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Exploring Blockchain Adoption in Food Safety: A Dual-Stakeholder Perspective Using the UTAUT Model

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Abstract

Blockchain adoption in the food industry will bring a major shift in business operations. This study delivers a two-level stakeholder comparison between enterprises and consumers on which group prioritises what while adopting blockchain technology. The study uses a two-level empirical approach with 150 participants from each group, extending the Unified Theory of Acceptance and Use of Technology (UTAUT) to trust. The findings show that enterprise managers prioritise blockchain performance benefits, including cost reduction, process optimisation, and supply chain transparency to meet organisational efficiency goals. However, consumers trust blockchain's traceability and accountability to assure food safety. This differentiation emphasises targeted blockchain implementation and marketing initiatives. The study emphasises performance and trust. However, sample size restrictions and convenience sampling are addressed. UTAUT is extended by emphasising trust in safety as a key factor in the food business, providing managers and policymakers with practical insights to boost blockchain adoption.

Keywords: *Blockchain, UTAUT, food safety, supply chain, SEM, technology adoption.*

Introduction

Six hundred million people fall ill due to the consumption of contaminated food every year, and 420000 of them die (World Health Organization, 2024). China is the largest producer of agri-food and the second largest importer of Agri-products (Suri, 2024) despite 12 million tons of agri-foods getting contaminated yearly (He et al., 2023). The result is that China has frequent outbreaks of issues like the hepatitis outbreak in 2008 (Yan et al., 2022) or the Melamine Incident of 2008 (Gossner et al., 2009). This indicates that food safety is an issue that needs innovative solutions (Geng et al., 2015; Martindale, 2021). However, why this issue has not been solved properly remains a question. Studies say food safety depends on traceability (Patidar et al., 2021). Unfortunately, food traceability has been quite challenging for the food supply chains for the last few decades until technologies took over operations (Tanwar et al., 2022). Technology and innovation are redefining what could not be done in the past few decades.

The innovation phenomenon that showcases promising industry applicability in food is blockchain (Rejeb et al., 2020; Tanwar et al., 2022). The food industry has already acknowledged the unlimited potential of blockchain technology (Mohammed et al., 2023). The global food and agriculture blockchain technology industry was expected to expand from USD 32.2 million in 2017 to USD 1.4 billion in 2028. From 2018 to 2028, the market was predicted to grow 42.85% in Europe, 40.42% in North America, 7.85% in Asia-Pacific, and 48.33% elsewhere (Mohammed et al., 2023). The reason behind this growth is the opportunity blockchain technology can provide to its stakeholders. The success of blockchain implementation in food safety depends on its acceptance by essential stakeholders. These stakeholders are mainly businesses and consumers. However, acceptance of blockchain in Agriculture and food supplies has seen limited exploration (Gurtu and Johny, 2019). Also, much of the existing research has focused on the perspectives of individual stakeholders rather than adopting a comparative approach that evaluates the interplay between these groups. Each of these stakeholders has their expectations towards blockchain adoption. Therefore, from a comparative point, there might be some different criteria that each group prefers from blockchain technology. Currently, singularly focused researchers have pointed out that most managers expect

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performance and effort expectancy to be met by implementing new technology (Oliveira et al., 2014; Zhou et al., 2010). This means from a business or enterprise standpoint; performance and effort can be the two major drivers of blockchain adoption. Similarly, from a consumer standpoint, social influence and performance expectancy are key to technology acceptance. Contextually, these performance expectancy, effort expectancy, and social influence are part of the Unified Theory of Acceptance and Use of Technology (UTAUT) (Marikyan and Papagiannidis, 2021). Further, very few studies have focused on whether trust in blockchain safety impacts acceptance and adoption among these two groups. A study will be needed to understand whether blockchain is perceived as a trust-based technology. A study will be needed to understand whether blockchain is perceived as a trust-based technology. With food safety being a significant concern, enterprises and consumers view blockchain as a trusty solution for ensuring product safety. Does this trust-based dimension also influence adoption intention among these two groups?

This research utilises the UTAUT to investigate blockchain adoption in food safety, focusing on the viewpoints of 2 key stakeholders. In its supply chain operations, an enterprise or organisation needs to evaluate the efficacy of blockchain through performance and effort expectancy. Consumers, who immediately benefit from improved food safety and transparency, possess the ability to influence demand for blockchain-enabled products. The study analyses how performance expectancy, effort expectancy, and social influence related to business enterprises and consumers affect blockchain adoption. Similarly, an additional trust-based safety dimension will be explored to understand whether blockchain technology is perceived within a trust-based safety dimension, further explaining how different agri-food stakeholders' groups accept this technology. The study answers the two following questions:

Considering diverse expectations and requirements, how does the blockchain usage intention differ between enterprises and consumers?

Is trust in food safety being ensured by blockchain that explains most the adoption intention?

Literature Review

Blockchain use intention

Usage intention is acceptance of a system, technology, or product and continued use for regular purposes. This has often been researched in technology acceptance models since it predicts usage behaviour (Williams et al., 2015). In the technology aspect, accepting a technology and then using it instead of other options. Blockchain is also a technology; its intention is when a person or organisation decides to use it in daily operations. It should be referred to as the consumer or business's intention to adopt this technology (Kamble et al., 2019). The likelihood of individuals or enterprises engaging with blockchain solutions has reliability on performance effort and social influence expectancy. Similarly, use intention is the resultant factor of the UTAUT model. Stakeholders have their reasons for adopting blockchain technology. Previous studies showed consumers might use blockchain for food tracking and transparency (Yiannas, 2018; Singh & Sharma, 2023). Enterprises may use blockchain for operational efficiency, safe data sharing, or industry compliance (Hastig and Sodhi, 2020). Thus, blockchain usage intention serves as a critical indicator for understanding the adoption dynamics of this technology across different sectors, influenced by individual and organisational factors such as performance expectancy, trust, and social influence.

Enterprise level

Enterprise performance expectancy

UATUT's performance expectancy refers to the construct that a specific technology will increase productivity and effectiveness in achieving goals (Saurabh & Dey, 2021). In this study, performance expectancy was proposed from an enterprise's perspective. The term "enterprise performance expectancy" describes a company's conviction that using certain technologies like blockchain will successfully resolve operational issues and enhance overall business performance. Regarding blockchain adoption, this idea refers to companies' trust in using blockchain technology to improve supply chain operations, boost

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efficiency, promote transparency, and adhere to industry compliance norms. It represents the advantages that blockchain technology offers a company, like improved efficiency (Bai et al., 2024), cost savings (Ullah et al., 2022), and resource optimisation procedures (Mylrea and Gourisetti, 2018). For instance, Blockchain usage has enhanced logistics and supply chain efficiency by reducing transaction time (Sharma et al., 2023). These benefits areas are the primary areas enterprise looks at when adopting a new technology and looking to stay ahead of the competition. Therefore, enterprise-level performance expectancy consisting of efficiency, cost savings, and optimisation expectations should influence behavioural intention to use. Based on this following hypotheses are proposed:

H1: Enterprise's performance expectancy of blockchain technology increases blockchain use intention

Enterprise effort expectancy

UTAUT's effort expectancy refers to the ease of using a technology or system (Venkatesh et al., 2003). Usage ease increases the intentional use of technology in the early adoption stage (Venkatesh and Davis, 2000). A user-friendly and seamlessly implemented blockchain system minimises operational disruptions, reduces resistance to change, and enhances the likelihood of adoption (Tariq, 2024). For instance, Toader et al. (2024) said supply chain players perceive blockchain-based technologies are minimising efforts and helping them to navigate easily, increasing satisfaction towards usage. Similarly, Nguyen & Nguyen's (2021) study pointed out that many companies expect operational complexity to drop after implementing blockchain. Food safety businesses can easily track and verify the information to ensure products fulfil safety standards and respond quickly to hazards, protecting customers and brand integrity (Tian, 2017; Iftekhar et al., 2020). This indicating blockchain can minimise the food tracking effort and establish a faster communication-based supply chain for enterprises. Therefore, food companies are more likely to adopt it, making the food supply chain safer and more transparent. Based on this effort's expectancy of ease and less complexity, the following hypothesis for the enterprise's blockchain use intention can be proposed:

H2: Enterprise's effort expectancy of blockchain technology increases blockchain use intention

Consumer-level

Consumer's performance expectancy

UTAUT's performance expectancy can be measured from a consumer perspective as well. From a consumer's perspective, this refers to how effectively blockchain technology can address their concerns about food safety, traceability, and transparency in the food supply chain (Astill et al., 2019). Sharma et al. (2023) say that if a technology is harder to use than the current method, there is less chance that consumers will adopt it. This means consumers expect food relational information to be easily obtained through blockchain. If this is fulfilled consumers are more likely to feel that blockchain has helped them towards easy information gathering on food safety. Effort expectancy of consumers is the key determinant in the early adoption stage, although Ali et al. (2023) say impact lessens with time and familiarity of users. Several studies have shown that effort expectancy significantly influences behaviour (Al-Sabaawi et al., 2023). Therefore, it is expected that food consumers getting information related to food safety will have a positive expectancy, thus increasing their intention to use. Considering this following hypothesis can be proposed

H3: Consumer's performance expectancy has a significant impact on blockchain use intention

Social influence

UTAUT's social influence construct is well-suited as a factor on which consumer decision depends. Social influence is how users feel other's personal opinions of their use of specific technology (Venkatesh et al., 2003). Some studies have mentioned that people showcase unique behaviour towards technology while they use which in turn influences others. For instance, consumers are influenced by other users' usage reviews of a blockchain (Sharma et al., 2023). Such influences can come from colleagues, friends, or family and affect individual actions (Alshebami, 2022). Some studies have shown that the initial decision to adopt

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a technology can be largely swayed due to others having a positive or negative opinion during usage (Allah Pitchay et al., 2022). For instance, other consumers can adopt such technology if friends and family use blockchain-based food safety applications and get a positive result on food-related information. This is the social influence phenomenon found in consumer-level adoption of technology. Therefore, it can be a key determinant of blockchain adoption as well. Also, several studies have proven that social influence is related to behavioural intention (Al-Sabaawi et al., 2023). Considering this, the following hypothesis can be proposed regarding how social influence at the consumer level might have a relationship with blockchain use intention:

H4: Consumer's social influence has a significant impact on blockchain use intention

Perceived trust in safety

Originally not part of the UTAUT model, however, various studies have used trust as an extended construct with acceptance of technology (Alalwan et al., 2017). Trust was introduced in the UTAUT model to extend the current factor areas influencing technology acceptance. Trust is particularly relevant in blockchain technology and food safety scenarios, where transparency, data security, and credibility are significant criteria (Oriekhoe et al., 2024). However, trust has been used from a 'perceived' dimension. Shared trust between a client and a technology provider is important (Al-Saedi et al., 2022). Perceived trust is one of the leading factors affecting the adoption intention of a new technology (Alalwan et al., 2017; Cody-Allen and Kishore, 2006; Al-Saedi et al., 2017; Namahoot and Jantasri, 2023). Several studies have shown that consumers' or users' trust in products or services related to financial transactions significantly affects adopting such technology in the short or long term (Moon and Kim, 2016; Damghanian et al., 2016). Blockchain is also a finance technology; hence, perceived trust should play a major role when people adopt such technology in the long run.

Al-Saedi et al. (2022) found that a relationship between the technology provider and the end user (businesses or consumers) depends heavily on shared trust. A lack of trust can hinder the widespread adoption of blockchain systems (Lin et al., 2021). Trust becomes an essential driver of technology usage in industries like food safety, where reliability is key. Previous studies have shown it is important to have trust and acceptance regarding emerging technologies getting integrated into daily operations (Shin and Bianco, 2020; Alazab et al., 2021; Albayati et al., 2020). Enterprises with high trust in technology are more likely to integrate blockchain into their systems, leveraging its potential to transform supply chain operations, including food safety (Toader et al., 2024). Saurabh & Dey's (2021) study has shown how trust has been a factor that affected food supply chains and related enterprises to adopt blockchain technologies. Similarly, some studies have stated how consumers receive end-to-end transparent information from blockchain-based technologies (Astill et al., 2019). If consumers want to know whether a food has met safety criteria, they do not have to get data from the government or any centralised organisation; the blockchain will provide this data. Consumers do not have to rely on the government or producers to get this information. Put simply, blockchain technology allows consumers to trust a product even if they do not have developed personal trust with the producers (Li et al., 2023). Trust can be either a direct or an intermediary factor influencing behavioural intention use, whether consumer or enterprise. Considering this, from an enterprise perspective, trust can explain how performance expectancy or effort expectancy increases blockchain use intention within an organisation. Similarly, consumers' trust in blockchain technology in giving accurate information on the food source, journey, and quality of their food can explain most of the impact of consumer performance expectancy and social influence on acceptance and use intention of this technology. Considering this, the following hypotheses can be proposed:

H5: Perceived trust in safety increases behavioural intention of usage for enterprise-level blockchain use intention.

H6: Perceived trust in safety increases behavioural intention of usage for consumer-level blockchain use intention.

H7: Perceived trust mediates between the enterprise's performance expectancy and blockchain use intention.

H8: Perceived trust mediates between the enterprise's effort expectancy and blockchain use intention.

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H9: Perceived trust mediates between the consumer's performance expectancy and blockchain use intention.

H10: Perceived trust mediates between the consumer's social influence and blockchain use intention.

Theoretical underpinnings

According to the UTAUT model (Venkatesh et al., 2003), three main elements influence behavioural intention to embrace new technology. Most studies have adopted this model since the technology acceptance model was deemed reasonably outdated for recent technologies. This model is chosen because it can explain up to 70% variance in behavioural intention and around 50% in actual Usage Behavior (Venkatesh et al., 2003). This study also concerns this behavioural intention to use and accept blockchain technology under enterprise and consumer contexts. Therefore, UTAUT will be the most suitable framework to explain what factors are in play for enterprises and consumers increasing their behavioural usage intention of this technology. The degree to which consumers think the technology will live up to their expectations and improve their performance is known as performance expectancy. Users' opinions of the technology's usability, which reflects its user-friendliness, are the main emphasis of effort expectations. Finally, social influence looks at how social factors or outside pressures affect the choice to use technology. This study uses these three main factors about enterprise and consumers. For consumers, performance expectancy and social influence have been chosen as the primary facilitators of behavioural intention to use blockchain technology. Similarly, performance and effort expectancy are critical in the enterprise context, highlighting the need for blockchain technology to deliver measurable improvements while being accessible and efficient to implement. The below concept figure suggests two levels: enterprise and consumer. This study establishes a path on which each group decides and compares. This tailored approach recognises these stakeholder groups' distinct priorities and expectations influencing their intention to adopt blockchain technology.

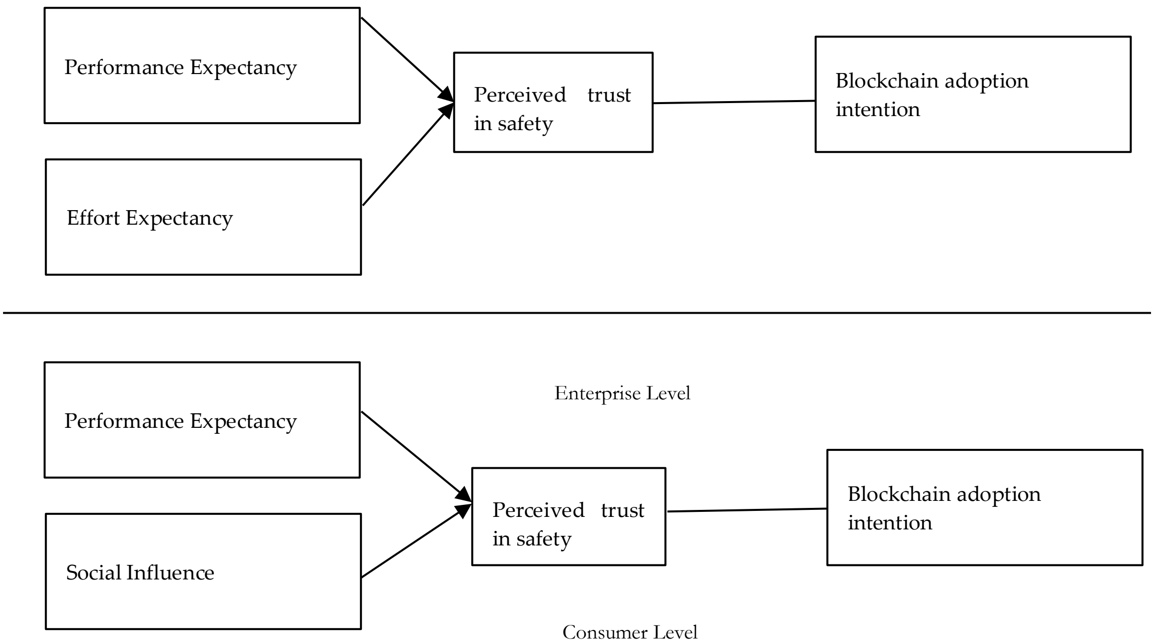

Figure 1: Conceptual framework

Methodology

This study has applied an empirical research design, prioritising primary data collection from two target groups: food supply cold chain managers, employees and administrators in enterprise groups, and agrifood users in consumer groups. Considering the diversity of sample distribution and the differences in enterprise

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types and consumer backgrounds, during the enterprise type stage, the surveyed individuals with over 5 years of work experience were selected, while for consumers, convenience sampling was used. The scales have been adapted from Davis (1989), Venkatesh et al. (2012), Jena (2022), Queiroz et al. (2020), and Albayati et al. (2020) [Refer to appendix]. Completing the data collection revealed that each group had 150 participants (Group 1: 150, Group 2: 150). One questionnaire was prepared for each group and distributed via social media channels. The sample collected from groups has been analysed through SMART PLS software. A Confirmatory Factor Analysis (CFA) was conducted to evaluate the measurement model's reliability and validity, ensuring that constructs were accurately represented. Here, the mode fit and reliability of the constructs were identified. The final structural model was approved once fit indices like RMSEA, CFA, NLI, SRMR, and Chi-square were tested. The structural equation modelling method was then applied to test the hypothesised relationships between variables, providing insights into the factors influencing blockchain adoption. Two models (Model 1 and Model 2) were constructed, and each hypothesis has been tested through path analysis and significance values obtained from these models.

Result

Descriptive statistics

Table 1: Descriptive statistics

Category	Attribute	Frequency	Per cent	Valid Percent	Cumulative Percent
Consumer Level					
Age	Below 18	2	1.3	1.3	1.3
	18-25	18	12.0	12.0	13.3
	26-30	31	20.7	20.7	34.0
	31-40	69	46.0	46.0	80.0
	41-50	20	13.3	13.3	93.3
	51-60	5	3.3	3.3	96.7
	Above 60	5	3.3	3.3	100.0
Gender	Male	70	46.7	46.7	46.7
	Female	80	53.3	53.3	100.0
Education	Below 18	6	4.0	4.0	4.0
	18-25	19	12.7	12.7	16.7
	26-30	104	69.3	69.3	86.0
	31-40	21	14.0	14.0	100.0
Enterprise level					
Gender	Male	106	70.7	70.7	70.7
	Female	44	29.3	29.3	100.0
Age	26-30	35	23.3	23.3	23.3
	31-40	103	68.7	68.7	92.0
	41-50	10	6.7	6.7	98.7
	51-60	2	1.3	1.3	100.0
Education	High school/technical secondary school	7	4.7	4.7	4.7
	College	57	38.0	38.0	42.7
	Undergraduate	80	53.3	53.3	96.0
	> Graduate	6	4.0	4.0	100.0
Experience in Cold Chain	<5 Years	16	10.7	10.7	10.7
	5-10 Years	106	70.7	70.7	81.3
	10-15 Years	23	15.3	15.3	96.7
	> 15 Years	5	3.3	3.3	100.0
Position	Management Post	77	51.3	51.3	51.3

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	Administrative Post	11	7.3	7.3	58.7
	Grassroot Employees	62	41.3	41.3	100.0

The descriptive data in Table 1 above demonstrates the demographic characteristics of the two chosen groups. Most participants were 31–40 (46%) and 26–30 (20.7%), indicating that most participants were middle-aged. The percentage of females is slightly larger (53.3%) than that of males (46.7%). Regarding education, 69.3% of consumers have an undergraduate degree, suggesting they are highly educated.

Most responders (68.7%) are between the ages of 31 and 40, and men predominate at the enterprise level (70.7%). The educational diversity among enterprise representatives is highlighted by a sizable number (53.3%) who have undergraduate degrees and 38% who have college-level credentials. 77% have five to ten years of cold chain expertise, indicative of seasoned industry specialists. The majority of positions in businesses are held by managers (51.3%), with grassroots workers coming in second (41.3%). Therefore, both groups have significant participant variety, reflecting diverse demographic and professional characteristics.

Cronbach and reliability

Level	Factor	Cronbach's Alpha (Standardized)
Enterprise	Blockchain Use Intention (BUI)	0.887
	Effort Expectancy (EEE)	0.868
	Performance Expectancy (EPE)	0.885
	Perceived Trust in Safety (PTS)	0.938
Consumer	Blockchain Use Intention (BUI)	0.680
	Social Influence (CSI)	0.629
	Performance Expectancy (CPE)	0.727
	Perceived Trust in Safety (PTS)	0.713

Table 2: Reliability of the constructs

The reliability analysis in the above table 2 highlights strong internal consistency at the enterprise level, with Cronbach's alpha values for factors such as Blockchain Use Intention (0.887), Effort Expectancy (0.868), Performance Expectancy (0.885), and Perceived Trust in Safety (0.938), all exceeding the acceptable threshold of 0.7. These results indicate robust measurement reliability for enterprise-level constructs. At the consumer level, Blockchain Use Intention (0.680) and Social Influence (0.629) have lower alpha values, though Performance Expectancy (0.727) and Perceived Trust in Safety (0.713) meet the threshold. While consumer-level constructs are slightly weaker, as some studies say having >0.7 is good (Taber, 2018), they still provide acceptable reliability from some other researchers' perspectives (Ursachi et al., 2015), underscoring trust and performance expectancy as critical factors.

Confirmatory factor analysis

Table 3: CFA Model fit

Metric	Acceptable Value	Enterprise Level (Model 1)	Consumer Level (Model 2)

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RMSEA	≤ 0.06 (Good), ≤ 0.08 (Acceptable) ≤ (moderate)	0.096	0.062
Ch Square	<3	1.332	1.552
RMSEA LOW 90% CI	---	0.077	0.041
RMSEA HIGH 90% CI	---	0.115	0.072
GFI	≥ 0.90	0.854	0.903
AGFI	≥ 0.80	0.784	0.879
SRMR	≤ 0.08	0.033	0.070
NFI	≥ 0.90	0.925	0.795
TLI	≥ 0.90	0.942	0.889
CFI	≥ 0.90	0.955	0.911

The above table 3 shows the fit indices of each CAF model obtained at the Enterprise Level (Model 1) and Consumer Level (Model 2). With sample sizes between 75 and 200, the chi-square test is typically an appropriate indicator of model fit (Stone, 2021). Our study has 150 sample sizes for each; therefore, chi-square fit indices become important to evaluate. With CFA Model 1 at 1.324 and CFA Model 2 at 1.552, both models attain a Chi-square/df ratio below the permissible cutoff of 3. Both models are statistically valid and fit the data within acceptable thresholds, with Model 1 showing a slightly better fit due to its lower Chi-square/df ratio. The SRMR value should be <0.08 (Cho et al., 2020). Similarly, it is less than the threshold value (Model 1=0.033, Model 2:0.070). This means both models have observed correlation, and the model predicted creation is similar. Model 1 has a strong fit across all metrics: NFI = 0.925, TLI = 0.942, and CFI = 0.955 (all exceeding the threshold of 0.90). Conversely, Model 2 shows mixed results, with CFI = 0.911 (good fit) but NFI = 0.795 and TLI = 0.889 (below 0.90). All these indices in models 1 and 2 meet or surpass the suggested levels (Xi & Yang, 2019). The RMSEA value for model 1 (0.096<0.1) has a marginal fit, whereas model 2 (0.060<0.8) shows a good fit (Fabrigar et al., 1999). Classical theories like Hu & Bentler (1999) have suggested that the RMSEA value needs to be under 0.08 to observe a good ft. However, model 1 does not achieve this fit despite having a reasonable fit as it is not over 0.10 (Kline, 2016). These results imply few differences between the expected and observed covariances, indicating that the measurement models successfully capture the latent components. Based on Hu & Bentler (1999), Model 1 showcases a reasonable fit, whereas Model 2 has a good fit. According to the CFA results, both models (Figure 2) are valid and accurate for understanding blockchain usage intention at the enterprise and consumer levels. In summary, both models are rational choices for their respective contexts, offering complementary perspectives to understand blockchain usage intentions comprehensively.

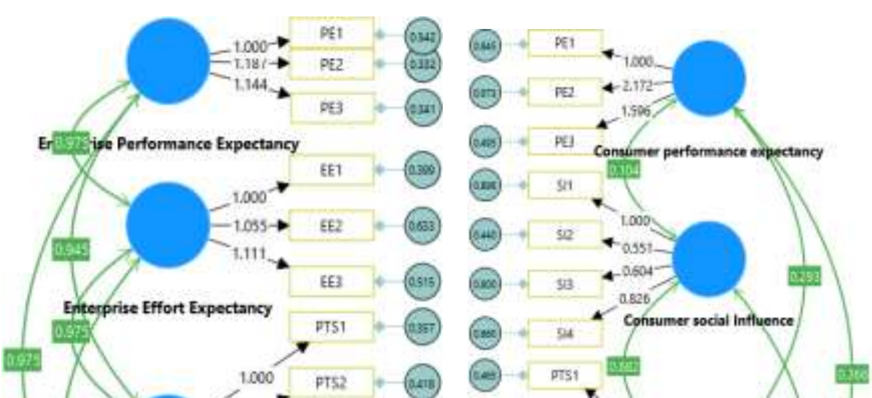

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Figure 2: Confirmatory model

Path analysis

Table 4: Result

Level	Path	O	M	STDEV	T	P	Hypothesis	Result
Enterprise	Effort Expectancy → Blockchain Use Intention	0.313	0.312	0.098	3.202	0.001	H2	Accepted
	Performance Expectancy → Blockchain Use Intention	0.404	0.401	0.087	4.624	0.000	H1	Accepted
	Perceived Trust & Safety → Blockchain Use Intention	0.236	0.241	0.088	2.701	0.007	H5	Accepted
	Effort Expectancy → Perceived Trust & Safety → Blockchain Use Intention	0.122	0.126	0.053	2.299	0.022	H8	Accepted
	Performance Expectancy → Perceived Trust & Safety → Blockchain Use Intention	0.100	0.101	0.042	2.387	0.017	H7	Accepted
Consumer	Social Influence → Blockchain Use Intention	0.180	0.183	0.071	2.539	0.011	H4	Accepted
	Performance Expectancy →	0.175	0.180	0.073	2.650	0.008	H3	Accepted

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	Blockchain Use Intention							
	Perceived Trust & Safety → Blockchain Use Intention	0.510	0.493	0.076	6.826	0.000	H6	Accepted
	Consumer Social influence→ → Perceived Trust & Safety→ Blockchain Use Intention	0.225	0.226	0.054	4.155	0.000	H10	Accepted
	Consumer performance Expectancy → → Perceived Trust & Safety→ Blockchain Use Intention	0.122	0.129	0.058	2.020	0.043	H9	Accepted

The table suggests the effects on both enterprise and consumer levels. At the enterprise level, performance and effort expectations have significantly influenced blockchain adoption. It can be seen that blockchain usage intention for business owners was mostly influenced by performance expectancy (sig= 0.000, O = 0.404, *t = 4.624*). This is suggested by the observable advantage business owners perceive blockchain can give from its performance angle. The relationship between performance expectancy and blockchain use intention is mediated by trust, thus suggesting that using blockchain does increase trust, which also explains most of the changes in adoption intention (*sig=0.017, O = 0.100, t= 2.387*). Similarly, at the enterprise level, a significant positive relationship (*sig=0.017, O = 0.313, t = 3.202*) can be found between effort expectancy and blockchain use intention. Moreover, perceiving trust and safety partially mediates (sig=0.022, O=0.122, t=2.299) and explains most changes in business owner's blockchain adoption intention.

Similarly, the consumer-level results show that performance expectancy is also the most significant factor that affects blockchain use intention (*sig = 0.000, O = 0.510, t = 6.826*). Trust also mediates the relationship between performance expectancy and blockchain use intention (*sig= 0.027 O = 0.129, t = 2.219*). Social influence as a direct factor positively relates to the blockchain use intention among consumers (*sig = 0.011, O = 0.180, t = 2.539*). Moreover, perceiving trust and safety partially mediates (*sig=0.000, O*=0.225*, t*=4.155) and explains most of the changes in consumer's blockchain adoption intention.

All hypotheses have been accepted at both enterprise and consumer levels, thus suggesting that performance expectancy, effort expectancy, and social influence are major contributors to the adoption of blockchains. However, a comparison needs to be made to know which factor contributes the most to the adoption of blockchains at both these levels. At the enterprise level, performance expectancy from blockchain technology seems to be the most important factor that affects adoption intention (β=0.404). Effort expectancy also plays a significant role, primarily through its impact on trust (β = 0.122, t = 2.299), emphasising the need for user-friendly implementation. Considering β0.404>β0.122, the business owner's adoption intention of blockchain comes from how much performance it can deliver in the business. Trust in safety is the third significant contributor to the adoption intention (β=0.236). In contrast, consumer's adoption intention is mostly influenced by trust in the safety of this technology (β=0.499). At the consumer level, performance expectancy is the second (β=196) most important factor, whereas social influence is the third most (β=180). In both levels, predictors with t-values > 2 meet the statistical significance threshold, affirming the observed relationships' robustness. At a 5% significance level (Sig 0.05), the relationship between predictors and the resultant is not merely due to chance, but a significant relation exists between them. Similarly, in both models, predictors have a major relation with the factor involved. Henceforth, these are **statistically significant** factors that influence blockchain adoption, and their effects are not likely

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to be coincidental. Although trust in safety in both cases directly influences adoption, but also mediates the effects of other factors, making it a cornerstone of consumer adoption. Overall, the results highlight the differing priorities between enterprises and consumers. Performance benefits are the main driver for businesses, with trust and usability playing supportive roles. In contrast, consumer adoption is largely trust-driven, with performance and social influence as secondary and tertiary motivators. These insights suggest that strategies to promote blockchain adoption should be tailored to each audience, emphasising enterprise performance, integration, trust-building, and social proof for consumers.

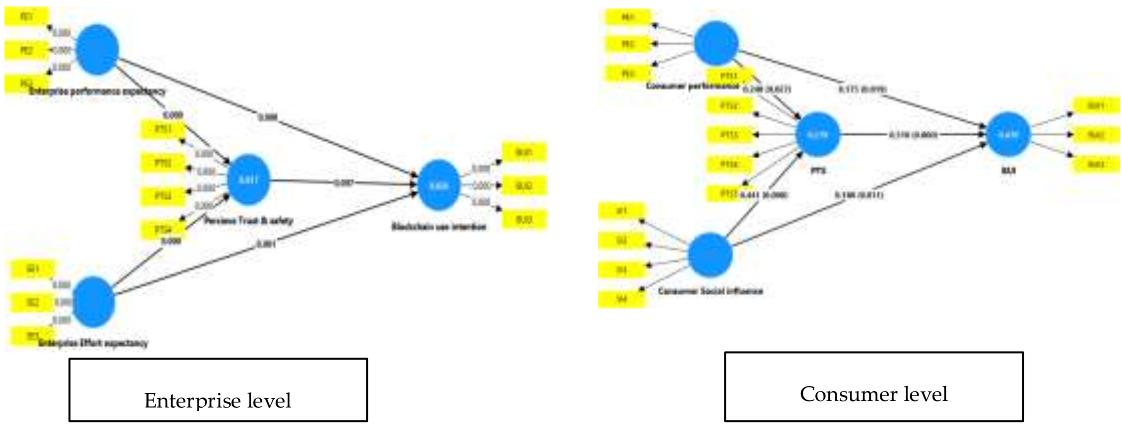

Figure 3: Final Model comparison

The final model's (Figure 3) side-by-side comparison suggests that enterprise effort expectancy, enterprise performance expectancy, and trust in safety explain about 82.6% of the variance observed in blockchain use intention. Similarly, consumer performance expectancy, social influence, and trust in safety explain about 47% of the variance observed in blockchain adoption.

This is quite interesting, considering that, at the enterprise level, blockchain adoption significantly depends on three factors (82%): enterprise effort expectancy, enterprise performance expectancy, and trust in safety. This means enterprise managers rely majorly on the blockchain system's performance, effort, and trust. There will be other factors; however, most decision-making depends on these three factors. On the contrary, consumers have observed that trust in safety is the most important factor influencing their adoption intention. However, interestingly, all three factors, such as social influence, performance expectancy, and trust in safety, account for 47.5% of observed changes in blockchain adoption intention. Hence, a consumer's adoption intention is dependent variety of factors. Thus, comparative analysis at the enterprise and consumer levels reveals that consumers value blockchain's trust more, while the enterprise values its performance. Moreover, it can also be said that at the enterprise level, blockchains have increased performance, while at the consumer level, trust in safety has evolved due to such technology.

Discussion

The findings reveal two aspects: whether blockchain adoption at enterprise and consumer levels differs and whether both these stakeholders consider blockchain-based trust in safety. The answer to the first question is yes, enterprise and consumer differ in blockchain adoption. However, this difference is about priorities.

Food enterprise managers prefer the performance of a technology. This has been established by many past studies by Toader et al. (2024), Khazaei (2020), and Chang et al. (2022). The present study also aligns with

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the findings that enterprises first prioritise performance expectancy from a technology. Food enterprises also prioritise the performance of blockchains. Managers believe adopting blockchain leads to efficient processes, cost reductions, and optimised supply chain operations (Toader et al., 2024). Similarly, studies have pointed out that blockchain has ensured transparency and accountability of all supplies (Hu & Ghadimi, 2022). In food supply chains, enterprises get all products traceability and resistance to tampering with the data involved with each product due to blockchain (Kumar et al., 2020; Charlebois et al., 2014; Vistro et al., 2022; Rejeb and Rejeb, 2020; Wang et al., 2019; Ellahi et al., 2023). These are all associated with the performance of an enterprise. Blockchain allowing all these ensures that enterprise managers perceive their performance in food tracing, cost reduction, and optimisation has improved. Considering all these, it can be said that from an enterprise level, blockchain adoption is mostly decided by the system's performance. Blockchain is seen as a transformative technology that aligns with enterprise performance goals. Hence, food enterprises primarily see blockchain technology from a performance perspective, although effort and trust also play a significant part in adoption decision makings.

Consumers prioritise perceived trust in the technology in ensuring the safety of products. Trust in technology adoption has not been explored much; however, trust becomes essential when discussing food safety and technology. This study found that trust in technology has the most direct effect on the blockchain adoption behavior of consumers. Similarly, trust also mediates and explains why consumers are influenced by blockchain performance and social influence. Trust directly affects blockchain adoption intention and partially mediates social influence and performance expectancy on blockchain adoption. This means trust-based safety that blockchain provides through traceability of the food items and related information has the most effect on consumers wanting to adopt blockchain-based solutions. Consumers want food production chain transparency and accountability, so they use technology to trace food from farm to fork (Lam et al., 2020; Lin et al., 2021). Traceability empowers customers and develops food safety trust (Lam et al., 2020). Lack of credible market information and dishonest actions can weaken consumer confidence. However, reliable food information boosts trust (Lin et al., 2021). Blockchain solves these issues with consumers and ensures that they trust the technology to provide information to ensure consumption safety.

Conclusion

This study aimed to determine how blockchain adoption in food safety works at the enterprise and consumer levels. It was necessary to fill a gap in the current literature, where most studies have focused on only one group. This study has extended the classic version of the Unified Theory of Acceptance and Use of Technology (UTAUT) framework by adding a trust-based safety dimension. The findings indicate that while both groups value blockchain's capabilities, their adoption drivers differ significantly. Comparing two groups through two different structural models suggests that enterprise managers consider the performance of a blockchain system during adoption. For food supply chains, blockchain means increasing performance towards traceability, efficiency, and optimisation. These attributes align with enterprise goals, underscoring blockchain's transformative potential in improving performance metrics and operational transparency. Enterprise also considers how much effort they are reducing along with trust-based safety provided by the technology. Conversely, from a consumer view point, blockchain gets evaluated under the lens of trust in food safety. Trust-based safety emerges as the primary determinant of blockchain adoption, directly influencing their behaviour and mediating factors such as social influence and performance expectancy. Blockchain's capacity to provide traceability and ensure transparency fosters consumer confidence in the safety and authenticity of food products. Ultimately, the study highlights blockchain's dual role in meeting enterprise performance needs and building consumer trust, showcasing its potential as a pivotal technology for the future of food safety and supply chain management.

This study extends the classic UTAUT theory, offering a new dimension essential to the food industry. Trust in safety is a direct driver of adoption and a mediator for other factors like performance expectancy, effort expectancy, and social influence. The theoretical framework suggests that while advocating for blockchain in the food industry, it is important to consider the trust dimension, as it can influence both enterprises and consumers. This inclusion highlights how technology adoption can be context-specific, especially in industries where transparency, accountability, and tamper-proof data are critical for stakeholder

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confidence. Hence, the applicability of the UTAUT theory has been broadened by making this framework more holistic.

There are some critical insights for the food industry and blockchain marketing managers. First, food industry managers must promote product safety by including blockchain-based traceability. It will resonate with the consumers more as they prefer trust over everything. Marketing campaigns should emphasise blockchain ensures transparency, accountability, and food traceability from farm to fork. They should consider promotion if their products have clear, verifiable product information, such as origins, production processes, and certifications, which can be retrieved via any of the consumer's chosen blockchain platforms. This will ensure that consumers increase their trust in the food items as information can be available through a blockchain-based system. Blockchain's ability to ensure food traceability and prevent tampering can set businesses apart in a market increasingly focused on sustainability and safety. Second, blockchain marketing managers should prioritise the performance of their offerings to the food industry leaders. Through this, they can convince more food industry managers to have a positive attitude toward blockchain adoption in their supply chains. Another implementation area that this study indicates through its findings is whether coordination between practitioners (enterprises) and consumers can increase blockchain adoption at both these stakeholder levels. The answer is yes. Coordination can happen, and it will increase adoption in both levels. However, both need to be on the same path: putting trust in the technology. Trust for consumers depends on whether blockchain-based food platforms are giving them timely and accurate traceability of items. Enterprises should ensure whatever platform they are using provides easily to the customers, increasing their trust. Enterprise trust depends on whether consumers accept and buy blockchain-based food items more. Customers need to show enthusiasm for these food items more so enterprises trust these technologies. When consumers enthusiastically engage with and purchase blockchain-based food items, enterprises perceive blockchain as a viable technology that aligns with market demands and sustains their investment. This mutual trust-based reinforcement can significantly drive blockchain adoption at both levels.

Despite a composite two-level evaluation of blockchain adoption in the food industry and supply chains, this strategy has limitations. First, due to a complex two-level study, the sample size had to be divided limits between food enterprise managers and consumers. This division reduced the individual sample sizes for each group, potentially limiting the statistical power and the generalizability of the findings. Larger, more representative samples may provide deeper insights and stronger conclusions. Second, this study only considers cold-chain managers despite several other groups using blockchain-based technology. This also limits the generalizability of the findings. Third, several past researches have also considered the government as a stakeholder in blockchain adoption. Still, this study has only compared enterprises and consumers. Future studies should consider a longitudinal study design with a three-level (Government-enterprise-consumer) comparison. Presenting such a comprehensive framework, future research can enhance the robustness and applicability of the findings.

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Appendix: Questionnaire

Construct	Item Code	Questionnaire Item
Enterprise Performance Expectancy (EPE)	PE1	I find the Food Chain Certification Traceability System (FCCTS) to be a useful system for traceability.
	PE2	Using the FCCTS to trace food helps me achieve things that are important to me.
	PE3	Using the FCCTS enables me to accomplish tasks more quickly.
Enterprise Effort Expectancy (EEE)	EE1	My interaction with the FCCTS is clear and understandable.
	EE2	I find the FCCTS easy to use.
	EE3	Learning to use the FCCTS is easy for me.
Perceived Trust and Safety (PTS)	PTS1	I believe that blockchain is trustworthy.
	PTS2	I feel that legal and technological structures adequately protect me from blockchain-related problems.
	PTS3	Blockchain can fulfil its tasks.
	PTS4	The service providers give the impression that they keep promises and commitments.
	PTS5	I believe the service providers keep my best interests in mind
Consumer Performance Expectancy (CPE)	PE1	Using the blockchain technology system will increase my productivity.
	PE2	Using the FCCTS will help me understand food information more quickly.
	PE3	If I were unable to monitor the food, I would be willing to trust the platform to get the job done properly.
Consumer Social Influence (CSI)	SI1	People who are important to me think that I should use the FCCTS.
	SI2	People who influence my behaviour think that I should use the FCCTS.
	SI3	People whose opinions I value would like me to use the FCCTS.
	SI4	In general, the authority would support the use of the FCCTS.
Blockchain User Intention (BUI)	BUI1	If there is access, I intend to use blockchain.
	BUI2	If there is access, I am willing to use blockchain.
	BUI3	I will use blockchain in the future.