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Factors Influencing Blockchain Adoption in Food Cold Chain Logistics: A PLS-SEM Analysis

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ABSTRACT

Introduction: Blockchain can enhance traceability, transparency, and tracking in food cold chain logistics (FCCL) which are crucial for minimizing food waste and ensuring food safety. However, its adoption among FCCL companies remains low.

Objectives: This paper intends to investigate what influences the decisions by FCCL companies to adopt blockchain based on the Unified Theory of Acceptance and Use of Technology (UTAUT), and incorporating policy support, perceived cost, and inter-organizational trust.

Methods: The study used PLS-SEM to analyze data from an online survey of 299 managers and owners of China's FCCL companies..

Results:The results indicate that facilitating conditions, performance expectancy, effort expectancy, social influence, facilitating conditions, and inter-organizational trust positively influence blockchain adoption, while perceived cost and policy support negatively affect it.

Conclusions: This study not only extends the UTAUT theoretically but also provides insights to promote the actual blockchain adoption in FCCL, thereby contributing to reduced food waste and enhanced food safety.

Keywords: Blockchain Adoption; Food Cold Chain Logistics; Extended UTAUT Model; Technology Acceptance Behavior; Food Safety.

INTRODUCTION

The lack of monitoring systems is a key factor leading to disruptions in food cold chain logistics (FCCL) (Zhang et al. Centobelli et al., 2021). Many developing economies, such as China (Liao et al., 2023; Han et al., 2021), India (Arora et al., 2023; Kumar & Agrawal, 2023), and ASEAN members (Sundram, 2023; Modisa & Jaikaew, 2022), have not established effective monitoring systems. This has led to high spoilage rates during food storage and transportation in these regions, causing severe food waste and safety issues (Mota et al., 2021). In 2023, the spoilage rates in China and India reached 25%–30% and 40%, respectively. Moreover, in ASEAN, the rate is even higher (Bai et al., 2023; Liao et al., 2023). This has raised concerns in both practical and academic circles.

Blockchain technology, as a disruptive innovation, provides an effective solution to the lack of monitoring systems in FCCL (Zhao et al., 2024; Wang et al., 2022; Samuel et al., 2022). The technology mitigates traceability and end-to-end monitoring issues by enabling all stakeholders to access a shared, real-time ledger that records every transaction and condition change throughout the supply chain. This transparency allows for immediate identification of any disruptions or deviations, facilitating rapid response and accountability (Abbas & Myeong, 2024; Almadadha, 2024; Wang et al., 2019). Additionally, blockchain records cannot be changed or deleted, which builds trust among participants and improves food safety. As a result, blockchain offers a robust framework for improving traceability, reducing spoilage, and ensuring the integrity of FCCL (Agarwal et al., 2024; Chiaraluce et al., 2024; Ellahi et al., 2023).

Many multinational corporations, such as Walmart, Carrefour, and Bumble Bee Foods, have implemented blockchain in FCCL to enhance traceability and prevent food degradation due to temperature breaches (Walmart Global Tech, 2021; Bumble Bee Foods, 2019; Carrefour, 2018). However, although the Chinese government has initiated several policies, few Chinese companies have adopted blockchain (Chakraborty et al., 2023; Deng et al., 2022). Consequently,

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the food spoilage rate during cold chain transportation in China remains alarmingly high, estimated at 20% to 30% (approximately 422.56 million tons) (Jia et al., 2022).

Currently, Chinese FCCL companies primarily rely on temperature sensors or data loggers, which are manually uploaded periodically to a central database or management system. They also use short-range wireless communication technologies such as RFID or Bluetooth for data transmission, but these methods are typically limited to short distances and harsh environments, resulting in data delays and poor real-time performance. Furthermore, the uploaded data are easy to tamper with, making it difficult to identify responsible parties and effectively address the root causes of disruptions (Zhang et al., 2023; Menon et al., 2021).

Accordingly, the main challenge for blockchain's success is convincing organizations to replace traditional monitoring and tracking methods with blockchain (Lustenberger et al., 2021; Choi et al., 2020). Since this technology is still relatively new in China, few studies (Yadlapalli et al., 2022; Singh et al., 2023) have explored its pertinent issues. Although these studies shed light on some key factors for blockchain adoption, other important factors, such as social environment (social influence, policy, facilitating conditions), organizational relationships (inter-organizational trust), and intrinsic motivations (performance expectancy, effort expectancy, and perceived costs), still need more research in China. This gap highlights the need for a model that explains blockchain adoption specifically for Chinese FCCL companies, along with statistical methods like Structural Equation Modeling (SEM) to test critical adoption factors. Therefore, this paper aims to answer the following questions:

Q1. What factors influence blockchain adoption in FCCL companies?

Q2. What are the main influencers in blockchain adoption in FCCL?

Q3. What measures can be proposed to promote blockchain adoption in FCCL?

To address the above research questions, this paper develops an extended conceptual framework based on UTAUT, incorporating policy support, perceived cost, and inter-organizational trust to investigate the influencing factors of blockchain adoption in China's FCCL companies. Moreover, this study employs PLS-SEM to explore how these factors influence blockchain adoption and which factors significantly influence the adoption behavior. Given that China accounts for over 25% of global FCCL demand but simultaneously suffers from high food spoilage and severe food security issues, it is necessary and meaningful for food cold chain logistics companies to adopt blockchain to address the above problems.

LITERATURE REVIEW

This section will first review blockchain as a technology and its characteristics that solve the traceability and monitoring issues in FCCL. Then, the literature that discussed the application of blockchain in FCCL will be presented. Thirdly, papers exploring the factors influencing blockchain adoption will also be reviewed. These studies analyzed blockchain adoption from different perspectives, providing important references for identifying and selecting factors that impact blockchain adoption in FCCL.

Blockchain

According to Durach et al., (2021), blockchain can record transactions across multiple computers safely and ensure data integrity and immutability. Unlike traditional centralized systems, blockchain data is stored across various network nodes rather than a single server. These nodes reach consensus using protocols like Proof of Work (PoW) or Proof of Stake (PoS), thereby maintaining the authenticity and consistency of data entries. Blockchain is structured as a series of blocks, each containing encrypted transaction information (Albshaier et al., 2024). These blocks are sequentially linked, creating an unchangeable record of past transactions. Key attributes of blockchain include transparency, traceability, and tamper-resistance, which make it highly applicable across diverse industries, such as finance (Schär, 2021; Kumar et al., 2020), supply chain management (Meier et al., 2023; Queiroz et al., 2020), and intellectual property protection (Bonnet & Teuteberg, 2023; Song et al., 2021), aiming to boost security, transparency, and operational efficiency. Blockchain's encrypted security features and monitoring mechanisms protect data from unauthorized access, embedding "trust" directly into the system and thereby eliminating the need for third-party validation (Hassan et al., 2022).

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Application of blockchain in food cold chain logistics

FCCL involves the complex handling, storage, and transportation of food products that must be kept within specific temperature ranges to maintain quality and safety. Maintaining proper temperature control is critical in FCCL, as temperature fluctuations can lead to food spoilage, bacterial growth, and contamination (Lorenc, 2023). Several studies have highlighted the issues related to inadequate temperature management throughout the supply chain. For example, Waldhans et al. (2024) discussed challenges in temperature monitoring in food supply chains and presented technological solutions for improving temperature tracking and control using digital systems. They highlighted the importance of maintaining proper temperatures to ensure food security and waste decrease. Another study by Wang et al. (2023) explored the role of temperature data exchange in maintaining quality throughout FCCL, focusing on how insufficient temperature control can lead to supply chain inefficiencies and food safety risks. Skawińska and Zalewski (2022) discussed the economic impact of temperature fluctuations during food transportation and the significant food losses and waste caused by temperature abuse, highlighting the critical role of real-time temperature measurement protocols and technologies in preventing spoilage and maintaining food safety in the cold chain.

In recent years, papers have mainly focused on advancing technologies and discussed the potential of their applications. The Internet of Things (IoT), blockchain, and sensor systems play crucial roles in monitoring the integrity of food products during transportation and storage (Bhatt et al. 2021a). While RFID, IoT, and other sensor technologies have improved FCCL, they still face limitations regarding data sharing, real-time monitoring, and system integration (Costa et al., 2022). For example, Laghari (2021) asserted that IoT systems still struggle with reliable real-time data transmission across broader networks without significant latency or data losses. Also, many supply chains still use manual record-keeping, which can lead to mistakes, delays, and limited visibility (Henninger & Mashatan, 2021; Zhang et al., 2021). Ensuring compliance with food safety regulations is another major challenge in FCCL, which requires strict monitoring and documentation of each step in the process (Mustafa et al., 2024). Blockchain can complement these technologies by offering a decentralized platform for data management (Kshetri, 2023). Blockchain's real-time traceability is one of its most significant advantages for FCCL. Each transaction or product movement is recorded on a shared ledger that is visible to everyone in the supply chain (Wei et al., 2023). Blockchain can also help reduce the risk of fraud in cold chains, such as misrepresenting food origins or manipulating temperature data. Real-time tracking of products allows for faster recalls during contamination or foodborne illness outbreaks (Feng et al., 2020). In addition, blockchain fosters collaboration between stakeholders, such as farmers, manufacturers, distributors, and retailers, by providing a single source of truth. This enhanced collaboration can increase efficiency, cost savings, and inter-organizational trust (Liu et al., 2022; Bhatt et al., 2021b).

Factors influencing blockchain technology adoption

Blockchain technology has received great interest for its capability to improve transparency, security, and efficiency across different industries. However, its use by organizations and individuals is still developing. Blockchain adoption refers to individuals, businesses, and governments' behavior in integrating the technology into their operations. Various theoretical models, such as the UTAUT, the Technology Acceptance Model (TAM), and the Theory of Planned Behavior (TPB) have been applied to understand the influencing factors on the blockchain adoption (Prisco et al., 2024; Kumari et al., 2023).

Researchers have explored the factors that impact the use of blockchain in various industries. Commonly identified determinants include perceived usefulness (Grover et al., 2019), ease of use (Rijanto, 2021; Kamble et al., 2019), trust and transparency (Centobelli et al., 2022; Chang & Chen, 2020), and perceived security (Esfahbodi et al., 2022; Ooi et al., 2021). Regulatory and institutional factors also impact its adoption. Regulatory uncertainty, especially in cryptocurrency and data protection, has been a major barrier to widespread blockchain adoption (Frederiks et al., 2024; Dehghani et al., 2022). Many businesses hesitate to adopt blockchain due to a lack of clear regulations concerning compliance, taxation, and intellectual property rights.

At the organizational level, several factors drive blockchain adoption, including the perceived competitive advantage, readiness of technological infrastructure, and the need for innovation. Due to the technology's clear benefits regarding efficiency, security, and transparency, some fields, such as finance, supply chain, and healthcare industries,

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are active in adopting blockchain (Iansiti & Lakhani, 2017). Organizations are more willing to use blockchain when they perceive it as a means to gain a competitive advantage (Fosso Wamba et al., 2020). Blockchain provides the ability to lower costs, increase efficiency, and promote transparency, making it an attractive option for businesses seeking to differentiate themselves. The readiness of an organization's technological infrastructure is also a critical factor in blockchain adoption. Larger firms with advanced IT capabilities and stronger financial resources to invest in blockchain technology are more inclined to adopt it compared to smaller firms that may lack the necessary infrastructure and expertise (Morkunas et al., 2019). The complexity of integrating blockchain with existing systems can also create adoption barriers for organizations with less mature IT capabilities.

Social influence and network effects have also been identified as key factors in adopting blockchain. Social influence involves the beliefs and behaviors of others that influence individuals or organizations regarding technology adoption (Venkatesh et al., 2003). In the blockchain ecosystem, businesses and governments are often influenced by the success or failure of early adopters. For instance, as more companies in industries like finance and logistics implement blockchain to improve supply chain traceability, others are likely to follow suit to avoid being left behind (Saberi et al., 2019). Network effects, where the value of blockchain increases as more participants join the network, also drive adoption. For example, blockchain's ability to facilitate more efficient and transparent cross-border transactions becomes more valuable as more organizations join the network (Tapscott & Tapscott, 2016).

Despite its advantages, several perceived risks and barriers hinder blockchain adoption, such as costs and complexity, scalability issues, and privacy concerns. High implementation costs, including infrastructure, training, and integration with existing systems, have been major barriers for small and medium-sized enterprises (SMEs) (Lanzini et al., 2021; Wong et al., 2020). Blockchain's complexity also requires specialized knowledge and skills, which can limit its adoption in industries where expertise is lacking. Blockchain's scalability remains a challenge, particularly for public blockchains. The slow processing times and high transaction costs associated with blockchain networks, such as Bitcoin and Ethereum, have made it challenging to scale large-scale enterprise applications (Tseng et al., 2023; Van Nguyen et al., 2023). While blockchain is inherently secure, privacy remains a concern for businesses, particularly in public blockchains where transaction data can be seen by all involved parties. Although private and permissioned blockchains offer more privacy, they can reduce transparency, which is one of blockchain's key advantages (Xu et al., 2021).

In conclusion, despite the literature identifying the impactors of blockchain adoption in food supply chains, study in the field is still in its fancy, and more research is required. First, prior research has shown that blockchain can be an effective tool to provide consistent temperature control in food cold chain during transportation (Kaur et al., 2022; Xu et al., 2022). However, the discussion on adopting blockchain in FCCL organizations is minimal (Agrawal et al., 2024; Gupta & Shankar, 2024). Advancing blockchain aims to foster its application in real scenarios and solve practical problems. These benefits will only materialize if the technology is adopted by users (Upadhyay, 2020). Organizations is important in the adoption process because they are the actual technology users, especially large companies (Malik et al., 2022; Choi et al., 2020). Understanding the impactors is critical to promoting its practical application (Wamba & Queiroz, 2020). China is a vast market with a massive demand for FCCL. Whether the problems of traceability, monitoring, and transparency can be successfully resolved is key to improving food security, reducing food waste, and protecting resources both domestically and globally (Gupta & Shankar, 2024; Chandan et al., 2023; Lei et al., 2022).

Second, blockchain is a pioneering technology, organizations' intrinsic motivation to use the technology is vital. However, previous studies mainly focused on technology, rules, and social factors, without fully exploring the role of internal motivation in embracing blockchain.

Third, policy support, such as government regulations, standards, and incentives, enables enterprises to embrace new technologies. Previous research highlights that regulatory frameworks and government-driven initiatives significantly influence technology adoption, particularly in industries with high compliance requirements like FCCL (Kumar et al., 2023; Han et al., 2021). When policymakers establish clear guidelines and provide financial or technical support, businesses are more inclined to regard blockchain as a conducive and viable solution for enhancing transparency and traceability (Chen et al., 2022). Furthermore, policy support reduces uncertainty and risks associated with technological investments, thereby encouraging enterprises to apply blockchain in their logistics

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operations (Shahzad et al., 2023). In addition, inter-organizational trust is a crucial determinant of blockchain adoption in FCCL, where collaboration between multiple stakeholders—such as suppliers, distributors, and retailers—is essential. Trust between organizations facilitates the sharing of information and resources, which is fundamental to the success of blockchain in a multi-stakeholder environment (Li et al., 2021; Wang et al., 2021). Besides, previous research has shown that perceived costs significantly influence blockchain adoption, although diverse outcomes have been revealed. While high initial investment costs may deter some businesses, others may perceive blockchain's long-term benefits—such as enhanced efficiency, reduced operational errors, and improved data integrity—as outweighing the initial financial burden (Clohessy & Acton, 2019). In FCCL, where temperature control, traceability, and inventory management are critical, the perceived value of blockchain's ability to mitigate losses and ensure food safety may justify its adoption despite upfront costs (Saberi et al., 2019). Research shows that companies with sufficient resources and a strategic focus on long-term gains view blockchain as a cost-effective investment for improving supply chain management, positively influencing their adoption decisions (Sternberg et al., 2021). Therefore, it would be worthwhile to examine how policy support, inter-organizational trust, and perceived cost influence blockchain adoption and ultimately contribute to improving the adoption rate.

More importantly, most studies on technology adoption rely on theories like the TAM, Diffusion of Innovation Theory (DIT), TPB, and Institutional Theory (IT) (Dai & Cheng, 2022; Sciarelli et al., 2022; Hartley et al., 2022; Saberi et al., 2019). Since decision-making is complex and influenced by many factors, more theories should be included to better explain it (Samad et al., 2023; Mohammed et al., 2023). The UTAUT is a robust model for understanding the impactors that influence blockchain adoption. By integrating several existing models (TAM, TPB), the theory simultaneously considers intrinsic motivations and external impactors to render a comprehensive understanding of blockchain adoption in organizations. This theory has been widely used in food supply chains (Sharma et al., 2023; Kamble et al., 2019), finance (Komulainen & Nätti, 2023; Pal et al., 2021), and healthcare (Singh et al., 2023; Balasubramanian et al., 2021). Therefore, UTAUT is appropriate for studying the impactors of blockchain adoption in organizations.

CONCEPTUAL FRAMEWORK

The unified theory of acceptance and use of technology (UTAUT)

Venkatesh et al. (2003) proposed UTAUT to identify the key factors that predict technology adoption intention and behavior. According to the theory, technology adoption depends mainly on performance expectancy, effort expectancy, social influence, and facilitating conditions. UTAUT has been extensively used in studies on the adoption of modern IT systems (Xavier & Oliveira, 2016; Bala & Venkatesh, 2016). Researchers have since proposed modifications to the original model. For example, UTAUT has been integrated with network theory to better understand motivations for adopting blockchain in supply chains in countries like India, the USA, and Brazil (Queiroz & Wamba, 2019; Wamba & Queiroz, 2019). Similar to the TAM, factors like how useful and easy blockchain is to use have been studied in supply chain contexts (Kamble et al., 2019). These factors have also been used to explain why people choose to use cryptocurrencies (Esfahbodi et al., 2022; Bharadwaj & Deka, 2021). These studies have empirically tested UTAUT's effectiveness in explaining technology adoption and usage across various sectors, organizations, regions, and applications. In addition to the distinctive aspects of UTAUT, certain variables might contribute to a more limited view of technology adoption when key variables are excluded (Patil & Undale, 2023; Bommer et al., 2022; Ooi & Tan, 2016), indicating the need for model expansion (Al-Adwan et al., 2024; Alghazi et al., 2021). Building on previous applications of UTAUT in technology acceptance studies, this paper incorporates UTAUT constructs—performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FC)—and extends the model with policy support (PS), perceived cost (PC), and inter-organizational trust (IT) as additional independent variables to analyze blockchain adoption intentions and decisions.

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Research framework and hypotheses development

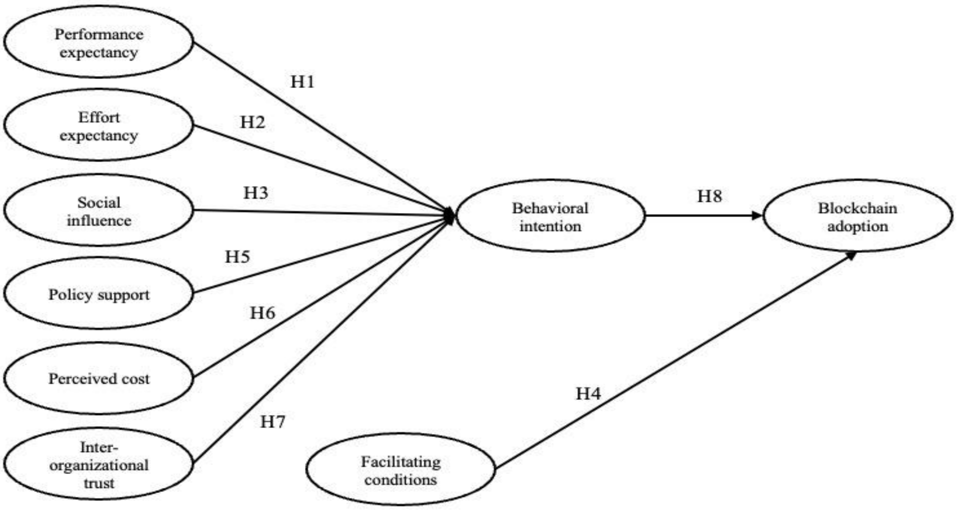

Figure 1 Proposed conceptual framework

Performance expectancy

PE refers to how much a person believes using a system will improve their job performance (Venkatesh et al., 2003). It is the most influential factor in whether someone will use a technology, whether they choose to or are required to (Venkatesh et al., 2016). Many studies have shown that PE positively affects the intention to adopt blockchain in areas like the food supply chain (Toader et al., 2024; Huang et al., 2023), supply chains (Wong et al., 2020), and organizations (Caldarelli et al., 2020). These papers show that PE is a crucial factor in deciding whether to use blockchain. Therefore, the proposed hypothesis is as follows:

H1: PE has a positive influence on behavioral intention.

Effort expectancy

EE is how easy an individual feels the system is to use (Venkatesh et al., 2003). It is based on concepts of ease of use and complexity from the TAM, the Model of Personal Computer Utilization (MPCU), and IDT. The construct's effect becomes non-significant after extended technology usage (Alazab et al., 2021). The existing literature has proved that EE has apparently positive influence on blockchain adoption in the supply chain (Queiroz & Wamba, 2021; Wong et al., 2020), finance (Gan & Lau, 2024; Nazim et al., 2021), and the healthcare industry (Chen et al., 2022); their results suggest that a higher degree of ease when using blockchain technology leads to a higher adoption rate. Therefore, the proposed hypothesis is as follows:

H2: EE has a positive influence on behavioral intention.

Social influence

Social influence refers to how much a person feels that others think they should use a new system (Venkatesh et al., 2003). This tendency is stronger when technology use is mandatory, as more people may adopt it to meet expectations than personal preference (Venkatesh & Davis, 2000). This compliance-based motivation can explain why social influence varies across studies (Chauhan & Jaiswal, 2016). Previous research shows social influence significantly impacts blockchain adoption. For instance, Pérez-Sánchez et al. (2021) found it influential in China, and Wamba & Queiroz (2020) also highlighted its positive impact in Brazilian supply chains due to peer and competitor pressure. Similar results were found in the United Arab Emirates, focusing on the social influence of industry leaders and government bodies in shaping the intention of blockchain adoption (Bleik, 2024). Therefore, the proposed hypothesis is as follows:

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H3: SI has a positive influence on behavioral intention.

Facilitating conditions

Facilitating conditions refer to a person's belief that an organization's technical setup will support their use of the system (Venkatesh et al., 2003). This concept includes compatibility, perceived control, and supportive conditions from models like TPB, Combined TAM-TPB, MPCU, and IDT. Facilitating conditions mainly affect the initial intentions to use a technology, but this influence fades with continued use, making them more relevant to actual use behavior than to sustained intention (Venkatesh et al., 2003). For example, Zhang et al. (2023) explored how facilitating conditions (government support and regulatory frameworks) positively impact blockchain adoption in Pakistan. The findings emphasized that strong facilitating conditions are critical for organizations considering blockchain. On the other hand, Kshetri (2021) examined the integration of blockchain into supply chain management, focusing on how facilitating conditions such as training, technical support, and organizational readiness influence their intention. The results showed that the likelihood of blockchain adoption significantly increased when these conditions were met. Wong et al. (2020) investigated how facilitating conditions, including organizational infrastructure and external support, influenced blockchain adoption and subsequent supply chain performance. The study concluded that facilitating conditions were critical determinants of blockchain adoption intention and substantially impacted the overall success of blockchain initiatives. These papers collectively demonstrated the significant role that facilitating conditions play in positively affecting the intention to adopt blockchain. Therefore, this study proposes the hypothesis as follows:

H4: FC has a positive influence on behavioral intention.

Policy support

Policy support refers to the support the government or its authorities provide to encourage innovation adoption (Oliveira et al., 2014). Undoubtedly, the adoption and dissemination of information technology cannot be separated from government support, and a favorable administrative environment will promote the adoption and dissemination of innovation (Al-Emran & Griffy-Brown, 2023). Policy support plays a critical role in facilitating cold chain infrastructure development. Governments worldwide increasingly recognize the importance of cold chains for national food security and public health (Zhu et al., 2022). Policies to support the growth of FCCL include financial incentives for infrastructure development, subsidies for energy-efficient technologies, and stricter regulations for food safety compliance. Moreover, international standards, such as the Hazard Analysis and Critical Control Points (HACCP), provide a framework for ensuring the quality of cold chain operations (Ghaani et al., 2016).

Government rules and policies can increase corporate adoption of blockchain technology if the government provides policy support and commits to blockchain technology. For instance, Li & Zhong (2020) explored how government policy, such as subsidies, tax incentives, and regulatory frameworks, positively impacted blockchain adoption in the financial services industry. The findings suggested that strong policy support significantly enhances the intention to adopt blockchain, reducing perceived risks and uncertainties associated with the technology. Similarly, Kouhizadeh et al. (2021) examined how regulatory support and public-private partnerships influence blockchain adoption in supply chain management. The study indicated that policy support is critical, with favorable government policies driving higher adoption rates. Sung & Park (2021) also investigated how policy support, including government funding, legal frameworks, and strategic initiatives, influenced blockchain adoption in the public sector in South Korea. The results indicated that robust policy support was a major driver of blockchain adoption, particularly in public administration and services. Therefore, this study proposes the hypothesis as follows:

H5: PS has a positive influence on behavioral intention.

Perceived cost

Perceived cost is the sum of various costs enterprises or users must pay to adopt new information technology. In addition to the cost of purchasing equipment, it also includes the expense of operation and maintenance while using the technology (Tannady & Dewi, 2024). Wong et al. (2020) investigated the impactors of blockchain adoption in supply chains, focusing on perceived benefits and costs. The findings indicated that while perceived benefits are powerful drivers of adoption, high perceived costs, including financial and operational expenses, were significant barriers. Thus, perceived cost negatively affected adoption intention. Kumar Bhardwaj (2021) explored the barriers to blockchain adoption among SMEs, focusing on perceived cost. The study revealed that high perceived costs, including initial investment and maintenance costs, were significant barriers to adoption, leading to a lower intention to adopt blockchain. Liu et al. (2024) examined the adoption of blockchain in the agricultural industry, focusing on perceived costs such as technology acquisition, implementation, and training costs. Their findings showed that higher perceived costs negatively impact the intention to adopt blockchain. Therefore, this study proposes the hypothesis as follows:

H6: PC has a negative influence on behavioral intention.

Inter-organizational trust

Inter-organizational trust refers to the degree of confidence and expectation that organizations have in their partner organizations' willingness and ability to cooperate, share accurate information, and adhere to agreed-upon norms and protocols within a blockchain network (Große et al., 2024). The cold chain for perishable foods often involves multiple stakeholders, including producers, distributors, and retailers, each with different priorities and responsibilities. Building inter-organizational trust ensures seamless operations, particularly when sharing sensitive information such as real-time data on product conditions (Li et al., 2020). Effective collaboration between stakeholders ensures that all parties adhere to the same quality standards, reducing the likelihood of failures in the chain. The use of blockchain has been cited as a pratical tool to improve trust through data transparency and traceability (Centobelli et al., 2022; Feng et al., 2020).

This trust mitigates perceived risks and uncertainties associated with adopting blockchain technology, fostering a positive attitude toward its implementation and integration (de Miranda et al., 2024). The importance of inter-organizational trust has been discussed in many previous papers in various fields. For example, Große et al. (2024) and Kostić & Sedej (2022) emphasized the role of trust in facilitating cooperation and enhancing performance in inter-organizational relationships. Saberi et al. (2019) also discussed inter-organizational trust as a critical factor for blockchain, stating that trust among supply chain partners is vital for the technology, as it assures organizations that their partners will use the shared blockchain platform fairly and transparently." Queiroz & Wamba (2019) defined inter-organizational trust as "the confidence that organizations have in their partners' commitment" to maintaining the integrity, security, and transparency of shared blockchain data, which is crucial for overcoming resistance and fostering blockchain. Chong (2021) emphasized that "inter-organizational trust is a pivotal factor in blockchain prospects as it reduces the perceived risks associated with blockchain's decentralized and transparent nature, encouraging organizations to commit to its implementation." Therefore, this study proposes the hypothesis as follows:

H7: IT has a positive influence on behavioral intention.

Behavioural intention

Existing research consistently shows that this is a key factor in determining whether new systems are used and mainstreamed into an organization (Ajzen, 1991; Venkatesh et al., 2003, 2012). Numerous studies on blockchain technology, including those by Malik et al. (2021), Chakraborty et al. (2023), and Sharma et al. (2021), confirmed this relationship. Accordingly, this study posits that the adoption of blockchain within the FCCL industry can be primarily predicted by organizational intention to adopt the technology. Therefore, the following hypothesis is proposed:

H8: Behavioral intention has a positive influence on blockchain adoption.

METHODS

Sampling and questionnaire administration

As the study focuses on China's FCCL industry, a pretest was conducted with food cold chain experts. A pretest helps eliminate ambiguity and lack of clarity in the questionnaire, ensuring it is intuitive and straightforward for participants (Patten, 2016). To validate the proposed conceptual model and test the research hypotheses, this study employed "Questionnaire Star," a professional online data collection platform, to distribute questionnaires to the

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owners or managers of China's FCCL companies. Five hundred questionnaires were distributed, and 299 valid responses were received, resulting in a response rate of 59.8%.

Instrument measurement

This study used nine constructs and thirty items. The main UTAUT constructs (PE, EE, SI, FC, BI) were measured using the same items as Venkatesh et al. (2012). Policy support was measured with four items from Badi et al. (2021) and Pan et al. (2020), and perceived cost was based on four items from Lin (2014). Items for inter-organizational trust were adopted from Saberi et al. (2019). Responses used a five-point Likert scale from "strongly disagree" to "strongly agree." Demographic data included gender, age, education, company area, and firm size. Since participants spoke Chinese, the back-translation method (Brislin, 1976) was used for accuracy.

Partial least squares structural equation modelling (PLS-SEM) analysis

PLS-SEM is used to evaluate and validate constructs and test the proposed model. This approach allows researchers to examine the relationships between variables while cross-checking that the research framework is valid and reliable (Hair et al., 2011). PLS-SEM is particularly suitable because it does not require normally distributed data, unlike traditional SEM, which assumes normality. This flexibility makes PLS-SEM popular across multiple domains, including management (Purwanto & Sudargini, 2021), marketing (Hair et al., 2012), and operations management (Panigrahi et al., 2023). PLS-SEM is highly valuable in empirical and exploratory studies, especially when data are non-normally distributed, when models are complex, or when sample sizes are small (Reinartz et al., 2009). Moreover, PLS-SEM is well-suited for analyzing data on developing topics (Mital et al., 2018; Shin et al., 2018), as demonstrated in this study, which analyzes data from FCCL company owners and managers regarding blockchain prospects in China. Accordingly, since this research is exploratory and aims to explore blockchain adoption in China's FCCL companies, PLS-SEM is an appropriate approach. This paper used SmartPLS version 4.0 to analyze the data.

RESULTS

Respondents' profile and characteristics

Table 1 Respondents' profile and characteristics

Characteristics' Type	Group	Frequency	Percentage
Gender	Male	165	55.18%
	Female	134	44.82%
Age	18~25	0	0%
	26~30	28	9.36%
	31~40	223	74.58%
	41~50	43	14.38%
	51~60	5	1.67%
	Above 60	0	0%
Education level	High school and under	14	4.68%
	Bachelor	233	77.93%
	Master	45	15.05%
	Doctoral or above	7	2.34%
Company's area	The Northern China	46	15.38%
	The Northeastern China	9	3.01%
	The Eastern China	124	41.47%
	The Middle China	25	8.36%
	The Southern China	76	25.42%
	The Northwestern China	2	0.67%
	The Southwestern China	17	5.69%
Firm size	Large	45	15.05%
	Medium	199	66.56%
	Small	51	17.06%
	Micro	4	1.33%

Note: please refer to Figure 2 for the details of the company's area

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Figure 2 Detail of the company's area

A total of 299 valid questionnaires were completed by the owners and managers of FCCL companies in China. Among the respondents, 55.18% were male and 44.82% were female. The age group of 31 to 40 years represented the largest segment of the sample, accounting for 74.58%. In terms of education, a significant majority (77.93%) of respondents held a bachelor's degree. Geographically, 124 respondents (41.47%) were from FCL companies in Eastern China, 76 (25.42%) were from Southern China, and 46 (15.38%) were from Northern China. Regarding firm size, 199 respondents (66.56%) were from medium-sized FCL companies.

Measurement model

The model was tested using Confirmatory Factor Analysis (CFA) to check if the data was valid (Hair et al., 2011). The tests for composite validity (CV), Cronbach's alpha (CA), and average variance extracted (AVE) showed good results with values above the recommended thresholds, specifically, CV, CA and CFA exceed 0.7 (Hair et al., 2021); and AVE surpass 0.5 (Hair et al., 2016). Table 2 shows that all item loadings were higher than 0.7, confirming strong validity (Fornell & Larcker, 1981; Hair et al., 2016; Nunnally & Bernstein, 1994).

To check if the measurements were distinct from other variables, discriminant validity was assessed. Based on Gefen & Straub (2005), this study used three methods. First, Fornell & Larcker (1981) indicated that discriminant validity was tested by checking the relationship among variables with the constructs' AVE. The results of the study showed good validity. Second, the study checked item loadings against cross-loadings, and the loadings were higher, which confirms its validity. Third, the Heterotrait-Monotrait Ratio (HTMT) as shown in Table 4 demonstrated sufficient discriminant validity.

To ensure the data wasn't biased, the study checked for common method bias (CMB). If the Variance Inflation Factor (VIF) for the variables is below 3.3, the data is considered free from CMB (Kock & Lynn, 2012). The Variance Inflation Factor (VIF) for all variables was below 2.7 in this study, which confirms there is no CMB in the data.

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Table 2 Loading, Composite Reliability, Cronbach's Alpha, and Average Variance Extracted

Construct	Items	Factor loading	α	CR	AVE
Performance expectancy	PE1	0.826			
	PE2	0.803	0.764	0.766	0.678
	PE3	0.840			
Effort expectancy	EE1	0.823	0.841	0.841	0.676
	EE2	0.819			
	EE3	0.825			
	EE4	0.823			
Social influence	SI1	0.846	0.761	0.760	0.677
	SI2	0.800			
	SI3	0.821			
Facilitating conditions	FC1	0.802	0.788	0.810	0.611
	FC2	0.736			
	FC3	0.724			
	FC4	0.857			
Policy support	PS1	0.795	0.766	0.829	0.675
	PS2	0.885			
	PS3	0.781			
Perceived cost	PC1	0.805	0.762	0.767	0.677
	PC2	0.838			
	PC3	0.825			
Inter-organizational trust	IT1	0.820	0.816	0.818	0.644
	IT2	0.750			
	IT3	0.811			
	IT4	0.827			
Behavioral intention	BI1	0.863	0.814	0.815	0.729
	BI2	0.838			
	BI3	0.861			
Blockchain adoption	BA1	0.842	0.825	0.828	0.740
	BA2	0.867			
	BA3	0.872			

Table 3 Discriminant Validity

Construct	BA	BI	EE	FC	IT	PC	PE	PS	SI
BA	0.788								
BI	0.674	0.828							
EE	0.591	0.565	0.821						
FC	0.672	0.596	0.666	0.744					
IT	0.728	0.679	0.627	0.678	0.792				
PC	-0.107	-0.052	-0.14	-0.005	-0.031	0.81			
PE	0.558	0.483	0.469	0.548	0.655	0.051	0.782		
PS	0.54	0.538	0.548	0.615	0.679	0.023	0.546	0.813	
SI	0.753	0.663	0.574	0.682	0.651	-0.014	0.538	0.603	0.765

Note: BA=blockchain adoption; BI=behavioral intention to adopt; PE=performance expectancy; EE=effort expectancy; SI=social influence; FC=facilitating conditions; PS=policy support; PC=perceived cost; IT=inter-organizational trust

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Table 4 HTMT Results

Construct	BA	BI	EE	FC	IT	PC	PE	PS	SI
BA									
BI	0.843								
EE	0.640	0.674							
FC	0.547	0.556	0.690						
IT	0.764	0.788	0.723	0.685					
PC	0.671	0.614	0.835	0.580	0.844				
PE	0.531	0.558	0.508	0.471	0.690	0.783			
PS	0.569	0.508	0.687	0.647	0.792	0.695	0.617		
SI	0.745	0.799	0.750	0.663	0.788	0.677	0.570	0.788	

Table 5. Hypothesis Testing

Hypothese	Paths	Path coefficient	Standard deviation	T-statistics	P-value	Remarks
H1	PE→BI	0.119	0.053	2.235**	0.026	Supported
H2	EE→BI	0.215	0.056	3.835***	0	Supported
H3	SI→BI	0.365	0.070	5.097***	0	Supported
H4	FC→BA	0.172	0.068	2.509**	0.012	Supported
H5	PS→BI	-0.186	0.069	2.704**	0.007	Unsupported
H6	PC→BI	-0.085	0.056	1.526NS	0.127	Supported
H7	IT→BI	0.405	0.072	5.665***	0	Supported
H8	BI→BA	0.615	0.065	9.533***	0	Supported

*Note: ***p<0.001. **p<0.03. NS: p>0.05*

Structural model results

A path analysis was conducted to test the relationships between the variables. The direct and indirect effects of the independent variables were analyzed to help understand their impact (Benitez et al., 2019). The results are shown in Table 5. To check for significance, a bootstrap method was used with 5,000 resamples, providing the most reliable results with no changes (Hair et al., 2016). Most hypotheses were supported, with one found to be insignificant. The results in Table 5 indicate that PE positively influences blockchain adoption (β=0.119; p<0.03), EE→BI (β=0.215; p=0), SI→BI (β=0.365; (β=0.172; p<0.02), IT→BI (β=0.405; p=0), and BI→BA (β=0.615; p=0). These findings suggest that H1, H2, H3, H4, H7, and H8 have a positive influence on blockchain adoption, whereas H5 (PS→BI, β= -0.186; p<0.01) and H6 (PC→BI, β= -0.085; p=0), FC→BA, p<0.13) have negative influences (Hair et al., 2016).

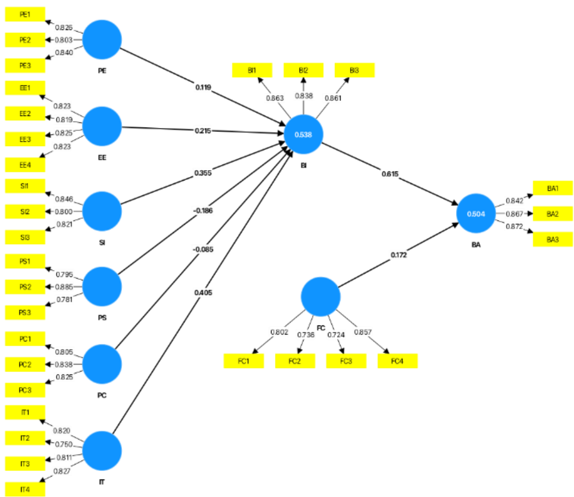

Figure 3 SmartPLS analysis result

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Secondly, the model's predictive ability was tested by assessing the R^2 coefficient, which shows how well the independent variables explain the variance in the model (Hair et al., 2016). As depicted in Figure 2, The model explained 1.042 of the total variances, with behavioral intention (BI) explaining 0.538 and blockchain adoption (BA) explaining 0.504. Additionally, the cross-validated redundancy (Q^2) was calculated using the blindfolding technique (Hair et al. (2016) to confirm the predictive relevance of the model. If a Q^2 value is greater than zero, it means that the model's predictive capability is satisfactory (Hair et al., 2017). In this study, the Q^2 value of 0.932 indicates that the model has strong predictive power.

DISCUSSION

The statistical results show that the model in this study has a good level of predictive power, with R^2 values of 53.8% for blockchain adoption and 50.4% for behavioral intention. Additionally, all criteria related to the measurement model, model fit, construct reliability, and validity were successfully met. By incorporating policy support (PS), perceived cost (PC), and inter-organizational trust (IT) into the UTAUT framework, the R^2 value for behavioral intention (BI) reached 53.8%, supporting the inclusion of PS, PC, and IT as extrinsic factors in the conceptual model. The R^2 values for behavioral intention and blockchain adoption also exceed the recommended thresholds found in the literature, such as 40% (Straub et al., 2004) and 30% (Kline, 2011).

Concerning path coefficient analyses, social influence (SI), inter-organizational trust (IT), and behavioral intention (BI) emerged as the three most significant factors predicting organizations' adoption behavior regarding blockchain, with coefficient values of 0.355, 0.405, and 0.615, respectively. These findings underscore the crucial roles that social opinions, inter-organizational trust, and behavioral intention play in promoting blockchain adoption among organizations. The substantial weight of social influence indicates that the owners or managers of China's FCCL companies are highly attuned to the suggestions and opinions of their reference groups—such as family, friends, peers, and supervisors—when forming their intentions to adopt this technology. Previous research by Al-Shamsi et al. (2022), Queiroz & Wamba (2021), and Ghode et al. (2020) has similarly confirmed the positive influence of social influence on behavioral adoption. Therefore, strategies aimed at enhancing social impact—such as establishing industry leaders, sharing success stories, and leveraging consumer demand and market pressure—can effectively encourage blockchain adoption behavior (Liang et al., 2021; Almarashdeh et al., 2021). Highlighting successful implementations of blockchain technology by leading FCCL companies can create a powerful ripple effect. When industry leaders or early adopters showcase tangible benefits such as improved transparency, enhanced food safety, and better monitoring capabilities, it generates social pressure for other companies to follow suit, as businesses often look to their competitors or peers before making strategic technology decisions (Pieters et al., 2021). Furthermore, as consumer demand for greater transparency and accountability in food sourcing and handling increases, companies will face competitive pressure to adopt technologies that meet these expectations. This is critical, as market-driven demand significantly influences business survival and competitiveness, rendering blockchain adoption a necessity (Tran & Nguyen, 2021).

The significant impact of inter-organizational trust (IT) on behavioral adoption (BA) can be attributed to the collaborative nature of food cold chain logistics (FCCL) and blockchain technology. FCCL companies often depend on various stakeholders—producers, distributors, retailers, etc.—to manage temperature-sensitive goods. Trust among these entities is essential, as blockchain necessitates data sharing across organizations. When IT is robust, companies are more inclined to adopt blockchain, confident that their partners will engage fairly, share accurate data, and refrain from misusing information. Similar findings are echoed in prior research, including that by Große et al. (2024), Choi & Siqin (2022), and Ramos & Queiroz (2022), which underscore the importance of inter-organizational trust among suppliers in blockchain adoption. Consequently, to facilitate blockchain adoption, it is recommended that governments establish industry-wide standards and regulations. Transparent and consistent regulations regarding blockchain usage offer clear guidelines for implementation and reassure companies that the technology will comply with regulatory standards for food safety, traceability, and data protection. Additionally, governments should certify blockchain service providers who meet stringent security and interoperability standards. This initiative fosters a trusted environment, enabling logistics companies to feel assured that they are collaborating with reliable providers (Agi & Jha, 2022). The Chinese government could mandate strict data privacy and security standards for blockchain platforms and develop clear legal frameworks to address disputes arising from blockchain transactions.

These measures will alleviate concerns regarding information misuse or data leakage, thereby strengthening inter-organizational trust (Lin, 2023). In this manner, improvements in IT can enhance the intention and behavior of FCCL companies to adopt blockchain.

This paper finds that behavioral intention positively influences behavioral adoption, with a coefficient of 0.615. This relationship has also been substantiated by numerous existing studies, which identify BI as an important predictor of adoption behavior (Marikyan et al., 2022; Tran & Nguyen, 2021). When food cold chain logistics (FCCL) companies exhibit a strong intention to adopt blockchain, they are more likely to proceed with implementing the technology. Specifically, when companies recognize blockchain as providing substantial benefits—such as enhancing supply chain transparency, mitigating fraud, and ensuring regulatory compliance—their intention to adopt increases. This intention, in turn, has a profound impact on whether they ultimately proceed with mainstreaming.

The results also support the positive relationship between PE and BI, with a regression weight of 0.119. This indicates that food cold chain logistics (FCCL) companies expect blockchain to enhance traceability and prevent fraud throughout the supply chain. However, this figure is not as high as that observed in earlier studies (Gan & Lau, 2024; Pieters et al., 2021; Wong et al., 2020). This phenomenon may be attributed to several factors. Firstly, although managers recognize the benefits of blockchain in enhancing transparency and monitoring across the supply chain, barriers such as high costs, integration issues with existing systems, and technological complexity may dilute the perceived benefits of blockchain (Friedman & Ormiston, 2022). This aligns with this paper's findings regarding the negative relationship between perceived cost and behavioral intention.

Secondly, as blockchain integration is still in its nascent stages within China's FCCL, companies may exhibit risk-averse behavior, resulting in a conservative approach to implementing the technology. This organizational hesitation could diminish perceived performance benefits and slow down the uptake, even when theoretical promises suggest better outcomes. Furthermore, for some companies with advanced logistics supply chain management systems, or for those lacking sufficient resources or funds to deploy the technology, the incremental performance benefits of using blockchain may not be perceived as groundbreaking, which weakens the influence of PE on adoption behavior (Toader et al., 2024; Norbu et al., 2024). Finally, many FCCL companies may prioritize compliance with food safety standards over efficiency or performance enhancements. If blockchain is mostly regarded as a tool for regulatory compliance but a means to improve performance, this view may further explain the weaker importance of performance expectancy.

The empirical findings show a strong connection between effort expectancy and the behavioral intention to adopt blockchain, with a regression coefficient of 0.215. This indicates that FCCL companies in China are concerned about the ease or difficulty associated with using blockchain technology. Such a relationship can be attributed to the fact that the nature of blockchain necessitates organizations to possess a certain level of knowledge and skills; furthermore, employing this technology requires employees in these organizations to integrate it with existing systems (Al-Shamsi et al., 2022; Queiroz & Wamba, 2021). Therefore, enhancing ease of use, minimizing implementation challenges, and ensuring compatibility with existing technological infrastructure are beneficial for promoting organizational adoption of the technology.

Statistical results offer strong evidence confirming the causal path between facilitating conditions and behavioral intention with a weight of 0.172. This indicates that participants are particularly concerned about the availability of facilities, resources, and skills necessary for the successful and effective use of blockchain. Indeed, the resources required for blockchain are fundamental to ensuring smooth and easy access to temperature monitoring services. The results regarding facilitating conditions are consistent with those in previous studies that have explored facilitating conditions or related factors (e.g., Zhang et al., 2023; Miraz et al., 2022).

Unexpectedly, the negative relationship between policy support and behavioral intention revealed differs from the hypothesis in the current conceptual model, with a regression weight of -0.186. This indicates that higher level of policy support results in a lower rate of blockchain adoption among China's FCCL companies. This finding contradicts previous studies that applied the UTAUT framework, such as those by Jena (2022), Malik et al. (2022), and Clohessy & Acton (2019), which all supported the notion that policy support positively influences behavioral intention. Conversely, other research in this domain has challenged the impact of policy support. For instance, studies conducted by Díaz-Arancibia et al. (2024), Al-Emran & Griffy-Brown (2023), and Kassouri & Alola (2023) found that policy support does not always correlate with a higher technology adoption rate, particularly in developing countries and emerging economies like Ghana, Nigeria, and Kenya, where infrastructure, skills, and awareness may be inadequate for adopting advanced technologies. Furthermore, despite governmental policy support, SMEs often exhibit lower intentions to adopt blockchain due to their generally limited financial resources for new technology adoption projects (Díaz-Arancibia et al., 2024).

The negative relationship between policy support and behavioral intention in the context of China can largely be attributed to inconsistent or unclear policy guidelines, excessive bureaucratic oversight, and misalignment of policy focus (Chen & Lloyd, 2024; Kuo & Shyu, 2021; Jiang et al., 2021). Ambiguous policies regarding the implementation of blockchain in the FCCL sector, coupled with frequently changing regulations, may create confusion for companies. When firms are uncertain about compliance with regulatory frameworks or whether their blockchain systems meet policy requirements, they are likely to delay adoption. Moreover, continuous updates or revisions in government policies can lead to concerns that current blockchain solutions may become obsolete or non-compliant with future regulations. If policy support necessitates excessive oversight or approvals, companies may perceive blockchain implementation as overly burdensome. Lengthy bureaucratic procedures could diminish the attractiveness of blockchain adoption. Additionally, if policies predominantly favor larger corporations or multinational firms, SMEs in the field may feel marginalized. These SMEs might struggle with the high costs of blockchain implementation without adequate policy support tailored to their specific needs.

As anticipated, perceived cost was empirically shown to negatively influence blockchain adoption, with a coefficient of -0.085, indicating that lower costs are associated with higher adoption rates. This negative correlation suggests that cost is not the primary barrier when organizations make decisions to adopt blockchain or not. This phenomenon may be attributed to the potential profits of adopting blockchain, such as improved food safety, transparency, and monitoring capabilities, which could partially offset cost concerns. Furthermore, it may indicate that market solutions aimed at reducing adoption costs have emerged. This result aligns with earlier papers, such as Aini et al. (2023), Salim et al. (2022), and Ullah et al. (2020), which identified perceived cost as a significant factor hindering blockchain adoption.

Theoretical contributions

Firstly, by concentrating on blockchain and its adoption within FCCL, this research addresses a notable gap in the literature that has yet to be thoroughly evaluated in the Chinese context. It makes a valuable contribution by exploring the key factors that influence blockchain adoption among FCCL companies in China. The research also examines other important aspects and uses advanced statistical methods like the PLS-SEM for analysis.

Secondly, the study extends the UTAUT by integrating new constructs—policy support, perceived cost, and inter-organizational trust—alongside the original UTAUT variables. This extension enriches the theoretical framework and offers a more holistic comprehension of organizational adoption behavior in emerging technologies like blockchain. This paper suggests new connections between important factors that influence behavioral intention and expands the use of the UTAUT model. It shows that this model can be applied to organizations and new technologies in developing countries, especially in China.

In addition, prior research typically concludes the positive connection between policy support and technology adoption, especially in the fields of technology and innovation. However, this study found a negative influence of policy support on technology adoption, thereby challenging the prevailing consensus. This finding suggests that the impact of policy support may vary under certain conditions or for specific types of firms, industries, policy environments, or countries, warranting further exploration. Moreover, mainstream technology adoption models (e.g., UTAUT, TPB) generally emphasize the positive role of policy support. This study, however, introduces a novel perspective, proposing that in certain contexts, policy support might have an adverse effect. The results make contributions to the theoretical diversity and complexity of technology adoption frameworks. Additionally, this study raises questions about the potential mechanisms behind the negative impact of policy support, such as increased dependency on government aid, reduced flexibility, or unbalanced resource allocation. These possible mechanisms offer new directions for future research and suggest that policy interventions may have multi-dimensional effects on technology adoption.

Furthermore, by examining inter-organizational trust, a factor that has received less attention in prior studies on blockchain adoption, this study illuminates the relational dynamics crucial for technology adoption within FCCL organizations. Given that blockchain technology necessitates the participation of all users in the supply chain, inter-organizational trust is pivotal for accelerating adoption and addressing challenges such as temperature disruptions. This emphasis on trust enriches our understanding of organizational behavior.

Lastly, the study addresses a research gap by applying the extended UTAUT model to China's FCCL industry, providing empirical evidence of the model's applicability in a new cultural and industrial context. This validation enhances the generalizability of the UTAUT model and underscores its relevance in analyzing technology adoption behaviors across diverse environments.

Implications to practice

Practically, the results highlight the key role of behavioral intention, social influence, inter-organizational trust, and facilitating conditions in driving blockchain adoption in the FCCL. These factors are critical in shaping the decision-making process for organizations considering blockchain adoption. Policymakers and industry leaders should prioritize these aspects to encourage organizations to embrace blockchain technology.

Additionally, considering the finding that policy support negatively influences blockchain adoption, future regulations or policies formulated by the Chinese government should focus on providing consistent and clear guidelines. Efforts should be made to reduce bureaucratic burdens, simplify procedures, and incorporate feedback from various industry stakeholders. These measures will enhance the effectiveness of policies and subsequently boost the rate of blockchain adoption.

The findings indicate that enhancing inter-organizational trust can significantly influence blockchain adoption. Therefore, FCCL companies should cultivate strong relationships with their supply chain partners, ensuring transparent and reliable information sharing through blockchain-enabled platforms. Governments and regulatory bodies can facilitate this by establishing standards and guidelines that promote trust and collaboration among industry participants.

Furthermore, the study reveals that perceived cost negatively impacts the intention to adopt blockchain technology. Organizations should conduct cost-benefit analyses to evaluate the long-term value of blockchain investments, while technology providers should consider offering scalable solutions and flexible pricing models to alleviate financial barriers.

The successful use of blockchain in China's FCCL companies can help minimize food waste and spoilage, increase the shelf life of perishable goods, and enhance food security. By addressing the identified factors, stakeholders can facilitate the integration of blockchain technology, thereby enhancing supply chain transparency, efficiency, and safety.

CONCLUSION AND FUTURE DIRECTION

Blockchain technology represents a compelling area for investigation, particularly given the significant challenges associated with its implementation. Acknowledging the low adoption rate of blockchain among China's FCCL companies, this study identified the need to investigate the key impactors on blockchain adoption intention and behavior.

By extending the UTAUT model to incorporate policy support, perceived cost, and inter-organizational trust, the study developed a conceptual framework tailored to the organizational context of FCCL companies in China. The empirical analysis, conducted using PLS-SEM on data collected from managers and owners, validated the predictive power of the conceptual model, explaining 64% of the variance in blockchain adoption behavior. The findings further proved that performance expectancy, effort expectancy, social influence, and inter-organizational trust are the main predictors of behavioral intention to adopt blockchain. Additionally, facilitating conditions and behavioral intention were important factors in predicting the actual adoption of blockchain. In contrast, perceived cost and policy support negatively influenced adoption intentions.

This study makes a theoretical contribution by expanding the UTAUT model and provides empirical insights specific to the FCCL industry in China. Practically, it offers guidance to organizations and policymakers on nurturing factors that facilitate blockchain adoption, ultimately enhancing food safety, reducing waste, and improving supply chain efficiency.

Despite making substantial efforts to explore blockchain adoption, this paper has certain limitations. Since the research was conducted solely within a single country (China), the generalizability of the findings may be constrained. Future research could extend this model to other developing economies to compare and validate the results across various cultural and economic contexts.

Additionally, the study focused on FCCL companies, with the sample limited to managers and owners within these organizations. Future studies should consider including other stakeholders in the supply chain, such as suppliers, distributors, and retailers, to offer a more holistic understanding of the impactors of blockchain adoption. Longitudinal studies could also be conducted to assess adoption behavior over time, providing insights into how the identified factors influence adoption at different stages.

Furthermore, qualitative research methods are recommended for future studies to complement the quantitative findings and offer deeper insights into the drivers and barriers faced by organizations in adopting blockchain technology.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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