Factors Influencing Blockchain Adoption in Logistics: A Customer-Centric Study in Vietnam

Huynh, Cong Minh and Nguyen, Minh Quoc Bao

Becamex Business School, Eastern International University, Binh Duong, Vietnam

15 June 2024

Factors Influencing Blockchain Adoption in Logistics: A Customer-Centric Study in Vietnam

Minh Quoc Bao Nguyen
Becamex Business School, Eastern International University, Binh Duong, Vietnam
Email: bao.nguyenminh.bbs19@eiu.edu.vn

Cong Minh Huynh
Becamex Business School, Eastern International University, Binh Duong, Vietnam
Email: minh.huynh@eiu.edu.vn
ORCID ID: 0000-0001-8169-5665

Abstract

This study investigates the factors influencing the adoption of blockchain technology in logistics in Vietnam, focusing on customer perspectives. Utilizing the Technology Acceptance Model (TAM), the research examines key determinants such as attitude, perceived ease of use, perceived usefulness, and behavioral intention, and their impact on actual use behavior. Data were collected from a refined sample of 208 respondents through structured offline surveys, initially drawn from a pool of 250 participants. The analysis was conducted using Smart PLS 4.0, a powerful tool for Partial Least Squares Structural Equation Modeling (PLS-SEM), to ensure robust and reliable results. The findings reveal that user attitude, perceived ease of use, and perceived usefulness significantly influence behavioral intention, which in turn positively affects the actual use of blockchain technology. The study emphasizes the importance of addressing user perceptions to enhance the adoption of blockchain in logistics, highlighting the potential for blockchain to improve transparency, efficiency, and security in the supply chain. These insights offer valuable guidance for businesses and policymakers aiming to foster blockchain integration in logistics, particularly in emerging markets like Vietnam.

Key words: Blockchain Adoption, Logistics, Technology Acceptance Model (TAM), Supply chain, Vietnam

JEL Classification: D20, D22, O30, O31, O32

1. Introduction

Today the current system for managing and observing logistics and supply chains is centralized, meaning that it relies on a single main system. It means there is only one entity running the supply chains and logistics system, usually the company providing logistics services. This setup has several problems: it's complicated to pass on information, it's not very efficient, it's expensive, and it's hard to trust. This leads to what's called "information asymmetry," where not everyone has the same information (Yuan, 2019). Trust, or the lack of it, is a major issue holding back the development of logistics (Yuan, 2019). However, the world of logistics and supply chains is changing rapidly thanks to new technologies. A key player in this transformation is blockchain technology. Blockchain is a distributed digital ledger technology that allows transactions between participants to be recorded in a secure and permanent manner. Blockchain effectively replaces the previous need for intermediaries and acts as a trusted third party to verify, record, and coordinate transactions by "sharing" a database among multiple parties. Originally developed for digital currencies in finance, blockchain is now making a big impact on logistics and supply chain management. Blockchain has some special features, like being decentralized (not controlled by any single entity), unchangeable, and transparent (Biggs et al., 2017). These qualities help solve old problems in supply chain management, like fraud, lack of clarity, and operational issues (Abeyratne & Monfared, 2016). Around seven in ten major global corporations are actively exploring ways to incorporate blockchain into their business models. This trend is exemplified by the Blockchain in Trucking Alliance (BiTA), which boasts a membership of over 60 companies, including well-known names like FedEx, DHL, UPS, Visa, and Uber Freight (Jain at el, 2020). In the world, IBM is one of the companies investing heavily in blockchain application. During the Covid-19 period, IBM applied blockchain in vaccine retrieval. Since August 2018, this group launched the TradeLens project in cooperation with Maersk with the goal of creating a platform based on blockchain technology to improve transparency, efficiency and safety in the logistics industry and supply chain management. response. Walmart is one of the largest retail corporations in the world and was also a pioneer in applying blockchain to supply chain management early on. Walmart partnered with IBM to develop the Food Trust platform that tracks the origin and timeline of food products across the supply chain, helping to improve food safety.

Some experts believe blockchain has huge, untapped potential (O'Marah, 2017). It's seen as a platform that could really change the way we make, sell, buy, and use goods in the 21st century

(Casey an& Wong, 2017; Dickson, 2016). Despite the many advantages of blockchain, there's a common misunderstanding about it, often because it's associated with cryptocurrencies (Parkhurst, 2019). This misconception can sometimes lead to unnecessary doubts about the broader, positive uses of blockchain in fields like logistics. Implementing blockchain technology can be compared to aligning sustainable practices with environmental policies – it's a complex but worthwhile endeavor (Saberi et al., 2018). One of the challenges in applying blockchain within organizations is the lack of understanding among customers, which makes adoption harder.

Numerous studies have explored blockchain technology across various sectors, highlighting its diverse applications and benefits. These investigations have largely concentrated on blockchain's utility and advantages for businesses (Toufaily et al., 2021), and its specific applications in areas like supply chain (Wong et al., 2020; Lu & Xu, 2017), finance (Chen & Bellavitis, 2020; Wong et al., 2019), energy systems (Wang et al., 2022), business management (Pal et al., 2021), and medical information data management (Qu, 2021). These existing literature predominantly focuses on the organizational implementation of blockchain, often overlooking how customers, as end-users, perceive and interact with these technological advancements. Hence, there are not many researches that focuses on the customer's perspective, particularly in the logistics sector. This gap is crucial as customer viewpoints are essential for the effective implementation and broader acceptance of blockchain in logistics.

This study explores how customers in Vietnam view and adopt blockchain technology. Focusing on blockchain's role in boosting transaction security and transparency, the research investigates how this technology can streamline operations and cut costs for businesses. Vietnam's rapid economic and technological development makes it a prime case study for understanding blockchain's integration in logistics and supply chains from a customer's perspective. The insights gained here are vital not only for Vietnam, which garners significant interest from scholars in the field of business management (Dam and Huynh, 2022; Ho and Huynh, 2022; Nguyen and Huynh, 2022; Nguyen and Huynh, 2023; Phan and Huynh, 2023; Vo and Huynh, 2023; Nguyen and Huynh, 2024), but also for other emerging markets. As these economies grow and embrace new technologies, understanding customer interactions and perceptions of blockchain is key. This research aims to identify the drivers of customer acceptance and their impact on the use of logistics services. The findings are expected to inform strategic implementations of blockchain, potentially improving efficiency and transparency in supply chains globally, a benefit that could extend well beyond Vietnam.

This study is structured around a conceptual framework that examines four key determinants: attitude, perceived ease of use (PEOU), perceived usefulness (PU) and behavioral intention, effect on the use behavior have been analyzed. These factors are instrumental in understanding how they impact the actual utilization of blockchain technology. Understanding the factors that drive customer acceptance of blockchain is crucial for businesses and policymakers. The findings from this research will be valuable for supply chain managers, logistics companies, and technology developers who aim to implement blockchain solutions. By identifying the key determinants of customer acceptance, this study will provide insights into how blockchain can be strategically implemented to enhance efficiency and transparency in supply chains.

2. Literature review

2.1. Theorical background

Blockchain in Supply chain

According to the Council of Supply Chain Management Professionals (CSCMP, 2018), supply chain management has two main functions: (i) planning, implementing, and controlling the core activities of the system to create and deliver value to the end customer (especially procurement, production, and logistics), and (ii) integrating and coordinating corresponding business processes within and among companies. According to AWS (2021), if integration addresses management and organizational challenges within a company, coordination among companies into a network involves the implementation of "technical" processes, including the installation of systems and processes to align resources such as materials, finance, and information in the supply chain management (SCM) system. The importance of information and communication technology in SCM systems has been widely recognized. Technology plays a crucial role in improving and enhancing the efficiency of the supply chain (Altaf et al., 2022). The Fourth Industrial Revolution has profoundly impacted various fields, including manufacturing and logistics (Cole et al., 2019). Therefore, it is evident that supply chain systems play a vital role in the operations of organizations and businesses, especially in the current era of digital transformation and business process automation (WTO, 2019; Hastig et al., 2020).

According to Sultan et al. (2018) and Swan (2017), a blockchain is a distributed ledger that is shared and used uniformly across a peer-to-peer network. A blockchain contains a single data record stored in blocks on each participant's node. Each block corresponds to a timestamped record and is verified through a consensus protocol, with security ensured through public key cryptography. Essentially, blockchain is a technology that stores and transmits information through interconnected blocks that expand over time. Each block contains information about its creation time and is linked to previous blocks. Blockchain is designed to resist data alteration. Information in a blockchain cannot be changed and can only be added with the consensus of all nodes in the system. Even if part of the blockchain system collapses, other computers and nodes will continue to operate to protect the information (Montecchi et al., 2019). Blockchain can transmit data without requiring intermediaries to verify the information. Essentially, blockchain is a chain of computers where all must agree on a transaction before it can be confirmed and recorded. In studies by Treiblmaier (2018), Sultan et al. (2018), Cole et al. (2019), and Vara et al. (2018), blockchain is viewed as a technology primarily aimed at enhancing system performance, but it can also promote coordination among economies, improve decentralization within enterprises, and support linking with partner companies. This helps companies form alliances in supply chains to create and exchange peer-to-peer value.

A significant difference between blockchain and traditional centralized networks is that data stored on a blockchain cannot be deleted or edited (Arman & Philip, 2018; Dursun et al., 2020). In centralized databases, there is always a risk of fraud or external hacker attacks, whereas for blockchain, the network remains stable unless attackers control the majority of the network; therefore, a large number of users significantly reduces the likelihood of fraud. This feature is particularly useful when applied to supply chain management. In supply chains, product ownership changes multiple times among participants until they are delivered to consumers. For low-value-added products such as agricultural goods and certain types of mining commodities, the supply chain operates as an aggregation method whereby goods are provided by many small-scale producers to larger supply chain partners for further processing. Thus, using blockchain to verify the origin and ownership of supplier products is highly effective, preventing fraud and ensuring transparency in origin.

Currently, consumers cannot be sure of the reliability of data in supply chain systems, and supply chain models without blockchain applications face more difficulties as supply chains grow and aim towards global supply chains (Nguyễn, 2023). Building a reliable system based on trust between individuals or organizations is very difficult, if not impossible, especially for newly established organizations, small and medium-sized enterprises that lack voice and reputation. The advent of blockchain as a groundbreaking technology for improving processes in all aspects of life, especially supply chain management, has become evident (CSCMP, 2018; Moosavi et al., 2021).

According to Kshetri (2018), the main goals of supply chains include cost reduction, quality improvement, speed, reliability, risk minimization, sustainability, and flexibility. The globalization of production and business activities of organizations and enterprises has made supply chain management increasingly important and valuable. Issues in today's supply chains, such as lack of transparency, high costs, and suboptimal processes, have been extensively discussed in various studies. For example, Litke (2019) has summarized the limitations of today's supply chains and suggested that these can be improved using blockchain. The following are current supply chain issues and how blockchain can enhance supply chain management for organizations and businesses.

For producers facing difficulties or limitations in proving the transparency of their product origin and quality, the supply chain can increase reliability through blockchain-based tracking of material paths and clear recording of production processes.

For manufacturers, who are limited in their ability to oversee products to the final stage in the supply chain, blockchain can support quality checks of products and track supplier materials and distribution networks. This enables manufacturers to monitor products to the customer and ensure the quality of their produced goods (Montecchi et al., 2019).

For distributors, current supply chains often have limited tracking systems that cannot be customized to each distributor's requirements. Blockchain helps them obtain proof of location and certification conditions registered in the ledger, enhancing customer trust and closely monitoring employees.

For agents facing difficulties in tracking each product's process, blockchain can enhance the ability to check and trace the origin of each product and conditions in transportation and storage. Retailers also find it easier to handle and trace defective products to return to the supplier. As a result, by combining delivery and payments, it can minimize operational time and narrow payment gaps for logistic partners (Wong et al., 2020).

For consumers, who lack confidence in compliance with quality assurance, origin, and standards, blockchain allows them to fully and clearly view product origins and the entire journey from raw materials to final products purchased from retailers (Tapscott & Tapscott, 2019). Consumers are more likely to accept the legitimacy of a product when it uses it (Ozdogru, 2019).

In summary, blockchain technology offers various benefits to different participants in the supply chain and across various application fields. Using blockchain in supply chain processes provides transparent, distributed, secure, fast, and low-cost transactions. In practice, blockchain technology provides the missing infrastructure that advanced technologies need. Therefore, increased focus on providing integration capabilities and collaboration with technologies such as artificial intelligence, big data analytics, cloud computing, and IoT will help realize advanced supply chain systems.

Technology acceptance model

In 1975, Fishbein and Ajzen (1975) proposed the Theory of Reasoned Action (TRA), as shown in Figure 1. This theory later became widely recognized in the area of psychological studies. According to TRA, one's behavioral intention affects his/her actual behavior. It is also stressed that one's behavioral intention for having a certain behavior is simultaneously affected by his/her attitude and subjective norms. Whether in terms of explanatory power or theoretical foundation, TRA has received a considerable degree of support and recognition (Felton, 1995)

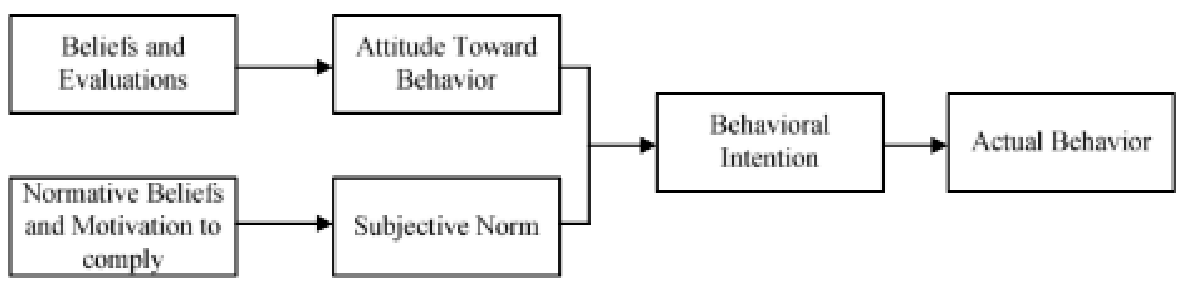


Figure 1. Framework of Theory of Reasoned Action (TRA), Source: Fishbein and Ajzen (1975)

Davis (1986) employed the Theory of Reasoned Action (TRA) to explore the relationship among perception, factors of affection, and technology usage, and he used the derived findings to construct the Technology Acceptance Model (TAM). This model, developed by Davis in 1986, aims to evaluate the factors affecting the acceptance of technology use. In this model, Davis identifies two main variables: Perceived Usefulness and Perceived Ease of Use. These two variables influence the attitude toward using and the actual system use. TAM proposes that users' acceptance of a new system is affected by their attitude toward using the system. This simple theory is expected to be applicable across different technology behaviors, user genders, and user groups. In other words, the fundamental idea of TAM is consistent with that of TRA—attitude and intention are determinants of beliefs. Figure 2 shows a framework of TAM.

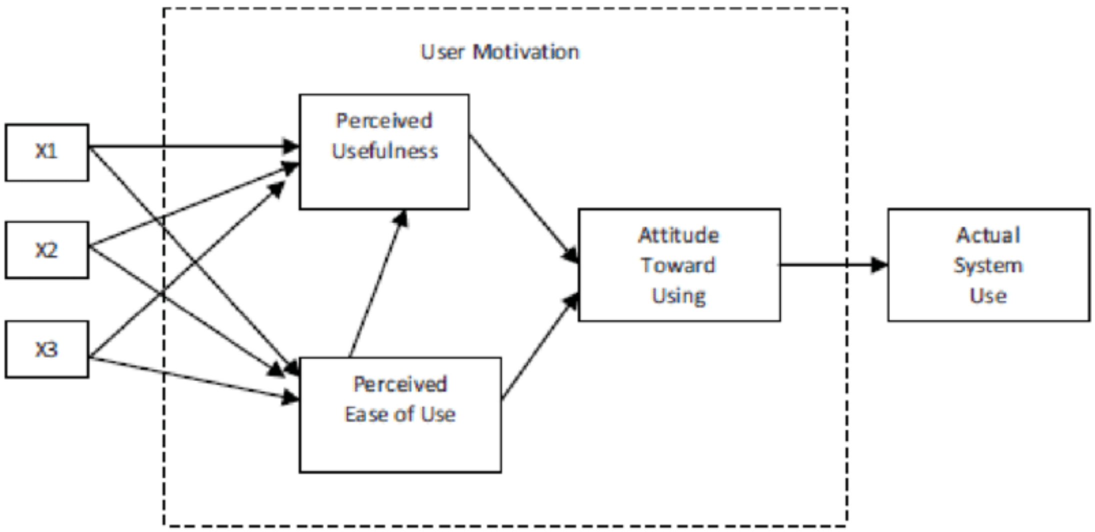


Figure 2. Technology Acceptance 1986 Model (TAM), Source: Davis et al. (1986)

In the 1989 adjusted model, the author modifies some relationships and impacts as follows: Firstly, external variables are added to the model, including factors such as: accessibility, system features, user support, technology skills, tool experience, profession, job relevance, and output quality. Secondly, the research results this time show that the attitude toward using technology affects the intention to use technology, which in turn affects the actual usage. Thirdly, the model also shows a relationship between Perceived usefulness & Perceived ease of use. The relationship between Perceived usefulness & Intention to use.

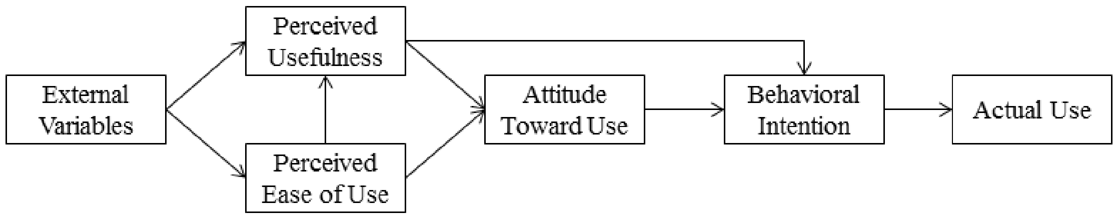


Figure 3. Technology Acceptance 1989 Model (TAM). Source: Davis et al. (1989)

In this 1996 model, the research results show that "Perceived usefulness & Perceived ease of use" directly affect "Intention," excluding the "Attitude" factor.

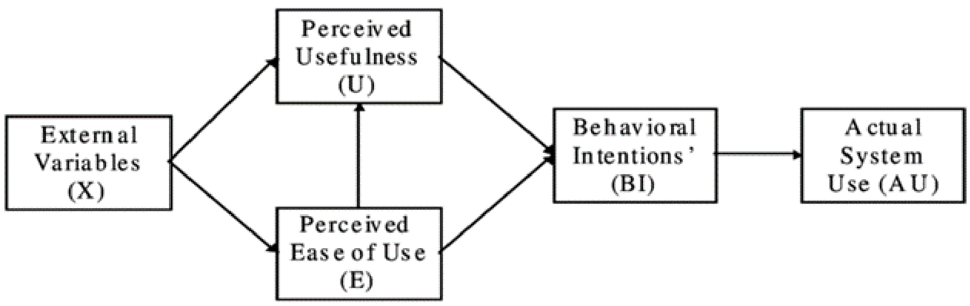


Figure 4. Technology Acceptance 1996 Model (TAM). Source: Davis et al. (1996)

TAM2 (as illustrated in Figure 3) was developed by Venkatesh and Davis (2000) on the basis of TAM. Two processes, the Social Influence Processes (Subjective Norm, Voluntariness, and Image) and the Cognitive Instrumental Processes (Job Relevance, Output Quality, Result Demonstrability, and Perceived Usefulness), were integrated into this model. The two processes were crucial to the study of user acceptance.

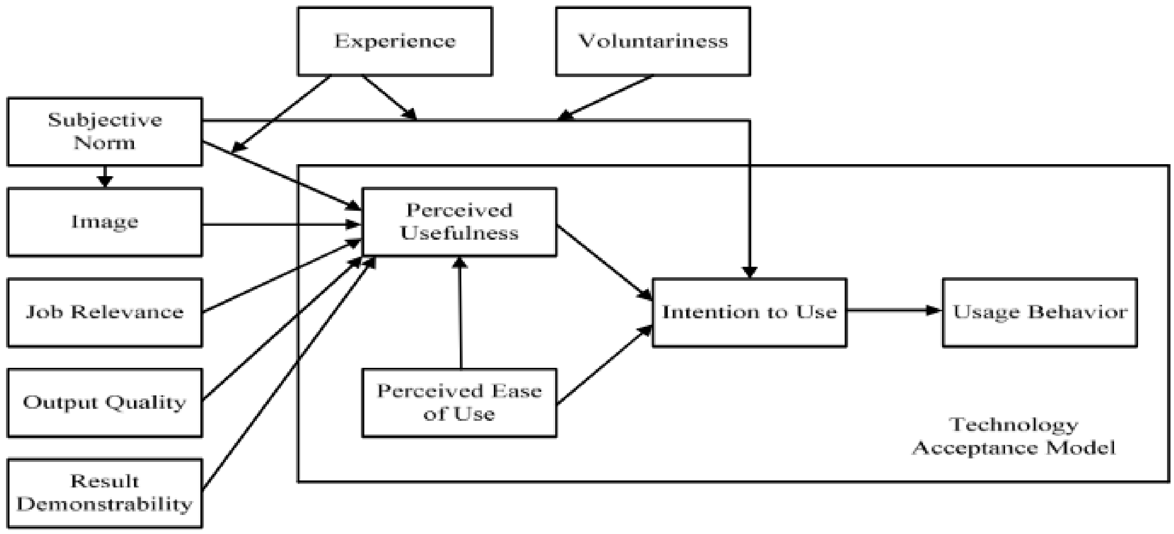


Figure 5. Technology Acceptance Model 2 (TAM 2). Source: Venkatesh and Davis (2000)

The TAM3 model was developed in 2008, compared to the TAM2 model, shows that more new factors affect the acceptance of technology use. TAM3 provides a clearer picture that when a new technology is introduced, for users to choose and use it, managers need to consider many external variables. Specifically, for potential customers to perceive usefulness, managers/companies must pay attention to factors such as subjective norm, image, job relevance, output quality, and result demonstrability. For potential customers to perceive ease of use of the new technology, companies/managers need to consider factors such as computer self-efficacy, perceptions of external control, computer anxiety, computer playfulness, perceived enjoyment, and objective usability. Additionally, factors such as experience and voluntariness also play significant roles in influencing perceived usefulness and perceived ease of use, ultimately affecting behavioral intention and use behavior.

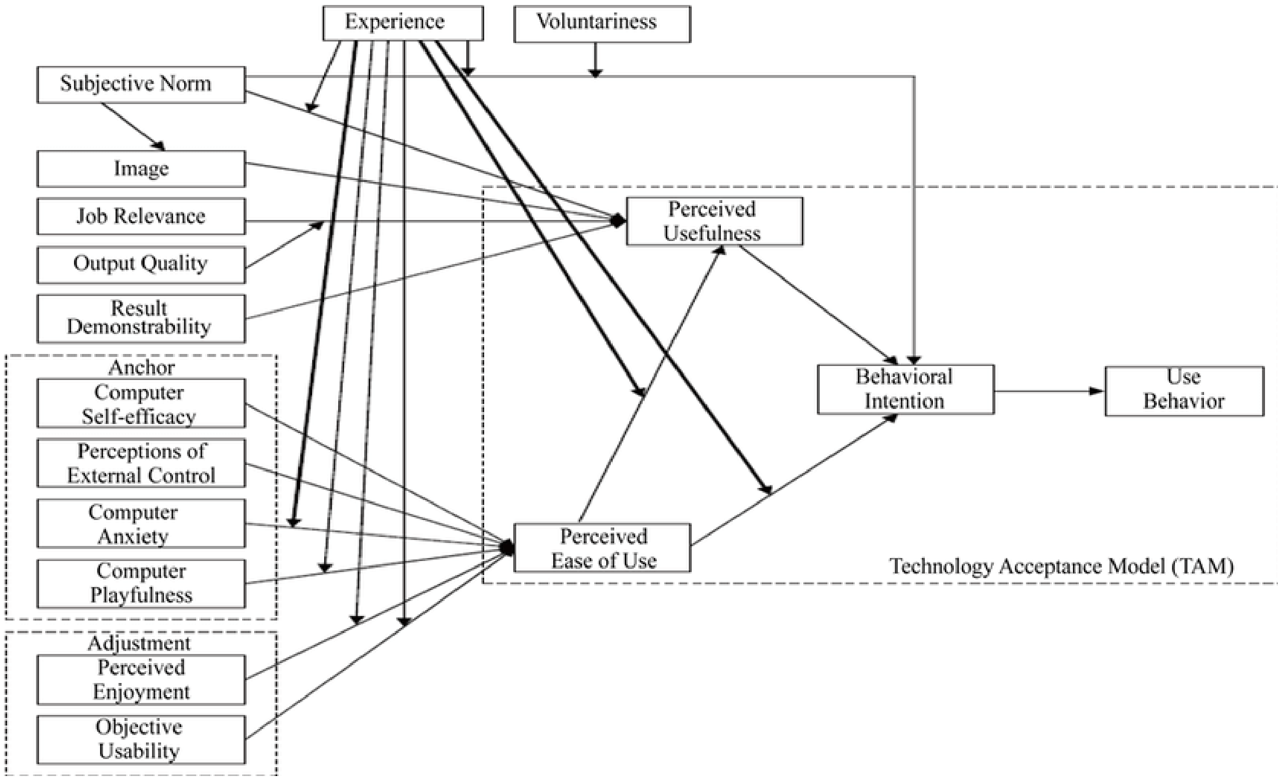


Figure 6. Technology Acceptance Model 3 (TAM 2). Source: Davis et al (2008)

Adopting new technology presents a variety of intricate challenges. Reluctance to adopt new technology can frequently be caused by a general disinterest in new tech solutions or a lack of technical understanding. This phenomenon is not just an individual reluctance but can also be observed at an organizational level. In his insightful work, Mougayar (2016) highlights a significant barrier: the absence of technically adept resources necessary for developing user-friendly tools, especially in the realm of blockchain technology. When delving further into the psychology of technology adoption, it's critical to understand that incorporating new technology into daily activities and adopting it is a gradual, ongoing process. People have different perspectives on and approaches to new technology. Numerous studies (Jharkharia & Shankar, 2005; Swan, 2015; Mougayar, 2016; Kumar et al., 2018; Singh et al., 2016) have examined this variation in perception and adoption. Every one of these research advances our knowledge of how people and organizations deal with the complicated terrain of technological transformation.

Central to this discussion is the Technology Acceptance Model (TAM), proposed by Davis in 1986 and further refined in 1989 and 1996. TAM posits that there are three primary dimensions to consider when predicting an individual's adoption towards using a new technology: Attitude, Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). These constructs are pivotal in understanding the mindset of individuals toward new technology, especially from a business perspective. In TAM, Attitude, PU and PEOU serve as external indicators, helping to assess the impact of these dimensions on the behavioral intentions of individuals when it comes to adopting new technology. This model was chosen because it offers a structured lens through which the complex interplay of individual perceptions, ease of use, and perceived usefulness can be understood and analyzed.

Numerous studies have analyzed PEOU, PU, and Attitudes to understand the practical application of TAM in various market scenarios (Pavlou, 2003; Gefen et al., 2003; Lee & Chen, 2019; Valaei et al., 2019). These dimensions are crucial in dissecting and understanding the attitude of an individual or an organization towards new technological solutions. The application of TAM in different studies underlines its significance in gauging the acceptance level of new technology among users. Hence, TAM has emerged as an ideal methodology to ascertain the acceptance of new technology. This is particularly true for the TAM 1989 and 1996 model, which provides a foundational understanding of the key factors influencing technology adoption. It offers a useful resource for practitioners and scholars to use when navigating the always changing field of technology adoption. By focusing on the constructs of Attitude, PU and PEOU, TAM 1996 and TAM 1989 specifically provide a comprehensive framework for evaluating the acceptance of new technology, making them invaluable tools for research and practical application in this domain.

2.2. Review of previous research

Previous studies are reviewed in Table 1 as follows.

Table 1. Review of previous research

Author and year	Key findings and results	Significance and limitations
Alkatheeri & Ahmad (2024)	Utilizes partial least squares structural equation modeling to analyze data from 500 respondents. Finds that technological readiness and knowledge sharing significantly drive blockchain adoption. Blockchain adoption enhances supply chain innovation capabilities (SCIC), competitive	Provides a validated framework connecting SCM and blockchain, offering valuable insights into technological readiness and knowledge sharing. However, focuses on large

	performance (CP), and overall supply chain performance (SCP).	organizations, potentially limiting applicability to smaller firms.
Cai et al. (2023)	Examines supply chain managers' intentions to adopt blockchain using the extended technology acceptance model. Survey of 203 managers shows that blockchain's traceability, transparency, information sharing, and decentralization enhance perceived usefulness, promoting adoption.	Highlights blockchain's potential to improve supply chain resilience and responsiveness. Limited by focus on perceived benefits rather than implementation challenges.
Rejeb et al. (2021)	Conducts a bibliometric review of 628 papers, identifying the intellectual structure of blockchain research in logistics and SCM. Highlights conceptualization, sustainability, adoption triggers, and barriers as key themes.	Provides a comprehensive mapping of the literature and identifies research gaps. Limited by its bibliometric nature, lacking empirical validation of concepts.
Sharma et al. (2023)	Uses structural equation modeling to analyze data from 200 stakeholders in the agri-food supply chain. Finds that performance expectancy, effort expectancy, social influence, facilitating conditions, inter-firm trust, and transparency drive blockchain adoption.	Offers a detailed framework for blockchain adoption in agri-food supply chains, emphasizing digitalization. Limited by its focus on a specific region (North India).
Sharma et al. (2023)	Identifies hierarchical and causal relationships among enablers of blockchain adoption in logistics, using a three-phased research framework. Highlights technological compatibility and regulatory support as crucial factors.	Provides a detailed analysis of enablers but limited by its regional focus, which may not be generalizable globally.
Chakraborty et al. (2023)	Examines the role of blockchain in enhancing supply chain transparency, safety, and	Offers insights into the benefits and challenges of

	auditability. Identifies cost, scalability, and technological complexity as significant barriers.	blockchain adoption in SCM. Lacks empirical data on long-term impacts.
Malisic et al. (2023)	Highlights the positive effects of blockchain on supply chain performance (SCP) by improving data accuracy, reducing fraud, and enhancing operational efficiency.	Provides empirical evidence of blockchain's benefits but does not address integration with existing supply chain systems.
Wang & Xie (2020)	Investigates blockchain's potential to improve logistics efficiency and customer satisfaction, identifying technological and regulatory challenges.	Highlights practical benefits and challenges of blockchain in logistics. Limited by focus on developing economies.
Khan et al., (2023)	Analyzes barriers to blockchain adoption in supply chains, such as high implementation costs, lack of standardization, and need for technological expertise.	Provides a comprehensive overview of adoption barriers but lacks specific case studies.
Ghode et al. (2019)	Examines blockchain's impact on logistics processes, emphasizing end-to-end visibility and tamper-proof data.	Highlights blockchain's potential to build trust among supply chain partners. Limited by focus on theoretical constructs without extensive empirical validation.
Ayan et al. (2022)	Uses a mixed-methods approach to investigate the factors influencing blockchain adoption in supply chains. Finds that organizational readiness, perceived benefits, and top management support are critical drivers.	Provides a holistic view of adoption factors but limited by its cross-sectional nature, which may not capture longitudinal effects.
Mohamed et al., (2023)	Investigates the role of blockchain in enhancing supply chain resilience. Finds that	Highlights the resilience benefits of blockchain but

	blockchain improves supply chain integration and risk management capabilities.	limited by its focus on specific industries (automotive).
Queiroz et al. (2022)	Employs the technology-organization-environment (TOE) framework to analyze blockchain adoption in supply chains. Identifies technological, organizational, and environmental factors as significant influencers.	Provides a structured framework for understanding adoption but limited by regional focus (Brazil).
Park & Li, (2021)	Analyzes the impact of blockchain on green supply chains. Finds that blockchain adoption enhances environmental sustainability and operational efficiency.	Highlights sustainability benefits but limited by its focus on the green supply chain context.
Agi & Jha (2022)	Examines blockchain's potential to improve supply chain transparency and accountability. Finds that blockchain adoption reduces information asymmetry and enhances trust among partners.	Provides insights into transparency benefits but limited by its conceptual approach without extensive empirical validation.

Current works on blockchain technology adoption in supply chain and logistics are beneficial in terms of suggesting advantages, challenges, and factors in promoting this innovation. There is ample research supporting blockchain's ability to increase transparency, traceability, and overall supply chain productivity and customer satisfaction. In this review, various factors which are contributing to the adoption of blockchain are classified and bifurcated into key criteria such as technology readiness, knowledge sharing, perceived usefulness and proficiency. Yet many obstacles - including expensive implementations, technical intricacies, and regulatory hurdles - remain as significant challenges. In short, these studies highlight the need to remove these obstacles and create financial motivation for the key players to help drive further blockchain adoption in logistics and supply chains. These results are the main content of our study in order to find out what affect acceptance and awareness of customers about blockchain technology in logistics sector in Vietnam. This study aims to identify customer perspectives to enable researchers and industry practitioners to find ways to mainstream the use of blockchain technology in emerging markets.

2.3. Definition of relevant constructs

Attitude

The concept of attitude, as explored within the framework of the Theory of Reasoned Action (TRA) by Ajzen and Fishbein in 1975 and further extended by Davis in 1989, holds a pivotal role in understanding the impact of new technology on an individual's behavioral beliefs. This perspective offers a nuanced view of how personal attitudes significantly influence one's interaction with and acceptance of technological advancements.

Attitude, in this context, is not a mere passive response but a dynamic and influential factor in determining an individual's inclination towards using technology. It encompasses a range of elements from personal beliefs, experiences, and expectations to societal influences and perceived benefits. The significance of attitude becomes particularly evident when considering the intention and desire of an individual in terms of technology usage. These personal attitudes directly contribute to shaping one's approach to and interaction with new technological systems.

In the realm of the Technology Acceptance Model (TAM), as elaborated by Davis in 1989, the construct of attitude is intricately linked with behavioral intentions. TAM posits that understanding an individual's acceptance of technology is not just about gauging their practical use but also about appreciating the underlying attitudinal factors that drive this acceptance. This model suggests that an individual's attitude towards technology can be a decisive factor in the successful adoption of that technology.

Perceived Ease of Use

Perceived Ease of Use (PEOU) is not just about how simple a technology is to use. It's about how comfortable and confident users feel when they use it for different tasks. It's a key part of the Technology Acceptance Model (TAM), developed by Davis and others in 1989. This model helps us understand why and how people start to use new tech. PEOU really taps into the user experience, showing us that it's not just the features of the tech, but how users feel about using them that matters.

The significance of PEOU in the context of TAM cannot be overstated. It plays a pivotal role in shaping an individual's behavioral intentions and overall attitude towards new technology.

While PEOU may not directly predict the full impact of technology on an individual's behavior, it serves as an influential precursor in forecasting how behavioral changes might occur due to technological shifts. This aspect becomes increasingly relevant in our current era, often referred to as the age of the petabyte, where technology's presence and influence in everyday life are profound and far-reaching.

Understanding PEOU within TAM provides insights into how technology is perceived, not just in terms of its functionality but also in terms of its usability and approachability. Whether a technology is adopted for its hedonic (pleasure-based) or utilitarian (functionality-based) features, the ease with which users can engage with it remains a critical factor. This concept of ease and comfort with technology extends beyond mere functionality; it encompasses the user's experience, expectations, and the perceived value of the technology in making life more manageable or enjoyable.

In the specific context of blockchain technology, PEOU takes on a unique dimension. Blockchain technology, known for its transparency and security, particularly in logistics and information management, presents new challenges and opportunities in terms of user interaction and acceptance. Understanding PEOU in this context is about gauging how users perceive the ease of engaging with a system that offers heightened transparency and potentially complex mechanisms. It's about understanding how these technological attributes align with user expectations and comfort levels.

Moreover, as considering the broader implications of PEOU in shaping technology adoption, it's important to recognize that the perception of ease of use evolves with the technology itself. As features and functionalities improve, what was once perceived as complex may become more intuitive, thereby altering the user's interaction and acceptance level. This dynamic nature of technology and user interaction underscores the importance of continuously studying and understanding PEOU within the framework of TAM.

In sum, PEOU is a multifaceted construct that plays a central role in understanding how individuals adapt to and embrace new technologies. It offers a lens through which people can examine not just the functional aspects of technology but also the human experience and psychological responses to technological advancements. As such, PEOU remains an essential element in the ongoing study and application of the Technology Acceptance Model in various technological domains.

Perceived Usefulness

Perceived Usefulness (PU), as outlined by Davis et al. in 1989, is a fundamental component of the Technology Acceptance Model (TAM). It plays a significant role in shaping an individual's approach to new technology. Essentially, PU reflects the degree to which a person believes that using a particular technology will enhance their job performance, knowledge, or skills. This belief in the utility of the technology is a key driver in the decision to adopt and use it.

In the context of TAM, PU is considered alongside Perceived Ease of Use (PEOU) as one of the two primary antecedents that influence an individual's attitude and intentions towards using new technology. These two constructs—PU and PEOU—work in tandem to shape the user's overall perception of the technology.

PU has a significant effect on the acceptance and use of technology. Studies have consistently found a positive correlation between PU and an individual's intention to use a technology. This implies that people are more likely to adopt and use technology when they believe it to be helpful. It's intriguing to see, though, that there is less of a correlation between PU and the way users feel about the technology. Further research by Lucas et al. (1999) and Jackson et al. (1997) emphasized this distinction. These results suggest that although PU plays a major role in determining an individual's decision to adopt a technology, it does not always determine how they feel about it in general.

This differentiation is important for understanding how technologies are adopted and used in real-world scenarios. It suggests that even if a technology is perceived as useful, this does not automatically translate to a favorable attitude towards it. There could be other factors influencing attitudes, such as the technology's design, its alignment with personal values, or external influences like peer opinions or organizational culture.

In practice, the concept of PU is essential for developers and marketers of new technologies. Technology solutions can be developed and presented more effectively if it is recognized that consumers are largely motivated by the benefits they believe a technology will bring. It highlights how important it is to explain and show prospective consumers the real-world benefits of a technology.

In conclusion, PU is a key antecedent in TAM that significantly influences the adoption and usage of new technologies. It highlights the importance of perceived benefits in shaping technology acceptance and provides valuable insights for those involved in the development, marketing, and implementation of new technological tools and systems.

Behavioral Intention

Behavioral intention (BI) is a crucial concept that connects our attitudes and beliefs with our actual actions, especially when it comes to adopting and using new technology. Think of it as the bridge between what we think and what we do.

In the context of the Theory of Reasoned Action (TRA) and the Technology Acceptance Model (TAM), behavioral intention is like our plan or willingness to use a new piece of technology. It's influenced by how we feel about the technology, including whether we think it's useful and easy to use. Plus, it takes into account other factors like what our friends or colleagues might think, as well as any external pressures we might feel.

Here's how it works: When we have a positive attitude towards a technology, find it user-friendly, and believe it'll be beneficial (that's perceived usefulness), we're more likely to make a solid plan or intention to use it. On the flip side, if any of these factors are negative, it can weaken our intention to use the technology, making it less likely for us to actually adopt it.

Behavioral intention also considers the timing of things. It's not just about whether we'll use a technology right now, but whether we plan to use it in the future. This acknowledges that sometimes it takes a bit of time for us to decide, make a plan, or overcome any obstacles before we fully embrace and use a new technology.

In a nutshell, behavioral intention is a key concept in understanding how we decide to adopt new technology. It's like the link between our thoughts and our actions, helping us predict whether we'll actually use a new tech tool. This understanding is super important for researchers, tech developers, and marketers because it helps them figure out what factors influence our willingness to use new technology and how to make it more appealing to us.

Actual Use

Actual Use (AU) in this research refers to the degree to which users have employed blockchain technology in their logistics operations. This construct measures the practical application and frequency of blockchain technology use among logistics customers, capturing the extent of integration into their daily activities.

Actual Use (AU) reflects how often and to what extent individuals use a technology in their routine operations. It is a key indicator of the success and impact of the technology, showing whether it has moved beyond theoretical acceptance and behavioral intention to practical, real-world application.

The significance of Actual Use in the context of the Technology Acceptance Model (TAM) cannot be overstated. It plays a pivotal role in understanding the actual behavior of individuals towards new technology. While other constructs like Perceived Ease of Use (PEOU) and Perceived Usefulness (PU) influence the intention to use a technology, AU provides direct evidence of technology adoption. It bridges the gap between intention and action, offering insights into how and why users integrate new technology into their work processes.

Understanding AU within TAM provides insights into the real-world application and effectiveness of technology. It helps to assess not just the potential benefits but the actual impact on users' workflows and productivity. This is particularly important in the logistics sector, where the adoption of blockchain technology can significantly enhance transparency, security, and efficiency.

In the specific context of blockchain technology, AU takes on a unique dimension. Blockchain is known for its transparency, security, and decentralization, especially in logistics and information management. These features present both opportunities and challenges for user adoption. Understanding AU in this context involves evaluating how users interact with a system that offers enhanced security and transparency but may also introduce new complexities. It is about understanding how these technological attributes align with users' practical needs and comfort levels.

Moreover, as technology evolves, the perception and patterns of its actual use may change. Features and functionalities that were once complex may become more intuitive, altering how users interact with and adopt the technology. This dynamic nature of technology and user interaction underscores the importance of continuously studying and understanding AU within the TAM framework.

In sum, AU is a multifaceted construct that plays a central role in understanding how individuals adapt to and embrace new technologies. It offers a lens through which we can examine not just the theoretical acceptance but the practical integration and impact of technology in real-world scenarios. As such, AU remains an essential element in the ongoing study and application of the Technology Acceptance Model in various technological domains.

2.4. Research model and hypothesis development

Based on TAM, Jain at el (2020) and prior studies, the conceptual framework to study the factors influencing blockchain adoption in logistics is proposed as follows:

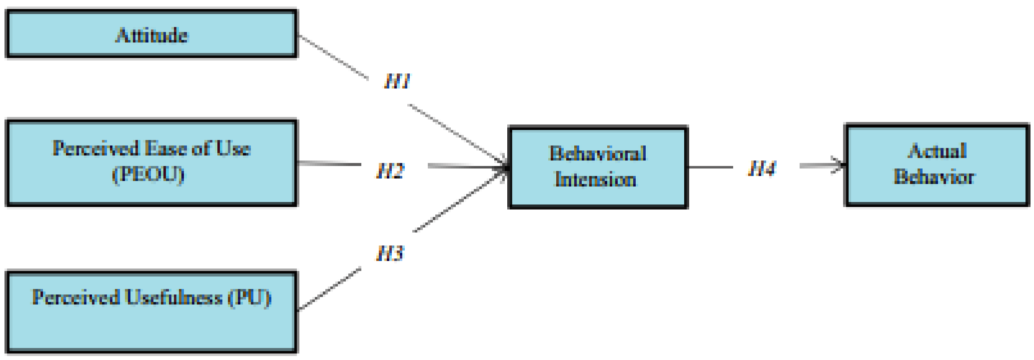


Figure 7. Conceptual Framework, adopted from Jain et el. (2020)

The relationship between user attitude and behavioral intention is well-documented and generally positive. Davis (1989) found that a favorable attitude towards technology significantly enhances the likelihood of its adoption. In e-learning, Alharbi and Drew (2014) showed that positive attitudes towards learning management systems increased behavioral intentions to use these systems. Additionally, Tarhini et al. (2015) observed that positive attitudes towards mobile banking systems similarly increased users' intentions to adopt these technologies. These studies indicate a consistent positive effect of user attitude on behavioral intention, as users who view a technology favorably are more likely to use it.

H1. User's attitude is positively related to the behavioral intention of using blockchain technology in the logistics sector, specifically regarding product information like tracking details and counterfeit products.

Perceived ease of use (PEOU) consistently shows a positive impact on behavioral intention. Davis et al. (1989) found that PEOU reduces the effort required to use a system, thereby increasing the likelihood of adoption. Roca et al. (2006) demonstrated that students who found an e-learning system easy to use were more likely to intend to use it. Moreover, Venkatesh and Davis (2000) highlighted that systems perceived as easy to use significantly increase users' intentions to adopt them.

H2. Perceived ease of use is positively related to behavioral intention of using blockchain technology in the logistics sector, specifically regarding product information like tracking details and counterfeit products.

Perceived usefulness (PU) is a crucial determinant of behavioral intention. Davis (1989) emphasized that users are more likely to adopt a technology if they find it useful. King and He (2006) confirmed this in a meta-analysis, showing PU's strong positive impact across various contexts. Shroff et al. (2011) also found that in e-learning environments, the perceived usefulness of a system significantly influenced students' intentions to use it.

H3. Perceived usefulness is positively related to behavioral intention of using blockchain technology in the logistics sector, specifically regarding product information like tracking details and counterfeit products.

Behavioral intention is a strong predictor of actual usage behavior. Ajzen (1991) explained that the intention to perform a behavior is the most immediate determinant of that behavior. Venkatesh et al. (2003) found that higher behavioral intentions often lead to actual system use in IT adoption. Mathieson (1991) also emphasized that behavioral intention reliably predicts actual technology usage.

H4. Behavioral intention to use is positively related to actual behavior of blockchain technology in the logistics sector, specifically regarding product information like tracking details and counterfeit products.

3. Data and research methodology

The quantitative method is used in this study, which is based on a questionnaire survey and then analyzes to determine the effect of attitude, perceived ease of use, and perceived usefulness on behavioral intention, and then the effect of behavioral intention on actual usage. Hypotheses are developed based on the Technology Acceptance Model and then empirically tested using collected data. It allows for the formulation of specific hypotheses that can be tested through quantitative methods which involves the systematic empirical investigation of relationships between variables by examining their numerical data, often utilizing statistical tools and procedures (Creswell, 2017). The study employed Partial Least Squares Structural Equation Modeling (PLS-SEM) v.4.1.0.0 for data analysis purpose.

We choose the convenience sampling method due to its ease of access and proximity. This approach offers numerous benefits such as simplicity, cost-effectiveness, and widespread availability. The research will target a demographic of individuals aged between 18 and 50 years who regularly employ technology for tracking shipments and managing financial transactions during online shopping activities within the past 4 to 5 months. The sample will consist of 250 active online shoppers selected based on their prior use of electronic media for purchases and their engagement with various online shopping platforms, including mobile applications, electronic commerce websites, and social media platforms like Instagram and Facebook. Out of the total sample, 200 responses will be finalized for analysis to account for incomplete responses or non-responses for certain questions. While the respondents may not have previous experience with blockchain technology, they are presumed to have familiarity with various mobile applications as part of their daily routine.

Variables in the research model, including perceived ease of use, perceived usefulness, attitude, behavioral intention, and actual usage, will be measured using validated scales from prior research. Each construct will be quantified using a 5-Likert scale, ranging from strongly disagree to strongly agree, measured as follows in given Table 2.

Table 2. Measurement items adapted from previous studies.

Likert Scale (1=strongly disagree; 5=strongly agree)		
Attitude (ATT)		Sources
ATT1	Getting product tracking information through blockchain technology is time-saving and enhances trust.	Davis et al., (1989), Jain at el, (2020)
ATT2	Personalized information about product shipments via blockchain is beneficial.	
ATT3	Blockchain technology promotes data transparency in financial transactions.	
Perceived Usefulness (PU)		
PU1	Enabling authorized users to log in for product information is advantageous.	Davis et al., (1989), Jain at el, (2020)
PU2	Access to valuable product tracking details is crucial.	
PU3	Accurate tracking information improves my ability to obtain useful product details.	

Perceived Ease of Use (PEOU)		
PEOU1	Blockchain technology facilitates easy access to product-specific information, aiding in counterfeit prevention.	Davis et al., (1989), Jain at el, (2020)
PEOU2	Secure access to personal data and information as per my requirements is conveniently available online.	
PEOU3	The interface for accessing blockchain information is user-friendly and intuitive.	Altamimi et al., (2022)
Behavioral Intention (BI)		
BI1	I intend to use blockchain for checking the status of shipments for products as much as possible.	Davis et al., (1989), Jain at el, (2020)
BI2	I intend to use the blockchain technology for tracking the ownership of titles in the future and also if services will be provided.	
BI3	I recommend the blockchain technology for use in logistics services.	Natasia et al., (2022)
Actual Use (AU)		
AU1	I am comfortable using blockchain for logistics over the Internet.	Davis et al., (1989), Jain at el, (2020)
AU2	Blockchain technology effectively manages my personal data in logistics operations.	
AU3	I will often use the blockchain technology in logistics services.	Natasia et al., (2022)

4. Results and discussions

4.1. Descriptive data

Demographic data analysis

Data were collected through structured offline surveys. The demographic distribution and summary is given in Figure 8 and Table 4.

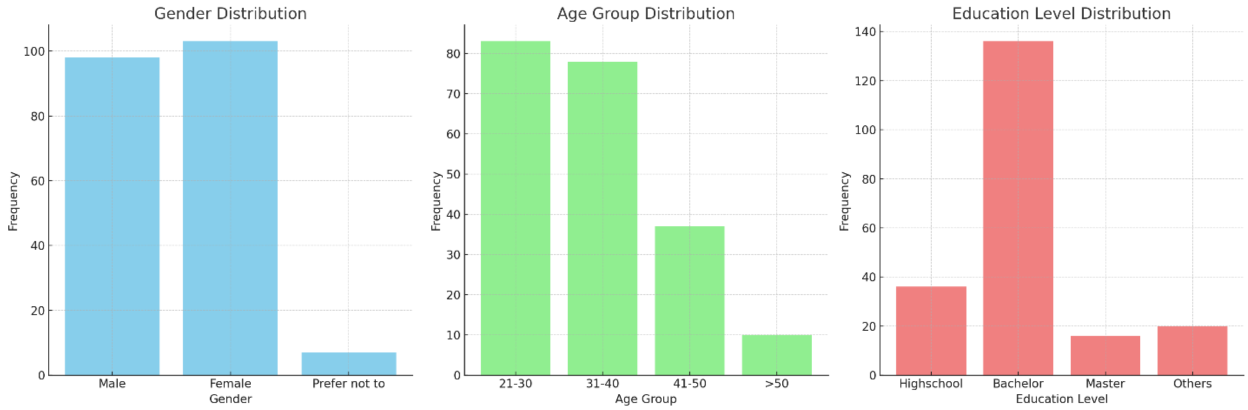


Figure 8. Demographic Distribution

The gender distribution among the survey respondents shows a fairly balanced representation between males and females, with a small percentage preferring not to disclose their gender. Specifically, about 47% of the respondents are male, 50% are female, and approximately 3% chose not to disclose their gender. This balance ensures that the survey findings can be applied to both genders, thereby reducing potential bias in the results.

The age group distribution among the respondents reveals a significant representation of younger adults, particularly those aged 21-30, who make up approximately 40% of the sample. This is followed by the 31-40 age group, constituting about 37% of the respondents. The 41-50 age group and those over 50 are less represented, making up about 18% and 5% of the sample, respectively.

The education level distribution among the respondents reveals that a significant proportion, about 65%, hold a Bachelor's degree. This suggests that higher education plays a crucial role in the logistics sector, possibly influencing openness to new technologies like blockchain. The data also shows that approximately 17% of the respondents have a high school education, while 8% hold a Master's degree, and another 10% fall into the "Others" category.

Table 3. Summary demographic

Demographics	Frequency	Percentage (%)
Gender		
Male	101	48.60%
Female	100	48.10%

Prefer not to say	7	3.40%
Age		
21-30	93	44.70%
31-40	72	34.60%
41-50	39	14.90%
>50	12	5.80%
Education level		
Highschool	31	14.90%
Bachelor	125	60.10%
Master	21	10.10%
Others	21	10.10%

Descriptive Analysis

Descriptive Statistics for ATT, PU, PEOU, BI and AU are provided in Tables 5, 6, 7, 8 and 9, respectively.

Table 4. Descriptive Statistics for ATT Group

Name	Scale Min	Scale Max	Mean	Median	Standard Deviation
ATT1	2	5	3.52	4	0.72
ATT2	1	5	3.62	4	0.7
ATT3	1	5	3.63	4	0.69

ATT Group Analysis: The Attitude (ATT) group focuses on the respondents' general perceptions and attitudes towards using blockchain technology in logistics. Comprising three items—ATT1, ATT2, and ATT3—this group measures different dimensions of these attitudes. Overall, the ATT group results reveal that respondents generally hold a positive attitude towards blockchain technology in logistics. They recognize its potential to save time, provide personalized shipment information, and enhance transparency in financial transactions. These attitudes are critical as they reflect the respondents' readiness to embrace blockchain, thereby indicating a higher likelihood of its successful implementation in logistics.

Table 5. Descriptive Statistics for PU Group

Name	Scale Min	Scale Max	Mean	Median	Standard Deviation
PU1	2	5	4.13	4	0.76
PU2	2	5	4.16	4	0.83
PU3	2	5	4.09	4	0.78

PU Group Analysis: The Perceived Usefulness (PU) group evaluates how beneficial respondents find blockchain technology in logistics. This group includes three items—PU1, PU2, and PU3—each measuring different aspects of perceived usefulness. The PU group's findings demonstrate that respondents find blockchain technology to be highly useful in logistics. They particularly appreciate its secure access to product information, detailed tracking capabilities, and the accuracy of the information it provides. These perceptions of usefulness are essential as they significantly influence the respondents' willingness to adopt and utilize blockchain technology in their logistics operations.

Table 6. Descriptive Statistics for PEOU Group

Name	Scale Min	Scale Max	Mean	Median	Standard Deviation
PEOU1	2	5	3.98	4	0.79
PEOU2	1	5	3.92	4	0.82
PEOU3	2	5	3.95	4	0.77

PEOU Group Analysis: The Perceived Ease of Use (PEOU) group assesses how easy respondents find blockchain technology to use in logistics. This group includes three items: PEOU1, PEOU2, and PEOU3. The PEOU group's findings indicate that respondents find blockchain technology relatively easy to use, which is crucial for its adoption. The ease of accessing product-specific information, the convenience of secure online access, and the user-friendliness of the interface all contribute to a positive perception of blockchain technology. These factors are essential in driving the adoption and effective use of blockchain in logistics.

Table 7. Descriptive Statistics for BI Group

Name	Scale Min	Scale Max	Mean	Median	Standard Deviation
BI1	2	5	3.69	4	0.74
BI2	2	5	3.64	4	0.81
BI3	2	5	3.71	4	0.74

BI Group Analysis: The Behavioral Intention (BI) group examines respondents' intentions to use blockchain technology in logistics. This group includes three items: BI1, BI2, and BI3. The BI group's findings demonstrate a strong intention among respondents to use and recommend blockchain technology in logistics. This positive intention is crucial for the successful adoption and implementation of blockchain technology. The respondents' willingness to use blockchain for tracking shipments and ownership, as well as their intention to recommend it, indicates a high level of acceptance and endorsement of blockchain technology.

Table 8. Descriptive Statistics for AU Group

Name	Scale Min	Scale Max	Mean	Median	Standard Deviation
AU1	2	5	3.5	3	0.79
AU2	2	5	3.53	4	0.74
AU3	2	5	3.52	3.5	0.8

AU Group Analysis: The Actual Use (AU) group assesses respondents' actual use of blockchain technology in logistics. This group includes three items: AU1, AU2, and AU3. The AU group's findings indicate a moderate level of actual use of blockchain technology in logistics. While respondents generally find blockchain effective in managing personal data, their comfort levels and frequency of use vary. These findings suggest that while there is positive sentiment towards blockchain technology, there may still be barriers to its widespread adoption. Understanding and addressing these barriers is crucial for increasing the actual use of blockchain in logistics.

4.2. Statistical result analysis

Assessment of Measurement Model

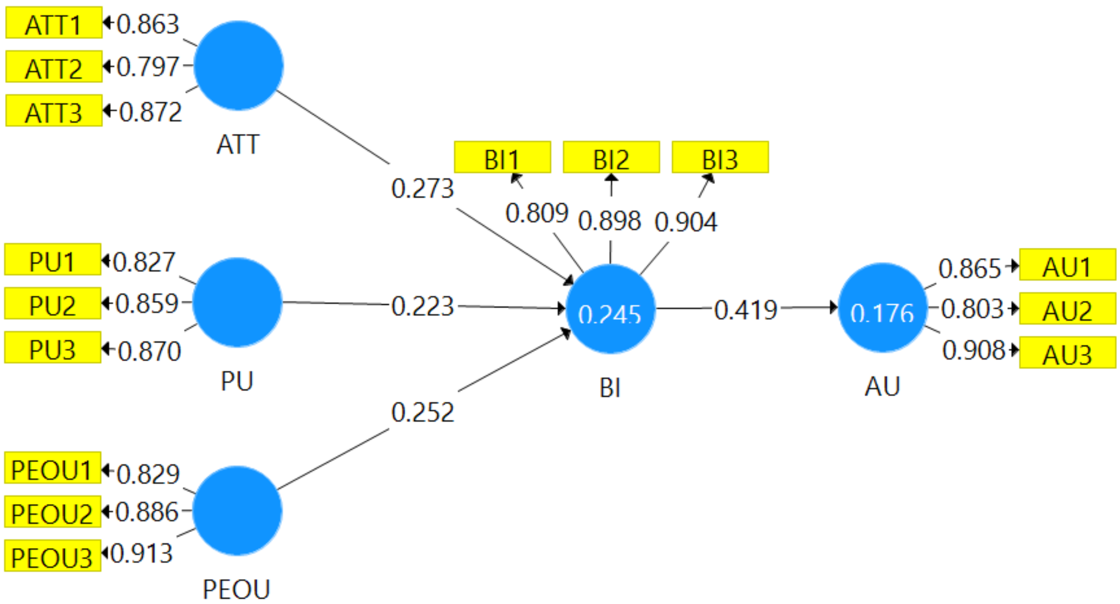


Figure 9. Measurement model

Quality of Observed Variables: Outer Loading

Table 9. Outer Loading

	ATT	AU	BI	PEOU	PU
ATT1	0.863				
ATT2	0.797				
ATT3	0.872				
AU1		0.865			
AU2		0.803			
AU3		0.908			
BI1			0.809		
BI2			0.898		
BI3			0.904		
PEOU1				0.829	
PEOU2				0.886	
PEOU3				0.913	
PU1					0.827
PU2					0.859
PU3					0.870

Evaluating the quality of observed variables is essential for ensuring that these variables adequately represent their corresponding latent constructs. This process involves assessing the outer loading coefficients for reflective measurement scales. Hair et al. (2017) in "A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)" provide comprehensive guidelines for this evaluation.

For reflective measurement scales, the outer loading coefficients indicate the strength of the relationship between observed variables and their latent constructs. According to Hair et al., an outer loading coefficient of 0.7 or higher signifies that the observed variable significantly represents the latent variable and is thus worth retaining in the model. When outer loadings fall below 0.4, the observed variables should be removed as they do not sufficiently explain the latent construct. Variables with outer loadings between 0.4 and 0.7 necessitate further evaluation based on additional metrics such as composite reliability (CR) and convergent validity (measured by Average Variance Extracted, or AVE).

The high outer loading values in the ATT group, all exceeding the 0.7 threshold, indicate that these variables are robust indicators of the latent construct. ATT1 and ATT3, with loadings of 0.86 and 0.87 respectively, particularly stand out, reflecting a strong consensus among respondents regarding the time-saving and trust-enhancing benefits of blockchain technology. ATT2, with an outer loading of 0.79, while slightly lower, still demonstrates a strong representation of the latent variable. These high loadings suggest that respondents consistently recognize the practical advantages of blockchain technology in enhancing trust and saving time in logistics operations.

The outer loading values in the PEOU group, ranging from 0.829 to 0.913, demonstrate that all observed variables are excellent representatives of their latent construct. The high outer loading values reflect respondents' perception that blockchain technology is easy to use, particularly in terms of accessing product-specific information and preventing counterfeits. These values underscore the respondents' positive assessment of the user-friendliness and intuitive nature of blockchain technology interfaces, crucial for its adoption and effective use.

For the PU group, outer loading values are similarly high, with PU3 having the highest loading at 0.87. These figures suggest that respondents perceive significant utility in using blockchain technology for tracking and obtaining valuable product details. The high outer loading values confirm that these variables are key indicators of perceived usefulness, reflecting respondents' appreciation for the detailed and accurate product information that blockchain technology provides.

The outer loading values in the BI group are all above 0.8, with BI2 and BI3 particularly strong at 0.89 and 0.90, respectively. These high values indicate that respondents have a strong intention to use and recommend blockchain technology for logistics services. The consistency in high outer loading values across all BI items suggests a robust latent construct, reflecting a solid behavioral intention among respondents to adopt blockchain technology in their logistics operations.

The AU group also shows high outer loading values, signifying that respondents are comfortable and effective in using blockchain technology for logistics. AU1 and AU3, with loadings of 0.86 and 0.90 respectively, suggest a strong actual use of blockchain technology. This reflects high adoption and comfort levels among users, indicating that the technology is not only theoretically appealing but also practically implemented by the respondents in their logistics operations.

In summary, the outer loading values provided for the reflective measurement scales indicate that the observed variables are significant and robust indicators of their respective latent constructs. High outer loading values across the ATT, PEOU, PU, BI, and AU groups suggest that the model is well-constructed with reliable indicators. These robust indicators enhance the validity and reliability of the structural equation model, ensuring that the final model is both accurate and meaningful. This rigorous assessment aligns with the guidelines by Hair et al. (2017) and underscores the importance of evaluating observed variables to refine the model, thus contributing to high-quality research outcomes in PLS-SEM analysis.

Construct Reliability and Validity: Cronbach's Alpha, Composite Reliability, and Average Variance Extracted (AVE)

Evaluating the reliability and validity of constructs in a structural equation model is a fundamental step to ensure the robustness of the measurement model. This analysis involves the use of several key metrics: Cronbach's Alpha, Composite Reliability (CR), and Average Variance Extracted (AVE). These metrics help to confirm that the constructs are both reliable and valid representations of the underlying latent variables. The provided data includes these metrics for the constructs Attitude (ATT), Actual Use (AU), Behavioral Intention (BI), Perceived Ease of Use (PEOU), and Perceived Usefulness (PU).

Table 10. Reliability and Validity

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
ATT	0.802	0.829	0.882	0.713
AU	0.823	0.842	0.894	0.739
BI	0.843	0.876	0.904	0.76
PEOU	0.85	0.867	0.908	0.768
PU	0.812	0.813	0.888	0.726

Cronbach's Alpha is a measure of internal consistency, indicating how well the items in a construct are positively correlated to one another. A higher value of Cronbach's Alpha suggests that the items measure the same underlying construct. The recommended threshold for Cronbach's Alpha is generally 0.7 or above, indicating acceptable reliability. For the Attitude (ATT) group, the Cronbach's Alpha of 0.802 exceeds the recommended threshold, indicating good internal consistency among the items measuring attitude towards blockchain technology. This high Cronbach's Alpha value suggests that the respondents' attitudes are reliably measured by the items ATT1, ATT2, and ATT3. Similarly, the Actual Use (AU) group demonstrates a Cronbach's Alpha of 0.823, reflecting high internal consistency among the items AU1, AU2, and AU3, thus confirming the reliability of these indicators in measuring the actual use of blockchain technology in logistics.

The Behavioral Intention (BI) group shows a Cronbach's Alpha of 0.843, suggesting very good internal consistency and reliability of the items BI1, BI2, and BI3. This high value reinforces the robustness of the behavioral intention construct. The Perceived Ease of Use (PEOU) group exhibits a Cronbach's Alpha of 0.850, which indicates that the items measuring perceived ease of use (PEOU1, PEOU2, and PEOU3) are highly consistent. This high internal consistency suggests that respondents uniformly perceive blockchain technology as easy to use. Lastly, the Perceived Usefulness (PU) group, with a Cronbach's Alpha of 0.812, demonstrates good internal consistency among the items PU1, PU2, and PU3, indicating that respondents consistently perceive blockchain technology as useful in logistics.

Composite Reliability (CR) is another measure of internal consistency that considers the actual factor loadings of the items, providing a more comprehensive reliability assessment compared to Cronbach's Alpha. A CR value of 0.7 or higher is considered acceptable. The CR value for the Attitude (ATT) group is 0.882, indicating excellent reliability. This high CR value confirms that the items in the ATT group reliably measure the attitude construct, reinforcing the findings from Cronbach's Alpha. Similarly, the Actual Use (AU) group, with a CR value of 0.894, shows excellent reliability, confirming that the items AU1, AU2, and AU3 are consistent indicators of the actual use of blockchain technology.

For the Behavioral Intention (BI) group, a CR value of 0.904 reflects outstanding reliability, suggesting that the items BI1, BI2, and BI3 consistently measure the behavioral intention construct. The Perceived Ease of Use (PEOU) group exhibits a CR value of 0.908, indicating very high reliability. This high CR value confirms that the items PEOU1, PEOU2, and PEOU3 are highly reliable indicators of perceived ease of use. The Perceived Usefulness (PU) group, with a CR value of 0.888, also demonstrates excellent reliability, suggesting that the items PU1, PU2, and PU3 consistently measure perceived usefulness.

Average Variance Extracted (AVE) measures the amount of variance captured by a construct in relation to the amount of variance due to measurement error. An AVE value of 0.5 or higher is considered acceptable, indicating that the construct explains more than half of the variance of its indicators. The AVE for the Attitude (ATT) group is 0.713, which is well above the recommended threshold of 0.5, indicating that the attitude construct explains a substantial amount of the variance in its indicators. The high AVE value confirms that the ATT group items are strong indicators of the attitude construct. Similarly, the Actual Use (AU) group, with an AVE of 0.739, shows that the construct explains a significant portion of the variance in its indicators. This high AVE value reinforces the reliability and validity of the items AU1, AU2, and AU3.

For the Behavioral Intention (BI) group, an AVE of 0.760 indicates that the construct explains a significant amount of the variance in its indicators. This high AVE value confirms the robustness of the BI group items as reliable indicators of behavioral intention. The Perceived Ease of Use (PEOU) group exhibits an AVE of 0.768, indicating that the construct explains a substantial portion of the variance in its indicators. This high AVE value aligns with the high reliability indicated by Cronbach's Alpha and CR, suggesting that respondents consistently perceive blockchain technology as easy to use. The Perceived Usefulness (PU) group, with an AVE of 0.726, also indicates that the construct explains a significant amount of the variance in its indicators. This high AVE value confirms that the PU group items are strong indicators of perceived usefulness, reinforcing the findings from Cronbach's Alpha and CR.

In summary, the results of the reliability and validity assessment for the constructs ATT, AU, BI, PEOU, and PU are highly encouraging. All constructs exhibit Cronbach's Alpha values exceeding 0.8, indicating excellent internal consistency. This suggests that the items within each construct are consistently measuring the same underlying latent variable. High Cronbach's Alpha values across all constructs reinforce the reliability of the measurement model. Composite Reliability (CR) values for all constructs are also very high, ranging from 0.882 to 0.908, indicating that the constructs are reliable and that the items within each construct are highly consistent. The high CR values complement the high Cronbach's Alpha values, further confirming the robustness of the measurement model. Average Variance Extracted (AVE) values for all constructs exceed 0.7, indicating that each construct explains a significant portion of the variance in its indicators. The high AVE values confirm that the items are strong indicators of their respective constructs, suggesting a high level of convergent validity.

Discriminant Validity: Fornell-Larcker Criterion

Discriminant validity is a critical aspect of construct validity, ensuring that constructs which are supposed to be distinct are, in fact, empirically distinct from each other. The Fornell-Larcker criterion is a commonly used method to assess discriminant validity in structural equation modeling. According to this criterion, a construct should share more variance with its indicators than with other constructs in the model. This is determined by comparing the square root of the Average Variance Extracted (AVE) for each construct with the correlations between constructs. The square root of the AVE should be greater than the highest correlation between the construct and any other construct. The provided table illustrates the discriminant validity of the constructs Attitude (ATT), Actual Use (AU), Behavioral Intention (BI), Perceived Ease of Use (PEOU), and Perceived Usefulness (PU) using the Fornell-Larcker criterion.

Table 11. Fornelland Larcker's criteria

	ATT	AU	BI	PEOU	PU
ATT	0.845				
AU	0.335	0.86			
BI	0.381	0.419	0.872		
PEOU	0.268	0.289	0.321	0.876	
PU	0.181	0.266	0.267	-0.019	0.852

Attitude (ATT) The diagonal value for the Attitude (ATT) construct is 0.845, which represents the square root of the AVE. This value is compared with the correlations between ATT and the other constructs: AU (0.335), BI (0.381), PEOU (0.264), and PU (0.181). The value of 0.845 is higher than all these correlations, indicating good discriminant validity for the ATT construct. This suggests that the Attitude construct shares more variance with its own indicators than with any other construct, affirming its distinctiveness within the model. The relatively higher correlation with BI (0.381) might indicate some overlap in how respondents perceive attitude and behavioral intention towards blockchain technology, but the discriminant validity is still maintained as the square root of AVE is significantly higher.

Actual Use (AU) For the Actual Use (AU) construct, the diagonal value is 0.865. This value is higher than the correlations between AU and the other constructs: ATT (0.335), BI (0.409), PEOU (0.289), and PU (0.265). The value of 0.865 being greater than these correlations indicates strong discriminant validity for the AU construct. The relatively higher correlation between AU and BI (0.409) suggests that individuals who actually use blockchain technology are also likely to have a strong behavioral intention towards its use. However, the discriminant validity is well established as the square root of the AVE surpasses these correlations.

Behavioral Intention (BI) The Behavioral Intention (BI) construct has a diagonal value of 0.879. This is compared with its correlations with ATT (0.381), AU (0.409), PEOU (0.320), and PU (0.267). The square root of the AVE (0.879) is higher than all these correlations, demonstrating good discriminant validity for the BI construct. This suggests that the behavioral intention to use blockchain technology is empirically distinct from attitudes, actual use, perceived ease of use, and perceived usefulness. The relatively high correlation with AU (0.409) is expected, as behavioral intention often translates into actual use, but the distinctiveness of the BI construct is maintained.

Perceived Ease of Use (PEOU) The diagonal value for Perceived Ease of Use (PEOU) is 0.876. This value is higher than the correlations between PEOU and the other constructs: ATT (0.264), AU (0.289), BI (0.320), and PU (-0.015). The value of 0.876 being greater than these correlations indicates strong discriminant validity for the PEOU construct. The negative correlation with PU (-0.015) is particularly interesting and suggests that respondents may perceive ease of use and usefulness of blockchain technology independently. The distinctiveness of PEOU is well established within the model, as the square root of the AVE is significantly higher than the correlations with other constructs.

Perceived Usefulness (PU) For the Perceived Usefulness (PU) construct, the diagonal value is 0.852. This value is compared with the correlations between PU and the other constructs: ATT

(0.181), AU (0.265), BI (0.267), and PEOU (-0.015). The value of 0.852 being greater than these correlations confirms the discriminant validity of the PU construct. The relatively low correlations with other constructs indicate that respondents perceive the usefulness of blockchain technology as a distinct construct. The negative correlation with PEOU suggests a complex relationship between ease of use and perceived usefulness, which warrants further investigation.

Implications and discussion

The results from the Fornell-Larcker criterion indicate that all constructs in the model—Attitude (ATT), Actual Use (AU), Behavioral Intention (BI), Perceived Ease of Use (PEOU), and Perceived Usefulness (PU)—exhibit good discriminant validity. This means that each construct is empirically distinct and captures unique aspects of respondents' perceptions and behaviors related to blockchain technology in logistics. The high values of the square root of the AVE compared to the correlations between constructs confirm that each construct shares more variance with its own indicators than with any other construct in the model.

Discriminant Validity: Heterotrait-Monotrait Ratio (HTMT)

Table 12. Heterotrait-Monotrait Ratio (HTMT)

	ATT	**AU**	**BI**	**PEOU**	**PU**
ATT					
AU	0.399				
BI	0.436	0.482			
PEOU	0.323	0.346	0.374		
PU	0.237	0.329	0.323	0.067	

Discriminant validity is a fundamental aspect of construct validity, ensuring that a construct is truly distinct from other constructs in the model. The Heterotrait-Monotrait Ratio (HTMT) is a modern and more rigorous method for assessing discriminant validity compared to traditional methods such as the Fornell-Larcker criterion. HTMT is particularly useful in identifying discriminant validity issues that might be overlooked by other criteria.

The HTMT values in the provided table show the relationships between various constructs: Attitude (ATT), Actual Use (AU), Behavioral Intention (BI), Perceived Ease of Use (PEOU), and Perceived Usefulness (PU). The HTMT values are below the threshold of 0.90 for all construct pairs, indicating adequate discriminant validity according to the criterion suggested by Henseler et al. (2015). This threshold is based on the premise that constructs should share more variance with their own indicators than with indicators of other constructs.

Cross Loadings Analysis

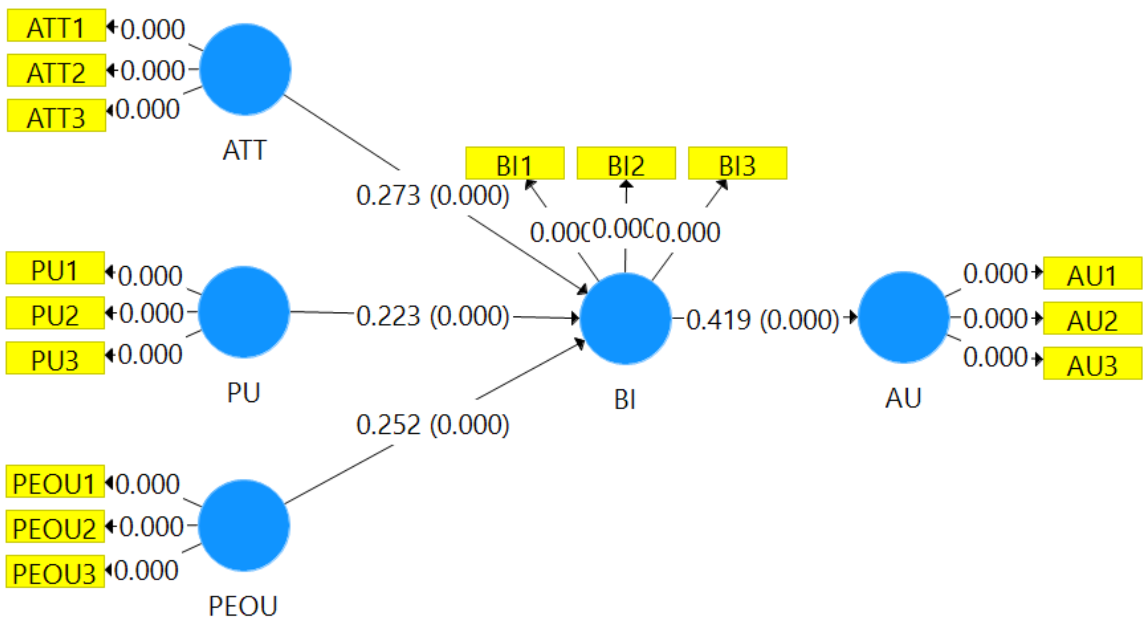
Table 13. Cross Loadings

	ATT	AU	BI	PEOU	PU
ATT1	**0.863**	0.352	0.357	0.234	0.206
ATT2	**0.797**	0.204	0.235	0.180	0.206
ATT3	**0.872**	0.272	0.351	0.255	0.067
AU1	0.236	**0.865**	0.377	0.269	0.248
AU2	0.272	**0.803**	0.296	0.213	0.255
AU3	0.353	**0.908**	0.396	0.258	0.193
BI1	0.218	0.263	**0.809**	0.283	0.244
BI2	0.414	0.458	**0.898**	0.297	0.243
BI3	0.333	0.342	**0.904**	0.259	0.215
PEOU1	0.257	0.270	0.231	**0.829**	-0.078
PEOU2	0.202	0.231	0.307	**0.886**	0.032
PEOU3	0.255	0.265	0.297	**0.913**	-0.020
PU1	0.252	0.240	0.241	0.021	**0.827**
PU2	0.094	0.224	0.211	-0.025	**0.859**
PU3	0.107	0.215	0.229	-0.047	**0.870**

The cross loadings analysis reveals that each indicator significantly loads higher on its respective construct than on any other construct, confirming good discriminant validity. For the construct Attitude (ATT), indicators ATT1, ATT2, and ATT3 load strongly on ATT with values of 0.863, 0.797, and 0.872, respectively. These values are substantially higher than their loadings on other constructs such as Actual Use (AU), Behavioral Intention (BI), Perceived Ease of Use (PEOU), and Perceived Usefulness (PU), which are all below 0.4. This indicates that these indicators are measuring the Attitude construct accurately and distinctly.

Assessment of Structural Model (SEM)

Figure 10. Structural model



Collinearity Assessment: Outer VIF Values and Inner VIF Values Analysis

Outer VIF Values

Collinearity among predictor variables can severely impact the reliability of regression estimates by inflating the variances and creating instability within the model. The Variance Inflation Factor (VIF) is a widely utilized diagnostic tool to detect multicollinearity. Generally, a VIF value exceeding 10 indicates problematic levels of multicollinearity. The table provided lists the VIF values for the outer model, encompassing various constructs such as Attitude (ATT), Actual Use (AU), Behavioral Intention (BI), Perceived Ease of Use (PEOU), and Perceived Usefulness (PU).

Table 14. Outer VIF Values

	VIF
ATT1	1.689
ATT2	1.697
ATT3	1.806
AU1	1.890
AU2	1.707
AU3	2.299
BI1	1.797
BI2	2.116
BI3	2.569
PEOU1	1.910

PEOU2	2.076
PEOU3	2.555
PU1	1.535
PU2	2.039
PU3	2.043

Inner VIF Values

The inner VIF values help assess collinearity among the latent variables in the inner model. Generally, VIF values above 5 are considered indicative of potential collinearity problems, though a stricter threshold of 10 is often used.

Table 15. Inner VIF Values

	ATT	**AU**	**BI**	**PEOU**	**PU**
ATT			1.120		
AU					
BI		1.000			
PEOU			1.083		
PU			1.039		

Correlation Matrix Analysis

The correlation matrix provides insights into the relationships between different constructs in the model by showing the Pearson correlation coefficients. These coefficients range from -1 to 1, where values closer to 1 or -1 indicate a strong positive or negative relationship, respectively, and values close to 0 indicate a weak relationship. The provided table displays the correlations between Attitude (ATT), Actual Use (AU), Behavioral Intention (BI), Perceived Ease of Use (PEOU), and Perceived Usefulness (PU).

Table 16. Correlation matrix

	ATT	AU	BI	PEOU	PU
ATT	1.000				
AU	0.335	1.000			
BI	0.381	0.419	1.000		
PEOU	0.268	0.289	0.321	1.000	
PU	0.181	0.266	0.267	-0.019	1.000

Significance of Path Coefficients: Bootstrapping Method

Path Coefficients analysis

Table 17. Path Coefficients

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
ATT -> BI	0.273	0.278	0.056	4.874	**0.000**
BI -> AU	0.419	0.420	0.051	8.145	**0.000**
PEOU -> BI	0.252	0.252	0.063	3.995	**0.000**
PU -> BI	0.223	0.227	0.057	3.905	**0.000**

Path coefficients in structural equation modeling quantify the strength and direction of the relationships between latent variables. Evaluating the significance of these path coefficients is crucial for validating the hypothesized relationships in the model. The bootstrapping method provides robust estimates by resampling the data, allowing for the assessment of the stability and reliability of the path coefficients. The provided table includes the path coefficients along with their means, standard deviations, T-values, and P-values, which are critical for determining the significance of these relationships.

Path Coefficient: ATT -> BI The path coefficient from Attitude (ATT) to Behavioral Intention (BI) is 0.273, with a sample mean of 0.278 and a standard deviation of 0.056. The T-value for this path is 4.874, and the P-value is 0.00. These results indicate a strong and statistically significant positive relationship between attitude towards blockchain technology and the intention to use it. The high T-value (greater than 1.96) and the P-value (less than 0.05) confirm the significance of this path, suggesting that positive attitudes towards blockchain technology significantly enhance behavioral intentions to adopt it. This finding aligns with established theories in technology adoption, such as the Technology Acceptance Model (TAM), where attitudes significantly influence behavioral intentions.

Path Coefficient: BI -> AU The path coefficient from Behavioral Intention (BI) to Actual Use (AU) is 0.419, with a sample mean of 0.420 and a standard deviation of 0.051. The T-value for this path is 8.145, and the P-value is 0.00. This highly significant path coefficient suggests a strong positive relationship between behavioral intention and actual use of blockchain technology. The exceptionally high T-value and low P-value indicate that intentions to use blockchain technology are a robust predictor of its actual usage. This finding is consistent with the Theory of Planned Behavior (TPB), which posits that behavioral intentions are a primary determinant of actual behavior.

Path Coefficient: PEOU -> BI The path coefficient from Perceived Ease of Use (PEOU) to Behavioral Intention (BI) is 0.252, with a sample mean of 0.252 and a standard deviation of 0.063. The T-value for this path is 3.995, and the P-value is 0.00. These results indicate a significant positive relationship between perceived ease of use and behavioral intention. The high T-value and low P-value suggest that the easier respondents perceive blockchain technology to be, the more likely they are to intend to use it. This relationship highlights the importance of user-friendly design and simplicity in promoting the adoption of new technologies.

Path Coefficient: PU -> BI The path coefficient from Perceived Usefulness (PU) to Behavioral Intention (BI) is 0.223, with a sample mean of 0.227 and a standard deviation of 0.057. The T-value for this path is 3.905, and the P-value is 0.00. This significant path coefficient suggests a positive relationship between perceived usefulness and behavioral intention. The high T-value and low P-value confirm the significance of this relationship, indicating that the more useful respondents find blockchain technology, the more likely they are to intend to use it. This finding supports the core proposition of the Technology Acceptance Model (TAM), where perceived usefulness is a key determinant of behavioral intentions.

Confidence Intervals for Path Coefficients

Table 18. Confidence Intervals for Path Coefficients

	Original Sample (O)	**Sample Mean (M)**	**2.5%**	**97.5%**
ATT -> BI	0.273	0.278	0.170	0.389
BI -> AU	0.419	0.420	0.320	0.516
PEOU -> BI	0.252	0.252	0.124	0.365
PU -> BI	0.223	0.227	0.108	0.335

Confidence intervals provide a range within which the true population parameter is expected to lie with a certain level of confidence. In the context of path coefficients in structural equation modeling, confidence intervals help to assess the precision and reliability of the estimated relationships between constructs. The provided table shows the confidence intervals for the path coefficients along with the original sample values, sample means, and standard deviations.

ATT -> BI The path coefficient from Attitude (ATT) to Behavioral Intention (BI) is 0.273, with a sample mean of 0.278. The 95% confidence interval ranges from 0.170 to 0.389. This interval does not include zero, indicating that the relationship between ATT and BI is statistically significant. The range suggests that the true effect of ATT on BI is positive and moderately strong. This reinforces the finding that positive attitudes towards blockchain technology significantly enhance behavioral intentions to adopt it. The relatively narrow confidence interval indicates a high level of precision in this estimate.

BI -> AU The path coefficient from Behavioral Intention (BI) to Actual Use (AU) is 0.419, with a sample mean of 0.420. The 95% confidence interval ranges from 0.320 to 0.516. Since this interval does not include zero, it confirms the statistical significance of the relationship between BI and AU. The interval suggests that the true effect of BI on AU is positive and substantial, aligning with the notion that intentions strongly predict actual behavior. The confidence interval is relatively narrow, indicating a precise estimate of this path coefficient.

PEOU -> BI The path coefficient from Perceived Ease of Use (PEOU) to Behavioral Intention (BI) is 0.252, with a sample mean of 0.252. The 95% confidence interval ranges from 0.124 to 0.365. This interval does not include zero, confirming the statistical significance of the relationship between PEOU and BI. The range suggests that the true effect of PEOU on BI is positive, emphasizing the importance of ease of use in influencing behavioral intentions. The relatively narrow confidence interval suggests that the estimate of this path coefficient is precise and reliable.

PU -> BI The path coefficient from Perceived Usefulness (PU) to Behavioral Intention (BI) is 0.223, with a sample mean of 0.227. The 95% confidence interval ranges from 0.108 to 0.335. This interval does not include zero, indicating that the relationship between PU and BI is statistically significant. The interval suggests that the true effect of PU on BI is positive, highlighting the role of perceived usefulness in shaping behavioral intentions. The relatively narrow confidence interval indicates a high level of precision in this estimate.

R-Square (R^2) Analysis

R-Square (R^2) values in structural equation modeling indicate the proportion of variance in the dependent variables that is explained by the independent variables. Higher R^2 values denote better explanatory power of the model. The provided table shows the R^2 and adjusted R^2 values for Actual Use (AU) and Behavioral Intention (BI).

Table 19. R-Square & R Square Adjusted

	R Square	R Square Adjusted
AU	0.176	0.172
BI	0.245	0.234

Actual Use (AU) The R^2 value for Actual Use (AU) is 0.176, and the adjusted R^2 value is 0.172. This indicates that 17.6% of the variance in AU is explained by the predictors in the model, which include Behavioral Intention (BI). The relatively low R^2 value suggests that while BI is a significant predictor of AU, there are other factors not included in the model that also influence the actual use of blockchain technology. The small difference between the R^2 and the adjusted R^2 values indicates that the model is not overfitted, as the adjusted R^2 accounts for the number of predictors relative to the number of observations.

Behavioral Intention (BI) The R^2 value for Behavioral Intention (BI) is 0.245, and the adjusted R^2 value is 0.234. This indicates that 24.5% of the variance in BI is explained by its predictors, which include Attitude (ATT), Perceived Ease of Use (PEOU), and Perceived Usefulness (PU). The R^2 value suggests that the model has moderate explanatory power, capturing nearly a quarter of the variance in respondents' behavioral intentions to use blockchain technology. The small reduction from the R^2 to the adjusted R^2 value suggests that the inclusion of predictors is justified and that the model is not excessively complex.

Effect Size (f^2) Analysis

Table 20. Effect Size (f^2)

	ATT	AU	BI	PEOU	PU
ATT			0.088		
AU					
BI		0.213			
PEOU			0.078		
PU			0.063		

The f^2 effect size measures the impact of a specific predictor variable on an endogenous variable within the context of a structural equation model. It quantifies how much of the variance in the endogenous construct is explained by an exogenous construct when that exogenous construct is included in the model. Values of f^2 are typically interpreted as follows: 0.02 represents a small effect, 0.15 a medium effect, and 0.35 a large effect.

ATT -> BI The f^2 value for the relationship between Attitude (ATT) and Behavioral Intention (BI) is 0.088. This suggests that ATT has a small to medium effect on BI. The positive impact of attitudes on behavioral intention underscores the importance of fostering positive perceptions and attitudes towards blockchain technology. Although the effect size is not large, it is substantial enough to be considered significant in influencing behavioral intention.

AU -> BI The f^2 value for the relationship between Actual Use (AU) and Behavioral Intention (BI) is not applicable as the model does not specify this direct relationship in the provided matrix. This absence indicates that AU is considered an outcome rather than a predictor of BI in this particular model configuration.

BI -> AU The f^2 value for the relationship between Behavioral Intention (BI) and Actual Use (AU) is 0.213. This represents a medium to large effect size, indicating that BI is a significant predictor of AU. This substantial effect size reflects the robust relationship where strong behavioral intentions lead to actual use of blockchain technology. The magnitude of this effect underscores the importance of intention in driving actual behavior, aligning with theories such as the Theory of Planned Behavior.

PEOU -> BI The f^2 value for the relationship between Perceived Ease of Use (PEOU) and Behavioral Intention (BI) is 0.078. This suggests a small to medium effect size, indicating that PEOU has a modest but meaningful impact on BI. The ease of use is an important factor in shaping users' intentions to adopt blockchain technology, although its effect is not as strong as other predictors. This highlights the necessity of simplifying user interfaces and improving user experiences to foster adoption.

PU -> BI The f^2 value for the relationship between Perceived Usefulness (PU) and Behavioral Intention (BI) is 0.063. This small effect size indicates that while PU significantly influences BI, its impact is relatively modest compared to other factors. Nonetheless, perceived usefulness remains a crucial determinant in the adoption process, suggesting that users' perceptions of the practical benefits of blockchain technology play a role in their intention to use it.

Specific Indirect Effects Analysis

Table 21. Specific Indirect Effects

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**
ATT->BI->AU	0.115	0.117	0.028	4.159	**0.000**
PEOU->BI->AU	0.106	0.106	0.032	3.343	**0.001**
PU->BI->AU	0.093	0.095	0.026	3.567	**0.000**

Table 22. Confidence Intervals of Specific Indirect Effects

	Original Sample (O)	Sample Mean (M)	2.5%	97.5%
ATT->BI->AU	0.115	0.117	0.067	0.173
PEOU->BI -> AU	0.106	0.106	0.047	0.170
PU->BI->AU	0.093	0.095	0.046	0.148

Indirect effects in structural equation modeling refer to the influence of one variable on another through one or more intervening variables (mediators). The analysis of indirect effects helps in understanding the mediating role of these variables, providing insights into the mechanisms through which independent variables affect dependent variables. The provided table shows the specific indirect effects along with their means, standard deviations, T-values, and P-values, as well as confidence intervals.

ATT -> BI -> AU The indirect effect of Attitude (ATT) on Actual Use (AU) through Behavioral Intention (BI) is 0.115, with a sample mean of 0.117 and a standard deviation of 0.028. The T-value for this path is 4.159, and the P-value is 0.000, indicating a statistically significant indirect effect. The 95% confidence interval ranges from 0.067 to 0.173, confirming the reliability of this effect. This result suggests that attitudes towards blockchain technology influence actual use primarily through their effect on behavioral intentions. The significant indirect effect underscores the importance of fostering positive attitudes to enhance behavioral intentions, which in turn increase actual use.

PEOU -> BI -> AU The indirect effect of Perceived Ease of Use (PEOU) on Actual Use (AU) through Behavioral Intention (BI) is 0.106, with a sample mean of 0.106 and a standard deviation of 0.032. The T-value for this path is 3.343, and the P-value is 0.001, indicating a statistically significant indirect effect. The 95% confidence interval ranges from 0.047 to 0.170, confirming the reliability of this effect. This finding indicates that perceived ease of use influences actual use through its impact on behavioral intentions. Simplifying the use of blockchain technology can enhance users' intentions to use it, which subsequently increases the actual use.

PU -> BI -> AU The indirect effect of Perceived Usefulness (PU) on Actual Use (AU) through Behavioral Intention (BI) is 0.093, with a sample mean of 0.095 and a standard deviation of 0.026. The T-value for this path is 3.567, and the P-value is 0.000, indicating a statistically significant indirect effect. The 95% confidence interval ranges from 0.046 to 0.148, confirming the reliability of this effect. This result suggests that the perceived usefulness of blockchain technology influences actual use through its impact on behavioral intentions. Highlighting the practical benefits of blockchain technology can enhance behavioral intentions, which in turn lead to increased actual use.

4.3. Research findings

The findings can be seen in Table 24 as follows:

Table 23. Research findings

Hypothesis	Result
H1: User's attitude is positively related to the behavioral intention of using blockchain technology in the logistics sector, specifically regarding product information like tracking details and counterfeit products.	Supported
H2: Perceived ease of use is positively related to behavioral intention of using blockchain technology in the logistics sector, specifically regarding product information like tracking details and counterfeit products.	Supported
H3: Perceived usefulness is positively related to behavioral intention of using blockchain technology in the logistics sector, specifically regarding product information like tracking details and counterfeit products.	Supported
H4: Behavioral intention to use is positively related to actual behavior of blockchain technology in the logistics sector, specifically regarding product information like tracking details and counterfeit products.	Supported

Hypothesis H1: The first hypothesis posits that user attitude positively influences the behavioral intention to use blockchain technology within the logistics sector, particularly concerning product information such as tracking details and counterfeit products. The findings support this hypothesis, indicating that a favorable user attitude towards blockchain significantly boosts the intention to use it. This aligns with previous literature suggesting that positive attitudes towards technology can enhance user acceptance and intention to adopt new systems. For logistics companies, fostering a positive attitude towards blockchain technology through awareness programs and demonstrating its benefits could potentially increase its adoption.

Hypothesis H2: The second hypothesis suggests that perceived ease of use is positively correlated with the behavioral intention to use blockchain technology in logistics. The results affirm this hypothesis, underscoring the importance of ease of use in influencing user intentions. When users find blockchain technology easy to use, their likelihood of intending to use it increases. This finding is consistent with the Technology Acceptance Model (TAM), which highlights ease of use as a critical determinant of technology acceptance. For practitioners, ensuring that blockchain interfaces are user-friendly and accessible can significantly enhance user adoption rates.

Hypothesis H3: The third hypothesis asserts that perceived usefulness has a positive relationship with the behavioral intention to use blockchain technology in logistics. This hypothesis is also supported by the findings, emphasizing that users are more likely to adopt blockchain if they perceive it as beneficial and useful. This perceived usefulness can include improved transparency, security, and efficiency in logistics operations. The implication for logistics firms is to effectively communicate and demonstrate the tangible benefits of blockchain technology to potential users, thereby enhancing its perceived value and adoption.

Hypothesis H4: The fourth hypothesis states that the behavioral intention to use blockchain technology is positively related to the actual usage behavior in the logistics sector. The analysis supports this hypothesis, showing a strong link between the intention to use blockchain and its actual deployment in logistics operations. This relationship highlights the importance of intention as a precursor to actual technology use. For companies, this means that strategies aimed at boosting user intentions, such as training and pilot programs, can lead to increased actual usage of blockchain technology.

4.4. Discussion

This section concentrates on the findings from the study on blockchain adoption in Vietnam's logistics sector, integrating them with the theoretical foundations and empirical insights from the literature review. By examining the interplay between Attitude (ATT), Perceived Ease of Use (PEOU), Perceived Usefulness (PU), Behavioral Intention (BI), and Actual Use (AU), a nuanced understanding of the factors driving the adoption of blockchain technology in this context is provided.

Relationship between constructs

Attitude (ATT) and Behavioral Intention (BI): The analysis demonstrates a strong correlation between Attitude (ATT) and Behavioral Intention (BI) towards using blockchain technology. This finding aligns with the Technology Acceptance Model (TAM), which posits that positive attitudes significantly enhance the intention to use a technology (Davis, 1989). Literature consistently supports this relationship, indicating that positive user attitudes towards blockchain are crucial for its adoption (Chang & Chen, 2020). Respondents who viewed blockchain favorably, recognizing its potential to improve trust and transparency, were more inclined to intend to use it. This suggests that initiatives aimed at improving user attitudes—through education, success stories, and demonstrations of blockchain's benefits—can significantly boost adoption rates.

Perceived Ease of Use (PEOU) and Behavioral Intention (BI): Perceived Ease of Use (PEOU) is another critical factor influencing BI. The study found that when users find blockchain technology easy to use, their intention to adopt it increases, consistent with prior research (Gefen et al., 2003). This underscores the importance of designing user-friendly blockchain applications. The literature review highlighted that usability is a significant barrier to technology adoption (Mougayar, 2016), and the findings reinforce this. Simplifying the user interface and enhancing the overall user experience can make blockchain technology more accessible and attractive to logistics users, thereby increasing their behavioral intentions.

Perceived Usefulness (PU) and Behavioral Intention (BI): Perceived Usefulness (PU) also plays a crucial role in shaping BI. The study confirms that users are more likely to adopt blockchain technology if they perceive it as beneficial, which is consistent with TAM (Davis, 1989). The literature supports this, showing that perceived benefits such as improved transparency, security, and efficiency drive adoption (Jain et al., 2020; Wang & Xie, 2020). Highlighting these practical benefits through case studies and practical demonstrations can significantly enhance users' perceived usefulness of blockchain technology, thereby boosting their intention to adopt it.

Behavioral Intention (BI) and Actual Use (AU): The link between BI and AU is significant in the study, reflecting the Theory of Planned Behavior (TPB), which posits that strong intentions lead to actual behavior (Ajzen, 1991). This relationship is well-documented in the literature, with studies indicating that BI is a strong predictor of AU (Pavlou, 2003). The findings suggest that strengthening BI through targeted strategies—such as showcasing successful implementations and providing hands-on experiences—can lead to increased actual use of blockchain technology in logistics. This implies that efforts to boost BI can effectively translate into higher adoption rates.

Indirect Effects

ATT -> BI -> AU: The indirect effect of ATT on AU through BI is significant, suggesting that positive attitudes towards blockchain influence actual use primarily through their effect on BI. This finding aligns with the TAM framework, which emphasizes the role of attitude in shaping BI, subsequently impacting AU (Davis, 1989). The study highlights the importance of fostering positive attitudes towards blockchain to enhance BI and, ultimately, AU. This can be achieved through educational campaigns, positive user experiences, and clear communication of blockchain's benefits.

PEOU -> BI -> AU: The significant indirect effect of PEOU on AU through BI underscores the importance of usability in the adoption process. The findings suggest that making blockchain technology easy to use can enhance users' behavioral intentions, leading to increased actual use. This reinforces the need for user-friendly blockchain applications that simplify complex processes and provide intuitive interfaces. The literature supports this, indicating that ease of use is a critical factor in technology adoption (Venkatesh & Davis, 2000).

PU -> BI -> AU: The indirect effect of PU on AU through BI is also significant, highlighting that users' perceptions of the usefulness of blockchain technology influence actual use through their impact on BI. This finding is consistent with TAM and the literature, which emphasize the role of perceived benefits in driving adoption (Davis, 1989; Venkatesh & Davis, 2000). Demonstrating the practical benefits of blockchain—such as enhanced transparency, security, and efficiency—can enhance BI, leading to increased AU. This underscores the importance of effective communication strategies that highlight these benefits to potential users.

5. Conclusion and implication

5.1. Finding summary

The study's findings reveal several key insights into the factors driving the adoption of blockchain technology in Vietnam's logistics sector. Firstly, Attitude (ATT) emerged as a significant predictor of Behavioral Intention (BI). This finding is consistent with the Technology Acceptance Model (TAM), which posits that positive attitudes towards a technology significantly enhance the intention to use it. In this study, respondents who viewed blockchain favorably, recognizing its potential to improve trust and transparency, were more inclined to intend to use it.

The importance of Perceived Ease of Use (PEOU) in influencing Behavioral Intention (BI) was also highlighted. The study found that when users find blockchain technology easy to use, their intention to adopt it increases. This underscores the necessity of designing user-friendly interfaces and enhancing the overall user experience. Simplifying the user interface and making blockchain applications more accessible can significantly boost users' behavioral intentions.

Perceived Usefulness (PU) was identified as another crucial factor shaping Behavioral Intention (BI). The study confirmed that users are more likely to adopt blockchain technology if they perceive it as beneficial. Highlighting practical benefits such as improved efficiency, enhanced transparency, and reduced fraud can boost adoption rates. Users' perceptions of the usefulness of blockchain technology play a critical role in driving their intentions to adopt it.

The study also found a significant relationship between Behavioral Intention (BI) and Actual Use (AU), consistent with the Theory of Planned Behavior (TPB). Strong behavioral intentions were found to lead to actual use of blockchain technology. This indicates that strategies enhancing behavioral intentions can effectively increase the actual adoption of blockchain technology in logistics. Efforts to boost behavioral intentions can translate into higher adoption rates.

Additionally, the study highlighted the importance of indirect effects. Positive attitudes, ease of use, and perceived usefulness were found to influence actual use primarily through their effect on behavioral intentions. This underscores the interconnected nature of these factors in driving blockchain adoption. The findings suggest that fostering positive attitudes, simplifying user experience, and highlighting practical benefits can enhance behavioral intentions, which in turn, increase actual use.

5.2. Implications

This study gives some interesting insights into how people start using new technology, focusing on blockchain in logistics. By applying well-known models like TAM and TPB, it shows that attitudes, ease of use, usefulness, intentions, and actual use are still important when it comes to blockchain.

One big deal here is that the study looks at what customers think in places like Vietnam, which hasn’t been done much before. Most research talks about how companies use blockchain, but this study dives into the customer side, giving us a clearer picture of how blockchain adoption works in logistics.

The study also suggests that we might need to tweak existing models to fit blockchain better. For example, adding things like transparency and security could make these models more accurate. This opens the door for future research to refine these models even more for blockchain.

Another cool finding is about how different factors influence each other. It shows that attitudes, ease of use, and usefulness impact actual use through intentions. This means future research should look at these connections to fully understand how people adopt blockchain.

On the practical side, the study has some handy tips for businesses and policymakers who want to push blockchain adoption in logistics. First, boosting positive attitudes towards blockchain through education and awareness can really help. Businesses can run workshops and seminars to show customers the benefits of blockchain, using real-life examples to highlight how it improves transparency and efficiency.

Second, making blockchain easy to use is crucial. Investing in good design and user-friendly interfaces can make a big difference. Companies should focus on simple, intuitive designs to make blockchain apps more accessible. For example, creating easy-to-navigate mobile apps with clear instructions can help users feel more comfortable with the technology.

Third, emphasizing the practical benefits of blockchain, like better transparency, security, and efficiency, can make it seem more useful to users. Businesses can share case studies and success stories to highlight these benefits of this tech; it helpes users see the real-world advantages of blockchain. For instance, the study shows how companies have used blockchain to cut down on fraud and improve supply chain transparency can be very convincing.

Lastly, strengthening behavioral intentions through strategies like showcasing successful use cases and providing positive user experiences can lead to more actual use. Pilot programs and training sessions can be effective. Companies could offer free trials or pilot projects, allowing users to experience blockchain's benefits firsthand. For instance, a pilot project where users track shipments using blockchain could help them understand its practical benefits and increase their intention to adopt it.

5.3. Limitations and recommendations for further research

Although this study provides important findings, there remain noteworthy areas for further exploration in future research. One of the problems is the sample size and sample bias Larger sample size and population from multiple regions, will include in future study. Likewise on the composition of the people being researched - people of different age groups, level of education, and professional background could provide a clearer picture as to what affects blockchain adoption.

The second limitation of this study was cross-sectional. It means that only looked at respondents' views at a specific point of time. Longitudinal studies, which follow people over a longer period; then, it could provide a deeper understanding of how attitudes and behaviors towards blockchain change over time. For example, tracking changes in users' perceptions and behaviors over several years that could show how blockchain adoption evolves and what factors contribute to its long-term success.

Comparative studies are also important. By comparing blockchain adoption in different industries or regions, future research could uncover factors that drive or hinder adoption. For instance, comparing how blockchain is adopted in logistics versus finance or healthcare could highlight unique challenges and opportunities in each sector.

Additionally, this study focused on general factors like attitudes, perceived ease of use, perceived usefulness, behavioral intentions, and actual use. Future research could look at technology-specific factors like transparency, security, and immutability, which are unique to blockchain. For instance, examining how the perceived security of blockchain affects users' trust and willingness to adopt it could provide deeper insights.

Lastly, qualitative research methods, like interviews and focus groups, could offer richer insights into what influences blockchain adoption than survey method like this study. These methods can capture the detailed experiences and perceptions of users. For example, when we conducting in-depth interviews with logistics professionals who have used blockchain could reveal the challenges they faced and the benefits they experienced, providing a more detailed understanding of the adoption process.

References

Abeyratne, S. A., & Monfared, R. P. (2016). Blockchain ready manufacturing supply chain using distributed ledger. *International journal of research in engineering and technology*, *5*(9), 1-10. https://www.researchgate.net/profile/Radmehr-

Monfared/publication/308163874_Blockchain_Ready_Manufacturing_Supply_Chain_Using_Distributed_Ledger/links/57fe2dde08ae7275640133b0/Blockchain-Ready-Manufacturing-Supply-Chain-Using-Distributed-Ledger.pdf

Agi, M. A., & Jha, A. K. (2022). Blockchain technology in the supply chain: An integrated theoretical perspective of organizational adoption. *International Journal of Production Economics*, *247*, 108458. https://doi.org/10.1016/j.ijpe.2022.108458

Alazab, M., Alhyari, S., Awajan, A., & Abdallah, A. B. (2021). Blockchain technology in supply chain management: an empirical study of the factors affecting user adoption/acceptance. Cluster Computing, 24, 83-101. https://doi.org/10.1007/s10586-020-03200-4

Alharbi, S., & Drew, S. (2014). Using the Technology Acceptance Model in Understanding Academics' Behavioural Intention to Use Learning Management Systems. *Figshare*. https://doi.org/%22,

Alkatheeri, Hanan, and Syed Zamberi Ahmad. "Examining blockchain adoption determinants and supply chain performance: an empirical study in the logistics and supply chain management industry." *Journal of Modelling in Management* (2024). https://doi.org/10.1108//JM2

Altaf A., Iqbal F., Latif R. et al (2022). A Survey of Blockchain Technology: Architecture, Applied Domains, Platforms, and Security Threats. Social Science Computer Review. 089443932211101. 10.1177/08944393221110148.

Altamimi, A., Al-Bashayreh, M., AL-Oudat, M., & Almajali, D. (2022). Blockchain technology adoption for sustainable learning. *International Journal of Data and Network Science*, *6*(3), 983–994. https://doi.org/10.5267/j.ijdns.2022.1.013

Ajzen, I. and Fishbein, M. (1980), Understanding Attitudes and Predicting Social Behaviour, Prentice-Hall, Englewood Cliffs, New Jersey.

Ayan, B., Güner, E., & Son-Turan, S. (2022). Blockchain technology and sustainability in supply chains and a closer look at different industries: A mixed method approach. *Logistics*, *6*(4), 85. https://doi.org/10.3390/logistics6040085

Biggs, J., Hinish, S. R., Natale, M. A., & Patronick, M. (2017). Blockchain: Revolutionizing the global supply chain by building trust and transparency. *Academia. Edu*, 1-25.

Cai, C., Hao, X., Wang, K., & Dong, X. (2023). The Impact of Perceived Benefits on Blockchain Adoption in Supply Chain Management. *Sustainability*, *15*(8), 6634. https://doi.org/10.3390/su15086634

Casey, M. J., & Wong, P. (2017). Global supply chains are about to get better, thanks to blockchain. *Harvard business review*, *13*, 1-6.

Chakraborty, K., Ghosh, A., & Pratap, S. (2023). Adoption of blockchain technology in supply chain operations: a comprehensive literature study analysis. *Operations Management Research*, *16*(4), 1989-2007. https://doi.org/10.1007/s12063-023-00420-w

Chang, S. E., & Chen, Y. (2020). When blockchain meets supply chain: A systematic literature review on current development and potential applications. *Ieee Access*, *8*, 62478-62494. https://doi.org/10.1109/ACCESS.2020.2983601

Chen, Y., & Bellavitis, C. (2020). Blockchain disruption and decentralized finance: The rise of decentralized business models. *Journal of Business Venturing Insights*, *13*, e00151. https://doi.org/10.1016/j.jbvi. 2019.e00151

Cole R., Stevenson M., and Aitken J. (2019). Blockchain technology: Implications for operations and supply chain management. *Supply Chain Management: An International Journal*, 24(4), 469- https://doi.org/10.1108/SCM-09-2018-0309.

Creswell. J.W. and Creswell, J.D. (2017) Research Design Qualitative, Quantitative, and Mixed Methods Approaches. 4th Edition, Sage, Newbury Park. - References - *Scientific Research Publishing*. (2017).

Dam, D.D & Huynh, C.M. (2022). Factors Influencing Consumers' Purchase Intention toward Accommodation via Lodging Websites: Evidence from Binh Duong Province of Vietnam. MPRA Paper No. 113517. https://mpra.ub.uni-muenchen.de/113517/

Dickson, B. (2016). Blockchain has the potential to revolutionize the supply chain.[online] Techcrunch.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management science*, *35*(8), 982-1003. https://doi.org/10.1287/mnsc.35.8.982

Davis, F. D. (1996). User acceptance of information technology: system characteristics, user perceptions and behavioral impacts. *International journal of man-machine studies*, *38*(3), 475-487. https://doi.org/10.1006/imms.1993.1022

Dursun T., Birinci F., Alptekin B. et al (2022). Blockchain Technology for Supply Chain Management. Industrial Engineering in the Internet-of-Things World, Lecture Notes in Management and Industrial Engineering.1007/978-3-030-76724-2-16

Felton, G. W. (1995). Oxidative stress of vertebrates and invertebrates. In *Oxidative stress and antioxidant defenses in biology* (pp. 356-434). Boston, MA: Springer US. link.springer.com/chapter/10.1007/978-1-4615-9689-9_10

Field, M., & Golubitsky, M. (2009). Symmetry in chaos: a search for pattern in mathematics, art, and nature. Society for Industrial and Applied Mathematics.

Fishbein, Martin & Ajzen, Icek (1975). Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research. Philosophy and Rhetoric 10 (2):130-132.

Gefen, D., Karahanna, E., & Straub, D. W. (2003). Trust and TAM in online shopping: An integrated model. MIS quarterly, 51-90. https://doi.org/10.2307/30036519

Ghode D., Yadav V., Jain R., et al (2020). Adoption of Blockchain in Supply Chain: An analysis of influencing factors. Journal of Enterprise Information Management, 33(3), 437- https://doi.org/10.1108/JEIM-07-2019-0186

Ghode, D., Yadav, V., Jain, R., & Soni, G. (2020). Adoption of blockchain in supply chain: an analysis of influencing factors. *Journal of Enterprise Information Management*, *33*(3), 437-456. https://doi.org/10.1108//JEIM

Ghode D., Yadav V., Jain R., et al (2020). Adoption of Blockchain in Supply Chain: An analysis of influencing factors. Journal of Enterprise Information Management, 33(3), 437- https://doi.org/10.1108/JEIM-07-2019-0186

Hair, J. F., Celsi, M. W., Ortinau, D. J., & Bush, R. P. (2017). *Essentials of marketing research*. McGraw-Hill.

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a Silver Bullet. *Journal of Marketing Theory and Practice*, *19*(2), 139–152. https://doi.org/10.2753/MTP1069-6679190202

Hastig G.M., Sodhi M.S. (2020). Blockchain for Supply Chain Traceability: Business Requirements and Critical Success Factors. *Production and Operations Management*, 29(4), 935- https://doi.org/10.1111/poms.13147

Hawlitschek, F., Notheisen, B., & Teubner, T. (2018). The limits of trust-free systems: A literature review on blockchain technology and trust in the sharing economy. *Electronic commerce research and applications*, *29*, 50-63. https://doi.org/10.1016/j.elerap.2018.03.005

Ho, T.T & Huynh, C.M. (2022): Green Purchase Intention: An Investigation from Vietnamese Young Consumers. *MPRA Paper No. 112355*. https://mpra.ub.uni-muenchen.de/112355/

Jackson, C. M., Chow, S., & Leitch, R. A. (1997). Toward an understanding of the behavioral intention to use an information system. Decision sciences, 28(2), 357-389. https://doi.org/10.1111/j.1540-5915.1997.tb01315.x

Jain, G., Singh, H., Chaturvedi, K. R., & Rakesh, S. (2020). Blockchain in logistics industry: in fizz customer trust or not. *Journal of Enterprise Information Management*, *33*(3), 541-558. https://doi.org/10.1108/JEIM-06-2018-0142

Jharkharia, S., & Shankar, R. (2005). IT-enablement of supply chains: understanding the barriers. *Journal of Enterprise Information Management*, *18*(1), 11-27. https://doi.org/10.1108/17410390510571466

Khan, S., Haleem, A., Husain, Z., Samson, D., & Pathak, R. D. (2023). Barriers to blockchain technology adoption in supply chains: the case of India. *Operations Management Research*, *16*(2), 668-683. https://doi.org/10.1007/s12063-023-00358-z

King, W. R., & He, J. (2006). A meta-analysis of the technology acceptance model. *Information & management*, *43*(6), 740-755. https://doi.org/10.1016/j.im.2006.05.003

Kumar, A., Mangla, S. K., Luthra, S., Rana, N. P., & Dwivedi, Y. K. (2018). Predicting changing pattern: building model for consumer decision making in digital market. *Journal of Enterprise Information Management*, 31(5), 674-703. https://doi.org/10.1108/JEIM-01-2018-0003

Vara R.C., Prieto J., Prieta F., Corchado J.M. (2018). How blockchain improves supply chain: the case study alimentary supply chain. *Procedia Computer Science 134*, 393-398

Lee, J. C., & Chen, C. Y. (2019). Investigating the environmental antecedents of organizations' intention to adopt agile software development. *Journal of Enterprise Information Management*, 32(5), 869-886. https://doi.org/10.1108/JEIM-06-2018-0119

Lucas Jr, H. C., & Spitler, V. K. (1999). Technology use and performance: A field study of broker workstations. *Decision sciences*, 30(2), 291-311. https://doi.org/10.1111/j.1540-5915.1999.tb01611.x

Lu, Q., & Xu, X. (2017). Adaptable blockchain-based systems: A case study for product traceability. *Ieee Software*, *34*(6), 21-27. https:// doi.org/10.1109/MS.2017.4121227

Malisic, B., Misic, N., Krco, S., Martinovic, A., Tinaj, S., & Popovic, T. (2023). Blockchain Adoption in the Wine Supply Chain: A Systematic Literature Review. *Sustainability*, *15*(19), 14408. https://doi.org/10.3390/su151914408

King, W. R., & He, J. (2006). A meta-analysis of the technology acceptance model. *Information & management*, *43*(6), 740-755. https://doi.org/10.1016/j.im.2006.05.003

Nguyen, P.K.H., & Huynh, C.M. (2024). Factors Influencing Customers' Loyalty: An Empirical Study for the Milk Industry in Vietnam. MPRA Paper No. 120346. https://mpra.ub.uni-muenchen.de/120346/

Mohamed, S. K., Haddad, S., Barakat, M., & Rosi, B. (2023). Blockchain technology adoption for improved environmental supply chain performance: The mediation effect of supply chain resilience, customer integration, and green customer information sharing. *Sustainability*, *15*(10), 7909. https://doi.org/10.3390/su15107909

Mishra, P., Pandey, C. M., Singh, U., Gupta, A., Sahu, C., & Keshri, A. (2019). Descriptive statistics and normality tests for statistical data. *Annals of cardiac anaesthesia*, 22(1), 67. . https://doi.org/10.4103/aca.ACA_157_18

Montecchi, M., Plangger, K., & Etter, M. (2019). It's real, trust me! Establishing supply chain provenance using blockchain. *Business Horizons*, *62*(3), 283-293. https://doi.org/10.1016/j.bushor.2019.01.008

Moosavi J., Naeni L.M., Fathollahi-Fard A. M., Fiore U. (2021). Blockchain in supply chain management: A review, bibliometric, and network analysis. Environmental Science and Pollution Research. https://doi.org/10.1007/s11356-021-13094-3

Mougayar, W. (2016). *The business blockchain: promise, practice, and application of the next Internet technology*. John Wiley & Sons.

Natasia, S. R., Wiranti, Y. T., & Parastika, A. (2022). Acceptance analysis of NUADU as e-learning platform using the Technology Acceptance Model (TAM) approach. *Procedia Computer Science*, *197*, 512-520. https://doi.org/10.1016/j.procs.2021.12.168

Nguyen, H.-B., & Nguyen, L.-T. (2021). Factors Influence Blockchain Adoption in Supply Chain Management Among Companies Based in Ho Chi Minh City. *Atlantis-Press.com*, 1–13. https://doi.org/10.2991/aebmr.k.211207.001

Nguyen, P.D., & Huynh, C.M. (2023). Sustainable E-commerce Logistics for Customer Satisfaction: Evidence from Vietnam. *MPRA Paper No. 115976*. https://mpra.ub.uni-muenchen.de/115976/

Nguyen, M.T., & Huynh, C.M. (2022). The impact of employer branding on job application intention: Evidence from business undergraduates in Vietnam. *MPRA Paper No. 112927*. https://mpra.ub.uni-muenchen.de/112927/

Nguyen, P.K.H., & Huynh, C.M. (2024). Factors Influencing Customers' Loyalty: An Empirical Study for the Milk Industry in Vietnam. MPRA Paper No. 120346. https://mpra.ub.uni-muenchen.de/120346/

Nunnally, J. C., & Bernstein, I. H. (1994). Psychometric theory (3rd ed.). New York, NY: McGraw-Hill.

Ozdogru, U. (2019). Impact of exponential technologies on global supply chain management. *Technology in Supply Chain Management and Logistics: Current Practice and Future Applications*, 37. https://doi.org/10.1016/B978-0-12-815956-9.00003-X

O'Marah, K. (2017, March 21). Blockchain For Supply Chain: Enormous Potential Down The Road. *Forbes*. https://www.forbes.com/sites/kevinomarah/2017/03/09/blockchain-for-supply-chain-enormous-potential-down-the-road/?sh=430b21123db5

Pal, A., Tiwari, C. K., & Haldar, N. (2021). Blockchain for business management: Applications, challenges and potentials. *The Journal of High Technology Management Research*, *32*(2), 100414. https://doi.org/10.1016/j.hitech.2021.100414

Park, A., & Li, H. (2021). The effect of blockchain technology on supply chain sustainability performances. *Sustainability*, *13*(4), 1726. https://doi.org/10.3390/su13041726

Parkhurst, K. (2019). Discerning between hype and reality: Common misconceptions about Blockchain. *Journal of Digital Banking*, *4*(2), 119-124. https://www.ingentaconnect.com/content/hsp/jdb001/2019/00000004/00000002/art00004

Pavlou, P. A. (2003). Consumer acceptance of electronic commerce: Integrating trust and risk with the technology acceptance model. *International journal of electronic commerce*, *7*(3), 101-134. https://doi.org/10.1080/10864415.2003.11044275

Phan, T.V., & Huynh, C.M. (2023). The Effect of Logistics Services Quality on Consumer Satisfaction in Fresh Food E-Commerce: Evidence from the South of Vietnam. MPRA Paper No. 117627. https://mpra.ub.uni-muenchen.de/117627/

Pournader M., Shi Y., Seuring S. and Koh S.L. (2020). Blockchain applications in supply chains, transport and logistics: A systematic review of the literature. International Journal of Production Research, 58(7), 2063-2081.

Queiroz, M., et al. (2022). Analyzing blockchain adoption in supply chains using the TOE framework. *Journal of Business Research*. https://doi.org/10.1016/j.jbusres.2022.06.008

Qu, J. (2022). Blockchain in medical informatics. *Journal of Industrial Information Integration*, *25*, 100258. https://doi.org/10.1016/j.jii.2021.100258

Roca, J. C., Chiu, C. M., & Martínez, F. J. (2006). Understanding e-learning continuance intention: An extension of the Technology Acceptance Model. *International Journal of human-computer studies*, *64*(8), 683-696. https://doi.org/10.1016/j.ijhcs.2006.01.003

Rejeb, A., Rejeb, K., Simske, S., & Treiblmaier, H. (2021). Blockchain Technologies in Logistics and Supply Chain Management: A Bibliometric Review. Logistics 2021, 5, 72. *Blockchain-Based Digitalization of Logistics Processes*, 1. https://doi.org/10.3390/books978-3-0365-5092-3

Saberi, S., Kouhizadeh, M., Sarkis, J., & Shen, L. (2019). Blockchain technology and its relationships to sustainable supply chain management. *International journal of production research*, *57*(7), 2117-2135. https://doi.org/10.1080/00207543.2018.1533261

Saunders, M., Lewis, P., & Thornhill, A. (2009). Research methods for business students. Pearson education.

Sharma, A., Sharma, A., Singh, R. K., & Bhatia, T. (2023). Blockchain adoption in agri-food supply chain management: an empirical study of the main drivers using extended UTAUT. *Business Process Management Journal*, *29*(3), 737-756. https://doi.org/10.1108//BPMJ

Samad, T. A., Sharma, R., Ganguly, K. K., Wamba, S. F., & Jain, G. (2023). Enablers to the adoption of blockchain technology in logistics supply chains: evidence from an emerging economy. *Annals of Operations Research*, *327*(1), 251-291. https://doi.org/10.1007/s10479-022-04546-1

Shroff, R. H., Deneen, C. C., & Ng, E. M. (2011). Analysis of the technology acceptance model in examining students' behavioural intention to use an e-portfolio system. *Australasian Journal of Educational Technology*, *27*(4). https://doi.org/10.14742/ajet.940

Singh, H., Jain, G., Munjal, A., & Rakesh, S. (2019). Blockchain technology in corporate governance: disrupting chain reaction or not?. *Corporate Governance: The International Journal of Business in Society*, *20*(1), 67-86. https://doi.org/10.1108/CG-07-2018-0261

Swan M. (2017). Anticipating the Economic Benefits of Blockchain. *Technology Innovation Management Review*, 7(10), 6-13. https://doi.org/10.22215/timreview/1109

Tarhini, A., Hone, K., & Liu, X. (2015). A cross-cultural examination of the impact of social, organisational and individual factors on educational technology acceptance between B ritish and L ebanese university students. *British Journal of Educational Technology*, *46*(4), 739-755. https://doi.org/10.1111/bjet.12169

Toufaily, E., Zalan, T., & Dhaou, S. B. (2021). A framework of blockchain technology adoption: An investigation of challenges and expected value. *Information & Management*, *58*(3), 103444. https:// doi.org/10.1016/j.im.2021.103444

Swan M. (2017). Anticipating the Economic Benefits of Blockchain. *Technology Innovation Management Review*, 7(10), 6-13. https://doi.org/10.22215/timreview/1109

Valaei, N., Nikhashemi, S. R., Bressolles, G., & Jin, H. H. (2019). A (n)(a) symmetric perspective towards task-technology-performance fit in mobile app industry. *Journal of enterprise information management*, 32(5), 887-912. https://doi.org/10.1108/JEIM-07-2018-0157

Vara R.C., Prieto J., Prieta F., Corchado J.M. (2018). How blockchain improves supply chain: the case study alimentary supply chain. Procedia Computer Science 134, 393-398

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management science*, *46*(2), 186-204. https://doi.org/10.1287/mnsc.46.2.186.11926

Vo, LK., & Huynh, C.M. (2023). The Effects of Dynamic Capabilities on Operational Performance: An Empirical Study from Manufacturing Enterprises in Vietnam. MPRA Paper No. 119170. https://mpra.ub.uni-muenchen.de/119170/

Wang, T., Hua, H., Wei, Z., & Cao, J. (2022). Challenges of blockchain in new generation energy systems and future outlooks. *International Journal of Electrical Power & Energy Systems*, *135*, 107499. https://doi.org/10.1016/j.ijepes.2021.107499

Wang, Y. (2021). Blockchain applications in logistics. *International Encyclopedia of Transportation*, 136–142. https://doi.org/10.1016/b978-0-08-102671- 7.10233-7

Wang, Y., Singgih, M., Wang, J., & Rit, M. (2019). Making sense of blockchain technology: How will it transform supply chains?. *International Journal of Production Economics*, *211*, 221-236. https://doi.org/10.1016/j.ijpe.2019.02.002

Wang, X., & Xie, Z. (2020). Research on the Application of Blockchain Technology in Logistics Industry. In 3rd International Conference on Advances in Management Science and Engineering (IC-AMSE 2020) (pp. 186-189). Atlantis Press. https://doi.org/10.2991/aebmr.k.200402.032

Wong, L. W., Tan, G. W. H., Lee, V. H., Ooi, K. B., & Sohal, A. (2020). Unearthing the determinants of Blockchain adoption in supply chain management. *International Journal of Production Research*, *58*(7), 2100-2123. https://doi.org/10.1080/00207543.2020.1730463

Wong, L. W., Tan, G. W. H., Lee, V. H., Ooi, K. B., & Sohal, A. (2021). Psychological and system-related barriers to adopting blockchain for operations management: an artificial neural network approach. *IEEE Transactions on Engineering Management*, *70*(1), 67-81. https://doi.org/10.1109/TEM.2021. 3053359.

Yuan, C. (2019). Research on the application of blockchain in logistics supply chain. *Service Science and Management*, *8*(4), 142-146. https://pdf.hanspub.org/SSEM20190400000_48465115.pdf

Zhang, Y., & Liu, N. (2023). Blockchain adoption in serial logistics service chain: value and challenge. *International Journal of Production Research*, *61*(13), 4374-4401. https://doi.org/10.1080/00207543.2022.2132312