The Pharma Innovation Journal 2023; 12(6): 2475-2481

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(6): 2475-2481

www.thepharmajournal.com
Received: 09-04-2023
Accepted: 06-06-2023

Nandhini S
Research Scholar, Department of Agricultural and Rural Management (ARM), Coimbatore, Tamil Nadu, India

Sivakumar SD
Professor (ARM) & TPO to Vice Chancellor, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Venkatesa Palanichamy N
Venkatesa Palanichamy N, Dean (Agriculture), Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Anandhi V
Associate Professor, Department of Physical Sciences and Informational Technology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Balasubramanian P
Director, Open and Distance Learning, TNAU, Coimbatore, Tamil Nadu, India

Vasanthi R
Associate Professor, Department of Physical Sciences and Informational Technology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Corresponding Author:
Nandhini S
Research Scholar, Department of Agricultural and Rural Management (ARM), Coimbatore, Tamil Nadu, India

Interpretive structural Modeling approach to analyse the barriers of blockchain technology adoption in agricultural supply chain

Nandhini S, Sivakumar SD, Venkatesa Palanichamy N, Anandhi V, Balasubramanian P and Vasanthi R

Abstract
Blockchain, an innovative technology will bring a digital revolution in agribusiness by enabling transparency and traceability. Many firms have expressed inability to adopt this technology and its potential is unexploited. Therefore the study aims to identify the barriers for adoption of blockchain technology in agribusiness and also examines the interrelationship among the identified barriers. This can bring significant changes in agribusiness firms for successful and faster adoption of the blockchain technology. The study uses Interpretive Structural Modeling to develop a structural model for identified barriers. The results revealed that inadequate knowledge and expertise, huge initial investment and lack of government regulations, poor market facilities for traceable produce followed by lack of consumer demand for traceable produce were the major influential barriers hindering blockchain technology adoption. In addition, it provided managerial insights about how to overcome the challenges to increase the adoption rate in the agricultural supply chain. This will be helpful for the government, policymakers and businesses to make strategies to establish a blockchain based traceability system in the agricultural supply chain.

Keywords: Blockchain technology, adoption barriers, agricultural supply chain, ISM approach

Introduction
Precision agriculture is increasingly recommended to meet the global demand for traceable and quality food products. Consumer concern and awareness about food safety and security made the food industries to adopt appropriate technologies to meet the consumer demands for food safety. In recent years, digitization of the agricultural supply chain is done by integration and adoption of various technologies like radio frequency identification, wireless sensors network, and other ICT's. Blockchain is a decentralized ledger technology underpinned by industry 4.0 which prevents data tampering, ensures transparency, integrity and immutability, and adds value to the organization (Christidis and Devetsikiotis, 2016) [5]. It helps in secure handling and storage of administrative records that keeps adding new records, called "blocks" to create a network (Wang *et al.* 2019) [17] and (Guo and Yu, 2022) [7]. Such networks use consensus mechanism to verify that events are transparent and traceable. The primary function of blockchain is the traceability of stored data across business operations that shares sensitive data among various stakeholders in a decentralized manner (Risius and Spohrer, 2017) [14]. Thus adoption of blockchain technology can bring significant changes and reformation by enabling transparency and traceability in agricultural supply chain (Antonucci *et al.* 2019 and Zhao *et al*. 2019) [2, 20]. It also provides solutions to unsolved problems like lack of trust among the stakeholders, food fraud issues and low supply chain visibility. This technology has also enabled smart contract facilities for better decision making among the supply chain stakeholders (Behnke and Janssen, 2019) and provide real time information in agricultural supply chain. To meet sustainable development in the agricultural supply chain, the firm should ensure the involvement of farmers, input suppliers and other stakeholders to collaborate and take initiatives to meet the consumers demand for quality and traceable food products (Rocha *et al.* 2021) [15].

Blockchain in Indian agriculture
Indian agricultural supply chain faces many challenges in meeting consumer demand. Poor infrastructure facilities for storage and preservation leads to food losses and quality deterioration (Yawar and Kauppi, 2018) [19].

Involving many intermediaries in the supply chain leads to delayed payments and high lead time for transactions. Furthermore, consumers are more concerned about the product quality and safety. This made agribusiness firms to source the technologies for supply chain management. A few Indian companies have launched pilot blockchain project to manage agricultural supply chain. In India, Ministry of Commerce and Industry (2019), introduced blockchain platform for coffee trading, Vegetable and Fruit Promotion Council of Kerala (VFPCK) adopted BCT to export Nendran bananas which increased farmer revenue by eliminating middlemen (Thejaswini and Ranjitha, 2020) [16]. Still, there is little research about its achievements. Hence, it is difficult for supply chain stakeholders to understand how blockchain technology could be used in their business (Ahmad and Qahmash, 2021 and Paul *et al*., 2022) [1, 10]. Therefore, more research studies must be encouraged to gain potential knowledge about the adoption of blockchain technology in agriculture and supply chains. Identifying the adoption challenges helps us to understand the underlying problems and helps to find the solutions for the successful adoption of blockchain technology in agricultural supply chain. Hence, the present study attempts to identify the challenges in blockchain technology adoption in the agricultural supply chain. The addressed barriers and proposed solutions would be helpful to the government, decision and policy makers, and organizations to promote adoption of blockchain technology in future. Supply chain stakeholders could also prepare suitable strategies for the successful adoption of blockchain in agricultural supply chain.

Research Methodology

Kazhani Farmer Producer Company (KFPC), located in Erode district of Tamil Nadu provides input services to farmers, engage in processing activities of farm produce and owns retail outlet. In addition, it establishes forward and backward linkage for farm produce in order to assist small and marginal producers to increase their farm income and improve their standard of living. Kazhani FPC also focus on various business models such as banana exports, Smart IoT- based agriculture, traceability using blockchain technology, organic production practices and contributes to rural agricultural development in the region.

Madurai agribusiness incubation forum (MABIF) is a business incubator that assists start-ups and early stage businesses by providing network access, infrastructure facilities, and access to funds, mentoring entrepreneurs, and fostering agribusiness development. Kazhani FPC connects with MABIF to pilot the blockchain based traceability system to create a digital identity for the product in agricultural supply chain. It has implemented blockchain technology in red banana supply chain. Focus group discussion was done with the blockchain experts in the month of December 2022 to find the significant barriers for blockchain adoption in agricultural supply chain. Ten barriers were identified based on Expert's opinion and through literature review. A total of nine experts were included as sample respondents for this study in which three were blockchain service providers, two academicians cum practitioners, one manager from MABIF and one Chief executive officer and two members of Kazhani FPC. Further identified barriers from expert opinion was modelled using an Interpretive Structural Modelling (ISM) approach to find the cause and effect interrelationship. It also evaluates the intensity of the relationship between the identified barriers and provides a hierarchical structure for finding suitable solutions (Attri *et al*. 2017; Gardas *et al*. 2019 and Yadav *et al.* 2020) [3, 6, 18]. The stepwise procedure for ISM model are given below.

1. **Identification of barriers:** Most important and influential barriers identified through the literature review and experts opinion were taken to construct the model. List of barriers for blockchain technology adoption in agricultural supply chain is presented in the table 1.
2. **Self-structural interaction matrix:** After identification of barriers, a structural self-interaction matrix was constructed to define the contextual relationship between the identified barriers. The established relationship between the identified barriers were represented using the symbols V, A, X, O. If the factor i influence the factor j then the symbol V was used for representation, symbol A denotes that factor j influence factor i. when both factors i and j influence each other, it was represented as X and if there was no relationship between the factors i and j, it was represented as O.
3. **Initial and final reachability matrix:** Self-structural interaction matrix was transformed into an initial reachability matrix (IRM), by applying specific rules. In the next step, initial reachability matrix was checked for transitivity to get the final reachability matrix (FRM) by applying transitivity rule. The rules included in this substitution were as follows,
   - If (p, q) in structural self-interaction matrix is V, then (p→q) will be 1 and 0 vice versa.
   - If (p, q) in structural self-interaction matrix is A, then (p→q) will be 0 and 1 vice.
   - If (p, q) in structural self-interaction matrix is X, then (p q) and (q→p) will be 1.
   - If (p, q) in structural self-interaction matrix is O, then (p q) and (q→p) will be 0.

Table 1: Barriers in blockchain technology adoption in Agricultural supply chain

S. No	Barriers	Description	Denoted by
1	Inadequate knowledge and expertise	Lack of understanding and infant stage of technology in practical implementation in supply chain industries and unclear benefits	F1
2	Huge initial investment	Adopting BCT requires an organization to invest in new infrastructure for software development, installation, data collection, and processing, which is expensive.	F2
3	Technological infeasibility	Lack of large computing power, different levels of technical maturity among supply chain partners, and unfamiliarity with technology.	F3
4	Lack of collaboration between supply chain partners	Supply chain stakeholders avoid blockchain implementation due to financial risk and fear of change in business	F4
5	Lack of consumer demand for traceable produce	A dearth of awareness regarding traceability systems and food quality hampers the demand for traceable agricultural products.	F5
6	Poor market facilities for traceable produce	Non-availability of a domestic market for traceable products	F6

7	Stakeholders resistance to blockchain system	Supply chain stakeholders are unwilling to disclose the information due to a lack of confidence.	F7
8	Relying on blockchain software developers	Blockchain software is complicated and must be borrowed or set up by service providers. Many companies fear being dependent on blockchain operators despite its benefits.	F8
9	Lack of government regulations	The financial regulators and government bodies are not devising blockchain regulations, which may pose a barrier to its widespread acceptance and adoption.	F9
10	Lack of technical guidance	Lack of technical skill and guidance in initial setup, digital platforms, and complicated network protocols hinder the adoption of blockchain technology.	F10

4. **Level partioning and ISM structure:** The final reachability matrix was used for different level partition and to determine the hierarchical relationship between the variables. ISM structure was build based on the level partition. It was a pictorial representation about interrelationship between the identified barriers in hierarchical way. Using the arrow, the ISM structure illustrated the links between the barriers. This provided the conceptual framework for the barriers for elimination while adopting the technology.

Results and Discussion

Major barriers for blockchain technology adoption identified in the study was further analysed using ISM approach to develop relationship structure, prioritize and to make suitable measures for effective implementation of blockchain in agricultural supply chain. The identified barriers were in line with the existing studies (Kumar and Iyengar, 2017; Queiroz and Wamba, 2019 and Perumal *et al*. 2023) [9, 13, 11].

Developing structural self-interaction matrix

A structural self-interaction matrix was constructed to define the contextual relationship between the identified barriers. Here, pair-wise contextual relationships were identified between each of the barriers based on expert's opinions and presented in Table 2.

Table 2: Structural Self-Interaction Matrix (SSIM)

Factors	F10	F9	F8	F7	F6	F5	F4	F3	F2	F1
F1	V	O	O	A	O	A	V	O	A	
F2	A	O	A	A	A	V	O	O		
F3	V	V	A	O	V	O	A			
F4	A	V	A	X	A	A				
F5	X	A	A	A	A					
F6	A	V	A	O						
F7	V	V	V							
F8	V	O								
F9	X									
F10										

Establishing Initial reachability matrix

In ISM approach, after developing structural self-interaction matrix, initial reachability matrix was constructed. Here, structural self-interaction matrix was converted into Initial reachability matrix by substituting binary variables 1 and 0 for four symbols (V, A, X, O). Initial reachability matrix was constructed and presented in Table 3.

Table 3: Initial reachability matrix

Factors	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	1	0	0	1	0	0	0	0	0	1
F2	1	1	0	0	1	0	0	0	0	0
F3	0	0	1	0	0	1	0	0	1	1
F4	0	0	1	1	0	0	1	0	1	0
F5	1	0	0	1	1	0	0	0	0	1
F6	0	1	0	1	1	1	0	0	1	0
F7	1	1	0	1	1	0	1	1	1	1
F8	0	1	1	1	1	1	0	1	0	1
F9	0	0	0	0	1	0	0	0	1	1
F10	0	1	0	1	1	1	0	0	1	1

By applying transitivity rule, the initial reachability matrix was converted into final reachability matrix. The final reachability matrix obtained after transitivity check was denoted in (*) asterisk symbol and are presented in Table 4. The driving power (X) and dependence power (Y) for each barrier was obtained by adding all the factor values along the rows and columns respectively.

Table 4: Final reachability matrix

Factors	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	Driving power
F1	1	1*	1*	1	1*	1*	1*	0	1*	1	9
F2	1	1	0	1*	1	0	0	0	0	1*	5
F3	0	1*	1	1*	1*	1	0	0	1	1	7
F4	1*	1*	1	1	1*	1*	1	1*	1	1*	10
F5	1	1*	1*	1	1	1*	1*	0	1*	1	9
F6	1*	1	1*	1	1	1	1*	0	1	1*	9
F7	1	1	1*	1	1	1*	1	1	1	1	10
F8	1*	1	1	1	1	1	1*	1	1*	1	10
F9	1*	1*	0	1*	1	1	0	0	1	1	7
F10	1*	1	1*	1	1	1	1*	0	1	1	9
Dependence power	9	10	8	10	10	9	7	3	9	10	85

Level partioning

Partioning of levels was done to identify the level wise placement of barriers. The reachability, antecedents and intersection sets were developed from the final reachability matrix for each barriers. Reachability set includes row wise factors that have direct or indirect relationship with other factors in final reachability matrix. Antecedent set consist of column wise factors that have direct or indirect relationship with other factors in final reachability matrix. Intersection set includes the common factors in both reachability and antecedent sets.

Table 5: Level partioning - Iteration I

Factors	Reachability set	Antecedents set	Intersection set	Level
F1	1,2,3,4,5,6,7,9,10	1,2,4,5,6,7,8,9,10	1,2,4,5,6,7,9,10	
F2	1,2,4,5,10	1,2,3,4,5,6,7,8,9,10	1,2,4,5,10	I
F3	2,3,4,5,6,9,10	1,3,4,5,6,7,8,10	3,4,5,6,10	
F4	1,2,3,4,5,6,7,8,9,10	1,2,3,4,5,6,7,8,9,10	1,2,3,4,5,6,7,8,9,10	I
F5	1,2,3,4,5,6,7,9,10	1,2,3,4,5,6,7,8,9,10	1,2,3,4,5,6,7,9,10	I
F6	1,2,3,4,5,6,7,9,10	1,3,4,5,6,7,8,9,10	1,3,4,5,6,7,9,10	
F7	1,2,3,4,5,6,7,8,9,10	1,4,5,6,7,8,10	1,4,5,6,7,8,10	
F8	1,2,3,4,5,6,7,8,9,10	4,7,8	4,7,8	
F9	1,2,4,5,6,9,10	1,3,4,5,6,7,8,9,10	1,4,5,6,9,10	
F10	1,2,3,4,5,6,7,9,10	1,2,3,4,5,6,7,8,9,10	1,2,3,4,5,6,7,9,10	I

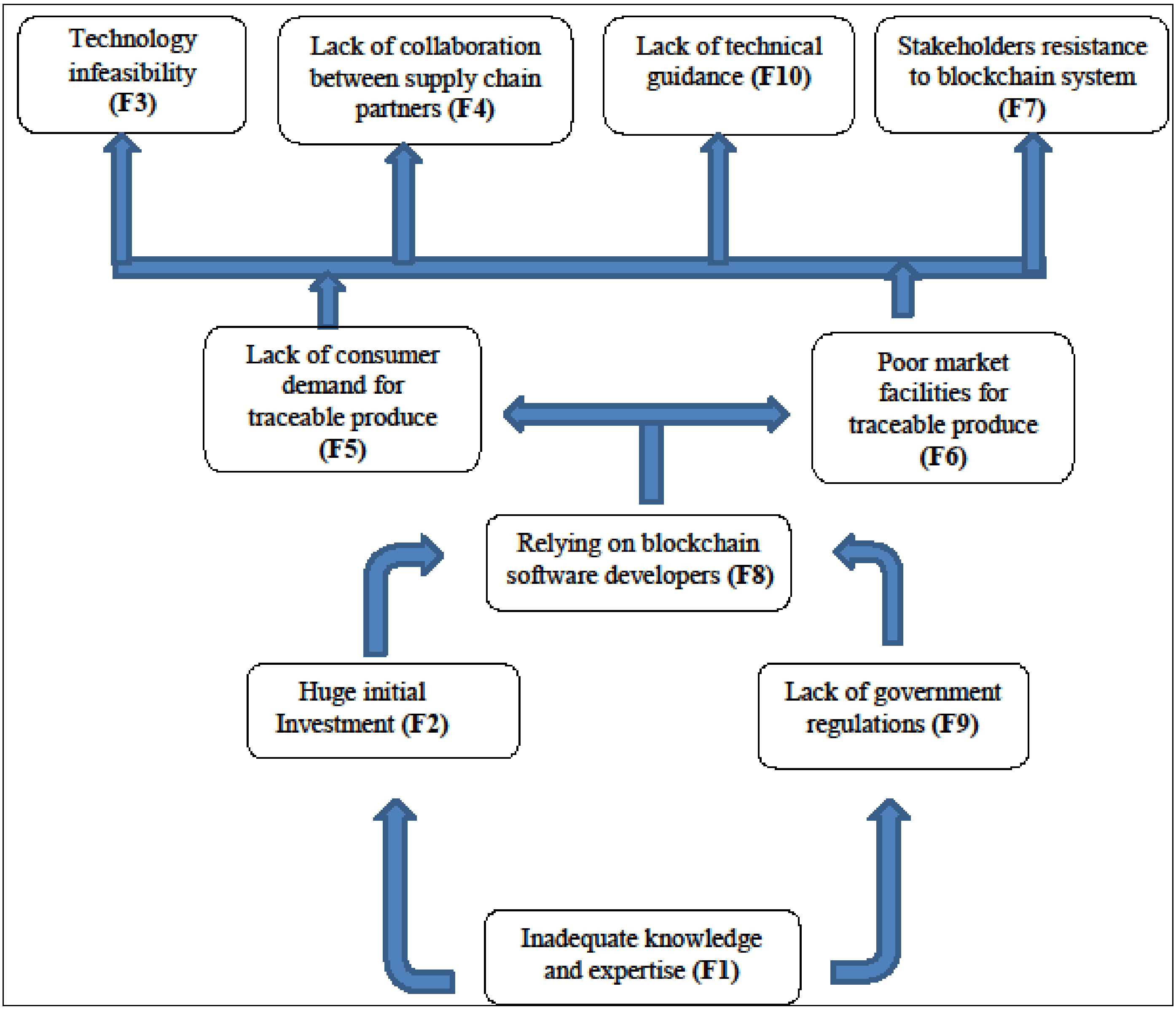
Thus level portioning was done for the barriers, when intersection set were same as the reachability set, the particular barrier was designated at the topmost level (Level I) in the ISM structure. Thus, level I barriers were removed from the entire set and further next iterations process was done until each barriers assigned with their corresponding levels. Finally, after 5 iterations all the factors were assigned their levels and the iterative process was presented in Table 6.

Table 6: Level partioning - Iteration II to V

Factors	Reachability set	Antecedents set	Intersection set	Level
Iteration process II				
F1	1,3,6,7,9	1,6,7,8,9	1,6,7,9	
F3	3,6,9	1,3,6,7,8	3,6	
F6	1,3,6,7,9	1,3,6,7,8,9	1,3,6,7,9	II
F7	1,3,6,7,8,9	1,6,7,8	1,6,7,8	
F8	1,3,6,7,8,9	7,8	7,8	
F9	1,6,9	1,3,6,7,8,9	1,6,9	II
Iteration process III				
F1	1,3,7	1,7,8	1,7	
F3	3	1,3,7,8	3	III
F7	1,3,7,8	1,7,8	1,7,8	
F8	1,3,7,8	7,8	7,8	
Iteration process IV & V				
F1	1,7	1,7,8	1,7	IV
F7	1,7,8	1,7,8	1,7,8	IV
F8	1,7,8	7,8	7,8	V

Developing ISM Structural Model

Based on the partition levels, phase wise identified barriers were arranged and given in the Figure 1. Technological infeasibility, lack of collaboration between supply chain partners, Lack of technical guidance, and stakeholders resistance to blockchain system were the influential barriers. found at the top most layer of the structural model in Figure 1. This implies that these were the major impediments for blockchain technology adoption in agricultural supply chain and influenced by the other critical barriers. Lack of consumer demand for traceable produce and poor market facilities for traceable produce were the barriers found in the second level of hierarchical structure. Relying on blockchain service providers was another barrier found in third level of hierarchical structure. Blockchain, an innovative technology could be developed by experts and hence any firm needs to adopt blockchain must rely on blockchain services providers for initial network setup and coding activities. Hence, the firm need huge initial investment for developing software. Huge initial investment and lack of government regulations fall under level four, hindering blockchain adoption. As the adoption process requires huge initial investment, small and marginal farmers cannot adopt the technology. Hence, collective organizations like FPOs can take an initiative to link farmers to high-value markets, including exports. Agribusiness firms requires initial investment for developing softwares and installation purpose. Hence financial support from government can improve blockchain technology adoption. Lack of government regulations was another barrier, hindering blockchain adoption. Government can bring produce traceability initiative training program, guides and tools for blockchain technology implementation in agricultural supply chain. This can prevent illegal operations and adultered foods entering into the supply chain and track the movement of produce from producer to consumer. Finally, inadequate knowledge and expertise was found in the bottom most layer of the model that interlinks the whole system and connected to all identified barriers found in the hierarchical structure. This result was supported by Queiroz and Wamba (2019) [13] and Kouhizadeh *et al.* (2021) [8].



Source: The author

Fig 1: Phases of ISM model

Further, the links between these identified barriers across the levels were indicated with the arrow symbols in Figure 2. The arrows were drawn based on the barriers direct or indirect relationships in the final reachability matrix. The blue dotted arrows represent the significant direct relationship and pink dotted arrows represent the indirect relationship between the barriers in the transitivity check. The arrows in red dotted colour indicates that barriers influences with each other Thus the Figure 2 shows the generated hierarchical structural model with direct and indirect relationships of the barriers. Inadequate knowledge and expertise have direct relationship with the barriers found in phase I which includes technological infeasibility, lack of collaboration between supply chain partners, lack of technical guidance, and stakeholder's resistance to blockchain system. This indicates that adequate knowledge can be imparted to business firms which directly influences other barriers in phase I and helps to eliminate those barriers for successful blockchain adoption. Next to that, lack of consumer demand for traceable products and poor market facilities both influences each other in phase II. Also, lack of government regulations directly influences poor market facilities for traceable products and indirectly influences lack of consumer demand for traceable products. It indicates that more funding support, awareness and training program from the government may influence stakeholders to get familiar with the blockchain and its benefits to agriculture and marketing activities of traceable quality food produce. Relying on blockchain software developers indirectly influences technological infeasibility and since it is an IT based technology stakeholders resist themselves from adopting blockchain system, which has direct impact. It also indirectly influences collaboration between the supply chain partners where they think about dependency on blockchain service providers. Further, inadequate knowledge and expertise indirectly influence poor market facilities for traceable produce in phase II. Poor market facilities for traceable produce indirectly influences the barriers like technological infeasibility and lack of collaboration between chain partners. The barriers found in phase I, each influences with one another in chain. Hence, these barriers must be rectified for successful and faster adoption of blockchain technology in agriculture.

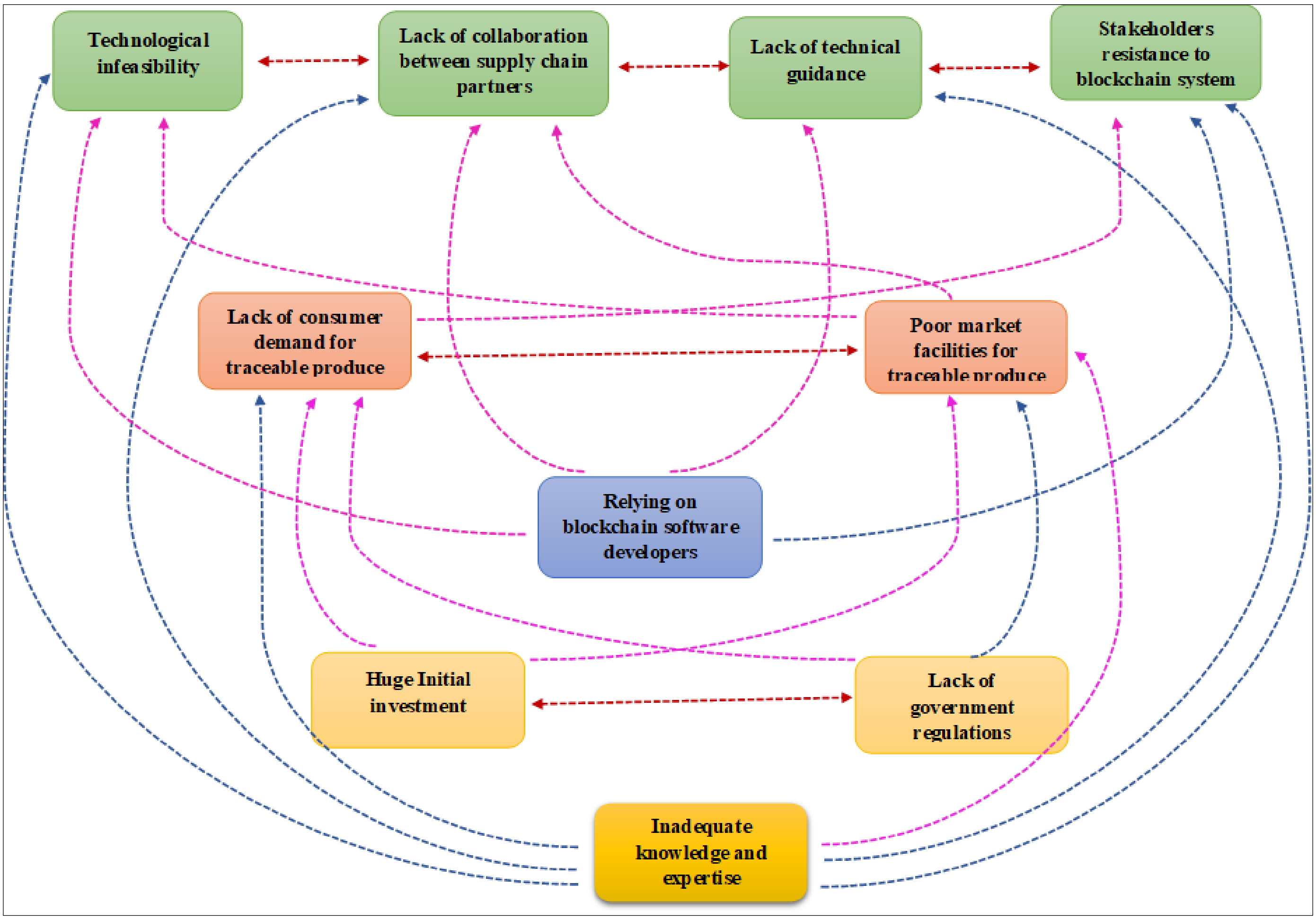


Fig 2: Direct and Indirect relationship between the barriers for BCT adoption

Managerial implications

To improve food quality and food safety, agribusiness firms need to incorporate blockchain enabled traceability system in its supply chain. The present study identified the important barriers that managers need to pay attention for successful adoption in supply chain. The study results revealed that inadequate knowledge and expertise to use blockchain technology in supply chain are the significant barriers for adoption. Huge initial investment and lack of government regulations were the next level barriers that need to be concentrated. Government can support agribusiness firms by providing funds in the form of subsidies for developing firms infrastructure facilities and encourage them to adopt blockchain technology. To adopt blockchain, a firm should depend on blockchain software developers. The firm should be encouraged to collaborate and form a public-private partnership model for successful implementation. Technological infeasibility and lack of collaboration between supply chain partners hinders the blockchain adoption. The managers should educate and train the stakeholders to develop skill sets and coordinate for blockchain technology adoption. Top management should discuss with various supply chain stakeholders and convince them for blockchain technology adoption. Hence, agribusiness firms should provide knowledge and technology transfer training to its supply chain partners. More capacity building training programmes need to be imparted for managers working in agribusiness firms. Adopting blockchain technology in a supply chain can enhance quality produce. The proposed framework categorises the barriers from most important to least important barriers. In firm's perspective, managers need to pay attention to these preferential barriers to assess the challenges and establish strategic practices to eliminate those barriers in a tactical way for the successful adoption of blockchain in agricultural supply chain.

Moreover, farmers collective organizations like farmer producer companies can bring sustainable changes with mapping and potential application of blockchain in their business activities and seek support from government for investment in blockchain adoption into their business. This can bring transparency, traceability, improves products quality and increase profitability for farmers as well as FPC business. The government has supported a few FPC business firms for adoption of blockchain technology, but they are still in its pilot form (Pournader *et al.*, 2020) [12]. Effective rules and regulations need to be framed by the government to increase the adoption rate of blockchain in agribusiness firms. Consumer awareness must be created to increase the demand for traceable food products thereby increases the agribusiness firms to supply quality and traceable food products. This can improve customer satisfaction and also increases the growth performance of agribusiness firms.

Conclusion

This study analyzed the barriers for the adoption of blockchain in the agricultural supply chain. A total of ten barriers were identified from the literature review and experts opinion. The identified barriers were analysed with interpretive structural modeling approach. The results concluded that the barriers were influential and had a direct and indirect relationship with each other. A structural model has been developed for the identified barriers. It revealed that inadequate knowledge and expertise, huge initial investment and lack of government support were the major barriers hinder the blockchain use in agricultural supply chain. Other barriers include Lack of consumer demand, poor market facilities for traceable produce, lack of collaboration between supply chain partners, technological infeasibility, and stakeholder resistance to blockchain system. While adopting blockchain technology, a firm must focus on these challenges to eliminate them and adoption process will become easier for successful implementation in agricultural supply chain.

References

1. Ahmad N, Qahmash A. Smartism: Implementation and assessment of interpretive structural modeling. Sustainability. 2021;13(16):8801.
2. Antonucci F, Figorilli S, Costa C, Pallottino F, Raso L, Menesatti P. A review on blockchain applications in the agri-food sector. Journal of the Science of Food and Agriculture. 2019;99(14):6129-6138.
3. Attri R, Singh B, Mehra S. Analysis of interaction among the barriers to 5S implementation using interpretive structural modeling approach. Benchmarking: An International Journal. 2017;24(8):1834-1853.
4. Behnke K, Janssen MF. WHA. Boundary conditions for traceability in food supply chains using blockchain technology. International Journal of Information Management. 2020;52:101969.
5. Christidis K, Devetsikiotis M. Blockchains and smart contracts for the internet of things. Ieee Access. 2016;4:2292-2303.
6. Gardas B, Raut R, Jagtap AH, Narkhede B. Exploring the key performance indicators of green supply chain management in agro-industry. Journal of modelling in management. 2019;14(1):260-283.
7. Guo H, Yu X. A Survey on Blockchain Technology and its security. Blockchain: research and applications. 2022;3(2):100067.
8. Kouhizadeh M, Saberi S, Sarkis J. Blockchain technology and the sustainable supply chain: Theoretically exploring adoption barriers. International Journal of Production Economics. 2021;231:107831.
9. Kumar MV, Iyengar NCS. A framework for Blockchain technology in rice supply chain management. Adv. Sci. Technol. Lett. 2017;146:125-130.
10. Paul S, Ali SM, Hasan MA, Paul SK, Kabir G. Critical success factors for supply chain sustainability in the wood industry: an integrated PCA-ISM model. Sustainability. 2022;14(3):1863.
11. Perumal S, Alhameli H, Alhosani AM, Gharib MN. An ISM and MICMAC approach for evaluating the barriers hindering the implementation of blockchain technology in supply chains. Blockchain in a Volatile-Uncertain-Complex-Ambiguous World; c2023. p. 233-249.
12. Pournader M, Shi Y, Seuring S, Koh SL. Blockchain applications in supply chains, transport and logistics: a systematic review of the literature. International Journal of Production Research. 2020;58(7):2063-2081.
13. Queiroz MM, Wamba SF. Blockchain adoption challenges in supply chain: An empirical investigation of the main drivers in India and the USA. International Journal of Information Management. 2019;46:70-82.
14. Risius M, Spohrer K. A blockchain research framework: What we (don’t) know, where we go from here, and how we will get there. Business & information systems engineering. 2017;59:385-409.
15. Rocha T, Costa P, Sousa V, Coelho P, Sousa F, Cardoso N. Smart Agri Chain: A Blockchain Based Solution for Agri-Food Certification and Supply Chain Management. Int. J Environ. Agric. Biotechnol. 2021;6:235-245.
16. Thejaswini S, Ranjitha KR. Blockchain in agriculture by using decentralized peer to peer networks. In 2020 fourth international conference on inventive systems and control (ICISC). IEEE; c2020. p. 600-606.
17. Wang Y, Han JH, Beynon-Davies P. Understanding blockchain technology for future supply chains: a systematic literature review and research agenda. Supply Chain Management: An International Journal. 2019;24(1):62-84.
18. Yadav VS, Singh AR, Raut RD, Govindarajan UH. Blockchain technology adoption barriers in the Indian agricultural supply chain: an integrated approach. Resources, Conservation and Recycling. 2020;161:104877.
19. Yawar SA, Kauppi K. Understanding the adoption of socially responsible supplier development practices using institutional theory: Dairy supply chains in India. Journal of Purchasing and Supply Management. 2018;24(2):164-176.
20. Zhao G, Liu S, Lopez C, Lu H, Elgueta S, Chen H, Boshkoska BM. Blockchain technology in agri-food value chain management: A synthesis of applications, challenges and future research directions. Computers in industry. 2019;109:83-99.