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The Intention of Adopting Blockchain Technology in Agri-Food Supply Chains: Evidence from an Indian economy

Aditi Saha

Department of Operations and Supply Chain Management,

Indian Institute of Manageemnt (IIM), Mumbai, Vihar Lake, NITIE, Powai, Mumbai, Maharashtra, India. Pin- 400087

Email: aditi.saha.2020@nitie.ac.in

Rakesh D. Raut

Department of Operations and Supply Chain Management,

Indian Institute of Manageemnt (IIM), Mumbai, Vihar Lake, NITIE, Powai, Mumbai, Maharashtra, India. Pin- 400087

Email: rraut@nitie.ac.in

Mukesh Kumar

Department of Mechanical Engineering,

National Institute of Technology (NIT) Patna, India 800005

Email: mukesh.me18@nitp.ac.in

Sanjoy Kumar Paul

UTS Business School,

University of Technology Sydney, Sydney, Australia

Email: sanjoy.paul@uts.edu.au

Naoufel Cheikhrouhou

Department of Geneva School of Business Administration

HES-SO

Rue de la Tambourine 17, 1227 Carouge, Switzerland

Email: naoufel.cheikhrouhou@hesge.ch

Corresponding email: rraut@nitie.ac.in (R.D. Raut)

Abstract

Purpose -This research explores the underlying intention behind using blockchain technology (BLCT) in the agri-food supply chain (AFSC). This is achieved by employing a conceptual framework based on Technology Acceptance Models (TAM) that considers various factors influencing user behavior towards implementing this technology in their practices.

Methodology- The conceptual framework developed is empirically validated using Structural Equation Modeling (SEM). A total of 258 respondents from Agri -food domain in India were involved in this survey, and their responses were analyzed through SEM to validate our conceptual framework.

Findings- The findings state that food safety and security, traceability, *transparency*, and *cost* highly influence the intention to use BLCT. Decision makers of the AFSCs are more inclined to embrace BLCT if they perceive the usefulness of the technology as valuable and believe it will enhance their productivity.

Implications- The study contributes to the existing literature by providing thorough examination of the variables that influence the intention to adopt BLCT within the AFSC. The insights aim to benefit industry decision-makers, supply chain practitioners, and policymakers in their decision-making processes regarding BLCT adoption in the AFSC.

Originality/Value- The current study investigates how decision-makers' perceptions of BLCT influence their intention to use it in AFSCs, as well as the impact of the different underlying factors deemed valuable in the adoption process of this technology.

Keywords: Blockchain (BLCT); Food security and safety; Agri-food supply chain (AFSC); Technology Acceptance Models (TAM); structural equation modelling (SEM)

1. Introduction

Food and agriculture are crucial for the Indian economy, but traditional technologies remain prevalent. With an estimated population of 9.6 billion by 2050, the food supply must increase by 70% (FAO 2009; Gardas et al.,2017). Blockchain technology (BLCT) is a potential solution to maintain traceability and transparency in the agri-food supply chain. Modern companies require transparency in food product history and secure information throughout the supply chain (Dabbene et al. 2014). Globalization and increased competition have strained the agri-food supply chain, leading to increased competition and a more complex supply chain. BLCT can help provide proof and authenticity of sources.

BLCT can initiate many changes in the industry (Agrawal et al., 2023). It can change the business models of existing firms, change the level and nature of demand, affect the competitive positions of various players in the industry, and have a profound impact on the market (Lanzolla et al., 2012; Saurabh et al., 2023). Technology has proven effective as information moves through the SC (Guggenberger et al.,2020; Ali et al., 2021). As a new decentralized and distributed technology, BLCT can transform a wide range of industries by enabling transactions to be recorded and verified in a secure, transparent, and immutable manner. It can address major supply chain management (SCM) issues like visibility, traceability, and transparency (Ahmed et al., 2022). The concept of Blockchain for Good (B4G) gives rise to novel applications that can drive the United Nations Sustainable Development Goals (Trollman et al., 2022).

Integrating BLCT in AFSC can provide innovative solutions for product traceability and food safety (Feng et al., 2020; Kumar et al., 2023a). As a result, many of the current challenges of food safety, security, and transparency faced by SCs can be resolved (Gardas et al.,2019). The immutable and decentralized nature of the BLCT helps to eliminate information asymmetry in SCs by storing data in the form of blocks, enabling the storage and trading of tangible and intangible assets with increased efficiency, reducing risks, and lowering costs (Li. et al.,2021). By providing direct linkages between farmers, retailers, customers, and producers, BLCT helps to restructure AFSCs, improving food quality and transparency and minimizing food fraud and wastage (Li et al., 2021; Collart and Canales, 2022). According to Wang et al. (2021), a BLCT tracing system increases SC transparency and process management and reduces intermediary costs, improving SC service and confidence. With the importance of Blockchain technology in advancing AFSC to greater transparency and traceability, it still faces issues in adoption; thus, the research question still needs to be addressed: *What factors are perceived as helpful in adopting the BLCT in AFSC?*

Successful adoption of BLCT in AFSC will confer a competitive edge and unparallel opportunities to the sector. A significant number of practitioners and scholars point out the BLCT's ability to transform SCs (Schmidt and Wagner, 2019; Wang et al., 2019b; Chang et al., 2020; Wamba et al., 2020) and (Zhang et al., 2020; Ali et al., 2021; Mangla et al., 2021; Vikaliana et al., 2021) studied BLCT in many agri-food industries to understand the implementation benefits and challenges. However, the scarcity of information and an inability to apply BLCT to widely spread applications have hindered such applications, specifically in developed economies. Also, gaining acceptance from key stakeholders and decision-makers remains a pivotal factor in successfully implementing such innovations. Therefore, it is critical to establish the intention to use BLCT in AFSC to understand the factors influencing its adoption and develop strategies for promoting its successful implementation. And thus, this study intends to address the second research question: *How do the factors identified influence the intention to adopt BLCT in AFSC?*

Integrating BLCT into the AFSC requires user acceptance and understanding of the factors they perceive as essential for adoption. To ensure the benefits of BLCT, AFSC decision-makers must ensure it benefits their organization and secures consumer trust. To achieve this, a comprehensive assessment of user perceptions and attitudes towards the new technology is necessary (Saha et al., 2023; 2023a). Over time, numerous studies have explored this topic with varying degrees of detail, including seminal works authored by (Venkatesh et al., 2003; 2012; Queiroz and Wamba, 2019a). The Technology Acceptance Model (TAM) is a theoretical framework used to evaluate users' willingness to accept and utilize new technology. The original TAM model, proposed by Davis in 1989, has evolved into different versions, each with unique features. It focuses on perceived usefulness and ease of use, making it a straightforward and practical model for researchers and practitioners studying and improving user acceptance of technology.

User acceptance of the BLCT and its influencing factors, play an important role in the technology's adoption. By considering different technology adoption models and independent variables that influence user acceptance of BLCT, it is possible to predict the level of user acceptance of BLCT in the AFSC domain. Furthermore, it is crucial to understand the decision makers' intention in adopting BLCT, considering this technology's disruptive potential (Wamba and Queiroz 2020) and its unprecedented impact on SCs. Though recent research (Yadav et al., 2020; Liu et al., 2021; Trollman et al.,2022; Kumar et al., 2023a) investigated the potential and factors of BLCT in AFSC, the factors contributing to its widespread acceptance and intention to acknowledge the technology have been overlooked. While few authors (Kamble et al., 2019; Nayal et al.,2021; Paul et al.,2021) emphasized its impact on SC, they did not identify the key factors influencing decision -makers' intentions for BLCT adoption, resulting in gaps in understanding the SC dynamics and stakeholders' perspective. Thus, this study investigates the factors influencing decision-makers intentions to use BLCT in AFSC. The study conducts empirical research using SEM and proposes a conceptual framework based on TAM to study the intention to use BLCT and shed light on the following research objectives (ROs):

RO1: To explore the factors helpful in adopting the BLCT in AFSC.

RO2: To examine the user intention to adopt BLCT in AFSC.

Since blockchain is still in the inception stage and adoption of the technology remains a challenge, this research delves deeper into identifying and understanding the factors that influence the adoption and intention to use BLCT in AFSC. To achieve this, the study is based on TAM, which prioritizes perceived usefulness (PU) and perceived ease of use (PEU) as predictors of intentions to use (ITU). TAM is used to build the study's conceptual framework, which identifies critical factors impacting ITU while also studying their effects on the TAM construct to gain better insights toward successful implementation. These findings will enable the decision-makers to develop more robust strategies to integrate BLCT across the AFSC effectively. By understanding the factors that drive technology adoption, tailored implementation plans can be fostered for the Indian AFSC.

The research paper is laid out in the following pattern. Section 2 discusses the overview of the relevant literature. Section 3 presents the conceptual framework's development and the formulation of the hypotheses. Section 4 addresses the research design. In Section 5, the data analysis and findings are presented. Section 6 includes a discussion and theoretical and practical contribution of the study. Finally, section 7 concludes the paper with a discussion on future directions.

2. Literature Review

2.1. Blockchain technology and AFSC

Integrating BLCT in AFSC offers a comprehensive solution to trace, track and monitor the entire length of the supply chain (Kayikci et al.,2022; Srivastava et al., 2022), ultimately leading to greater transparency and trust (Liu et al., 2022; Sharma, 2023). While traditional SC have long struggled with food safety concerns, BLCT can address these issues by increasing visibility throughout the chain (Kshetri 2019). Research studies conducted on BLCT and SC integration revealed that adopting this technology improves transparency, authenticity, and real-time transactions (Mukherjee et al., 2021; Feng et al.,2020; Xu et al.,2020). Furthermore, (Sunny et al., 2020) suggest that transparency and traceability are critical factors that impact a logistics organization's overall performance – making it essential for businesses to prioritize integrating BLCT into their SCs. Providing complete visibility upstream and downstream of AFSC-BLCT helps establish accountability across all supply chain stages while enhancing its trustworthiness (Rogerson and Parry, 2020). More and more value chains are incorporating BLCT to make them flexible and strengthen customer ties (Murki et al., 2018). This is a major movement in the rapidly expanding food industry, where BLCT is seen as the best option for tracking and changing. The potential uses of BLCT in the agri-food value chain have been the subject of several studies (Zhao et al., 2019).

One such study used RFID and blockchain to create a system to track the agri-food supply chain in China (Tian. 2016).

Further applications of blockchain technology include an IoT software connector, a distributed ledger manufacturing supply chain that is blockchain-ready, and a supply chain traceability solution that is both transparent and decentralized. By facilitating the transfer of more precise and trustworthy data between producers and consumers, BLCT has shown to be more effective than conventional approaches in food supply chains (Zhao et al., 2019). Because of this, the food sector is now more efficient and cost effective. Ultimately, the food sector is realizing the importance of BLCT, which provides a safer and more effective method to monitor and record food supply chains. Businesses may improve their operations and cut expenses by using BLCT in several industries, including supply chains, logistics, and agriculture.

As the research shows, integrating BLCT in AFSC is an innovative move that promises many advantages. With its ability to improve transparency and trust throughout the SC, BLCT has been proven beneficial for AFSC. However, it is worth noting that despite this promising development, the intention to use BLCT in AFSC is still relatively new and requires further exploration before its potential benefits can be fully realized. For decision-makers to effectively integrate BLCT into their AFSC, they must first believe in its perceived usefulness and ease of use of the technology. This requires a deeper understanding of how BLCT works, and which factors benefit and fit within their specific industry context.

2.2. ***Research Gaps***

BLCT adoption and intention to use in SC has been studied by various authors such as Wamba & Queiroz (2020) in the Brazilian SC, Queiroz et al. (2021) in logistics and SC, Karamchandani et al. (2022) for the service SC, Sternberg et al. (2021) in inter-organizational SC. While several models on BLCT adoption have emerged in recent years within the agriculture and food sectors context, studies such as (Saurabh and Dey, 2021; Ronaghi, 2021; Paul et al., 2021; Liu et al., 2021; Yadav et al., 2020; Susanty et al., 2021), did not fully explore critical issues that drive its widespread acceptance. Queiroz et al. (2021) conducted a comprehensive study on adopting BLCT, predicting the likelihood of implementing BLCT, while Queiroz and Wamba (2019) emphasized that performance expectancy is one of the enabling conditions of BLCT adoption. Interestingly enough, both US-based firms and Indian organization were found to be influenced by this factor. Furthermore, Wong et al. (2020a) focused on additional considerations related to adopting BLCT - specifically costs incurred during the implementation phase, regulatory support from authorities, top management involvement & encouragement towards its utilization within organization frameworks. The results indicated that cost implications had widespread influence over intentions regarding adoption rates among respondents surveyed. Several scholarly studies have delved into the multifaceted ways in which BLCT can impact and influence the performance of SCs, as observed by Nayal et al. (2021), Masudin et al. (2021), and Paul et al. (2021). Vasan et al. (2023) has explored the farmers' belief in adopting technology, but the entire supply chain has not been discussed. These investigations shed light on a complex interplay between BLCT and SC but fail to uncover the potential factors that are perceived useful by decision makers and lead to the intention to use the technology. Also, the intention to use BLCT in Indian AFSC has not been explored much through TAM.

Although few studies have been conducted on the potential for blockchain adoption in supply chain management, a more comprehensive analysis of users' intentions to use BLCT is necessary. Understanding the factors that motivate users to embrace this technology will be crucial in driving its widespread adoption throughout AFSC. To truly integrate blockchain as a solution, it is essential to examine BLCT's perceived usefulness and user motivation. To shed light on these key aspects of blockchain implementation, empirical research has focused on ITU BLCT in AFSC and variables deemed useful by prior literature. Notably, cost (COS), food safety and security (FSS), transparency and traceability (TT) have emerged as salient concerns related to adopting this technology within supply chains. A TAM framework has been adopted to comprehend how independent variables affect both PU and PEU of the technology, ultimately leading towards higher rates of ITU- BLCT in AFSC.

3. Hypotheses Development and Conceptual Framework

3.1 Technology Acceptance Models (TAM)

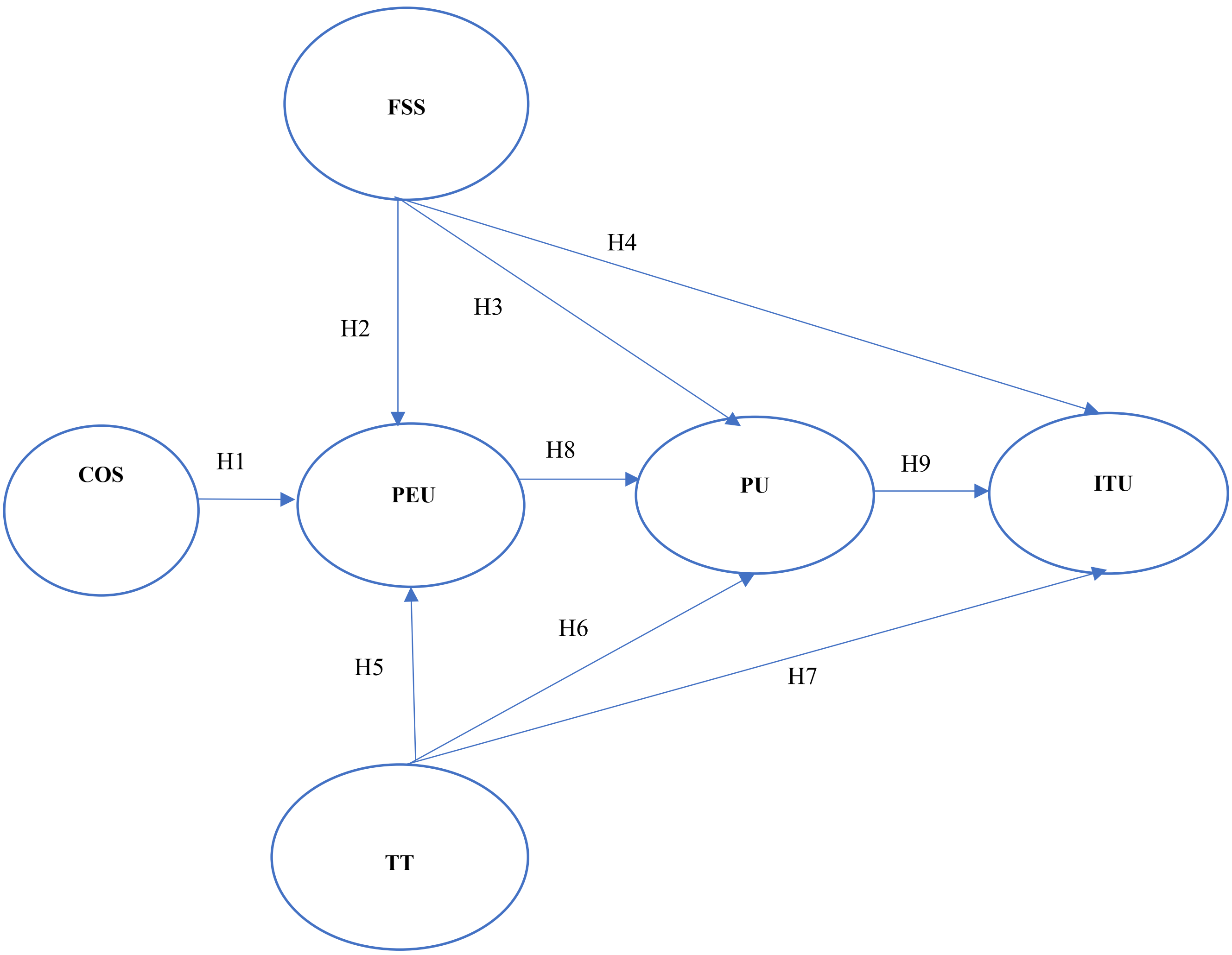
Technological advancements continue to be significant in business, and acceptance of technology is required to implement them successfully. In light of this reality, companies must deeply understand the factors contributing to successful implementation. To elucidate these complexities, this study relies on TAM, originally proposed by Davis (1985), as an instrumental tool for assessing technological adoption. Extensive research has been conducted exploring different aspects of TAM over the years, including but not limited to the works by (Davis, 1985, 1989; Venkatesh and Davis, 2000; Venkatesh et al., 2003; Venkatesh and Bala, 2008; Venkatesh, Thong and Xu, 2012). By examining individual or organizational reasons behind technology uptake through applying the TAM framework, we can gain insight into how best to facilitate its utilization within businesses.

TAM has long been a cornerstone in the field of technology acceptance research. Although numerous variations, such as TAM2 and extended TAM models, have emerged, the original model still holds significant weight due to its extensive validation. Venkatesh and Davis (2000) argue that while newer versions introduce new variables like social influence and cognitive instrumental processes, their complexity may limit practical application. This debate was put to the test by Wu and Wang's (2005) study comparing the usefulness of both original TAM versus extended version- results showed that although expanded versions explained more variance in data, the simplicity provided by the original model made it an effective tool for predicting technology acceptance patterns with reasonable accuracy. Ultimately, this affirms support for utilizing original TAM as an undeniably successful methodology for seeking insights into understanding how users accept new technologies effectively under varying contexts.

TAM explores the link between PU, PEU, and ITU characteristics. Using TAM, Davis et al. (1989) proposed that PU, and the attitude toward use, influence technology adoption. PU assesses an individual's attitude towards technology. This attitude usually reflects how much benefit they expect from using the technology and how much effort they think they will have to expend to use it. Furthermore, it is anticipated that PEU has a direct effect on PU. PEU represents how easy it is for an individual to use the product/service. A product with a high PEU score will be perceived as easy to use and therefore more likely to be adopted by users. ITU is the willingness of an individual to use a technology once the individual is aware of it. It is determined by measuring the level of motivation to use the technology in question as well as a person's attitude toward using such technology.

3.2 Conceptual framework

The conceptual framework has been adapted from Venkatesh et al. (2003). The framework based on the TAM concept studies the perceived usefulness (PU) of the BLCT in the AFSC. The framework consists of three variables: COS, FSS, and TT, identified from the literature review as influential on the adoption and ITU the BLCT technology. Figure 1 shows the proposed conceptual framework. While the model is comprehensive, it may not cover all factors influencing the adoption of BLCT. However, to ensure parsimonious measurement instrumentation and considering the survey length, the study was limited to only three variables FSS, COS, and TT.



"*COS- Cost; FSS- Food safety and security; TT- Transparency and traceability; PEU- Perceived ease of use; PU- Perceived usefulness; ITU- Intention to use"

Figure 1: Conceptual framework (Authors own creation)

3.1 Cost

The cost of adopting a new technology goes beyond just the financial aspect. It also includes emotional effort, time, and energy investment to learn and integrate it into existing systems. However, this initial expense can eventually save money by streamlining operations and reducing transactional costs in the long run. Decision-makers are more likely to invest in technologies that will significantly reduce operational expenses over time. One such innovative solution proposed by Li et al. (2021) is using BLCT for automation, which eliminates manual involvement, intermediaries, and paperwork, thus minimizing costs associated with supply chain management. Incorporating smart contracts further helps optimize procurement processes as suppliers receive prompt payment upon delivery confirmation while reducing human interaction between parties. Vu et al., (2021) demonstrate that such automated procedures streamline workflows and cut down on transaction expenditures like distribution expenses or data encryption fees, thereby boosting overall efficiency levels. A recent study conducted by Du et al. (2020) found that adopting blockchain technology can lead to improved efficiency and cost reduction. Building on this, Ko et al. (2018) discovered that the costs associated with implementing new technologies directly impact users' perception of usefulness, ultimately influencing their decision to adopt or reject these innovations. However, the perceived cost might not directly influence users' beliefs about the usefulness of the technology or their intention to use it. These aspects are more related to the perceived benefits and value that the technology provides. The influence of cost is mediated through the perceived ease of use of the technology rather than directly impacting perceived usefulness or intention (Luarn et al., 2005; Amoako-Gyampah, 2007; Yen et al., 2010). So, we propose the hypothesis:

H1. Cost positively influences the PEU of BLCT.

3.2 Food Safety and Security

Food safety and quality assurance are more challenging with the increase in the global flow of goods (Fischer, 2013). Food safety and security methods include handling, processing, preparing, and storing meals in a way that reduces the likelihood of people becoming ill due to contaminated foods. Thus, FSS refers to delivering a product that has not been contaminated, damaged, or tampered (Marucheck et al., 2011). BLCT helps make the FSC more visible, traceable, and accountable, ensuring safety and security (Gupta and Shankar, 2023). BLCT minimizes food fraud by ensuring that records are transparent and traceable (Danese et al., 2021). As financial records for all operations are documented and stored in the chain, it can also speed up auditing and conflict resolution (Chang et al., 2020). In addition, the BLCT allows parties to update product information in near real-time, minimizing the possibility of cross-contamination and improving responsiveness. It also assists in providing food safety status in real-time to all SC decision-makers, thereby providing a secure, distributed, transparent, and collaborative information system. In their research, Roy et al. (2020) state that food safety and security are essential in earning SC decision-maker trust. Trust leads to the PEU of technology, thereby increasing the PU and ITU the technology leading to the following hypotheses:

H2. Food safety and security positively influence the PEU of BLCT.

H3. Food safety and security positively influence the PU of BLCT.

H4. Food safety and security positively influence the ITU BLCT for AFSC.

3.3 Traceability and Transparency

SC traceability and transparency has become increasingly important to sustainable management (Mollenkopf et al.,2022) A traceable and transparent SC demonstrates that an organization is honest and upfront about how it conducts business (Kafetzopoulos et al., 2023) A blockchain-based traceable SC increases visibility, improves quality controls, and reduces risk (Chavalala et al., 2022). Transparency builds trust among suppliers, companies, and customers. Astill et al. (2019) state that traceable and transparent food production systems must facilitate data exchanges between stakeholders as this will lead to expediting processes and a reduction of transaction times. Kamath (2018) discusses how BLCT helps trace and identify the SC's origin and path and build SC decision-maker trust. Being an immutable technology, BLCT reduces human intervention and is thereby helpful in food recall and food wastage (Duan et al., 2020). The traceability and transparency benefit of BLCT leads to the PU and ITU of the technology. Hence, we suggest the following hypotheses:

H5. Traceability and transparency positively influence the PEU of BLCT.

H6. Traceability and transparency positively influence the PU of BLCT.

H7. Traceability and transparency positively influence the ITU BLCT for AFSC.

3.4 Intention to Use

Perceived adoption intention refers to a user's active intention to adopt a specific technology (Queiroz & Wamba, 2019). Among the main strands of the technology management literature, an important focus is on adoption intention, which explains how individuals or decision-makers respond to a given technology that may lead to its actual usage. Research has shown that adoption intention is one of the most significant predictors of technology usage (Venkatesh et al., 2012) and competitiveness (Kshetri, 2018). In their research, Davis et al. (1989) define perceived usefulness as the degree to which a user believes employing a given framework would improve productivity and efficiency. The literature shows that perceived usefulness significantly influences users' attitudes and intentions. Currently, BLCT is being used in a wide range of sectors. The users are more likely to be positive towards BLCT if they perceive it as useful and can increase efficiency. "Perceived ease of use" refers to how easily someone believes a particular technology or system is used (Davis, 1989). The literature shows that PEU positively affects PU (Venkatesh and Davis, 1996). Increasing user perceptions of BLCT as useful will make users more positive (Liu et al., 2021). Maintaining competitiveness, easy tracking and tracing of products, monitoring fair trade, cooperating with multiple participants, and building SC decision-maker trust may influence the use of BLCT for achieving benefits for firms and lead to the ITU of the technology. Hence, the followings hypotheses have been formed:

H8. PEU positively influences the PU of BLCT.

H9. PU positively influences the ITU BLCT for AFSC.

4 Research Design

4.1 Questionnaire Design

The study uses in-depth interviews and questionnaires to examine the impact of different factors on the intention to use BLCT. The survey method is used to elicit information about respondents' backgrounds and attitudes as well as their intentions for using BLCT. A five-point Likert scale ("strongly agree to strongly disagree") was selected to measure the items and variables. The survey questionnaire was designed based on the previous literature and were validated by experts (industry and academician). Six variables and 24 items were used in the survey. The constructs utilized in the questionnaire are listed in their sources in Table 1. Six industry and 4 academic experts working in the agri-domain were asked to evaluate the questionnaire and check each construct for its reliability and validity. They reviewed the items for ambiguity, consistency, and relevance to the survey (Kumar et al.,2022). In addition to ensuring the consistency and reliability of the questionnaires for large-sample surveys, the validity and reliability of each scale are also checked.

Table 1: Variables and Items Table (Authors own creation)

Variable		Item	Description	References
Cost	COS1	Adoption cost	"The elements indicate the entire expenses linked with the implementation of BLCT. It	"Tapscott et al., (2018); Creydt and Fischer, (2019);

	COS2	Technology cost	helps in reducing the overall AFSC expenses by minimizing the middle entities. It also helps in reducing the operating cost, manpower cost, and maintenance costs via investing less in consumable items, compact data storage, sharing database, faster payments, less human interaction, rapid decision-making, strong management, and an efficient SC."	Ivanov et al., (2019); Yadav and Singh (2020); Wong et al., (2020a); Sternberg et al., (2021); Vu et al., (2021)."
	COS3	Maintenance cost		
	COS4	Transaction cost		
Food Safety and Security	FSS1	Improve food quality	"Food Safety and Security suggest that BLCT is an effective technology to avoid food fraud, reduce cross contamination, and increase trust in the AFSC. BLCT helps to retrieve the required information, confine contaminated products from suppliers, and minimize the products recall range. BLCT also provides data security from cyber threat and food fraud. The data are stored in immutable blocks and cannot be tampered."	"Galvez et al., (2018); Tan et al., (2018); Astill et al., (2019); Creydt and Fischer, (2019); Duan et al., (2020); Lin et al., (2020)."
	FSS2	Reduce cross contamination		
	FSS3	Maintain records		
	FSS4	Ensure security		
Traceability and Transparency	TT1	Reduce food wastage	"BLCT helps to manage inventory, transportation, and tracking of products. Firms can track the information on the storage life of food products better thereby improving profits. BLCT can also assist in promoting economic sustainability of the AFSC by reducing food waste and food recalls. It shortens the time to process the food and track the inaccessible data which can be utilized to improve SC procedures and build SC decision-maker trust."	"Kamath, (2018); Astill et al., (2019); Jen Yin Yeh et al., (2019)."
	TT2	Reduce food fraud		
	TT3	Easier food recall		
	TT4	Improved tracking		
	TT5	Increase in SC decision-maker trust		
Perceived ease of use	PEU1	ease of use	"BLCT contributes to address the complex industrial systems (CISs) challenges. BLCT reduces the intricacy of cash data	"Venkatesh et al., 2003, 2012); Christopher Lee et
	PEU2	ease of understanding		

	PEU3	Compatible to use	storage and recovery system of AFSC, inventory, marketing, finance, and other departments. Operational usefulness has a positively influence on the BLCT's ease of use."	al., (2019); Queiroz et al., (2019)."
Perceived usefulness	PU1	Improve performance	"BLCT enhances the AFSC's performance and simplifies the complex AFSC network by tracking and tracing the entire SC. Thereby improving safety and security. It also maintains and stores records in an immutable form which is easy to access but difficult to tamper."	"Kamath, (2018); Christopher Lee et al., (2019); Creydt and Fischer, (2019); Kshetri, (2019); Hew et al., (2020); Gao et al., (2020); Vu et al., (2021)."
	PU2	Simplify process		
	PU3	Improve safety and security		
	PU4	Increase traceability		
	PU5	Maintain records		
Intention to use	ITU1	Innovative technology	"BLCT is an innovative distributed technology that helps build trust, reliability, and satisfaction among the SC decision-maker as it can provide farm to fork data. BLCT helps to build a better and smooth-running transaction facility."	"Kamath, (2018); Kamilaris et al., (2019); Kshetri, (2019); Lin et al., (2020); Schinckus, (2020); Wang et al., (2020)."s
	ITU2	SC decision-maker satisfaction		
	ITU3	Better transaction facility		

4.2 Sampling and data collection

Data are collected from the questionnaires provided to Indian agri-food practitioners working in the domain for at least 2.5 years and having a basic knowledge of BLCT. Data are collected between June and August 2022 from multiple agro-based Indian companies to generalize the findings to a broader range of companies (Nayal et al., 2021). The purposive sampling technique is used as the sampling method to identify the interviewee. Respondents are also addressed individually whenever possible to enhance the survey response rate. Five hundred professionals from the agri-based industry, including vegetables and fresh fruits, dairy, and beverage industry, knowing the technology implementation benefit, are invited to participate in the study. Of 550 professionals, 258 provided useful answers (a response rate of 46.9%). The average participant's ages are between 36 and 55 years old. It has been observed that the male respondents outweigh the female respondents, with the majority of participants aged 25 to 75 years. The participants' demographic characteristics are categorized in "Table 2".

Table 2: "Demographic profile of the respondents" (N -258) (Authors own creation)

Items		**N**	**Percentage**
Age	25-35	96	37.2

	36-55	104	40.3
	56-75	58	22.5
	Total	**258**	
Gender	Male	140	54.26
	Female	118	45.73
	Total	**258**	
Educational Qualification	UG	98	38
	PG	107	41.5
	PhD	53	20.5
	Total	**258**	
Years of Experience	0-5	87	33.7
	5-10	58	22.5
	10-15	62	24
	15-20	51	19.8
	Total	**258**	

4.3 Non response and common method bias (CMB)

Non-response bias was mitigated by employing exploratory and subjective approaches (Armstrong and Overton, 1977). To evaluate the difference in means for every scale, the t-test is conducted for the early and late responses of the participants for a non-response bias test (Karamchandani et al.,2020). No significant difference in the scale items for each construct was found for this study. To prevent the common method bias (CMB), the questionnaire was conscientiously designed and tested with expert practitioners. Anonymity was ensured during data collection, and respondents were assured that there were no right and wrong answers, emphasizing the significance of truthful answers (Podsakoff et al., 2003). It is important to check and control CMB when the data from all the constructs in a model are collected from a single respondent (Podsakoff and Organ, 1986). To minimize the effect of common method variance, the sequences of the survey questions for every respondent were randomly assigned, and the respondents were asked to give honest feedback while they were also assured that their responses would remain anonymous (Podsakoff et al., 2003). In addition, Harman's single-factor analysis was performed to evaluate and mitigate the potential presence of biases. The results showed a single factor of less than 40% of the variance, suggesting no CMB. Even though common method bias affects the linear relationships, it seems to have fewer effects on the analysis of interactions between variables.

5. Data Analysis and findings

SEM is the statistical method used for hypotheses testing. With SEM, one can validate the suitability of TAM in analyzing BLCT's ITU. SEM helps specify, estimate, and evaluate models of linear relationships among variables in relation to a relatively small number of unobserved variables

(Shah et al.,2006). The data analysis was carried out using AMOS software, which has all the tools necessary for creating and examining SEM path diagrams (Nayal et al., 2021) and analyzing SPSS files (Mangla et al., 2020). IBM-SPSS Amos is robust software for SEM that allows users to validate their research and hypotheses by expanding conventional multivariate analysis techniques, such as regression, factor analysis, correlation, and analysis of variance. Using SPSS-Amos, one can develop intricate attitudinal and behavioral models that depict complex relationships more precisely than traditional multivariate statistical methods through an intuitive graphical or programmatic user interface (IBM, 2017; Dash et al., 2021).

SEM relies on path diagrams to provide a clear picture of the relationships between variables (Ullman and Bentler, 2012). For the SEM model fit, 100 sample size is qualified as fair; the current sample size is 258 beyond the threshold value (Ganbold et al., 2021). "Exploratory factor analysis (EFA)" and "confirmatory factor analysis (CFA)" were performed before the SEM analysis. EFA measures the correlation between constructs in a dataset by analyzing the correlations between them. It also reduces the broad data set to smaller set. Bartlett's test of sphericity and "Kaiser-Meyer-Olkin (KMO)" helps to understand the suitability of the data. The results show that the KMO value is 0.851(value>0.7), which is satisfactory. The measurement model is validated using CFA to identify how well the conceptual framework reflects the data. The results show that the Chi-square test result is 1.716 (< 3.0), the "Goodness fit index (GFI)" is 9.51 (>9.50), the "comparative fit index (CFI)" is 0.951, and the "Root mean square error of approximation (RMSEA)" is 0.053, which suggests that the model is a close fit.

5.1. Structural model assessment

To evaluate how reliable or consistent the questionnaires are, they are tested for dependability. The analysis reveals the extent to which measurement inaccuracies impact (or do not affect) the gathered data. In general, it is acknowledged that data can be regarded as credible if Cronbach's alpha is greater than 0.70 (Teo et al., 2015; Kumar et al. 2022). Table 3 shows that all the item loadings exceeded the 0.70 threshold, providing evidence of convergent validity (Jiang et al.,2020). Therefore, the items for each construct and the complete questionnaire have good internal consistency. Composite reliability (CR) in Table 4 shows that all six constructs are higher than 0.7, indicating that all the six are valid. Tabachnica and Fidell (2007) state that if the average variance extracted (AVE) is larger than 40%, the measurement questions represent the features of each study variable in the model. Each variable in Table 3 has an AVE value higher than 0.5, denoting convergent validity of the scale. Convergent validity can be further examined by analyzing the AVE t-values for factor loadings, and composite reliability (construct reliability) (Chau, 1997; Fornell & Larcker, 1981).

Discriminant validity can be evaluated by examining the square root of AVEs for each latent variable with its correlation to the other constructs (Fornell and Larcker, 1981). Table 4 shows the correlations between the constructs and demonstrates the discriminant validity of the variables. The correlation coefficient is higher than the square root of the AVE, and the AVE value for every construct is more than 0.5, suggesting that the constructs have significant discriminant coefficients, and that the model's intrinsic quality is ideal.

The path diagram of SEM prepared in "AMOS-20.0" is shown in Figure 2 and Figure A1 (Annexure). The results of the SEM and the path analysis of the conceptual framework are displayed in Table 5. They include "the path, coefficient, standard deviation, t-value, and p-value". The findings show that all nine hypotheses support, which leads to the conclusion that all the independent variables, COS, FSS, and TT, positively influence the dependent PEU, PU, and ITU. Statistical significance was found across all paths in the framework, with standardized "path coefficients ranging from 0.1 to 0.4". The path coefficient(β), (+/-1) indicates the degree of change in the outcome variable for each one unit change in the predictor variable. P values (<0.05) determine that the hypothesis results are statistically significant. The value shows a positive relationship between the independent variables (COS, FSS, and TT) and the dependent variables (PEU, PU, ITU). The findings reveal that food safety and security is perceived as the most important useful factor influencing the ITU the technology, followed by cost and traceability.

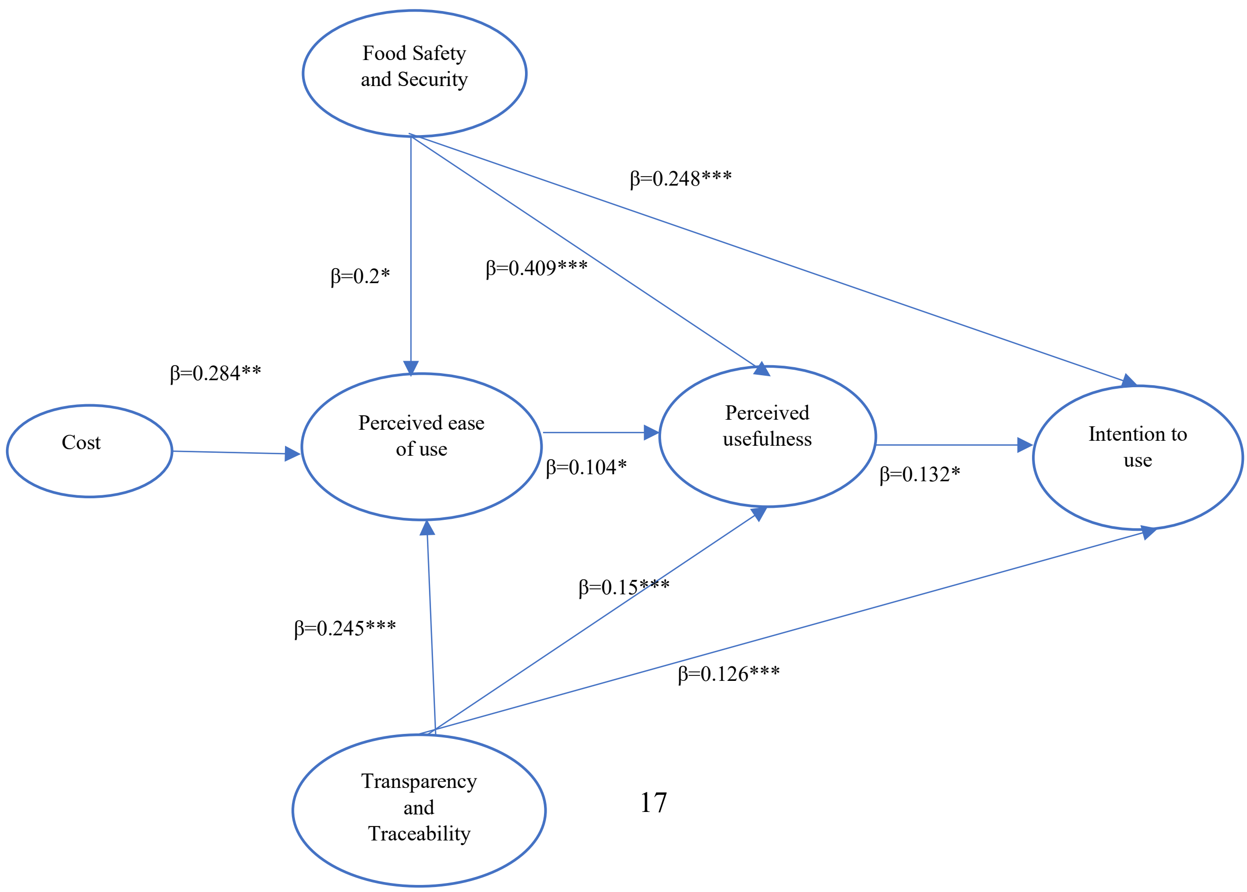


Figure 2: Measurement model (*** p<0.001, ** *p<=0.01, *p<= 0.05)* (Authors own creation)

Table 3: Items; loading factors; Cronbach's alpha (α); Composite reliability (CR); average variance extracted (AVE) (Authors own creation)

Constructs	Items	Loading factors	α	CR	AVE
Perceived usefulness	PU3	0.961	0.946	0.946	0.596
	PU4	0.943			
	PU2	0.839			
	PU5	0.811			
	PU1	0.804			
Perceived ease of use	PEU3	0.861	0.887	0.888	0.602
	PEU1	0.842			
	PEU2	0.793			
	PEU4	0.757			
Transparency and traceability	TT1	0.952	0.899	0.9	0.539
	TT5	0.923			
	TT2	0.730			
	TT3	0.678			
	TT4	0.638			
Food safety and security	FSS3	0.994	0.911	0.913	0.543
	FSS2	0.935			
	FSS5	0.719			
	FSS1	0.674			
	FSS4	0.673			
Cost	COS3	0.798	0.751	0.756	0.523
	COS2	0.729			
	COS4	0.618			
intention to use	ITU4	0.780	0.819	0.834	0.621
	ITU3	0.778			
	ITU2	0.754			
	ITU1	0.614			
	ITU5	0.584			

Table 4: Discriminant validity (Authors own creation)

Factor	PU	FSS	TT	ITU	PEU	COS
PU	**0.772**					
FSS	0.53	**0.776**				
TT	0.393	0.348	**0.734**			
ITU	0.44	0.51	0.42	**0.737**		

PEU	0.343	0.311	0.381	0.327	**0.723**	
COS	0.14	0.221	0.214	0.173	0.297	**0.788**

Table 5: Path coefficients, standard error, t-statistics, and *p*-values (Authors own creation)

"Hypotheses"	**"Path"**	**"Coefficient"**	**"Standard error"**	**"t-statistics"**	**"P-values"**	**"Supported/ Not supported"**
H1	COS---PEU	0.284	0.1	2.837	**	Supported
H2	FSS---PEU	0.2	0.081	2.471	*	Supported
H5	TT---PEU	0.245	0.062	3.921	***	Supported
H3	FSS---PU	0.409	0.063	6.437	***	Supported
H6	TT---PU	0.15	0.046	3.269	***	Supported
H8	PEU---PU	0.104	0.051	2.027	*	Supported
H9	PU---ITU	0.132	0.059	2.229	*	Supported
H4	FSS---ITU	0.248	0.059	4.192	***	Supported
H7	TT-ITU	0.126	0.039	3.204	***	Supported

*# Significant at P-value p<0.05; *** p<=0.001; ** p<=0.01, *p<= 0.05*
 # t-statistics > 1; β strongest relationship (0 to 1)

5.2. Mediation effect

Mediation analysis in SEM is a statistical method to investigate the underlying mechanisms or pathways through which an independent variable affects a dependent variable. Mediation analysis helps identify one or more intermediate between the predictor and outcome variables and explain their relationship. The results of the mediation effect denote that all the paths (TT-PU-ITU, FSS-PU-ITU, TT-PEU-PU, FSS-PEU-PU) have a partial mediation effect. Partially mediated relationships assume that the mediating variable contributes to some of the relationships between the independent and dependent variables. Partially mediated relationships are not merely characterized by a substantial association between the mediator and the dependent variable but also by direct interactions between them. The results of the mediation effect are shown in Table 6.

Table 6: Results of mediation effect (Authors own creation)

Path	Direct effect	Indirect effect	Decision
TT—PU—ITU	0.245 (0.001)	0.041 (0.009)	PM
FSS—PU--ITU	0.374 (0.001)	0.079 (0.009)	PM
TT—PEU-PU	0.210 (0.001)	0.037 (0.003)	PM
FSS—PEU—PU	0.450 (0.001)	0.021 (0.008)	PM

**Significant at P-value < 0 .1; parenthesis values (P-values); Partial Mediation (PM)

6. Discussion

The study identifies that the customer's willingness and the variables they perceived to be useful lead to adopting the technology. The study shows that FSS, COS, and TT positively influence ITU technology. Dwivedi et al. (2016) state that cost is essential in the implementation and intention to adopt the technology. The study hypothesis "H1(β = 0.284, T= 2.837, p=0.005)" supports the claim that PEU, PU and ITU of the technology are influenced by cost. The path coefficient COS significantly relates to the predetermined variables PEU and PU. The study of (Wong et al., 2020a; Nayal et al.,2021) agrees with our finding that cost saving significantly impacts the perceived usefulness and ITU of the technology. The analysis of the results indicates that the more the decision-maker believes in the usefulness of the technology and the value for money it provides, the more the intention to adopt the technology increases. The β value of PEU and PU of the variable COS is less than FSS and TT as BLCT is a high-end technology, and implementation cost as an individual technology can be higher even if implementing it as a group will reduce its initial investment cost (Roeck et al. ,2020). It decreases overall expenses and supports more users using its services than a single user. Also, its safety mechanism is more secure as the users are verified under a certain criterion before it can be used. Customer preferences often lead to processing small volumes of transactions as quickly as possible and at a low cost, which can be possible by adopting BLCT. Chen et al. (2020) state that BLCT will help reduce the network's intermediaries, leading to cost reduction. Jiang et al. (2022) state that customers tend to emphasize whether the transactions can be approved quickly and cost-effectively. By investing in blockchain resources, all trading partners will be able to coordinate their activities on one platform, facilitating instant, transparent transactions that are free of delays (Ali et al., 2021). BLCT is believed to boost security while saving time and money by minimizing documentation processes (Karakas et al., 2021). However, the initial capital required to implement BLCT might cause difficulties for the developing AFSC sector and may limit its adoption.

FSS describes a food product's level of assurance that it will not cause illness or injury during its production, serving, or consumption, which helps customers build trust in the product by reducing their concerns about food products. The variable FSS and the supporting hypothesis "H2(β = 0.2, T = 2.471, p = 0.013)"; "H3(β = 0.409, T= 6.437, p<0.001)"; and "H4(β = 0.248, T= 4.192, p<0.001)". state that FSS positively influences the intention and adoption of BLCT. A higher β value of the PEU and PU of FSS confirms that the FSS plays an important parameter that influences the adoption of the BLCT. The FSS, in particular, has not been discussed in any adoption model.

Nevertheless, Wang and Scrimgeour (2022) highlight that decision maker perception of food quality influences the intention to use the technology. The existing literature (Tan et al., 2018; Duan et al., 2020; Lin et al., 2020) provides a similar view. Integrating BLCT in the AFSC enhances decision confidence as it helps the food manufacturers to share information about the origin, batch numbers, and production dates, as well as promote food safety, certification, and organic products (Galvez et al., 2018), which act as a motivator for PEU and PU. BLCT enhances the ability to identify potential sources of contamination (Alladi et al., 2019), stop the illegal purchase of pesticides (Leng et al., 2018), and track the manufacturing and expiration date, which in turn helps reduce wastage. For instance, Walmart and Carrefour partnered with IBM's Food Trust blockchain network (Vu et al.,2021) to achieve real-time and end-to-end visibility at low costs.

Similarly, JBS integrated BLCT in their livestock farming to eliminate food fraud in their SC (Saha et al., 2022). These initiatives aim to enhance customers' trust and ensure safety and security in the AFSC. The decision-makers believe that a specific technology will help attain the objective, which leads to the ITU technology.

The variable TT of the SC can help increase decision-maker trust. Tracing the products to their origin has immensely helped to gain the trust of the decision-maker. Integrating BLCT in food traceability and transparency is an identification tool that helps track and trace food products quickly and accurately. The results "H5($\beta = 0.245$, $T= 3.269$, $p<0.001$)", "H6($\beta = 0.15$, $T= 3.269$, $p=0.001$)", and "H7($\beta = 0.126$, $T= 3.204$, $p=0.001$)" are in support of the hypotheses and show significant positive reliability to the adoption and intention to use the BLCT. The analysis supports (Queiroz and Wamba 2019; Wang et al., 2021; Wang and Scrimgeour, 2022), who state that TT is an essential determinant for the adoption of BLCT. TT brings trust and reliability to the system, which supports our analysis and is verified by (Queiroz et al., 2020) but in disagreement with (Queiroz et al., 2019). BLCT provides a reliable source of information about the origin of food products, allowing businesses to differentiate themselves from competitors (Vu. et al., 2021) and is perceived as valuable by decision-makers. However, the PU of TT falls short of FSS, maybe due to the SC members' lack of trust or the availability of other integrated technology like IoT, which is perceived as easier to use. Schulze-Ehlers et al. (2014) state that supplier, processor, and buyer asymmetry leads to a poor supplier-buyer relationship and an unoptimized SC. Li et al. (2022) and Wamba and Queiroz (2022) state that BLCT is ideal for increasing SC traceability, efficiencies, responsiveness, and managing supplier relationships. Adopting BLCT can help companies manage food safety crises more effectively, minimize the impact of food recalls, and enhance their SC productivity. BLCT's ability to track and trace also helps in storing and transporting the food, easing the process. In addition, it can also assist in speeding up the auditing and conflict resolution process, as financial records of all transactions can be documented and stored in the chain (Chang et al., 2020). Thus, the benefits of traceability and transparency are highly perceived to be useful and influence the adoption of BLCT in companies. In addition, the decision-maker will gain confidence in the provider and stop looking for alternative solutions, which will benefit the company (Villena et al., 2019). The technology's benefits contribute to perceived usefulness, significantly affecting the intention to use BLCT.

The last two Hypotheses (H8) and (H9) analysis show how PU and PEU of the technology positively influence the intention to use the technology. "H8($\beta = 0.104$, T= 2.027, p=0.043)" and "H9 ($\beta = 0.132$, T= 2.229, p=0.026)" support the hypotheses which are aligned with the findings in Lie et al. (2021) and Ullah et al. (2022). This suggests that the more decision-makers find the usefulness of the BLCT, the more they see the value of the technology and want to adopt it. Furthermore, the H9 has the smallest t value (t=2.027), which implies PEU of technology plays an important parameter in the ITU of the technology. The simpler the technology's ease of use, the better the decision-maker is ready to use it. Comparing our results with Queiroz et al. (2019), shows that trust, transparency, and traceability among the stakeholders and decision-makers influence the intention to adopt BLCT in the developing economy. To fully leverage the power of ease of use for BLCT adoption, organizations that use BLCT should showcase the benefits in their applications to increase customer trust. Governments and private organizations run many pilot projects to implement the technology in the system. In Latin America, the GrainChain startup company used BLCT to track the movement of the grain from farm to market, ensuring that farmers receive fair prices for their crops. Similarly, Agri10X, a startup in India, leverages digital technologies, including BLCT, to provide comprehensive solutions to every phase of the agricultural value chain, aiming to improve farmers' lives. By introducing trust in the system and lowering the cost of online transactions, BLCT also improves the organizations' synergy and efficiencies.

7. Conclusion

This research aims to shed light on the ITU BLCT in AFSC. According to the findings of this study, users intend to use a technology once they perceive its usefulness and ease of use. The study uses an empirical approach based on the proposed conceptual framework on TAM to analyze the ITU and the BLCT in the AFSC domain. The conceptual model was evaluated using SEM, and the results validated the proposed framework. Based on our statistical results, we can conclude that the perceived benefits of BLCT are translated into practical usefulness in three dimensions: food safety and security, transparency and traceability, and cost. According to the study, the perceived value of BLCT among AFSC practitioners in India is not driven by hype but by the knowledge of the perceived benefits. The findings show that practitioners and decision-makers believe in the usefulness of BLCT, which enhances the SC by reducing food losses and wastage and increasing quality and efficiency. The decision-maker believes that integrating BLCT will help to trace and track the product and identify the origin and flow of the product and any potential sources of contamination occurring in the network. When SC intermediaries can get a good quality product and a visible SC, it helps to build trust between the supplier and consumer, leading to a higher likelihood of technology adoption.

Finally, it is essential to recognize that implementing BLCT cannot be expected to happen overnight, particularly in developing nations where infrastructure and regulatory frameworks are still evolving. However, instead of relying solely on government intervention or aid programs for progress, the global aid community should focus on establishing standards and enabling investors and companies to adopt diverse solutions. This approach will promote platform interoperability and provide potential investors with deeper insights into blockchain-based investment opportunities while emphasizing their societal benefits within the AFSC domain. A well-designed standardization system could enhance transparency across borders by streamlining cross-border transactions and promoting ethical practices among businesses operating in emerging markets- ultimately benefiting both stakeholders involved and facilitating sustainable economic growth globally.

7.1. Research Contributions

7.1.1. Theoretical Contribution

The current study contributes to both theory and practice. Our research studies the acceptance of blockchain adoption technology by providing a TAM approach practical for innovative technology-based services. We find several factors that positively influence AFSC's intention to use BLCT. Our study highlights the driving factors, FSS, TT, and COS, influencing the intention to use BLCT based on TAM. Our results highlight the importance of including these factors as they help build the lane for adopting the technology.

As theorized by TAM, both PU and PEU significantly influence the intention to use BLCT (Yen et al., 2010). According to the empirical findings of (Kamble et al.,2018), PU is influenced by PEU, and the PU is explained by 28%, suggesting other factors may be at play. Our study shows similar results: R^2 (PEU)= 0.37, R^2 (PU)= 0.21 with three different constructs for PU. The value of R^2 accounted for PU for (COS)= 0.24, (TT)= 0.65, and (FSS)=0.38. The study implies that the higher the perceived benefits of implementing BLCT (saving time, efficiency, and convenience), the more likely users are to use it. The empirical results also indicate that BLCT's characteristics can influence

PU and PEU directly; the higher the ease of use and perceived benefit, the higher the chances of intention to use.

Furthermore, these findings highlight the importance of addressing technical considerations and user perceptions when introducing new technology solutions into an organization's workflow. This approach will help foster greater employee acceptance and engagement while maximizing ROI. The contingency perspective in this study advances our understanding of technology acceptance and makes the results relevant to practice.

7.1.2. Managerial Contribution

The emergence of BLCT technology has been a significant development in agriculture and food security. However, as this technology is still in its inception stage, it requires a more comprehensive understanding and awareness among manufacturers, policymakers, governments, and individuals for its effective implementation on a wider scale. BLCT demands higher technical knowledge from system designers or developers than traditional agricultural technologies, so they must simplify the setup process by providing clear instructions with an accompanying manual. Additionally, managers should collaborate closely with technology service providers to mitigate the high computing costs of adopting this new system. In particular, initial investment costs may be prohibitively expensive for some companies, which could deter them from investing in such advanced systems; therefore, reducing these expenses would encourage further adoption of this innovative approach toward farming practices - particularly given the increased demand for skilled professionals required during installation phases. Furthermore, given the potential benefits of BLCT technology for food security and agricultural sustainability, policymakers must develop supportive regulatory frameworks to promote investment in BLCT research and development.

7.2 Limitations and future research direction

Although the study provides insight into the intentions of using BLCT in AFSC, further research is required to address some limitations. Firstly, for the empirical study to find the ITU BLCT in AFSC, only the single SC decision maker perspective has been observed. Future research focusing on the dual perspective of the supplier- buyer’s ITU the technology is recommended. Secondly, while transparency and traceability, food safety and security, and cost were deemed essential variables examined by this study, incorporating additional factors such as technical knowledge, government intervention, regulatory framework about governance, and policy implementation practices aimed at societal benefits are recommended avenues worthy of exploration. Thirdly, the model is tested on a sample of 258 working professionals in the Indian AFSC domain, thus restricting its generalizability across other countries unless supplemented by further studies.

Nevertheless, practitioners, researchers, and scholars can apply and extend our proven model to other nations through additional research. A comparative study between the developed and developing nations can be conducted to understand ITU BLCT. In addition, the food- and agriculture-specific industries and country-specific ones may be examined to understand better the variables affecting or leading to adopting BLCT. Furthermore, a longitudinal study of practitioners' perceptions and the advanced industrial use cases would provide great insight into time-tested results.

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Annexure

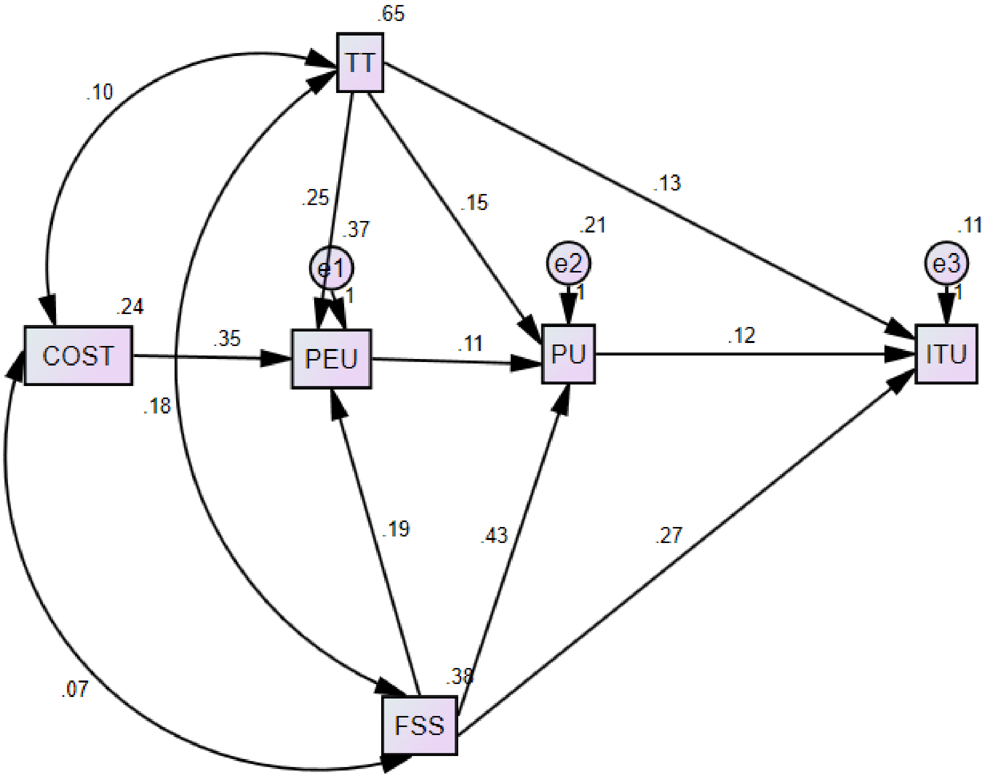


Figure A1 – Path analysis diagram of the conceptual framework (Authors own creation)

The Intention of Adopting Blockchain Technology in Agri-Food Supply Chains: Evidence from an Indian economy

Abstract

Purpose -This research explores the underlying intention behind using blockchain technology (BLCT) in the agri-food supply chain (AFSC). This is achieved by employing a conceptual framework based on Technology Acceptance Models (TAM) that considers various factors influencing user behavior towards implementing this technology in their practices.

Methodology- The conceptual framework developed is empirically validated using Structural Equation Modeling (SEM). A total of 258 respondents from Agri -food domain in India were involved in this survey, and their responses were analyzed through SEM to validate our conceptual framework.

Findings- The findings state that food safety and security, traceability, *transparency*, and *cost* highly influence the intention to use BLCT. Decision makers of the AFSCs are more inclined to embrace BLCT if they perceive the usefulness of the technology as valuable and believe it will enhance their productivity.

Implications- The study contributes to the existing literature by providing thorough examination of the variables that influence the intention to adopt BLCT within the AFSC. The insights aim to benefit industry decision-makers, supply chain practitioners, and policymakers in their decision-making processes regarding BLCT adoption in the AFSC.

Originality/Value- The current study investigates how decision-makers' perceptions of BLCT influence their intention to use it in AFSCs, as well as the impact of the different underlying factors deemed valuable in the adoption process of this technology.

Keywords: Blockchain (BLCT); Food security and safety; Agri-food supply chain (AFSC); Technology Acceptance Models (TAM); structural equation modelling (SEM)

4. Introduction

Food and agriculture are crucial for the Indian economy, but traditional technologies remain prevalent. With an estimated population of 9.6 billion by 2050, the food supply must increase by 70% (FAO 2009; Gardas et al.,2017). Blockchain technology (BLCT) is a potential solution to maintain traceability and transparency in the agri-food supply chain. Modern companies require transparency in food product history and secure information throughout the supply chain (Dabbene et al. 2014). Globalization and increased competition have strained the agri-food supply chain, leading to increased competition and a more complex supply chain. BLCT can help provide proof and authenticity of sources.

BLCT can initiate many changes in the industry (Agrawal et al., 2023). It can change the business models of existing firms, change the level and nature of demand, affect the competitive positions of various players in the industry, and have a profound impact on the market (Lanzolla et al., 2012; Saurabh et al., 2023). Technology has proven effective as information moves through the SC (Guggenberger et al.,2020; Ali et al., 2021). As a new decentralized and distributed technology, BLCT can transform a wide range of industries by enabling transactions to be recorded and verified in a secure, transparent, and immutable manner. It can address major supply chain management (SCM) issues like visibility, traceability, and transparency (Ahmed et al., 2022). The concept of Blockchain for Good (B4G) gives rise to novel applications that can drive the United Nations Sustainable Development Goals (Trollman et al., 2022).

Integrating BLCT in AFSC can provide innovative solutions for product traceability and food safety (Feng et al., 2020; Kumar et al., 2023a). As a result, many of the current challenges of food safety, security, and transparency faced by SCs can be resolved (Gardas et al.,2019). The immutable and decentralized nature of the BLCT helps to eliminate information asymmetry in SCs by storing data in the form of blocks, enabling the storage and trading of tangible and intangible assets with increased efficiency, reducing risks, and lowering costs (Li. et al.,2021). By providing direct linkages between farmers, retailers, customers, and producers, BLCT helps to restructure AFSCs, improving food quality and transparency and minimizing food fraud and wastage (Li et al., 2021; Collart and Canales, 2022). According to Wang et al. (2021), a BLCT tracing system increases SC transparency and process management and reduces intermediary costs, improving SC service and confidence. With the importance of Blockchain technology in advancing AFSC to greater transparency and traceability, it still faces issues in adoption; thus, the research question still needs to be addressed: *What factors are perceived as helpful in adopting the BLCT in AFSC?*

Successful adoption of BLCT in AFSC will confer a competitive edge and unparallel opportunities to the sector. A significant number of practitioners and scholars point out the BLCT's ability to transform SCs (Schmidt and Wagner, 2019; Wang et al., 2019b; Chang et al., 2020; Wamba et al., 2020) and (Zhang et al., 2020; Ali et al., 2021; Mangla et al., 2021; Vikaliana et al., 2021) studied BLCT in many agri-food industries to understand the implementation benefits and challenges. However, the scarcity of information and an inability to apply BLCT to widely spread applications have hindered such applications, specifically in developed economies. Also, gaining acceptance from key stakeholders and decision-makers remains a pivotal factor in successfully implementing such innovations. Therefore, it is critical to establish the intention to use BLCT in AFSC to understand the factors influencing its adoption and develop strategies for promoting its successful implementation.

And thus, this study intends to address the second research question: *How do the factors identified influence the intention to adopt BLCT in AFSC?*

Integrating BLCT into the AFSC requires user acceptance and understanding of the factors they perceive as essential for adoption. To ensure the benefits of BLCT, AFSC decision-makers must ensure it benefits their organization and secures consumer trust. To achieve this, a comprehensive assessment of user perceptions and attitudes towards the new technology is necessary (Saha et al., 2023; 2023a). Over time, numerous studies have explored this topic with varying degrees of detail, including seminal works authored by (Venkatesh et al., 2003; 2012; Queiroz and Wamba, 2019a). The Technology Acceptance Model (TAM) is a theoretical framework used to evaluate users' willingness to accept and utilize new technology. The original TAM model, proposed by Davis in 1989, has evolved into different versions, each with unique features. It focuses on perceived usefulness and ease of use, making it a straightforward and practical model for researchers and practitioners studying and improving user acceptance of technology.

User acceptance of the BLCT and its influencing factors, play an important role in the technology's adoption. By considering different technology adoption models and independent variables that influence user acceptance of BLCT, it is possible to predict the level of user acceptance of BLCT in the AFSC domain. Furthermore, it is crucial to understand the decision makers' intention in adopting BLCT, considering this technology's disruptive potential (Wamba and Queiroz 2020) and its unprecedented impact on SCs. Though recent research (Yadav et al., 2020; Liu et al., 2021; Trollman et al.,2022; Kumar et al., 2023a) investigated the potential and factors of BLCT in AFSC, the factors contributing to its widespread acceptance and intention to acknowledge the technology have been overlooked. While few authors (Kamble et al., 2019; Nayal et al.,2021; Paul et al.,2021) emphasized its impact on SC, they did not identify the key factors influencing decision -makers' intentions for BLCT adoption, resulting in gaps in understanding the SC dynamics and stakeholders' perspective. Thus, this study investigates the factors influencing decision-makers intentions to use BLCT in AFSC. The study conducts empirical research using SEM and proposes a conceptual framework based on TAM to study the intention to use BLCT and shed light on the following research objectives (ROs):

RO1: To explore the factors helpful in adopting the BLCT in AFSC.

RO2: To examine the user intention to adopt BLCT in AFSC.

Since blockchain is still in the inception stage and adoption of the technology remains a challenge, this research delves deeper into identifying and understanding the factors that influence the adoption and intention to use BLCT in AFSC. To achieve this, the study is based on TAM, which prioritizes perceived usefulness (PU) and perceived ease of use (PEU) as predictors of intentions to use (ITU). TAM is used to build the study's conceptual framework, which identifies critical factors impacting ITU while also studying their effects on the TAM construct to gain better insights toward successful implementation. These findings will enable the decision-makers to develop more robust strategies to integrate BLCT across the AFSC effectively. By understanding the factors that drive technology adoption, tailored implementation plans can be fostered for the Indian AFSC.

The research paper is laid out in the following pattern. Section 2 discusses the overview of the relevant literature. Section 3 presents the conceptual framework's development and the formulation of the hypotheses. Section 4 addresses the research design. In Section 5, the data analysis and findings are presented. Section 6 includes a discussion and theoretical and practical contribution of the study. Finally, section 7 concludes the paper with a discussion on future directions.

5. Literature Review

5.1. Blockchain technology and AFSC

Integrating BLCT in AFSC offers a comprehensive solution to trace, track and monitor the entire length of the supply chain (Kayikci et al.,2022; Srivastava et al., 2022), ultimately leading to greater transparency and trust (Liu et al., 2022; Sharma, 2023). While traditional SC have long struggled with food safety concerns, BLCT can address these issues by increasing visibility throughout the chain (Kshetri 2019). Research studies conducted on BLCT and SC integration revealed that adopting this technology improves transparency, authenticity, and real-time transactions (Mukherjee et al., 2021; Feng et al.,2020; Xu et al.,2020). Furthermore, (Sunny et al., 2020) suggest that transparency and traceability are critical factors that impact a logistics organization's overall performance – making it essential for businesses to prioritize integrating BLCT into their SCs. Providing complete visibility upstream and downstream of AFSC-BLCT helps establish accountability across all supply chain stages while enhancing its trustworthiness (Rogerson and Parry, 2020). More and more value chains are incorporating BLCT to make them flexible and strengthen customer ties (Murki et al., 2018). This is a major movement in the rapidly expanding food industry, where BLCT is seen as the best option for tracking and changing. The potential uses of BLCT in the agri-food value chain have been the subject of several studies (Zhao et al., 2019). One such study used RFID and blockchain to create a system to track the agri-food supply chain in China (Tian. 2016).

Further applications of blockchain technology include an IoT software connector, a distributed ledger manufacturing supply chain that is blockchain-ready, and a supply chain traceability solution that is both transparent and decentralized. By facilitating the transfer of more precise and trustworthy data between producers and consumers, BLCT has shown to be more effective than conventional approaches in food supply chains (Zhao et al., 2019). Because of this, the food sector is now more efficient and cost effective. Ultimately, the food sector is realizing the importance of BLCT, which provides a safer and more effective method to monitor and record food supply chains. Businesses may improve their operations and cut expenses by using BLCT in several industries, including supply chains, logistics, and agriculture.

As the research shows, integrating BLCT in AFSC is an innovative move that promises many advantages. With its ability to improve transparency and trust throughout the SC, BLCT has been proven beneficial for AFSC. However, it is worth noting that despite this promising development, the intention to use BLCT in AFSC is still relatively new and requires further exploration before its potential benefits can be fully realized. For decision-makers to effectively integrate BLCT into their AFSC, they must first believe in its perceived usefulness and ease of use of the technology. This requires a deeper understanding of how BLCT works, and which factors benefit and fit within their specific industry context.

5.2. ***Research Gaps***

BLCT adoption and intention to use in SC has been studied by various authors such as Wamba & Queiroz (2020) in the Brazilian SC, Queiroz et al. (2021) in logistics and SC, Karamchandani et al. (2022) for the service SC, Sternberg et al. (2021) in inter-organizational SC. While several models on BLCT adoption have emerged in recent years within the agriculture and food sectors context, studies such as (Saurabh and Dey, 2021; Ronaghi, 2021; Paul et al., 2021; Liu et al., 2021; Yadav et al., 2020; Susanty et al., 2021), did not fully explore critical issues that drive its widespread acceptance. Queiroz et al. (2021) conducted a comprehensive study on adopting BLCT, predicting the likelihood of implementing BLCT, while Queiroz and Wamba (2019) emphasized that performance expectancy is one of the enabling conditions of BLCT adoption. Interestingly enough, both US-based firms and Indian organization were found to be influenced by this factor. Furthermore, Wong et al. (2020a) focused on additional considerations related to adopting BLCT - specifically costs incurred during the implementation phase, regulatory support from authorities, top management involvement & encouragement towards its utilization within organization frameworks. The results indicated that cost implications had widespread influence over intentions regarding adoption rates among respondents surveyed. Several scholarly studies have delved into the multifaceted ways in which BLCT can impact and influence the performance of SCs, as observed by Nayal et al. (2021), Masudin et al. (2021), and Paul et al. (2021). Vasan et al. (2023) has explored the farmers' belief in adopting technology, but the entire supply chain has not been discussed. These investigations shed light on a complex interplay between BLCT and SC but fail to uncover the potential factors that are perceived useful by decision makers and lead to the intention to use the technology. Also, the intention to use BLCT in Indian AFSC has not been explored much through TAM.

Although few studies have been conducted on the potential for blockchain adoption in supply chain management, a more comprehensive analysis of users' intentions to use BLCT is necessary. Understanding the factors that motivate users to embrace this technology will be crucial in driving its widespread adoption throughout AFSC. To truly integrate blockchain as a solution, it is essential to examine BLCT's perceived usefulness and user motivation. To shed light on these key aspects of blockchain implementation, empirical research has focused on ITU BLCT in AFSC and variables deemed useful by prior literature. Notably, cost (COS), food safety and security (FSS), transparency and traceability (TT) have emerged as salient concerns related to adopting this technology within supply chains. A TAM framework has been adopted to comprehend how independent variables affect both PU and PEU of the technology, ultimately leading towards higher rates of ITU- BLCT in AFSC.

6. Hypotheses Development and Conceptual Framework

3.1 Technology Acceptance Models (TAM)

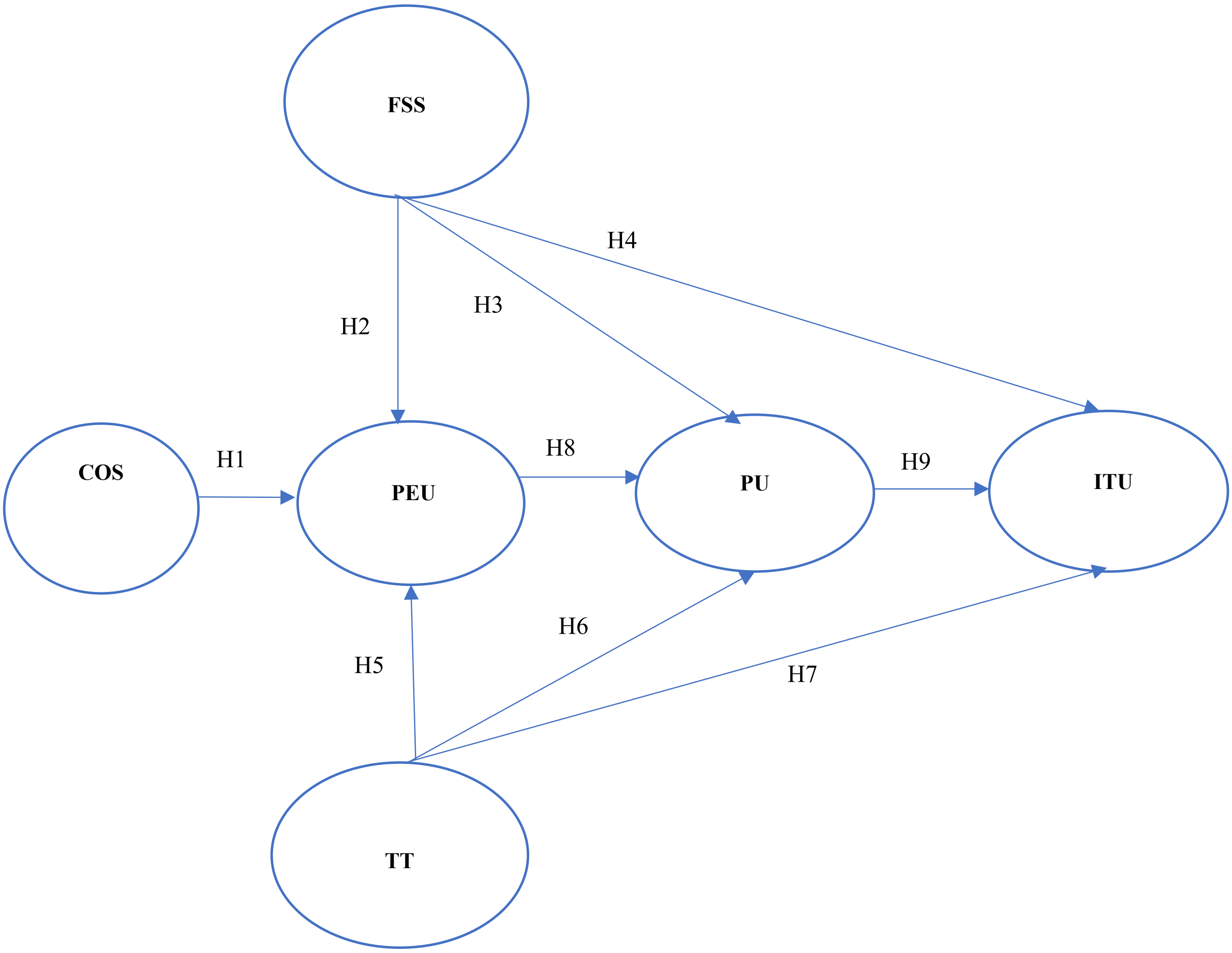
Technological advancements continue to be significant in business, and acceptance of technology is required to implement them successfully. In light of this reality, companies must deeply understand the factors contributing to successful implementation. To elucidate these complexities, this study relies on TAM, originally proposed by Davis (1985), as an instrumental tool for assessing technological adoption. Extensive research has been conducted exploring different aspects of TAM over the years, including but not limited to the works by (Davis, 1985, 1989; Venkatesh and Davis, 2000; Venkatesh et al., 2003; Venkatesh and Bala, 2008; Venkatesh, Thong and Xu, 2012). By examining individual or organizational reasons behind technology uptake through applying the TAM framework, we can gain insight into how best to facilitate its utilization within businesses.

TAM has long been a cornerstone in the field of technology acceptance research. Although numerous variations, such as TAM2 and extended TAM models, have emerged, the original model still holds significant weight due to its extensive validation. Venkatesh and Davis (2000) argue that while newer versions introduce new variables like social influence and cognitive instrumental processes, their complexity may limit practical application. This debate was put to the test by Wu and Wang's (2005) study comparing the usefulness of both original TAM versus extended version- results showed that although expanded versions explained more variance in data, the simplicity provided by the original model made it an effective tool for predicting technology acceptance patterns with reasonable accuracy. Ultimately, this affirms support for utilizing original TAM as an undeniably successful methodology for seeking insights into understanding how users accept new technologies effectively under varying contexts.

TAM explores the link between PU, PEU, and ITU characteristics. Using TAM, Davis et al. (1989) proposed that PU, and the attitude toward use, influence technology adoption. PU assesses an individual's attitude towards technology. This attitude usually reflects how much benefit they expect from using the technology and how much effort they think they will have to expend to use it. Furthermore, it is anticipated that PEU has a direct effect on PU. PEU represents how easy it is for an individual to use the product/service. A product with a high PEU score will be perceived as easy to use and therefore more likely to be adopted by users. ITU is the willingness of an individual to use a technology once the individual is aware of it. It is determined by measuring the level of motivation to use the technology in question as well as a person's attitude toward using such technology.

4.2 Conceptual framework

The conceptual framework has been adapted from Venkatesh et al. (2003). The framework based on the TAM concept studies the perceived usefulness (PU) of the BLCT in the AFSC. The framework consists of three variables: COS, FSS, and TT, identified from the literature review as influential on the adoption and ITU the BLCT technology. Figure 1 shows the proposed conceptual framework. While the model is comprehensive, it may not cover all factors influencing the adoption of BLCT. However, to ensure parsimonious measurement instrumentation and considering the survey length, the study was limited to only three variables FSS, COS, and TT.



"*COS- Cost; FSS- Food safety and security; TT- Transparency and traceability; PEU- Perceived ease of use; PU- Perceived usefulness; ITU- Intention to use"

Figure 1: Conceptual framework

3.1 Cost

The cost of adopting a new technology goes beyond just the financial aspect. It also includes emotional effort, time, and energy investment to learn and integrate it into existing systems. However, this initial expense can eventually save money by streamlining operations and reducing transactional costs in the long run. Decision-makers are more likely to invest in technologies that will significantly reduce operational expenses over time. One such innovative solution proposed by Li et al. (2021) is using BLCT for automation, which eliminates manual involvement, intermediaries, and paperwork, thus minimizing costs associated with supply chain management. Incorporating smart contracts further helps optimize procurement processes as suppliers receive prompt payment upon delivery confirmation while reducing human interaction between parties. Vu et al., (2021) demonstrate that such automated procedures streamline workflows and cut down on transaction expenditures like distribution expenses or data encryption fees, thereby boosting overall efficiency levels. A recent study conducted by Du et al. (2020) found that adopting blockchain technology can lead to improved efficiency and cost reduction. Building on this, Ko et al. (2018) discovered that the costs associated with implementing new technologies directly impact users' perception of usefulness, ultimately influencing their decision to adopt or reject these innovations. However, the perceived cost might not directly influence users' beliefs about the usefulness of the technology or their intention to use it. These aspects are more related to the perceived benefits and value that the technology provides. The influence of cost is mediated through the perceived ease of use of the technology rather than directly impacting perceived usefulness or intention (Luarn et al., 2005; Amoako-Gyampah, 2007; Yen et al., 2010). So, we propose the hypothesis:

H1. Cost positively influences the PEU of BLCT.

3.2 Food Safety and Security

Food safety and quality assurance are more challenging with the increase in the global flow of goods (Fischer, 2013). Food safety and security methods include handling, processing, preparing, and storing meals in a way that reduces the likelihood of people becoming ill due to contaminated foods. Thus, FSS refers to delivering a product that has not been contaminated, damaged, or tampered (Marucheck et al., 2011). BLCT helps make the FSC more visible, traceable, and accountable, ensuring safety and security (Gupta and Shankar, 2023). BLCT minimizes food fraud by ensuring that records are transparent and traceable (Danese et al., 2021). As financial records for all operations are documented and stored in the chain, it can also speed up auditing and conflict resolution (Chang et al., 2020). In addition, the BLCT allows parties to update product information in near real-time, minimizing the possibility of cross-contamination and improving responsiveness. It also assists in providing food safety status in real-time to all SC decision-makers, thereby providing a secure, distributed, transparent, and collaborative information system. In their research, Roy et al. (2020) state that food safety and security are essential in earning SC decision-maker trust. Trust leads to the PEU of technology, thereby increasing the PU and ITU the technology leading to the following hypotheses:

H2. Food safety and security positively influence the PEU of BLCT.

H3. Food safety and security positively influence the PU of BLCT.

H4. Food safety and security positively influence the ITU BLCT for AFSC.

3.3 Traceability and Transparency

SC traceability and transparency has become increasingly important to sustainable management (Mollenkopf et al.,2022) A traceable and transparent SC demonstrates that an organization is honest and upfront about how it conducts business (Kafetzopoulos et al., 2023) A blockchain-based traceable SC increases visibility, improves quality controls, and reduces risk (Chavalala et al., 2022). Transparency builds trust among suppliers, companies, and customers. Astill et al. (2019) state that traceable and transparent food production systems must facilitate data exchanges between stakeholders as this will lead to expediting processes and a reduction of transaction times. Kamath (2018) discusses how BLCT helps trace and identify the SC's origin and path and build SC decision-maker trust. Being an immutable technology, BLCT reduces human intervention and is thereby helpful in food recall and food wastage (Duan et al., 2020). The traceability and transparency benefit of BLCT leads to the PU and ITU of the technology. Hence, we suggest the following hypotheses:

H5. Traceability and transparency positively influence the PEU of BLCT.

H6. Traceability and transparency positively influence the PU of BLCT.

H7. Traceability and transparency positively influence the ITU BLCT for AFSC.

3.4 Intention to Use

Perceived adoption intention refers to a user's active intention to adopt a specific technology (Queiroz & Wamba, 2019). Among the main strands of the technology management literature, an important focus is on adoption intention, which explains how individuals or decision-makers respond to a given technology that may lead to its actual usage. Research has shown that adoption intention is one of the most significant predictors of technology usage (Venkatesh et al., 2012) and competitiveness (Kshetri, 2018). In their research, Davis et al. (1989) define perceived usefulness as the degree to which a user believes employing a given framework would improve productivity and efficiency. The literature shows that perceived usefulness significantly influences users' attitudes and intentions. Currently, BLCT is being used in a wide range of sectors. The users are more likely to be positive towards BLCT if they perceive it as useful and can increase efficiency. "Perceived ease of use" refers to how easily someone believes a particular technology or system is used (Davis, 1989). The literature shows that PEU positively affects PU (Venkatesh and Davis, 1996). Increasing user perceptions of BLCT as useful will make users more positive (Liu et al., 2021). Maintaining competitiveness, easy tracking and tracing of products, monitoring fair trade, cooperating with multiple participants, and building SC decision-maker trust may influence the use of BLCT for achieving benefits for firms and lead to the ITU of the technology. Hence, the followings hypotheses have been formed:

H8. PEU positively influences the PU of BLCT.

H9. PU positively influences the ITU BLCT for AFSC.

5 Research Design

4.1 Questionnaire Design

The study uses in-depth interviews and questionnaires to examine the impact of different factors on the intention to use BLCT. The survey method is used to elicit information about respondents' backgrounds and attitudes as well as their intentions for using BLCT. A five-point Likert scale ("strongly agree to strongly disagree") was selected to measure the items and variables. The survey questionnaire was designed based on the previous literature and were validated by experts (industry and academician). Six variables and 24 items were used in the survey. The constructs utilized in the questionnaire are listed in their sources in Table 1. Six industry and 4 academic experts working in the agri-domain were asked to evaluate the questionnaire and check each construct for its reliability and validity. They reviewed the items for ambiguity, consistency, and relevance to the survey (Kumar et al.,2022). In addition to ensuring the consistency and reliability of the questionnaires for large-sample surveys, the validity and reliability of each scale are also checked.

Table 1: Variables and Items Table

Variable		Item	Description	References
Cost	COS1	Adoption cost	"The elements indicate the entire expenses linked with the implementation of BLCT. It helps in reducing the overall AFSC expenses by minimizing the middle entities. It also helps	"Tapscott et al., (2018); Creydt and Fischer, (2019); Ivanov et al., (2019); Yadav and Singh (2020); Wong
	COS2	Technology cost		

	COS3	Maintenance cost	in reducing the operating cost, manpower cost, and maintenance costs via investing less in consumable items, compact data storage, sharing database, faster payments, less human interaction, rapid decision-making, strong management, and an efficient SC.”	et al., (2020a); Sternberg et al., (2021); Vu et al., (2021).”
	COS4	Transaction cost		
Food Safety and Security	FSS1	Improve food quality	“Food Safety and Security suggest that BLCT is an effective technology to avoid food fraud, reduce cross contamination, and increase trust in the AFSC. BLCT helps to retrieve the required information, confine contaminated products from suppliers, and minimize the products recall range. BLCT also provides data security from cyber threat and food fraud. The data are stored in immutable blocks and cannot be tampered.”	“Galvez et al., (2018); Tan et al., (2018); Astill et al., (2019); Creydt and Fischer, (2019); Duan et al., (2020); Lin et al., (2020).”
	FSS2	Reduce cross contamination		
	FSS3	Maintain records		
	FSS4	Ensure security		
Traceability and Transparency	TT1	Reduce food wastage	“BLCT helps to manage inventory, transportation, and tracking of products. Firms can track the information on the storage life of food products better thereby improving profits. BLCT can also assist in promoting economic sustainability of the AFSC by reducing food waste and food recalls. It shortens the time to process the food and track the inaccessible data which can be utilized to improve SC procedures and build SC decision-maker trust.”	“Kamath, (2018); Astill et al., (2019); Jen Yin Yeh et al., (2019).”
	TT2	Reduce food fraud		
	TT3	Easier food recall		
	TT4	Improved tracking		
	TT5	Increase in SC decision-maker trust		
Perceived ease of use	PEU1	ease of use	“BLCT contributes to address the complex industrial systems (CISs) challenges. BLCT reduces the intricacy of cash data storage and recovery system of AFSC, inventory, marketing, finance, and other departments. Operational usefulness has a	“Venkatesh et al., 2003, 2012); Christopher Lee et al., (2019); Queiroz et al., (2019).”
	PEU2	ease of understanding		
	PEU3	Compatible to use		

			positively influence on the BLCT's ease of use."	
Perceived usefulness	PU1	Improve performance	"BLCT enhances the AFSC's performance and simplifies the complex AFSC network by tracking and tracing the entire SC. Thereby improving safety and security. It also maintains and stores records in an immutable form which is easy to access but difficult to tamper."	"Kamath, (2018); Christopher Lee et al., (2019); Creydt and Fischer, (2019); Kshetri, (2019); Hew et al., (2020); Gao et al., (2020); Vu et al., (2021)."
	PU2	Simplify process		
	PU3	Improve safety and security		
	PU4	Increase traceability		
	PU5	Maintain records		
Intention to use	ITU1	Innovative technology	"BLCT is an innovative distributed technology that helps build trust, reliability, and satisfaction among the SC decision-maker as it can provide farm to fork data. BLCT helps to build a better and smooth-running transaction facility."	"Kamath, (2018); Kamilaris et al., (2019); Kshetri, (2019); Lin et al., (2020); Schinckus, (2020); Wang et al., (2020)."s
	ITU2	SC decision-maker satisfaction		
	ITU3	Better transaction facility		

4.2 Sampling and data collection

Data are collected from the questionnaires provided to Indian agri-food practitioners working in the domain for at least 2.5 years and having a basic knowledge of BLCT. Data are collected between June and August 2022 from multiple agro-based Indian companies to generalize the findings to a broader range of companies (Nayal et al., 2021). The purposive sampling technique is used as the sampling method to identify the interviewee. Respondents are also addressed individually whenever possible to enhance the survey response rate. Five hundred professionals from the agri-based industry, including vegetables and fresh fruits, dairy, and beverage industry, knowing the technology implementation benefit, are invited to participate in the study. Of 550 professionals, 258 provided useful answers (a response rate of 46.9%). The average participant's ages are between 36 and 55 years old. It has been observed that the male respondents outweigh the female respondents, with the majority of participants aged 25 to 75 years. The participants' demographic characteristics are categorized in "Table 2".

Table 2: "Demographic profile of the respondents" (N -258)

Items		**N**	**Percentage**
Age	25-35	96	37.2
	36-55	104	40.3
	56-75	58	22.5
	Total	**258**	
Gender	Male	140	54.26

	Female	118	45.73
	Total	**258**	
Educational Qualification	UG	98	38
	PG	107	41.5
	PhD	53	20.5
	Total	**258**	
Years of Experience	0-5	87	33.7
	5-10	58	22.5
	10-15	62	24
	15-20	51	19.8
	Total	**258**	

4.3 Non response and common method bias (CMB)

Non-response bias was mitigated by employing exploratory and subjective approaches (Armstrong and Overton, 1977). To evaluate the difference in means for every scale, the t-test is conducted for the early and late responses of the participants for a non-response bias test (Karamchandani et al.,2020). No significant difference in the scale items for each construct was found for this study. To prevent the common method bias (CMB), the questionnaire was conscientiously designed and tested with expert practitioners. Anonymity was ensured during data collection, and respondents were assured that there were no right and wrong answers, emphasizing the significance of truthful answers (Podsakoff et al., 2003). It is important to check and control CMB when the data from all the constructs in a model are collected from a single respondent (Podsakoff and Organ, 1986). To minimize the effect of common method variance, the sequences of the survey questions for every respondent were randomly assigned, and the respondents were asked to give honest feedback while they were also assured that their responses would remain anonymous (Podsakoff et al., 2003). In addition, Harman's single-factor analysis was performed to evaluate and mitigate the potential presence of biases. The results showed a single factor of less than 40% of the variance, suggesting no CMB. Even though common method bias affects the linear relationships, it seems to have fewer effects on the analysis of interactions between variables.

6. Data Analysis and findings

SEM is the statistical method used for hypotheses testing. With SEM, one can validate the suitability of TAM in analyzing BLCT's ITU. SEM helps specify, estimate, and evaluate models of linear relationships among variables in relation to a relatively small number of unobserved variables (Shah et al.,2006). The data analysis was carried out using AMOS software, which has all the tools necessary for creating and examining SEM path diagrams (Nayal et al., 2021) and analyzing SPSS files (Mangla et al., 2020). IBM-SPSS Amos is robust software for SEM that allows users to validate their research and hypotheses by expanding conventional multivariate analysis techniques, such as regression, factor analysis, correlation, and analysis of variance. Using SPSS-Amos, one can develop intricate attitudinal and behavioral models that depict complex relationships more precisely than traditional multivariate statistical methods through an intuitive graphical or programmatic user interface (IBM, 2017; Dash et al., 2021).

SEM relies on path diagrams to provide a clear picture of the relationships between variables (Ullman and Bentler, 2012). For the SEM model fit, 100 sample size is qualified as fair; the current sample size is 258 beyond the threshold value (Ganbold et al., 2021). “Exploratory factor analysis (EFA)” and “confirmatory factor analysis (CFA)” were performed before the SEM analysis. EFA measures the correlation between constructs in a dataset by analyzing the correlations between them. It also reduces the broad data set to smaller set. Bartlett’s test of sphericity and “Kaiser-Meyer-Olkin (KMO)” helps to understand the suitability of the data. The results show that the KMO value is 0.851(value>0.7), which is satisfactory. The measurement model is validated using CFA to identify how well the conceptual framework reflects the data. The results show that the Chi-square test result is 1.716 (< 3.0), the “Goodness fit index (GFI)” is 9.51 (>9.50), the “comparative fit index (CFI)” is 0.951, and the “Root mean square error of approximation (RMSEA)” is 0.053, which suggests that the model is a close fit.

5.1. Structural model assessment

To evaluate how reliable or consistent the questionnaires are, they are tested for dependability. The analysis reveals the extent to which measurement inaccuracies impact (or do not affect) the gathered data. In general, it is acknowledged that data can be regarded as credible if Cronbach’s alpha is greater than 0.70 (Teo et al., 2015; Kumar et al. 2022). Table 3 shows that all the item loadings exceeded the 0.70 threshold, providing evidence of convergent validity (Jiang et al.,2020). Therefore, the items for each construct and the complete questionnaire have good internal consistency. Composite reliability (CR) in Table 4 shows that all six constructs are higher than 0.7, indicating that all the six are valid. Tabachnica and Fidell (2007) state that if the average variance extracted (AVE) is larger than 40%, the measurement questions represent the features of each study variable in the model. Each variable in Table 3 has an AVE value higher than 0.5, denoting convergent validity of the scale. Convergent validity can be further examined by analyzing the AVE t-values for factor loadings, and composite reliability (construct reliability) (Chau, 1997; Fornell & Larcker, 1981).

Discriminant validity can be evaluated by examining the square root of AVEs for each latent variable with its correlation to the other constructs (Fornell and Larcker, 1981). Table 4 shows the correlations between the constructs and demonstrates the discriminant validity of the variables. The correlation coefficient is higher than the square root of the AVE, and the AVE value for every construct is more than 0.5, suggesting that the constructs have significant discriminant coefficients, and that the model's intrinsic quality is ideal.

The path diagram of SEM prepared in "AMOS-20.0" is shown in Figure 2. The results of the SEM and the path analysis of the conceptual framework are displayed in Table 5. They include "the path, coefficient, standard deviation, t-value, and p-value". The findings show that all nine hypotheses support, which leads to the conclusion that all the independent variables, COS, FSS, and TT, positively influence the dependent PEU, PU, and ITU. Statistical significance was found across all paths in the framework, with standardized "path coefficients ranging from 0.1 to 0.4". The path coefficient(β), (+/-1) indicates the degree of change in the outcome variable for each one unit change in the predictor variable. P values (<0.05) determine that the hypothesis results are statistically significant. The value shows a positive relationship between the independent variables (COS, FSS, and TT) and the dependent variables (PEU, PU, ITU). The findings reveal that food safety and security is perceived as the most important useful factor influencing the ITU the technology, followed by cost and traceability.

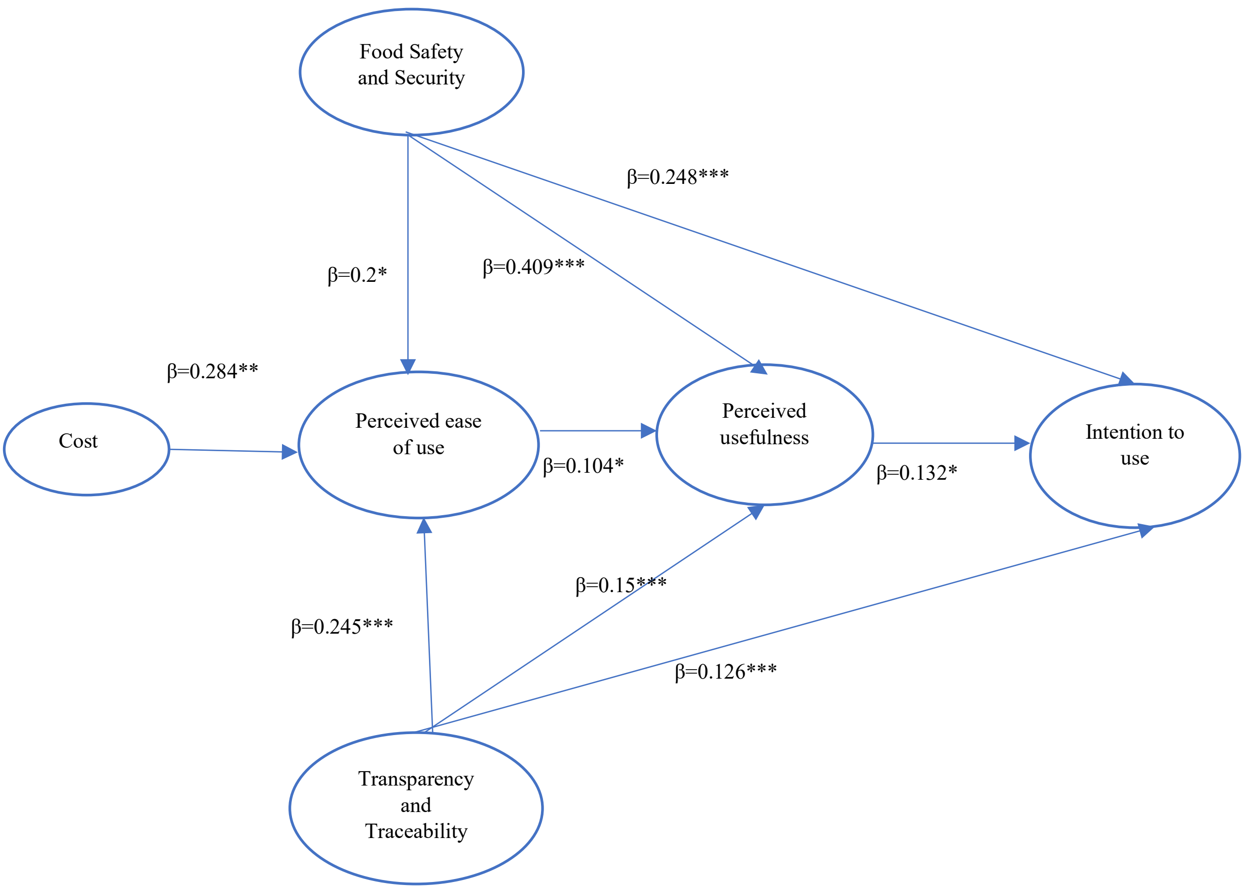


Figure 2: Measurement model (*** p<0.001, ** *p<=0.01, *p<= 0.05)*

Table 3: Items; loading factors; Cronbach's alpha (α); Composite reliability (CR); average variance extracted (AVE)

Constructs	Items	Loading factors	α	CR	AVE
Perceived usefulness	PU3	0.961	0.946	0.946	0.596
	PU4	0.943			
	PU2	0.839			
	PU5	0.811			
	PU1	0.804			
Perceived ease of use	PEU3	0.861	0.887	0.888	0.602
	PEU1	0.842			
	PEU2	0.793			
	PEU4	0.757			
Transparency and traceability	TT1	0.952	0.899	0.9	0.539
	TT5	0.923			
	TT2	0.730			
	TT3	0.678			
	TT4	0.638			
Food safety and security	FSS3	0.994	0.911	0.913	0.543
	FSS2	0.935			
	FSS5	0.719			
	FSS1	0.674			
	FSS4	0.673			
Cost	COS3	0.798	0.751	0.756	0.523
	COS2	0.729			
	COS4	0.618			
intention to use	ITU4	0.780	0.819	0.834	0.621
	ITU3	0.778			
	ITU2	0.754			
	ITU1	0.614			
	ITU5	0.584			

Table 4: Discriminant validity

Factor	PU	FSS	TT	ITU	PEU	COS
PU	**0.544**					
FSS	0.53	**0.776**				
TT	0.393	0.348	**0.734**			
ITU	0.44	0.51	0.42	**0.737**		
PEU	0.343	0.311	0.381	0.327	**0.723**	
COS	0.14	0.221	0.214	0.173	0.297	**0.788**

Table 5: Path coefficients, standard error, t-statistics, and *p*-values

“Hypotheses”	“Path”	“Coefficient”	“Standard error”	“t-statistics”	“P-values”	“Supported/ Not supported”
H1	COS---PEU	0.284	0.1	2.837	**	Supported
H2	FSS---PEU	0.2	0.081	2.471	*	Supported
H5	TT---PEU	0.245	0.062	3.921	***	Supported
H3	FSS---PU	0.409	0.063	6.437	***	Supported
H6	TT---PU	0.15	0.046	3.269	***	Supported
H8	PEU---PU	0.104	0.051	2.027	*	Supported
H9	PU---ITU	0.132	0.059	2.229	*	Supported
H4	FSS---ITU	0.248	0.059	4.192	***	Supported
H7	TT-ITU	0.126	0.039	3.204	***	Supported

*# Significant at P-value p<0.05; *** p<=0.001; ** p<=0.01, *p<= 0.05*
 # t-statistics > 1; β strongest relationship (0 to 1)

5.2. Mediation effect

Mediation analysis in SEM is a statistical method to investigate the underlying mechanisms or pathways through which an independent variable affects a dependent variable. Mediation analysis helps identify one or more intermediate between the predictor and outcome variables and explain their relationship. The results of the mediation effect denote that all the paths (TT-PU-ITU, FSS-PU-ITU, TT-PEU-PU, FSS-PEU-PU) have a partial mediation effect. Partially mediated relationships assume that the mediating variable contributes to some of the relationships between the independent and dependent variables. Partially mediated relationships are not merely characterized by a substantial association between the mediator and the dependent variable but also by direct interactions between them. The results of the mediation effect are shown in Table 6.

Table 6: Results of mediation effect

Path	Direct effect	Indirect effect	Decision
TT—PU—ITU	0.245 (0.001)	0.041 (0.009)	PM
FSS—PU--ITU	0.374 (0.001)	0.079 (0.009)	PM
TT—PEU-PU	0.210 (0.001)	0.037 (0.003)	PM
FSS—PEU—PU	0.450 (0.001)	0.021 (0.008)	PM

**Significant at P-value < 0 .1; parenthesis values (P-values); Partial Mediation (PM)

8. Discussion

The study identifies that the customer's willingness and the variables they perceived to be useful lead to adopting the technology. The study shows that FSS, COS, and TT positively influence ITU technology. Dwivedi et al. (2016) state that cost is essential in the implementation and intention to adopt the technology. The study hypothesis "H1(β = 0.284, T= 2.837, p=0.005)" supports the claim that PEU, PU and ITU of the technology are influenced by cost. The path coefficient COS significantly relates to the predetermined variables PEU and PU. The study of (Wong et al., 2020a; Nayal et al.,2021) agrees with our finding that cost saving significantly impacts the perceived usefulness and ITU of the technology. The analysis of the results indicates that the more the decision-maker believes in the usefulness of the technology and the value for money it provides, the more the intention to adopt the technology increases. The β value of PEU and PU of the variable COS is less than FSS and TT as BLCT is a high-end technology, and implementation cost as an individual technology can be higher even if implementing it as a group will reduce its initial investment cost (Roeck et al. ,2020). It decreases overall expenses and supports more users using its services than a single user. Also, its safety mechanism is more secure as the users are verified under a certain criterion before it can be used. Customer preferences often lead to processing small volumes of transactions as quickly as possible and at a low cost, which can be possible by adopting BLCT. Chen et al. (2020) state that BLCT will help reduce the network's intermediaries, leading to cost reduction. Jiang et al. (2022) state that customers tend to emphasize whether the transactions can be approved quickly and cost-effectively. By investing in blockchain resources, all trading partners will be able to coordinate their activities on one platform, facilitating instant, transparent transactions that are free of delays (Ali et al., 2021). BLCT is believed to boost security while saving time and money by minimizing documentation processes (Karakas et al., 2021). However, the initial capital required to implement BLCT might cause difficulties for the developing AFSC sector and may limit its adoption.

FSS describes a food product's level of assurance that it will not cause illness or injury during its production, serving, or consumption, which helps customers build trust in the product by reducing their concerns about food products. The variable FSS and the supporting hypothesis "H2(β = 0.2, T = 2.471, p = 0.013)"; "H3(β = 0.409, T= 6.437, p<0.001)"; and "H4(β = 0.248, T= 4.192, p<0.001)". state that FSS positively influences the intention and adoption of BLCT. A higher β value of the PEU and PU of FSS confirms that the FSS plays an important parameter that influences the adoption of the BLCT. The FSS, in particular, has not been discussed in any adoption model.

Nevertheless, Wang and Scrimgeour (2022) highlight that decision maker perception of food quality influences the intention to use the technology. The existing literature (Tan et al., 2018; Duan et al., 2020; Lin et al., 2020) provides a similar view. Integrating BLCT in the AFSC enhances decision confidence as it helps the food manufacturers to share information about the origin, batch numbers, and production dates, as well as promote food safety, certification, and organic products

(Galvez et al., 2018), which act as a motivator for PEU and PU. BLCT enhances the ability to identify potential sources of contamination (Alladi et al., 2019), stop the illegal purchase of pesticides (Leng et al., 2018), and track the manufacturing and expiration date, which in turn helps reduce wastage. For instance, Walmart and Carrefour partnered with IBM’s Food Trust blockchain network (Vu et al.,2021) to achieve real-time and end-to-end visibility at low costs.

Similarly, JBS integrated BLCT in their livestock farming to eliminate food fraud in their SC (Saha et al., 2022). These initiatives aim to enhance customers’ trust and ensure safety and security in the AFSC. The decision-makers believe that a specific technology will help attain the objective, which leads to the ITU technology.

The variable TT of the SC can help increase decision-maker trust. Tracing the products to their origin has immensely helped to gain the trust of the decision-maker. Integrating BLCT in food traceability and transparency is an identification tool that helps track and trace food products quickly and accurately. The results “H5($\beta = 0.245$, T= 3.269, $p<0.001$)”, “H6($\beta = 0.15$, T= 3.269, $p=0.001$)”, and “H7($\beta = 0.126$, T= 3.204, $p=0.001$)” are in support of the hypotheses and show significant positive reliability to the adoption and intention to use the BLCT. The analysis supports (Queiroz and Wamba 2019; Wang et al., 2021; Wang and Scrimgeour, 2022), who state that TT is an essential determinant for the adoption of BLCT. TT brings trust and reliability to the system, which supports our analysis and is verified by (Queiroz et al., 2020) but in disagreement with (Queiroz et al., 2019). BLCT provides a reliable source of information about the origin of food products, allowing businesses to differentiate themselves from competitors (Vu. et al., 2021) and is perceived as valuable by decision-makers. However, the PU of TT falls short of FSS, maybe due to the SC members' lack of trust or the availability of other integrated technology like IoT, which is perceived as easier to use. Schulze-Ehlers et al. (2014) state that supplier, processor, and buyer asymmetry leads to a poor supplier-buyer relationship and an unoptimized SC. Li et al. (2022) and Wamba and Queiroz (2022) state that BLCT is ideal for increasing SC traceability, efficiencies, responsiveness, and managing supplier relationships. Adopting BLCT can help companies manage food safety crises more effectively, minimize the impact of food recalls, and enhance their SC productivity. BLCT's ability to track and trace also helps in storing and transporting the food, easing the process. In addition, it can also assist in speeding up the auditing and conflict resolution process, as financial records of all transactions can be documented and stored in the chain (Chang et al., 2020). Thus, the benefits of traceability and transparency are highly perceived to be useful and influence the adoption of BLCT in companies. In addition, the decision-maker will gain confidence in the provider and stop looking for alternative solutions, which will benefit the company (Villena et al., 2019). The technology's benefits contribute to perceived usefulness, significantly affecting the intention to use BLCT.

The last two Hypotheses (H8) and (H9) analysis show how PU and PEU of the technology positively influence the intention to use the technology. "H8(β = 0.104, T= 2.027, p=0.043)" and "H9 (β = 0.132, T= 2.229, p=0.026)" support the hypotheses which are aligned with the findings in Lie et al. (2021) and Ullah et al. (2022). This suggests that the more decision-makers find the usefulness of the BLCT, the more they see the value of the technology and want to adopt it. Furthermore, the H9 has the smallest t value (t=2.027), which implies PEU of technology plays an important parameter in the ITU of the technology. The simpler the technology's ease of use, the better the decision-maker is ready to use it. Comparing our results with Queiroz et al. (2019), shows that trust, transparency, and traceability among the stakeholders and decision-makers influence the intention to adopt BLCT in the developing economy. To fully leverage the power of ease of use for BLCT adoption, organizations that use BLCT should showcase the benefits in their applications to increase customer trust. Governments and private organizations run many pilot projects to implement the technology in the system. In Latin America, the GrainChain startup company used BLCT to track the movement of the grain from farm to market, ensuring that farmers receive fair prices for their crops. Similarly, Agri10X, a startup in India, leverages digital technologies, including BLCT, to provide comprehensive solutions to every phase of the agricultural value chain, aiming to improve farmers' lives. By introducing trust in the system and lowering the cost of online transactions, BLCT also improves the organizations' synergy and efficiencies.

9. Conclusion

This research aims to shed light on the ITU BLCT in AFSC. According to the findings of this study, users intend to use a technology once they perceive its usefulness and ease of use. The study uses an empirical approach based on the proposed conceptual framework on TAM to analyze the ITU and the BLCT in the AFSC domain. The conceptual model was evaluated using SEM, and the results validated the proposed framework. Based on our statistical results, we can conclude that the perceived benefits of BLCT are translated into practical usefulness in three dimensions: food safety and security, transparency and traceability, and cost. According to the study, the perceived value of BLCT among AFSC practitioners in India is not driven by hype but by the knowledge of the perceived benefits. The findings show that practitioners and decision-makers believe in the usefulness of BLCT, which enhances the SC by reducing food losses and wastage and increasing quality and efficiency. The decision-maker believes that integrating BLCT will help to trace and track the product and identify the origin and flow of the product and any potential sources of contamination occurring in the network. When SC intermediaries can get a good quality product and a visible SC, it helps to build trust between the supplier and consumer, leading to a higher likelihood of technology adoption.

Finally, it is essential to recognize that implementing BLCT cannot be expected to happen overnight, particularly in developing nations where infrastructure and regulatory frameworks are still evolving. However, instead of relying solely on government intervention or aid programs for progress, the global aid community should focus on establishing standards and enabling investors and companies to adopt diverse solutions. This approach will promote platform interoperability and provide potential investors with deeper insights into blockchain-based investment opportunities while emphasizing their societal benefits within the AFSC domain. A well-designed standardization system could enhance transparency across borders by streamlining cross-border transactions and promoting ethical practices among businesses operating in emerging markets- ultimately benefiting both stakeholders involved and facilitating sustainable economic growth globally.

9.1. Research Contributions

9.1.1. Theoretical Contribution

The current study contributes to both theory and practice. Our research studies the acceptance of blockchain adoption technology by providing a TAM approach practical for innovative technology-based services. We find several factors that positively influence AFSC's intention to use BLCT. Our study highlights the driving factors, FSS, TT, and COS, influencing the intention to use BLCT based on TAM. Our results highlight the importance of including these factors as they help build the lane for adopting the technology.

As theorized by TAM, both PU and PEU significantly influence the intention to use BLCT (Yen et al., 2010). According to the empirical findings of (Kamble et al.,2018), PU is influenced by PEU, and the PU is explained by 28%, suggesting other factors may be at play. Our study shows similar results: R^2 (PEU)= 0.37, R^2 (PU)= 0.21 with three different constructs for PU. The value of R^2 accounted for PU for (COS)= 0.24, (TT)= 0.65, and (FSS)=0.38. The study implies that the higher the perceived benefits of implementing BLCT (saving time, efficiency, and convenience), the more likely users are to use it. The empirical results also indicate that BLCT's characteristics can influence PU and PEU directly; the higher the ease of use and perceived benefit, the higher the chances of intention to use.

Furthermore, these findings highlight the importance of addressing technical considerations and user perceptions when introducing new technology solutions into an organization's workflow. This approach will help foster greater employee acceptance and engagement while maximizing ROI. The contingency perspective in this study advances our understanding of technology acceptance and makes the results relevant to practice.

9.1.2. Managerial Contribution

The emergence of BLCT technology has been a significant development in agriculture and food security. However, as this technology is still in its inception stage, it requires a more comprehensive understanding and awareness among manufacturers, policymakers, governments, and individuals for its effective implementation on a wider scale. BLCT demands higher technical knowledge from system designers or developers than traditional agricultural technologies, so they must simplify the setup process by providing clear instructions with an accompanying manual. Additionally, managers should collaborate closely with technology service providers to mitigate the high computing costs of adopting this new system. In particular, initial investment costs may be prohibitively expensive for some companies, which could deter them from investing in such advanced systems; therefore, reducing these expenses would encourage further adoption of this innovative approach toward farming practices - particularly given the increased demand for skilled professionals required during installation phases. Furthermore, given the potential benefits of BLCT technology for food security and agricultural sustainability, policymakers must develop supportive regulatory frameworks to promote investment in BLCT research and development.

7.3 Limitations and future research direction

Although the study provides insight into the intentions of using BLCT in AFSC, further research is required to address some limitations. Firstly, for the empirical study to find the ITU BLCT in AFSC, only the single SC decision maker perspective has been observed. Future research focusing on the dual perspective of the supplier- buyer’s ITU the technology is recommended. Secondly, while transparency and traceability, food safety and security, and cost were deemed essential variables examined by this study, incorporating additional factors such as technical knowledge, government intervention, regulatory framework about governance, and policy implementation practices aimed at societal benefits are recommended avenues worthy of exploration. Thirdly, the model is tested on a sample of 258 working professionals in the Indian AFSC domain, thus restricting its generalizability across other countries unless supplemented by further studies.

Nevertheless, practitioners, researchers, and scholars can apply and extend our proven model to other nations through additional research. A comparative study between the developed and developing nations can be conducted to understand ITU BLCT. In addition, the food- and agriculture-specific industries and country-specific ones may be examined to understand better the variables affecting or leading to adopting BLCT. Furthermore, a longitudinal study of practitioners' perceptions and the advanced industrial use cases would provide great insight into time-tested results.

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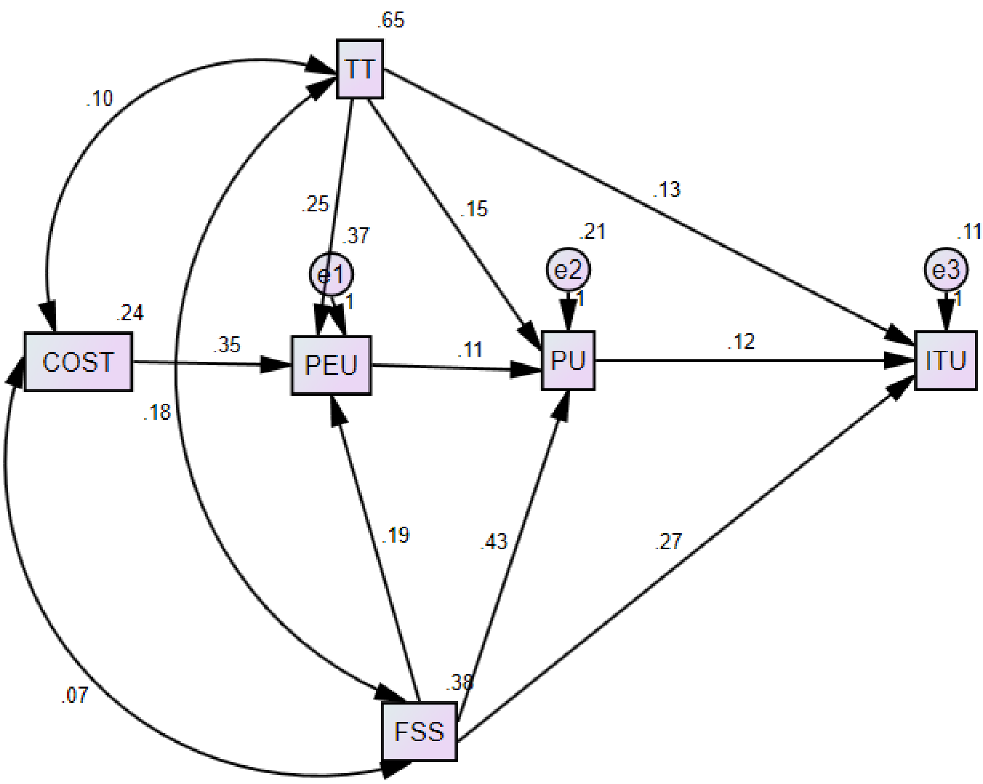
Annexure



A1 – Path analysis diagram of the conceptual framework