Analysis

Data analysis was conducted using SmartPLS, a powerful tool for structural equation modeling (SEM) that is particularly well-suited for complex models involving multiple constructs and relationships. The analysis followed a structured approach, beginning with the evaluation of the measurement model and proceeding to the evaluation of the structural model. This step-by-step methodology ensured that the findings were robust and that the hypothesized relationships were tested rigorously. The first step in the data analysis process involved evaluating the measurement model. This evaluation focused on assessing the reliability and validity of the constructs used in the study. Reliability was measured using Cronbach's alpha and composite reliability (CR). Cronbach's alpha provided an estimate of the internal consistency of each construct, ensuring that the items within each scale were sufficiently correlated. Composite reliability further supported this assessment by providing a more accurate measure of the construct's overall reliability. Both Cronbach's alpha and composite reliability values above 0.7 were considered acceptable, indicating that the scales used to measure the constructs were reliable.

Validity was evaluated through convergent validity and discriminant validity. Convergent validity was assessed using the Average Variance Extracted (AVE),

which measured the extent to which the items within a construct explained the variance in the construct. An AVE value above 0.5 was considered indicative of adequate convergent validity, suggesting that the construct explained more than half of the variance in the items. Discriminant validity was assessed using the Fornell-Larcker criterion, which compared the square root of the AVE for each construct with the correlations between that construct and others in the model. If the square root of the AVE was greater than the correlations, discriminant validity was confirmed, indicating that the constructs were sufficiently distinct from one another. Following the evaluation of the measurement model, the structural model was assessed to test the hypothesized relationships between the constructs. This involved examining the path coefficients, which indicated the strength and direction of the relationships between variables in the model. Hypothesis testing was conducted using the t-values and p-values associated with these path coefficients, where a t-value greater than 1.96 and a p-value less than 0.05 indicated a statistically significant relationship. Model fit indices were also examined to assess the overall fit of the structural model. These indices included the R-squared (R^2) values, which measured the proportion of variance explained by the independent variables for each dependent variable, and the Standardized Root Mean Square Residual (SRMR), which provided a measure of the difference between the observed and predicted correlations. This structured approach to data analysis ensured that the findings were both reliable and valid, providing strong empirical support for the conclusions drawn from the study. The use of SmartPLS allowed for a detailed examination of the relationships between constructs, offering valuable insights into the factors that drive blockchain adoption in supply chain management.

Result and Discussion

Descriptive Statistics

The demographic characteristics of the sample were summarized to provide a clear understanding of the respondents' backgrounds. The study involved 309 participants, with a fairly balanced distribution across different age groups. The majority of respondents (31.07%) were aged between 18-24 years, followed by those aged 35-44 years (28.16%), 25-34 years (26.54%), and a smaller proportion (14.24%) aged 45 years and above. This distribution indicated that the sample included a diverse age range, with a slight predominance of younger professionals in the supply chain management sector. In terms of gender, the sample consisted of 171 males (55.34%) and 138 females (44.66%), reflecting a near-equal representation of both genders. The educational background of the respondents revealed that a slight majority held a Bachelor’s degree (54.05%), while 45.95% possessed a Master’s degree or higher. This educational distribution suggested that the respondents were well-educated, which is typical in sectors that involve complex decision-making processes like supply chain management. Internet usage among the respondents was also recorded, with a significant portion of the sample (43.69%) reporting that they spent 4-6 hours online each day. Additionally, 33.33% of respondents indicated that they used the internet for 7 or more hours daily, while a smaller percentage reported 1-3 hours (18.77%) and less than 1 hour (4.21%) of internet use per day. These findings suggested that most respondents were frequent internet users, which could be indicative of their familiarity and comfort with digital

technologies, including blockchain. Table 2 provided a detailed breakdown of these demographic characteristics, offering insights into the composition of the sample.

Table 2. Demographic Data

Demographic Characteristic	Category	Frequency	Percentage (%)
Age	18-24 years	96	31.07%
	25-34 years	82	26.54%
	35-44 years	87	28.16%
	45+ years	44	14.24%
Gender	Female	138	44.66%
	Male	171	55.34%
Education Level	Bachelor's Degree	167	54.05%
	Master's Degree or higher	142	45.95%
Internet Usage	Less than 1 hour	13	4.21%
	1-3 hours	58	18.77%
	4-6 hours	135	43.69%
	7+ hours	103	33.33%

The descriptive statistics for each variable were also summarized to provide an overview of the key constructs in the study. Variance Inflation Factor (VIF) values were calculated to check for multicollinearity among the independent variables. The results indicated that all VIF values were below the threshold of 5, suggesting that multicollinearity was not a significant concern in this study. Specifically, the VIF for PU and SC influencing TR was 4.532, indicating moderate correlation but not enough to cause multicollinearity issues. TR influencing IU had a VIF of 2.205, while RS and FC influencing IU had VIFs of 2.029 and 1.498, respectively. C influencing IU had the lowest VIF value of 1.384, further confirming that multicollinearity was not problematic. Table 3 summarized these findings, ensuring the robustness of the statistical analysis and the validity of the model used in this study. These descriptive statistics provided a foundational understanding of the data, setting the stage for more detailed analyses in subsequent sections.

Table 3. Inner Variance Inflation Factor (VIF) Results

Hypothesis	Path	VIF
H1	PU -> TR	4.532
H2	SC -> TR	4.532
H3	TR -> IU	2.205
H4	RS -> IU	2.029
H5	FC -> IU	1.498
H6	C -> IU	1.384

Measurement Model Evaluation

The measurement model was evaluated to ensure the reliability and validity of the constructs used in the study. Reliability was assessed using Cronbach's

alpha and composite reliability (CR) metrics. Cronbach's alpha values above 0.7 are typically considered acceptable for establishing internal consistency. In this study, Cronbach's alpha values ranged from 0.704 to 0.859, indicating that the constructs were reliable. For example, TR had a Cronbach's alpha of 0.859, demonstrating a high level of internal consistency among its indicators. Composite reliability further supported these findings, with values ranging from 0.728 to 0.879, which confirmed that the constructs were reliable. FC, for instance, had a composite reliability of 0.879, indicating strong reliability across its items. Convergent validity was evaluated by calculating the Average Variance Extracted (AVE) for each construct. The AVE measures the extent to which a construct explains the variance of its indicators, with a value above 0.5 indicating adequate convergent validity. In this study, the AVE values for all constructs exceeded 0.5, ranging from 0.521 to 0.713. FC exhibited the highest AVE at 0.713, suggesting that a significant proportion of variance in the indicators was captured by the construct. Similarly, RS had an AVE of 0.646, confirming adequate convergent validity. Table 4 provided a comprehensive summary of the reliability and convergent validity results, demonstrating that the measurement model was both reliable and valid.

Table 4. Reliability Analysis and Convergent Validity

Construct	Item	Factor Loading	Cronbach's Alpha	Composite Reliability	AVE
C	C1	0.882	0.729	0.728	0.521
	C2	0.722			
	C3	0.858			
FC	FC1	0.926	0.802	0.879	0.713
	FC2	0.763			
	FC3	0.917			
IU	IU1	0.811	0.716	0.716	0.573
	IU2	0.719			
	IU3	0.765			
PU	PU1	0.774	0.708	0.734	0.576
	PU2	0.751			
	PU3	0.718			
RS	RS1	0.841	0.726	0.845	0.646
	RS2	0.796			
	RS3	0.865			
SC	SC1	0.776	0.704	0.728	0.572
	SC2	0.735			
	SC3	0.757			
TR	TR1	0.783	0.859	0.79	0.537
	TR2	0.761			

Construct	Item	Factor Loading	Cronbach's Alpha	Composite Reliability	AVE
	TR3	0.696			

Discriminant validity was assessed using the Fornell-Larcker criterion, which compares the square root of the AVE for each construct with the correlations between that construct and others in the model. For discriminant validity to be established, the square root of the AVE should be greater than the correlations with other constructs. The results of this analysis confirmed discriminant validity for all constructs, as the square root of the AVE for each construct was indeed higher than the corresponding inter-construct correlations. For example, the square root of the AVE for PU was 0.613, which was greater than its highest correlation with another construct (0.609 with IU). This finding indicated that the constructs were distinct and measured different underlying concepts. Table 5 summarized these findings, clearly showing that each construct was sufficiently distinct from the others in the model. The results of the discriminant validity assessment reinforced the robustness of the measurement model, ensuring that the constructs used in the study provided a reliable and valid basis for subsequent analysis of the structural model. The comprehensive evaluation of the measurement model thus confirmed that the instruments used in this research were both reliable and valid, supporting the integrity of the study's findings.

Table 5. Discriminant Validity

Construct	C	FC	IU	PU	RS	SC	TR
C	0.622						
FC	-0.465	0.644					
IU	-0.52	0.559	0.688				
PU	-0.331	0.349	0.609	0.613			
RS	-0.393	0.44	0.654	0.588	0.604		
SC	-0.292	0.319	0.67	0.583	0.553	0.61	
TR	-0.433	0.497	0.658	0.695	0.601	0.658	0.661

Summary of Inner Model Results

Each hypothesis in the study was tested using the structural equation modeling (SEM) approach, with results providing insights into the relationships between the constructs involved in blockchain adoption within the supply chain management sector. The path coefficients, t-values, and significance levels were examined to determine the strength and significance of these relationships. The first hypothesis (H1: PU → TR) posited that PU positively influences TR. The results supported this hypothesis, with a path coefficient of 0.57, a t-value of 5.888, and a p-value of 0.000, indicating a strong and statistically significant positive relationship between PU and TR. This finding suggested that when users perceived blockchain technology as useful, their TR in the technology increased, aligning with the theoretical expectations. The second hypothesis (H2: SC → TR) proposed that SC positively influences TR. This hypothesis was also supported, with a path coefficient of 0.256, a t-value

of 2.483, and a p-value of 0.013, indicating a significant positive relationship. This result highlighted the importance of SC features in building TR in blockchain technology, as users were more likely to TR the technology when they believed it was secure.

The third hypothesis (H3: TR → IU) examined whether TR positively influences the IU blockchain technology. The analysis confirmed this relationship, with a path coefficient of 0.447, a t-value of 12.076, and a p-value of 0.000, demonstrating a strong positive impact of TR on users' intentions to adopt blockchain. This result reinforced the idea that TR is a crucial mediator between PU, SC, and the IU blockchain technology. The fourth hypothesis (H4: RS → IU) suggested that RS positively influences the IU. This hypothesis was strongly supported, with a path coefficient of 0.462, a t-value of 14.077, and a p-value of 0.000. The significance of this relationship underscored the critical role of regulatory frameworks in encouraging blockchain adoption by reducing perceived risks and uncertainties. The fifth hypothesis (H5: FC → IU) proposed that FC positively influence the IU. The results supported this hypothesis, with a path coefficient of 0.084, a t-value of 3.389, and a p-value of 0.001, indicating a statistically significant, albeit weaker, positive relationship. This finding suggested that while FC such as infrastructure and support systems were important, their influence on the intention to adopt blockchain was less pronounced compared to other factors.

The sixth hypothesis (H6: C → IU) examined whether C negatively influences the IU. The analysis confirmed this negative relationship, with a path coefficient of -0.106, a t-value of 4.165, and a p-value of 0.000. This result indicated that higher C were indeed a barrier to blockchain adoption, as anticipated in the hypothesis. The overall model fit was assessed through the R-squared (R^2) values, which indicated the proportion of variance explained by the independent variables. The R^2 value for IU was 0.88, suggesting that 88% of the variance in IU was explained by the model. Similarly, the R^2 value for TR was 0.647, indicating that 64.7% of the variance in TR was accounted for by the model. These high R^2 values demonstrated that the model was effective in explaining the key factors influencing blockchain adoption. Table 6 provided a detailed summary of the hypothesis testing results, including the path coefficients, t-values, and significance levels for each hypothesized relationship. Additionally, Figure 2 visually represented these findings, illustrating the confirmed relationships within the context of the overall research model. The results provided strong empirical support for the hypothesized relationships, contributing valuable insights into the factors driving blockchain adoption in the supply chain management sector.

Table 6 Inner Model Results (Summary)

Hypothesis	Path	Coefficient Path	T Statistics	P Values	Supported
H1	PU -> TR	0.57	5.888	0	Yes
H2	SC -> TR	0.256	2.483	0.013	Yes
H3	TR -> IU	0.447	12.076	0	Yes
H4	RS -> IU	0.462	14.077	0	Yes

Hypothesis	Path	Coefficient Path	T Statistics	P Values	Supported
H5	FC -> IU	0.084	3.389	0.001	Yes
H6	C -> IU	-0.106	4.165	0	Yes

The inner model results demonstrated that all hypothesized paths were statistically significant, confirming the proposed relationships between the constructs. The significance levels, as indicated by the T-statistics and P-values, were well above the required thresholds, providing strong evidence for the model's predictive validity. The structural model analysis was visually represented in the Figure 2, highlighting the significant paths and the relationships between the constructs. This figure illustrated the strength and direction of each path, providing a clear overview of how the variables interacted within the model.

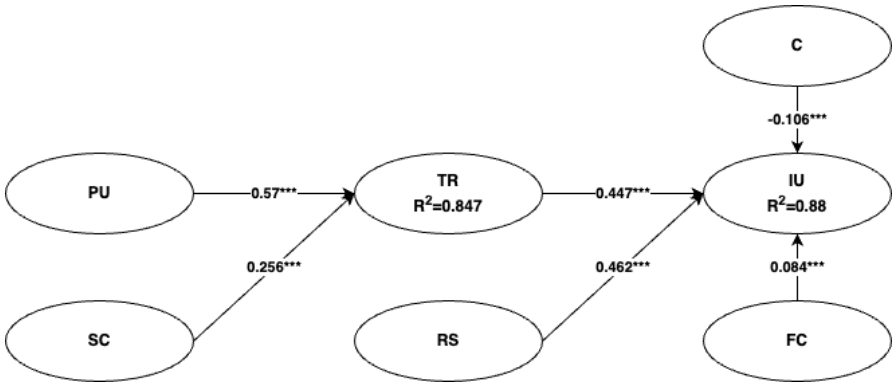

Figure 2 Inner Model Result Framework

Testing for Mediating Effects

The mediating effect of TR between PU and IU, as well as between SC and IU, was tested using the Sobel test. This statistical method was employed to determine whether TR significantly mediated the relationship between these independent variables and the dependent variable, providing insight into the role of TR in the adoption of blockchain technology within the supply chain management sector. For the first mediation path, PU → TR → IU, the Sobel test yielded a Z-value of 5.282. This result indicated a highly significant mediating effect, suggesting that TR played a crucial role in translating the PU of blockchain technology into a stronger intention to adopt it. The substantial Z-value highlighted the strength of this mediation, reinforcing the importance of TR as a key factor in the decision-making process for adopting blockchain technology. In the second mediation path, SC → TR → IU, the Sobel test produced a Z-value of 2.434. This result also indicated a statistically significant mediating effect, although it was less pronounced compared to the first path. The findings suggested that while SC was important in building TR, which in turn influenced the IU blockchain technology, the mediation effect was moderate but still meaningful. This emphasized that enhancing SC features could effectively bolster TR, thereby positively impacting adoption intentions. Table 7 presented a detailed summary of these Sobel test outcomes, displaying the Z-

values and confirming the statistical significance of TR as a mediator in both paths. The results underscored the pivotal role of TR in the adoption of blockchain technology, particularly in how PU and SC contributed to forming positive intentions to use the technology. This analysis provided a deeper understanding of the mechanisms through which blockchain adoption is influenced, highlighting the critical importance of TR in this context.

Table 7. Mediation Testing Results

Construct	Construct Relationship	t-value of Path Coefficient	Sobel test
PU → TR → IU	PU → TR	5.888	5.282
	TR → IU	12.076	
SC → TR → IU	SC → TR	2.483	2.434
	TR → IU	12.076	

Discussion

The findings of this study were interpreted in the context of existing literature on blockchain adoption, particularly within the supply chain management sector. The results confirmed the critical role of TR as a mediator between PU, SC, and IU blockchain technology. The significant mediation effect of TR in both pathways supported the notion that users' confidence in the reliability and integrity of blockchain technology is crucial for its adoption. These findings were consistent with previous studies, such as those by [38], who emphasized the importance of PU in building TR, and [19], who highlighted the role of SC in fostering TR in blockchain systems. The study's results also revealed that RS had a strong positive influence on the IU blockchain technology, underscoring the importance of a supportive regulatory environment in promoting technology adoption. This finding aligned with the research by [37], which demonstrated that clear and favorable regulatory frameworks are essential for reducing perceived risks and encouraging the adoption of blockchain solutions. Additionally, the influence of FC on the IU blockchain, although significant, was less pronounced than other factors, suggesting that while infrastructure and support are important, they may not be as critical as TR and RS in driving adoption decisions. The implications of these findings for theory and practice are substantial. The study reinforced the validity of the Technology Acceptance Model (TAM) and related frameworks in the context of blockchain adoption, particularly by highlighting the mediating role of TR. The results suggested that organizations seeking to promote blockchain adoption should focus on enhancing users' perceptions of the technology's usefulness and SC, as these factors significantly contribute to building TR. Moreover, the strong influence of RS indicated that policymakers play a crucial role in facilitating blockchain adoption by providing clear guidelines and legal protections. In practical terms, these findings suggested that supply chain management organizations should prioritize building TR among their stakeholders by ensuring the SC and usefulness of blockchain solutions. Additionally, companies should engage with regulators to advocate for policies that support the adoption of blockchain technology. The significant negative impact of C on the IU blockchain, as highlighted in the study, also pointed to the need for organizations to carefully

consider the financial implications of adopting blockchain and to seek ways to mitigate costs, possibly through collaborations or government incentives. When compared with previous studies, the findings of this research were largely consistent, though some differences emerged. For instance, while the study by [30] emphasized the role of C as a barrier to adoption, this research found that TR and RS had a more substantial impact on adoption intentions. This discrepancy might be due to the specific context of supply chain management, where the reliability and SC of transactions are particularly valued. Additionally, the relatively lower impact of FC in this study compared to others, such as [24], suggested that the maturity of the supply chain sector might influence the relative importance of different adoption factors.

Conclusion

This study examined the factors influencing the adoption of blockchain technology within the supply chain management sector. The key findings highlighted the significant role of TR as a mediator between PU, SC, and IU. The results demonstrated that TR was a crucial element in translating positive perceptions of blockchain's usefulness and SC into a stronger intention to adopt the technology. Additionally, RS was found to have a strong positive impact on the IU blockchain, emphasizing the importance of a supportive regulatory environment in facilitating adoption. C was also shown to negatively influence adoption intentions, suggesting that financial considerations remain a barrier to widespread implementation. The research made several contributions to the existing body of knowledge on technology adoption, particularly in the context of blockchain technology. It extended the Technology Acceptance Model (TAM) by integrating TR as a critical mediating factor, thus offering a more nuanced understanding of the mechanisms through which PU and SC influence adoption intentions. The study also provided empirical support for the role of RS in technology adoption, highlighting the need for policymakers to play an active role in fostering a conducive environment for new technologies. These contributions enriched the theoretical frameworks used to study technology adoption and offered new insights specific to the supply chain management sector. The findings of this study have important practical implications for organizations within the supply chain management sector. First, the significant role of TR suggests that companies should focus on building and maintaining TR among their stakeholders by ensuring that blockchain solutions are perceived as both useful and secure. This could involve investing in robust SC measures and clearly communicating the benefits of blockchain technology to potential users. Additionally, the strong influence of RS underscores the need for organizations to engage with regulators and advocate for policies that promote blockchain adoption. Addressing cost concerns, possibly through collaborations or seeking financial incentives, is also crucial to overcoming barriers to adoption. This study had several limitations that should be acknowledged. The use of a convenience sampling method may limit the generalizability of the findings, as the sample may not fully represent the broader population of supply chain professionals. Additionally, the cross-sectional nature of the study means that the findings provide a snapshot in time, rather than capturing the dynamics of adoption over a longer period. Future research could address these limitations by employing longitudinal designs and using more diverse and representative samples. Further studies could also explore the role of other potential mediators or moderators, such as

organizational culture or technological readiness, to gain a deeper understanding of the factors influencing blockchain adoption. In conclusion, this research provided valuable insights into the factors driving the adoption of blockchain technology in the supply chain management sector. The study highlighted the central role of TR as a mediator between PU, SC, and adoption intentions, as well as the critical importance of RS in facilitating adoption. While cost remained a barrier, the findings suggested that building TR and securing regulatory backing are key strategies for promoting blockchain adoption. These insights contribute to both theoretical understanding and practical strategies for organizations looking to implement blockchain technology, offering a pathway to more secure, efficient, and trusted supply chain operations.

Declarations

Author Contributions

Conceptualization: S.F.P.; Methodology: P.A.P.; Software: S.F.P.; Validation: P.A.P.; Formal Analysis: S.F.P.; Investigation: P.A.P.; Resources: S.F.P.; Data Curation: P.A.P.; Writing Original Draft Preparation: P.A.P.; Writing Review and Editing: S.F.P.; Visualization: S.F.P.; All authors have read and agreed to the published version of the manuscript.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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