Hue University Journal of Science: Economics and Development
pISSN 2588-1205;eISSN 2615-9716
Vol. 132, No. 5B, 2023, pp. 21–37, DOI: 10.26459/hueunijed.v132i5B.7187

BUILDING THE ASSESSMENT SCALE ON STAKEHOLDERS' READINESS LEVEL TO APPLY BLOCKCHAIN TECHNOLOGY TO THE AGRICULTURAL SUPPLY CHAIN

Duong Dac Quang Hao*, Nguyen Thi Minh Hoa, Hoang La Phuong Hien

University of Economics, Hue University, 99 Ho Dac Di St., Hue, Vietnam

* Correspondence to Duong Dac Quang Hao <quanghao@hce.edu.vn>
(*Submitted: April 19, 2023; Accepted: May 5, 2023*)

Abstract. This study is conducted to build an assessment scale on stakeholders' readiness level to apply blockchain technology to the agricultural supply chain. By referencing the theoretical model of Technology - Organization - Environment (TOE) combined with the qualitative research step, the study proposed a new scale with 65 observed items and 18 factors. Next, the study carries out a quantitative research step based on the case of the pork supply chain in Hue. The sample consists of 365 individual/organizational stakeholders. The analysis results shortened the proposed scale to 62 observed items, 18 factors, and 4 second-order factors – including readiness on technological conditions (TEC), readiness on inter-organizational conditions (INTER), readiness on intra-organizational conditions (INTRA), and readiness on environmental conditions (ENV). Further analyzing the importance of the factors, the results reveal that relative advantage (RA), trust (TRU), trading partner pressure (TPP), firm size (FS), top management support (TMS), and competitive pressure (CP) are considered the essential foundations for the adoption of blockchain technology to the agricultural supply chain.

Keywords: readiness level, blockchain technology, agricultural supply chain

1 Introduction

Along with the development of agricultural supply chains, more and more severe problems arise [1]. Contaminated food and unknown-origin food spreading on the market are considered the most urgent [2]. These issues seriously threaten the health of consumers and the stakeholders' reputation in the supply chain. In addition, weaknesses in the management and sharing of market information also lead to the phenomenon of "good season, devaluation," which reduces stakeholders' income in the agricultural supply chains [3]. With these realities, new information technologies are increasingly considered a strategic asset for firms to improve operational efficiency and create a sustainable competitive advantage for agricultural supply chains. Blockchain is one of those potential solutions [4].

Blockchain is a pledge of information blocks tied together into a chain, with the characteristics of being encrypted and invariant in order [5]. The unique structure of blockchain is the peer-to-peer membership structure. The block assembly process is transparent and is controlled by all members. Each block of information is stamped, indicating who put the information on the chain and at what time [6]. Blockchain helps access easily, quickly, and reliably export information about supply chain activities. Since then, blockchain has helped to raise the parties' consciousness in the supply chain, support the control of product origin, and improve the efficiency of sharing market information in the agricultural supply chain.

From academic aspect, current literature on the adoption of blockchain to agricultural supply chains focuses on two groups of topics: first, using qualitative research methods (such as in-depth interviews) to research the benefits and barriers to blockchain adoption [3],[4]. Second, use quantitative research tools and theoretical models, such as the technology acceptance model (TAM) and the unified theory of acceptance and use of technology (UTAUT), to explain stakeholders' acceptance of blockchain adoption in the agricultural supply chain [5],[6]. However, most of the previous theoretical models only studied the individual technology adoption case of an individual or an organization. The impact of the relationship among stakeholders in a supply chain on adopting new technology has not been thoroughly evaluated. In addition, current research models do not assess the readiness of supply chain stakeholders (such as the availability of finance, technology, and human resources).

In this study, the case study of the pork supply chain in Hue, Vietnam, is selected for two main reasons: first, the pork supply chains have a high potential for new ITs adoption. Indeed, the pork supply chains typically have a large number of individual/ household stakeholders, with a low level of interoperability among all stakeholders [11]. Thus, with its high complexity and high demand for information control, adopting new ITs in the pork and fruit supply chain is urgent [11]. In fact, in agricultural fields, the pork and fruit supply chains have the most adoption cases of the new ITs worldwide [12]. Therefore, this case is suitable, highly representative, and generalisable for all agricultural supply chains. Second, most current research on blockchain technology adoption is conducted in developed countries such as the US, Norway, and France. Research in a developing country like Vietnam helps to provide new and high reference valued results.

Stemming from the above reasons, through reference to the TOE theoretical model, this study contributes to developing a new assessment scale on the stakeholders' readiness level to apply blockchain technology to the agricultural supply chain. The new theoretical scale is validated through the case of the pork supply chain in Hue, Vietnam.

2 Literature review

Blockchain is a distributed database or ledger that is shared among the nodes of a peer-to-peer computer network in an encrypted manner. Current studies have pointed out three significant applications of blockchain technology for agricultural supply chains [13]: First, blockchain helps enhance agricultural product traceability. Second, blockchain has features such as smart contracts that allow building trust in transactions between strangers, helping to reduce intermediaries and complicated procedures that take time, effort, and money. In addition, there are many other applications of blockchain, such as allowing close connection of information among stakeholders involved in the supply chain, thereby improving the ability to forecast demand and market fluctuations; quick recall of contaminated products; support integration of agricultural technologies 4.0 such as IoT, AI, Big Data. In particular, blockchain can also form an e-commerce agricultural product exchange with high transparency and meager low transaction costs [14].

Given the enormous potential benefits that blockchain technology can bring to agricultural supply chains, many studies have been conducted to clarify the applicability of this technology. In which the analysis focuses mainly on two approaches. In the first approach, several studies using qualitative research tools, such as case studies and in-depth interviews, have helped to assess the benefits and barriers to applying blockchain technology. For instance, research by Kamilaris et al. [7] indicates that blockchain technology has been used by many projects and initiatives to establish a trusted environment for building transparent food production and distribution into the supply chain. Research by Rogerson & Parry [8] presented the theoretical benefits of blockchain in the supply chain, such as upstream visibility, fraud countering, and a new decentralized, consensus-based trust mechanism. However, many issues and challenges still need to be addressed regarding technical aspects, education, policy, and legal framework [15]. Research by Khan et al. [16] has pointed out many obstacles to blockchain application, such as the communication gap among supply chain stakeholders and the unavailability of information about the movement history and origin of the product. Research by Beck et al. [17] indicates that factors such as lack of knowledge, experience in blockchain technology, high security and privacy risks, high initial installation cost, interface complicated and confusing operations, or users' lack of necessary skills are the factors that hinder the widespread implementation of blockchain technology into supply chains in general and agricultural supply chains in particular.

In the second approach, many studies use quantitative research methods and suggest theoretical frameworks to analyze factors affecting consumers' and stakeholders' acceptance of blockchain adoption in agricultural supply chains. Specifically, the study by Johansen [18] indicates that usefulness, ease of use, compatibility, autonomy, relative advantage, traceability, transferability, and information security directly affect the acceptability of blockchain adoption in agricultural agriculture supply chains. Nayal et al. [19] have pointed out essential antecedents for blockchain adoption to build a sustainable agricultural supply chain, including green and lean practices, supply chain integration, supply chain risks, performance expectations, top management support, costs, internal and external environmental conditions, regulatory support, and innovation in the blockchain adoption process. In addition, the current literature also helps to identify important moderating variables that affect the adoption of blockchain applications by consumers and stakeholders in the supply chain. First, age, education level, income, and social status are factors belonging to the socio-demographic characteristics of consumers, which significantly affect their acceptance of blockchain adoption [20]. According to Lindman et al. [21], age often negatively impacts the adoption trend, and vice versa; education level, income, and social status positively impact the trend of new technology adoption.

Although much research on blockchain adoption has been done, some research gaps still need to be addressed. Firstly, the current studies mainly apply the technology acceptance theory models (TAM) and the unified theory of acceptance and use of technology (UTAUT) to explain individuals' acceptance of technology adoption in the case of an individual or a single company [18, 22]. Few studies measure the readiness of a supply chain to adopt blockchain in general [18]. In other words, the impact of the relationship between the parties in the supply chain on the decision to adopt new technology has yet to be thoroughly evaluated. Second, previous studies have focused on the acceptance level of consumers and stakeholders in the supply chain [5],[6]. The compatibility of blockchain technology with the existing information technology system operating in the current supply chain has yet to be thoroughly studied.

Similarly, current research models need to assess supply chain stakeholders' readiness (such as the availability of finance, technology, and human resources). Further, the external environment (such as legal and social influences) has yet to be considered. More research is needed to build a unified theoretical framework and broad scale to assess the stakeholders' readiness level to adopt blockchain in the agricultural supply chain [18].

In this study, by referring to the Technology - Organization - Environment (TOE) model of Depietro et al. [23], the study conducts the qualitative research step to build a new theoretical scale to evaluate readiness to apply blockchain to the agricultural supply chain. Specifically, from the results of in-depth interviews with experts, a new scale has been developed, with several recommendations have been made: First, the study has separated the organization factor into intra-organization and inter-organization to match the specific realities of the supply chain (many existing stakeholders, not just a single company - as in the assumption of the TOE model). Second, the observed variables for each factor in the new model are also adjusted to be consistent with the practice of the pork supply chain in Vietnam (Table 1).

Being aware of the limitations of the TOE model in explaining determinants of households' technology pork adoption which are very popular in the pork supply chain, the evaluation criteria in the scale are adjusted to ensure conformity with the practice of household stakeholders. Similarly, during the survey process, some terms in the scale are adjusted, such as top manager to the key decision maker in the household, organizational culture to family culture, and human resources to family members.

Table 1. Proposed assessment scale on stakeholders' readiness level for blockchain adoption

Criteria	Details	Source
	Readiness on technological conditions (TEC)	
Relative advantage (RA)	The perceived level of superior usefulness and effectiveness that new technology (such as blockchain) brings compared to existing technologies (such as computer-based or phone-based notes, ERP system).	Lin [24], Ali [25], Alvarez and nuthall [26]
Compatibility (CA)	Technical compatibility/conformity with existing systems, organizational integration and operation of new technology, and ability to standardize/replicate the technology in the supply chain.	Lin [24], Ali [25], Baker [27]
Complexity (CX)	Ease of use of new technology (such as blockchain). The lower the level of complexity, the faster and more convenient the adoption of technology.	Lin [24], Ali [25], Lin [24], Chittipaka et al. [28]
Trialability (TRI)	The ability to trial new technology (such as blockchain) before making the eventual decision to implement or not to implement this new technology.	Baker [27], Malik et al. [29]
Scalability (SC)	The extent to which all stakeholders in the supply chain widely use blockchain technology. Scalability also affects the speed of transactions and the size of blocks in the blockchain.	Baker [27], Malik et al. [29]
	Readiness on inter-organizational conditions (INTER)	
Trading partner pressure (TPP)	Cohesion and long-term relationships with key partners in the supply chain could encourage the adoption of blockchain.	Lin [24], Alvarez and nuthall [26], Saetang et al. [4]
Information disclosure (ID)	The willingness level to share information/knowledge among stakeholders in the supply chain.	Baker [27], Chittipaka et al. [28]

Criteria	Details	Source
Trust (TRU)	The trust among supply chain stakeholders to each other. This also evaluates the extent to which all stakeholders believe in the benefits of adopting new technology.	Alvarez and nuthall [26], Saetang et al. [4]
	Readiness on intra-organizational conditions (INTRA)	
Top management support (TMS)	Top managers' level of technical knowledge, adoption commitment, and risk tolerance when adopting new technology.	Lin [24], Ali [25], Malik et al. [29]
Resource availability (REA)	Availability of tangible means and equipment for adopting new technologies. Also, human resources, technical knowledge, and financial readiness are available.	Lin [24], Ali [25], Alvarez and nuthall [26], Malik et al. [29], Chittipaka et al. [28]
Organizational readiness (OR)	Organizational culture encourages the adoption of new technologies. Also, the organisation has the ability and experience to meet new technology requirements.	Lin [24], Baker [27], Chittipaka et al. [28]
Firm size (FS)	It relates to capital scale, revenue, and technology-savvy human resources in the existing supply chain.	Alvarez and nuthall [26], Malik et al. [29]
	Readiness on environmental conditions (ENV)	
Competitive pressure (CP)	Pressure from competitors and the need to develop new competitive capabilities of stakeholders in the supply chain.	Lin [24], Alvarez, and Nuthall [26]
Legal pressure (LP)	Regulations from government, local authorities, and focal companies in the supply chain.	Lin [24], Baker [27], Malik et al. [29], Chittipaka et al. [28]
Social pressure (SP)	Pressure from consumers, the community, and social organizations.	Saetang et al. [4]

Source: Compiled by the authors

3 Methodology

In this study, the authors simultaneously use secondary and primary data sources. The secondary data is collected from the Bureau of Food Hygiene and Safety, Bureau of market management, and Department of Agriculture and Rural Development in Hue. These data provide information about the status of the pork supply chain, and local authorities' policies, regulations, and development orientations to the pork supply chain.

The primary data source is collected using qualitative and quantitative research methods. The qualitative research step is initially conducted to validate the proposed assessment scale. In this step, a group of experts is recruited, including experienced researchers, local authorities, and managers at typical stakeholders in the pork supply chain in Hue. The interview results are the basis for developing a new assessment scale consisting of four aspects: readiness on technological conditions (TEC), readiness on inter-organizational conditions (INTER), readiness on intra-organizational conditions (INTRA), and readiness on environmental conditions (ENV). This scale comprises the foundations for adopting blockchain technology in the pork supply chain.

Next, in the quantitative research step, the study collects primary data using a structured questionnaire to survey five stakeholders in the supply chain. These stakeholders include pig breeders/fatteners; slaughterhouses, processors; livestock dealers; meat wholesalers, retail food stores, pork sellers; pork deliveries, and transportation firms. The sample size was determined using the average sample size method with n = 356 samples [8]. The sample was selected based on two techniques: simple random technique and referrals/ snowball sampling technique. The list of pig breeders is provided by the Thua Thien Hue sub-department of livestock production and animal health, and the list of businesses engaged in pork production and trading is provided by the Hue Department of Industry and Trade. Based on these two lists, survey informants are selected. Besides, due to the overall list of remaining stakeholders in the supply chain (such as livestock dealers, pork sellers, and pork deliveries) is not available, the study approaches these objects through referrals of stakeholders who have participated in the survey. This technique also helps to reduce the hesitance of participants. The official survey was conducted via phone, face-to-face, zoom and email. The email survey sends reminder notices to participants every ten days after receiving the questionnaire.

Regarding analytical methods, the collected data were analyzed using Excel, SPSS 20.0, and AMOS 20.0 software.

4 Research results

4.1 Sample description statistics

The results of descriptive statistical analysis of 356 samples reveal that pig breeders/fatteners and commercial stakeholders (Meat wholesalers, retail food stores, and pork sellers) accounted for the majority (with 33.4% and 35.7%, respectively) (Table 2). Stakeholders have a relatively long operating time (most are 10 years or more). Notably, these stakeholders must be more secure in grasping new technological know-how. This comes from many reasons, such as the need for more young employees and opportunities to be exposed to new technologies in the past. Finally, the annual expenditure for equipping IT facilities is relatively limited; 20 million VND or fewer accounts for 66.3%. Most individual stakeholders only spend on essential equipment such as phones and computers. In contrast, organizational stakeholders invest heavily in new technologies such as installing camera systems, barn sensors, and RFID systems.

Table 2. Sample description

Classification	Frequency	%	Classification	Frequency	%
Your firm's position in the pork supply chain			**Firm's ability to grasp new technology know-how**		
pig breeders/fatteners	119	33.4	Very fast	22	6.2
Slaughterhouse, processor	49	13.8	Fast	64	18.0
Livestock dealers	36	10.1	Neutral	97	27.2
Meat wholesalers, retail food stores, pork sellers	127	35.7	Slow	101	28.4
Pork delivers, transportation firm	25	7.0	Very slow	72	20.2
Operating time			**Annual expenditure for equipping IT facilities**		
Less than 3 years	19	5.3	Under 5 million VND	95	26.7
From 3 years to 10 years	57	16.0	From 5 to 20 million VND	141	39.6
From 10 years to 20 years	128	36.0	From 20 to 100 million VND	76	21.3
Over 20 years	152	42.7	Over 100 million VND	44	12.4

Source: Data Processing, 2022

4.2 Exploratory factor analysis (EFA)

The principal components factor analysis method with promax rotation is used. The results indicate that three variables are disqualified due to having factor loading values less than 0.5 - not meeting the convergence requirement [30]. It includes Information about the cryptocurrency (such as Bitcoin) that does not affect your perception of the benefits of blockchain to supply chain (SP5), your firm believes that competitors have recently begun to explore blockchain technology (CP4), the firm's management team has a high level of knowledge about new technologies (TMS3). The fourth extraction result obtained KMO = 0.900 (>0.5), and the significance level of Bartlett's Test of Sphericity is 0.000 (<0.05). Finally, 62 observed variables were grouped into 18 factors. The total variance extracted was 82.192% (>50%) [31] (Table 3).

4.3 Confirmatory factor analysis (CFA)

First order CFA

Next, the Confirmatory factor analysis (CFA) is used to verify the factor structure of a set of observed variables. CFA allows the researcher to test the hypothesis that a relationship exists between observed variables and their underlying latent constructs. The results of the CFA confirmatory factor analysis show that Considering the acceptance threshold of the model fit index (Model fit) according to Arbuckle [32], specifically: CMIN/df = 1,776 (less than 2) is good; TLI = 0.920 (greater than 0.9) is good; CFI = 0.924 (greater than 0.9) is good, RMSEA = 0.047 (less than 0.08) is good (Table 4).

Regarding the reliability of the scale, all variables have a construct reliability value greater than 0.7 (ranging from 0.836 to 0.917) and average variance extracted (AVE) values from 0.562 to 0.817 larger than the required value of 0.5 [33] Table 5. Similarly, conducting Cronbach's alpha test, the obtained values ranging from 0.804 to 0.900 are all more significant than the required value of 0.7 [34–36], and the scale just built has high reliability.

Table 3. EFA analysis results

Modification	KMO	Sig. of Barlett's test	Total variance extracted
1st EFA	0.900	0.000	80.328
4th EFA	0.900	0.000	82.192

Source: Data Processing, 2022

Table 4. CFA analysis results

CMIN/DF	TLI	CFI	RMSEA
1.776	0.920	0.924	0.047

Source: Data Processing, 2022

Table 5. Scale reliability analysis

Scale	Scale reliability		
	Alpha	CR	AVE
Relative advantage (RA)	0.904	0.905	0.606
Organizational readiness (OR)	0.901	0.905	0.705
Social pressure (SP)	0.916	0.917	0.735
Trialability (TRI)	0.875	0.877	0.641
Scalability (SC)	0.889	0.890	0.669
Complexity (CX)	0.878	0.879	0.646
Competitive pressure (CP)	0.858	0.857	0.784
Information disclosure (ID)	0.828	0.836	0.562
Top management support (TMS)	0.851	0.852	0.767
Legal pressure (LP)	0.907	0.906	0.764
Resource availability (REA)	0.929	0.930	0.817
Trading partner pressure (TPP)	0.881	0.883	0.716
Trust (TRU)	0.861	0.866	0.685
Firm size (FS)	0.874	0.886	0.723
Compatibility (CA)	0.901	0.904	0.758

Source: Data Processing, 2022

Regarding the convergent validity, all critical t-values have absolute values greater than 1.96 (statistically significant, p-value < 0.05), and all normalized weights are more important than 0.5, so all concepts have convergent values. Regarding the discriminant value, the difference between the Chi-square difference of the pairs corresponding to 15 groups of variables is more significant than 3.84, so these models all achieve discriminant validity [37].

Generally, the concepts' CFA is unidirectional, ensuring convergent, reliability and discriminant validity. The proposed scale is consistent with the research data.

Second order CFA

The study applies the second-order confirmatory factor analysis method to re-examine and re-confirm that the above measurement models are still stable in Second-order construct structure. The analysis results indicate that the second-level structural model of four concepts: readiness on technological conditions (TEC), readiness on inter-organizational conditions (INTER), readiness on intra-organizational conditions (INTRA), readiness on environmental conditions (ENV), all have composite reliability (CR) > 0.7 and total extracted variance (AVE) > 0.5, so it can be concluded that the scales in each hierarchical structure model 2 are both reliable.

Table 6. Regression path coefficients in second-order structural models

Factor	Path	Construct	Estimate	SE	CR	P	Result
LP	<---	ENV	0.847	0.083	10.157	***	significant
SP	<---	ENV	1			Reference point	
CP	<---	ENV	0.903	0.085	10.673	***	significant
TMS	<---	INTRA	1.085	0.096	11.330	***	significant
REA	<---	INTRA	1			Reference point	
ORG	<---	INTRA	0.980	0.090	10.934	***	significant
FS	<---	INTRA	0.925	0.086	10.722	***	significant
ID	<---	INTER	1.134	0.204	5.549	***	significant
TPP	<---	INTER	1			Reference point	
TRU	<---	INTER	1.043	0.190	5.484	***	significant
RA	<---	TECH	1.047	0.099	10.553	***	significant
CA	<---	TECH	1			Reference point	
CX	<---	TECH	0.861	0.090	9.551	***	significant
TRI	<---	TECH	0.879	0.088	9.958	***	significant
SC	<---	TECH	0.941	0.094	9.991	***	significant

Note: *** - equivalent to the value of 0.000

Source: Data Processing, 2022

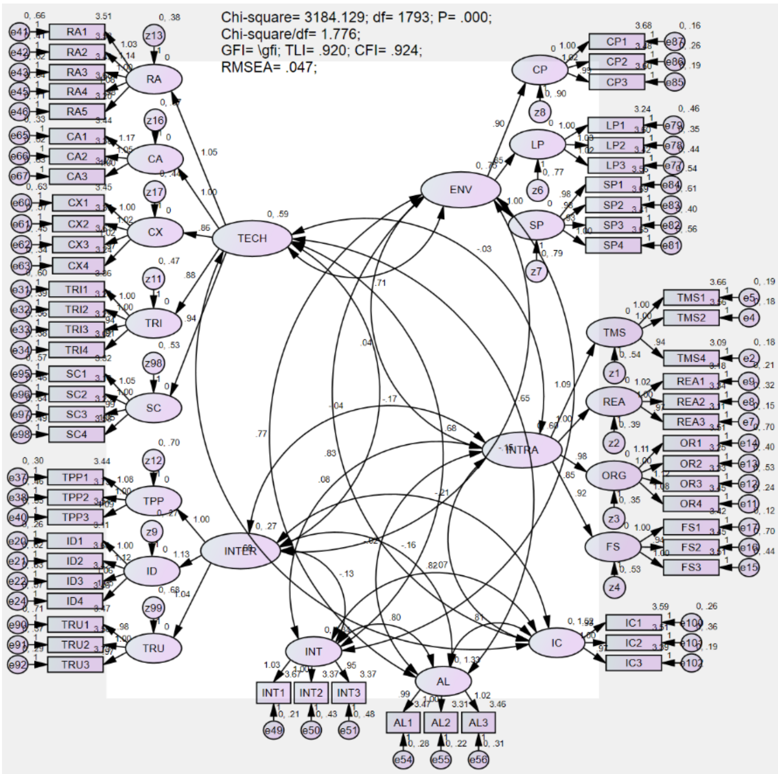

Figure 1. CFA results

Source: Data Processing, 2022

Besides considering the fit of the second-order structural model through the above analysis, the results of the regression coefficient analysis in Table 6 also show a close relationship between dummy variables: Readiness on technological conditions (TEC), readiness on inter-organizational conditions (INTER), readiness on intra-organizational conditions (INTRA), readiness on environmental conditions (ENV), and 15 latent variables. Specifically, the P-values of all components are significant, with their respective values less than 0.05. Thus, the second-order structural model is stable and can be used for other analysis steps.

4.4 Evaluate the importance of the criteria in the scale

Next, the study collects and analyzes the evaluation of stakeholders in the supply chain about the importance of the criteria in the proposed scale (based on the Likert scale - 5 levels). The results imply that related to the assessment of **Readiness on technological conditions (TEC)**, the relative advantage (RA) factor has the highest mean value (3.493) (Table 7). This is understandable because this is a decisive factor for replacing existing technologies with blockchain. In contrast,

Table 7. Evaluate the importance of the criteria in the scale

Criteria	Importance	Criteria	Importance
Readiness on technological conditions		**Readiness on intra-organizational conditions**	
Relative advantage (RA)	3.493	Top management support (TMS)	3.438
Compatibility (CA)	3.418	Resource availability (REA)	3.211
Complexity (CX)	3.415	Organizational readiness (OR)	3.385
Trialability (TRI)	3.237	Firm size (FS)	3.461
Scalability (SC)	3.327		
Readiness on inter-organizational conditions		**Readiness on environmental conditions**	
Trading partner pressure (TPP)	3.574	Competitive pressure (CP)	3.586
Information disclosure (ID)	3.402	Legal pressure (LP)	3.422
Trust (TRU)	3.591	Social pressure (SP)	3.582

Source: Data Processing, 2022

the average evaluation of the two factors, trialability (TRI) and scalability (SC), is not high (3.237 and 3.327).

These findings contrast to the research results of Takagi et al. [38] and Gunasekera et al. [39]. These results come from the fact that the survey participants are mainly individuals and households, so the risk when applying and the scale of technology adoption are not large, leading to the needs for trial and replication are not significant.

Regarding the **readiness assessment on inter-organizational conditions (INTER)**, the analysis results indicate that trust and trading partner pressure are considered the most critical factors (mean values are 3.591 and 3.574, respectively). This result is similar to the study of Vlachos [40]. Stemming from the high transparency feature, blockchain adoption requires a high willingness to share information and knowledge among stakeholders in the supply chain. This is also one of the most significant barriers to blockchain adoption due to concerns about security and undisclosed business secrets from supply chain stakeholders.

Regarding the **readiness assessment on intra-organizational conditions (INTRA)**, support from the management team and firm size (3.438 and 3.461) are considered two critical foundational factors for blockchain adoption. This result is similar to the research findings of Yoon et al. [41]. This comes from the reality that blockchain adoption requires relatively significant investment to set up the system, mobile apps, data storage, data sharing costs, and technical knowledge—new techniques for implementing data collection and retrieval. In addition, due to the characteristics of new technology, there have not been many pilot cases, so it is necessary to have support and high-risk tolerance from the top management team.

Regarding the **readiness assessment on environmental conditions (ENV)**, the criteria of competitive pressure (CP) and social pressure (SP) are rated at the highest level, at 3.586 and 3.584, respectively. This result is similar to the research findings of Yoon et al. [41]. In today's fiercely competitive business environment, finding new methods to improve operations and create unique competitive advantages are always great motivations for corporate governance decisions. In addition, the pressure from the consumer community is also considered very important because this is the targeted audience of any business.

5 Conclusion

Blockchain technology is considered a critical "key" for digital transformation and building a future information technology platform in the wave of agricultural revolution 4.0. This study has created a new assessment scale on stakeholders' readiness to apply blockchain technology to agricultural supply chains. The research results bring some significant contributions below.

Theoretical contributions

Firstly, by referencing the TOE theoretical model, the study outlines a new theoretical scale to assess the stakeholders' readiness level to adopt blockchain in the supply chain. By adding the readiness on inter-organizational conditions (INTER), this new theoretical scale is more suitable for the case of technology adoption in the "supply chain" instead of the possibility of just a single firm. Further, the scale is also highly ideal for technologies with specific characteristics that enable widespread information sharing, like blockchain.

Secondly, through surveying 365 individual/organizational stakeholders in the pork supply chain in Hue, the research has tested the relevance and reliability of the proposed scale. Specifically, the results of exploratory factor analysis shortened the scale to 62 observed items and 18 factors. Then, the first-order confirmatory factor analysis results helped test the overall scale's relevance and reliability of each component scale. Finally, the second-order confirmatory factor analysis step helped identify four underlying sub-constructs, including readiness on technological conditions (TEC), readiness on inter-organizational conditions (INTER), readiness on intra-organizational conditions (INTRA), and readiness on environmental conditions (ENV). These aspects have a substantial impact on the readiness to adopt blockchain technology. The scale from this study can be widely used in research on technology adoption in supply chains in general and agricultural supply chains in particular.

Practical contributions

Supply chain managers can apply the scale proposed in this study to measure their businesses' readiness for blockchain adoption. In addition, the results of further analysis have shown the six most essential platforms to meet when considering the adoption of blockchain in agricultural supply chains, including Relative advantage (RA), Trust (TRU), Trading partner pressure (TPP), Firm size (FS), Top management support (TMS) and Competitive pressure (CP). This result is quite similar to the results from the study of Alvarez and Nuthall [26] and Ali [25].

In general, the study has achieved the initial objectives. However, the study still has some limitations due to time and cost constraints. The research sample is collected based on a simple random sampling method. There needs to be a balance between units in the supply chain. In addition, the generalizability of the results could be better as the study was conducted only within the pork supply chain in Hue. Therefore, in future studies, it is possible to overcome these limitations by using a proportional random sampling method, and expand the research scope to many different supply chain fields, with a wide range of more comprehensive, spread all over Vietnam.

References

1. Tian, F. (2017), A supply chain traceability system for food safety based on HACCP, blockchain & Internet of things, in *2017 International conference on service systems and service management*, *IEEE*, 1–6.
2. Dabbene, F., Gay, P. and Tortia, C. (2014), Traceability issues in food supply chain management: A review, *Biosyst. Eng.*, 120, 65–80.
3. Agwu, A. E., Ekwueme, J. N., and Anyanwu, A. C. (2008), Adoption of improved agricultural technologies disseminated via radio farmer programme by farmers in Enugu State, Nigeria, *Afr. J. Biotechnol.*, 7(9).
4. Saetang, W., Tangwannawit, S., and Jensuttiwetchakul, T. (2020), The effect of technology-organization-environment on adoption decision of big data technology in Thailand, *Int J Electr Comput*, 10(6), 6412.
5. Alazab, M., Alhyari, S., Awajan, A., and Abdallah, A. B. (2021), Blockchain technology in supply chain management: an empirical study of the factors affecting user adoption/acceptance, *Clust. Comput.*, 24(1), Art. no.1.
6. Ghode, D., Yadav, V., Jain, R. and Soni, G. (2020), Adoption of blockchain in supply chain: an analysis of influencing factors, *J. Enterp. Inf. Manag.*
7. Kamilaris, A., Fonts, A., and Prenafeta-Boldu, F. X. (2019), The rise of blockchain technology in agriculture and food supply chains," *Trends Food Sci. Technol.*, vol. 91, pp. 640–652.
8. Rogerson, M. and Parry, G. C. (2020), Blockchain: case studies in food supply chain visibility, *Supply Chain Manag. Int. J.*
9. Hoa, V. T., Thai, P. T., and Phuong, N. T. H. (2018), Factors influencing the decision to buy fruits and vegetables from supermarket channel of consumers in Nha Trang, *Sci. Technol. Dev. J.-Econ.-Law Manag.*, 2(4), 22–35.

10. Sander, F., Semeijn, J. and Mahr, D. (2018), The acceptance of blockchain technology in meat traceability and transparency, *Br. Food J.*.
11. Van Campenhout, B. (2022), ICTs to address information inefficiencies in food supply chains, *Agric. Econ.*, 53(6), 968–975, doi: 10.1111/agec.12731.
12. Raj, A. and Jeyaraj, A. (2023), Antecedents and consequents of industry 4.0 adoption using technology, organization and environment (TOE) framework: A meta-analysis, *Ann. Oper. Res.*, 322(1), 101–124, doi: 10.1007/s10479-022-04942-7.
13. Laroiya, C., Saxena, D. and Komalavalli, C. (2020), Chapter 9 - Applications of blockchain technology, *Handbook of Research on Blockchain Technology*, 213–243. doi: 10.1016/B978-0-12-819816-2.00009-5.
14. Shahid, A., Almogren, A., Javaid, N., Al-Zahrani, F. A., Zuair, M. and Alam, M. (2020) Blockchain-based agri-food supply chain: A complete solution, *Ieee Access*, 8, 69230–69243.
15. Soriano, J. B. *et al.* (2020), Prevalence and attributable health burden of chronic respiratory diseases, 1990–2017: A systematic analysis for the Global Burden of Disease Study 2017, *Lancet Respir. Med.*, 8(6), 585–596, doi: 10.1016/S2213-2600(20)30105-3.
16. Khan, S., Kaushik, M. K., Kumar, R. and Khan, W. (2022), Investigating the barriers of blockchain technology integrated food supply chain: a BWM approach, *Benchmarking Int. J.*
17. Beck, R., Becker, C., Lindman, J. and Rossi, M. (2017), *Opportunities and risks of blockchain technologies (Dagstuhl Seminar 17132)*, in *Dagstuhl Reports*, Schloss Dagstuhl-Leibniz-Zentrum fuer Informatik.
18. Johansen, S. K. (2018), A comprehensive literature review on the Blockchain as a technological enabler for innovation, *Dept Inf. Syst. Mannh. Univ. Ger.*, 1–29.
19. Nayal, K., Raut, R. D., Narkhede, B. E., Priyadarshinee, P., Panchal, G. B., and Gedam, V. V. (2021), Antecedents for blockchain technology-enabled sustainable agriculture supply chain, *Ann. Oper. Res.*, 1–45.
20. Beck, R., Becker, C., Lindman, J., and Rossi, M. (2017), Opportunities and risks of blockchain technologies (Dagstuhl Seminar 17132), in *Dagstuhl Reports*, Schloss Dagstuhl-Leibniz-Zentrum fuer Informatik.
21. Lindman, J., Tuunainen, V. K., and Rossi, M. (2017), Opportunities and risks of Blockchain Technologies–a research agenda.
22. D. D. Q. Hao, T. T. Hoa, and N. H. Dung (2020), Factors affecting customers'acceptance of the adoption of blockchain technology at Dong A Commercial Joint Stock Bank, Hue Branch, *Hue Univ. J. Sci. Econ. Dev.*, 129(5A), 5–16.
23. Depietro, R., Wiarda, E. and Fleischer, M. (1990), The context for change: Organization, technology and environment, *Process. Technol. Innov.*, 151–175.

24. Lin, H. -F. (2014), Understanding the determinants of electronic supply chain management system adoption: Using the technology–organization–environment framework, *Technol. Forecast. Soc. Change*, 86, 80–92.
25. Ali, J. (2012), Factors affecting the adoption of information and communication technologies (ICTs) for farming decisions, *J. Agric. Food Inf.*, 13(1), 78–96.
26. Alvarez, J. and Nuthall, P. (2006), Adoption of computer based information systems: The case of dairy farmers in Canterbury, NZ, and Florida, Uruguay, *Comput. Electron. Agric.*, 50(1), 48–60.
27. Baker, J. (2012), The technology–organization–environment framework, *Inf. Syst. Theory Explain. Predict. Our Digit. Soc.*, 1(231–245).
28. Chittipaka, V., Kumar, S., Sivarajah, U., Bowden, J. L. H. and Baral, M. M. (2022) Blockchain technology for supply chains operating in emerging markets: An empirical examination of technology-organization-environment (TOE) framework, *Ann. Oper. Res.*, pp. 1–28, 2022.
29. Malik, S., Chadhar, M., Vatanasakdakul, S. and Chetty, M. (2021), Factors affecting the organizational adoption of blockchain technology: Extending the technology–organization–environment (TOE) framework in the Australian context, *Sustainability*, 13(16), 9404.
30. Cudeck, R. (2000), Exploratory factor analysis, in Handbook of applied multivariate statistics and mathematical modeling, *Elsevier*, 265–296.
31. Fabrigar, L. R. and Wegener, D. T. (2011), *Exploratory factor analysis*, Oxford University Press.
32. Arbuckle, J. L. (2006), 17.0 user's guide, in *Crawfordville, FL. Amos Development Corporation*, Citeseer.
33. Hair, J. F., Anderson, R. E., Tatham, R. L., and William, C. (1998), *Black (1998), Multivariate data analysis*, Upper Saddle River, NJ: Prentice Hall.
34. Nunnally, J. C. (1978), *Psychometric Theory 2nd ed.*, Mcgraw hill book company.
35. Peterson, R. A. (1994), A meta-analysis of Cronbach's coefficient alpha, *J. Consum. Res.*, 21(2), 381–391.
36. Slater, S. F. (1995), Issues in conducting marketing strategy research, *J. Strateg. Mark.*, 3(4), 257–270.
37. Anderson, J. C. and Gerbing, D. W. (1988), Structural equation modeling in practice: A review and recommended two-step approach., *Psychol. Bull.*, 103(3), 411.
38. Takagi, C., Purnomo, S. H. and Kim, M. K. (2021), Adopting smart agriculture among organic farmers in Taiwan, *Asian J. Technol. Innov.*, 29(2), 180–195.
39. Gunasekera, D. and Valenzuela, E. (2020), Adoption of blockchain technology in the australian grains trade: An assessment of potential economic effects, *Econ. Pap. J. Appl. Econ. Policy*, 39(2), 152–161.

40. Vlachos, I. P. (2004), Adoption of electronic data interchange by agribusiness organizations, *J. Int. Food Agribus. Mark.*, 16(1), 19–42.

41. Yoon, C., Lim, D., and Park, C. (2020), Factors affecting adoption of smart farms: The case of Korea, *Comput. Hum. Behav.*, 108, 106309.