Benchmarking the Interactions among Challenges for Blockchain Technology Adoption: A Circular Economy Perspective

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Abstract
The chances of food contamination and spoilage get enhanced as it passes through various stages, and prudent consumers often need transparency on the origin of food products, their production and processing facilities utilized. Blockchain, an emerging digital technology, offers food traceability solutions to consumers and supply chain partners. But presently, blockchain adoption in Indian supply chains is in the nascent stages. The present study identified the challenges of adopting blockchain technology in Indian food supply chains and modelled them using Interpretive Structural Modelling (ISM). As per the ISM, the 'regulatory structure' and 'lack of realised need' emerged as the most significant driving forces that impact other challenges, viz. 'privacy breach issues', 'high costs', 'lack of skills', 'lack of technology', 'lack of trust' and 'lack of infrastructure'. These challenges have an impact on the 'scalability problem'. The paper underlines the significance of enabling regulatory structure, improved information and communication technologies infrastructure, and convincing the supply chain stakeholders to use blockchain technology to resolve the underlying challenges and achieve its adoption and scalability in the Indian food industry.

Keywords- Blockchain technology, Supply chain, ISM approach, Food processing, Circular economy.

1. Introduction

The recent pandemic outbreak has drawn the attention of practitioners towards food traceability and transparency, sustainability, and resilience of supply chains (Nandi et al., 2021). Like elsewhere, the food supply chains in India are characterized by complex and lengthy channels, including a vast network of producers, retailers, wholesalers, and distributors to deliver food products to the consumer. The different supply chain stages lack information sharing and transparency. As a result, consumers are unaware of the origin and journey of the food products they consume. Similarly, one stage of the supply chain is ignorant about the practices adopted by the previous or subsequent stages. Due to food scandals and consumer awareness worldwide, food traceability has become highly significant (Behnke & Janssen, 2020; Malik et al., 2018). Food companies strive to search for viable solutions to problems; however, these are constrained due to infrastructure & resource insufficiencies and relative ignorance for possible solutions. Such issues have derived the need for economies to move towards circularity. The circular economy concept focuses on a holistic approach towards optimum utilization of resources, maximum usage and reuse, avoiding wastages in a closed-loop manner (Shojaei et al., 2021). The application of circular economy, specifically in the supply chain fields, has given birth to circular supply chains (Lahane et al., 2020). Current industry landscapes are eyeing rapid changes towards flexible, responsive and efficient closed-loop supply chains to meet the challenges of resilience and sustainability (Bekrar et al., 2021).

Recently, blockchain technology has emerged as a revolutionary solution for addressing transparency and traceability issues in food supply chains (Bechtsis et al., 2019; Kamble et al., 2020). The blockchain technology-enabled supply chains support the concept of a circular economy by enabling product tracing, tracking, and responsiveness (Nandi et al., 2021). At present, companies worldwide look at this technology as a key to unlocking the real potential of food supply chains (Caro et al., 2018; Galvez et al., 2018; Queiroz & Wamba, 2019). Blockchain is a digital distributed ledger, where information is entered and stored in interconnected, immutable, and secure blocks (Caro et al., 2018; Creydt & Fischer, 2019; Galvez et al., 2018). Blockchain is completely decentralized; it allows every supply chain node to put its inputs and transfer them to the next node. The information, once entered, cannot be modified or deleted, which makes this technology completely safe and tamperproof (Casino et al., 2019; Wang et al., 2019). A farmer can feed the complete information of crop sowing time, seed quality, crop treatments, etc., to the electronic platform. The information then goes to the next stage of the supply chain, which may be a food processor, who again provides details on the process and product and pass the information to the further stages and so on (Salah et al., 2019). In the end, to check the various details and quality of a food product, a consumer can scan the code on the product and see its complete supply chain. The information is entered exclusively at each supply chain node in blockchain technology, eliminating centralization. But the level of blockchain adoption varies in countries across the world (Behnke & Janssen, 2020; Kamilaris et al., 2019). In the Indian context, blockchain technology has faced stiff resistance from different stakeholders (Dadi et al., 2021; Queiroz & Wamba, 2019). Rana et al. (2021) suggest that IoT-enabled blockchain technology can significantly contribute to agri-food production sustainability. Still, the technology may lead to challenges like privacy issues, scalability problems, high costs, and connectivity issues, which need due consideration.

The literature discusses several considerations for blockchain adoption, like perceived benefits, data security, technology development, compatibility, organizational readiness, management support, organizational size, regulatory requirement, market dynamics, government support, and business model readiness (Clohessy et al., 2019). Similarly, critical success factors for adopting blockchain technology in the supply chain are also studied in literature like collaborations, governing clarity, cost and energy efficiency, business alliance to blockchain capability, etc. (Prasad et al., 2018). Factors like price, disintermediation, control, coordination and compliance may impact the decision of actors to adopt blockchain technology (Saurabh & Dey, 2021). Blockchain adoption in agri-food supply chains is associated with several challenges, including regulations and legislation related to funding and governing blockchain technology (Krzyzanowski & Boys, 2022); technical, regulatory, policy and educational barriers (Kamilaris et al., 2021). In developing nations like India, most farmers have small landholdings with a lack of knowledge and difficulty entering English data. Also, the availability of mobile phones with all the users is a challenge. The technology cost, trust factor, multiple types of data handling, governance, sustainability and non-uniform regulations are among the other challenges perceived while adopting blockchain technology (Mohapatra et al., 2021). Intraorganizational challenges like high costs of implementation, lack of technical expertise, transparency vs. privacy concerns and inter-organizational challenges like readiness, inaccurate entries and variable standards impact blockchain adoption. The system barriers like scalability, smart contract designing and government regulations add to the adoption challenges (Vu et al., 2021). Despite all the underlying challenges, blockchain technology can prove beneficial and offer real-time interventions to achieve sustainable development goals in food security, sustainable production & consumption (Hughes et al., 2019; Tsolakis et al., 2021). Blockchain-enabled circular economy practices support traceability and supply chain responsiveness (Nandi et al., 2021). Blockchain technology can shorten the supply chains and turn them into circular or closed-loop supply chains and solve several supply chain issues by providing a great extent of transparency and traceability (Kouhizadeh et al., 2020). As per Upadhyay et al. (2021), blockchain technology can contribute towards a circular economy by lessening transaction costs, improving communication, enhancing performance, protecting human rights, and reducing carbon footprint. Blockchain technology is thus emerging as an enabler for several circular economy principles (Kouhizadeh et al., 2019; Scott et al., 2017). Through blockchain technology, a user can employ the concepts of a circular economy by getting complete product traceability and enabling predictions for the recycling and reuse of materials (Shojaei et al., 2021). Although the literature addresses the challenges and benefits of blockchain technology, comprehensive research is still required to prioritize the challenges for resolving them in the correct direction.

In this line, this study aims to identify and model the various challenges of food processing companies in India vis-à-vis adopting blockchain technology in their supply chains. The rest of the paper is prepared as follows. Section 2 is the literature review, and section 3 contains the methodology part. Section 4 comprises the analysis and ISM model development, while section 5 covers results and discussions. Section 6 consists of the research implications, and section 7 includes the conclusion and the limitations and future scope in section 8.

2. Literature Review

Studies in the agri-food supply chain cover various aspects of blockchain application, including the benefits of blockchain technology (Casino et al., 2019; Kamilaris et al., 2019; Tan et al., 2018), enablers for blockchain adoption; challenges for its adoption (Kamilaris et al., 2019), customized blockchain models (Malik et al., 2018; Salah et al., 2019). However, a few scholars have contributed to challenges for adopting blockchain technology in the Indian context. Further, in this section, the challenges for the adoption of blockchain technology are identified from the literature review and discussed as follows:

2.1 Challenges for the Adoption of Blockchain Technology

(i) High costs: Food supply chains hesitate to adopt blockchain technology because of the high costs of developing blockchain-based supply chains (Bechtsis et al., 2019; Banerjee, 2018; Saberi et al., 2019; Schuetz and Venkatesh, 2020). High energy consumption cost is also there in the mining process in blockchain technology (Vranken, 2017).

(ii) Regulatory structure: Unclear government rules and regulations and organizational policies about the usage of blockchain technology challenge businesses in implementing blockchain technology (Kamble et al., 2020; Kamilaris et al., 2019; Mangla et al., 2018; Saberi et al., 2019). There are members in the blockchain from different countries; therefore, global regulations and policies will also be there.

(iii) Lack of skills: One of the main challenges in adopting blockchain technology is lack of skills viz. technology know-how, payment mechanism, data ascendency, and privacy (Batubara et al., 2018; Huckle et al., 2016; Kamble et al., 2019).

(iv) Technological issues: Blockchain is based on a technology, which is rapidly evolving. So, there always remains a need to bring technology updations. Implementation of blockchain technology requires huge investment and resources (Batubara et al., 2018; Kamilaris et al., 2019; Queiroz & Wamba, 2019; Saberi et al., 2019). Making this technology available in developing nations is a challenge.

(v) Scalability problems: Scalability is identified as a main technological challenge (Kamilaris et al., 2019). Unless there is a sufficient number of nodes/participants present in the chain, the application effectiveness of blockchain will not be there. The technology needs to be widely accepted by different stakeholders to scale up technology at the national level.

(vi) Privacy breach issues: Although blockchain technology is based on the fundamental of maintaining trade secrecy through digital nodes, companies may find it difficult to keep their business information secret because data need to be shared on the blockchain platform with all the members of the chain, which raises issues of privacy breach sometimes (Batubara et al., 2018; Kamble et al., 2019).

(vii) Lack of trust: Trust related issues in data security, the immutability of information, hacks, attacks, fraud, and privacy concerns are other challenges in the implementation of blockchain technology (Batubara et al., 2018; Saberi et al., 2019; Queiroz & Wamba, 2019; Wang et al., 2019).

(viii) Lack of realized need: Stakeholders of Indian food supply chains have not yet realized the need for blockchain technology in their existing supply chains. Therefore, they are not taking initiatives towards adopting this technology. The majority of supply chain participants are unaware of the benefits of the adoption of blockchain in their supply chains (Queiroz & Wamba, 2019).

(ix) Lack of infrastructure: India lacks IT infra, logistics, and training facilities (Batubara et al., 2018; Queiroz & Wamba, 2019). Most agri-food produce producers in India belong to rural areas where IT infrastructure and logistics availability are a serious concern. Even the majority of retailers and distributors in India are working with insufficient infrastructure.

2.2 Blockchain Technology for Circular Economy

A circular economy promises value addition to products and extends their life cycle, contributing to social, technological, and economic sustainability. Digital technologies support achieving the principles of a circular economy. The electronic mapping of supply chains can help in minimizing waste, developing resilience and sustainable supply chains (Nandi et al., 2021). Blockchain is a disruptive technology that aligns with circularity concepts (Kouhizadeh et al., 2020; Mukherjee et al., 2022). Blockchain has a technological capability for controlling wastes and managing product returns (Centobelli et al., 2022). Blockchain technology supports sustainable agri-food production but has associated challenges like scalability, high costs, security, and connectivity issues (Rana et al., 2021). Supply chain resilience can be one of the major factors in supporting a circular economy, which can be achieved by combining blockchain technology with circular economy principles (Nandi et al., 2020). An extensive review carried out by Bockel et al. (2021) highlights the need for in-depth analysis of blockchain technology's likely merits and challenges towards a circular economy for sustainable development. Kazancoglu et al. (2021) showcased ten drivers for adopting blockchain technology towards achieving circular economy goals. Blockchain technology can play a positive role in the circular economy and offer environmental and economic benefits to organizations because of its associated features like transparency, visibility, relationship management, and smart contracting (Khan et al., 2021). IoT-enabled Blockchain technology may smoothen the transactions process in the agri-food supply chains by reducing the number of intermediaries and increasing transaction pace, which is required in a country like India to handle food security issues (Patra et al., 2021).

3. Methodology

This study aims to identify and modelling the challenges that restrict blockchain technology adoption by Indian food processing firms in their supply chains. Modelling the challenges helps prioritize them based on their contextual relationships and supports the actors involved in agri-food supply chains to focus on the most emergent needs to achieve the aim.

The methodology involved three steps. The first two steps focused on the identification and validation of significant challenges. The third step included modelling challenges through Interpretive Structural Modelling (ISM), a qualitative data analysis technique (Mor et al., 2018; Sindhu & Panghal, 2016; Singh et al., 2003). ISM is a well-established technique for identifying the relationship between the variables under study and is extensively used in literature in various domains, such as for determining the factors for reducing food loss and waste in food supply chains (Gokarn and Choudhary, 2021); developing a process model for organic agriculture market development (Sandoughi et al., 2021); modelling the drivers for conservation agriculture (Latifi et al., 2021); modelling the critical drivers for milk supply chain vulnerability (Karwarsara et al., 2021); analyzing most effective green interventions for effective green supply chain management (Sharma et al., 2021) and many more domains.

The steps involved are described as follows.

3.1 Literature Screening

Through the literature review, including past studies, a total of nine challenges were identified, as presented in Section 2.

3.2 Variable (Challenge) Validation

For variable (challenge) authentication in the Indian context and to establish a contextual relationship among the variables, five experts were interviewed online (i.e., over the Zoom app). All five experts were chosen based on their role in the food supply chain. The professional profiles of these experts were as follows: an independent entrepreneur who worked closely with farmers providing them with farming solutions; a logistics manager at a leading food company; a retail head in a food company; and two active researchers involved in the field of blockchain and supply chain.

3.3 ISM Modelling

Based on the opinions of the five experts that the authors interviewed, nine variables(challenges) were identified, finalized and modelled through the ISM approach to identify their contextual relationships.

4. Analysis and ISM Model Development

All the identified challenges differ in their magnitude to affect the adoption of blockchain technology; further, these challenges may also impact each other. In this study, the ISM approach is used to identify the contextual relationships amongst the challenges and to model them as driving forces with the four steps (Ravi and Shankar, 2005; Sage, 1977; Warfield, 1974) described as follows:

4.1 Development of Structural Self-Interaction Matrix (SSIM)

The directional relationship was identified between the variables. Symbols were allotted to each variable to formulate the SSIM (Table 1) by following the rule that if the variable 'i' leads to variable 'j' (symbol V); if variable 'j' leads to the variable 'i' (symbol A); if both variables lead to each other (symbol X); if none of them leads to another (symbol O).

Table 1. Structural self-interaction matrix (SSIM).

i,j	9	8	7	6	5	4	3	2
1	V	O	O	O	V	X	V	A
2	V	O	V	V	V	V	V	
3	O	X	V	O	V	O		
4	O	O	O	V	V			
5	A	A	A	A				
6	A	O	V					
7	O	O						
8	O							

4.2 Final Reachability Matrix with Transitivity

SSIM was transformed into a binary matrix by replacing the symbols V, A, X and O by '1' or '0' as per the rule that each (i,j) entry of V or X in SSIM is replaced by '1' for the (i,j) entry in the binary matrix and by '0' for the (j, i) entry. Similarly, each (i,j) entry of A or O in SSIM is replaced by '0' for (i,j) entry in the binary matrix and by '1' for (j, i) entry, respectively (Agarwal et al., 2007). The matrix thus obtained is known as the Initial Reachability Matrix, in which further the transitivity was included as '1*' following the rule: if A=B and B=C, then A=C. Accordingly, the final reachability matrix with transitivity included and each variable's driving power and dependence are obtained (Table 2).

Table 2. Final reachability matrix (transitivity).

Variables	1	2	3	4	5	6	7	8	9	Driving Power
1	1	0	1	1	1	1*	1*	1*	1	8
2	1	1	1	1	1	1	1	1*	1	9
3	1*	1*	1	1*	1	1*	1	1	0	8
4	1*	0	1	1	1	1	1*	1*	0	7
5	0	0	0	0	1	0	0	0	0	1
6	1	0	1	1*	1	1	1	1*	1*	8
7	1	0	1*	1	1	1*	1	0	1*	7
8	1	1	1*	1	1	1	1	1	1*	9
9	1*	1*	1	1	1	1	1	1	1	9
Dependence	8	4	7	8	9	8	8	7	6	

4.3 Level Partition

For each variable, the reachability set (variable itself and the variables it led to) and the antecedent set (variable itself and the variables that led to that) were identified, and the intersection was derived; wherever the intersection set became equal to the reachability set, a level was allotted to that variable, and that specific variable was excluded from the calculations further. Thus, the iterations were continued until the appropriate levels were allotted to each variable. In this study, five iterations were required to allot levels to all the variables. Table 3 shows a detailed level-wise partition of all the variables.

Table 3. Consolidated table of level of variables.

Variable	Reachability Set	Antecedent Set	Intersection	Level
1	1, 3, 4, 5, 6, 7, 9	1, 2, 3, 4, 6, 7, 8, 9	1, 3, 4, 6, 7, 9	II
2	1, 2, 3, 4, 5, 6, 7, 8, 9	2, 8	2, 8	V
3	1, 3, 4, 5, 6, 9	1, 2, 3, 4, 6, 7, 8, 9	1, 3, 4, 6, 9	II
4	1, 3, 4, 5, 6, 7	1, 2, 3, 4, 6, 7, 8, 9	1, 3, 4, 6, 7	II
5	5	1, 2, 3, 4, 5, 6, 7, 8, 9	5	I
6	1, 3, 4, 5, 6, 7, 9	1, 2, 3, 4, 6, 8, 9	1, 3, 4, 6, 9	IV
7	1, 3, 4, 5, 7, 9	1, 2, 4, 6, 7, 8, 9	1, 4, 7, 9	III
8	1, 2, 3, 4, 5, 6, 7, 8, 9	8	8	V
9	1, 3, 4, 5, 6, 7, 9	1, 2, 3, 6, 7, 8, 9	1, 3, 6, 7, 9	III

5. Results and Discussion

The discussions related to MICMAC and ISM Model are presented in this section as follows:

5.1 MICMAC

All the identified variables were found to have different driving power and dependence towards influencing the adoption of blockchain technology in the Indian food supply chains. Accordingly, the authors conducted the MICMAC Analysis, which shows the possibilities of categorizing the variables into four different clusters (Figure 1).

The first cluster is ‘autonomous variables’ with weak driving power and weak dependence; hence, they are disconnected from the system. In the present study, no variable emerged as an autonomous variable.

The second cluster comprises ‘dependent variables’ which have weak driving power but strong dependence. In this study, Scalability Issues (C5) emerged as a dependent variable. Therefore, it may be interpreted that scalability of blockchain technology adoption is the challenge that depends strongly on other variables for its achievement; moreover, this dependent variable, i.e., Scalability Issues (C5), is strategic enough to support the blockchain technology adoption in the Indian food supply chain.

The third cluster has ‘linkage variables’, with strong driving power and strong dependence. They are highly unstable, and any change in them reflects on other variables and themselves (Faisal et al., 2006). In this study, the majority of the variables emerged as linkage variables viz. Lack of Realised Need (C8), Privacy Breach Issues (C6), Lack of Trust (C7), Lack of Infrastructure (C9), Lack of Technology (C4), Lack of Skills (C3), and High Costs (C1).

Lastly, the fourth cluster has the ‘independent variables’ with strong driving power but weak dependence. In this study, Regulatory Structure (C2) emerged as the most robust independent variable, which drives other variables to adopt blockchain technology in Indian food supply chains. It is otherwise also apparent that from time to time, regulatory bodies bring regulations that affect business decisions, especially in the emerging field of blockchain technology, which needs policies to be designed for proper and systematic implementation. A favorable regulatory structure can support the management of all other challenges efficiently.

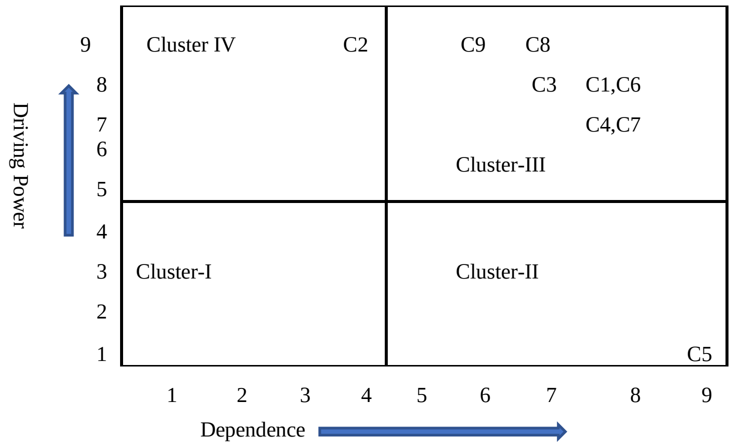

Figure 1. MICMAC analysis.

5.2 ISM Model (Diagraph)

Based on the levels achieved by different variables, the ISM model (Diagraph) was prepared (Figure 2). The variable with level 1 is placed at the top of the ISM model, and the variable with the lowest level is at the bottom. The arrows point upwards only, showing the relationship between variables.

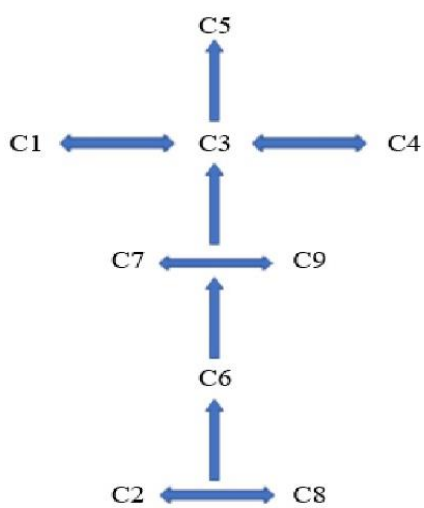

Figure 2. Diagraph (ISM Model).

The ISM model (Figure 2) shows that Regulatory Structure (C2) and Lack of Realised Need (C8) emerged as the most significant challenges towards blockchain technology adoption in Indian food supply chains. To establish an enabling regulatory structure and provide a supportive ecosystem, funding support, etc., the government can enable key stakeholders to adopt this blockchain technology. It is also widely accepted and understood that until stakeholders realise the need for blockchain's inclusion in the supply chain, technology cannot be promoted for its broader adoption. Many supply chain participants in India are unfamiliar with the benefits of blockchain inclusion in their existing supply chains. As the concept of blockchain is in its nascent stages in India, participants lack complete trust in this technology and feel that 'privacy breach issues' (C6) are a significant roadblock in their acceptance of this technology. If 'privacy breach issues' (C6) can be successfully addressed, then probably 'lack of trust' (C7) will not remain a challenge for adopting blockchain technology. Also, 'lack of infrastructure' (C9) is one of the most significant restricting factors for the participants. It is needed to develop reliable ICT infrastructure, logistics and training facilities and handling the issues of 'lack of technology' (C4), 'lack of skills' (C3), and 'high costs' (C1) for technology development and expansion.

Similarly, human resources and other infrastructure support are required to develop the skills necessary for operating and using blockchain technology. Since the concept of blockchain is relatively new in India, it requires huge investments from government regulatory bodies and supply chain participants; all of this makes the adaption of blockchain technology a costly affair. Once these underlying challenges are addressed, the 'scalability problem' (C5) can be resolved in India. Until the participants and stakeholders can use blockchain technology as a core component in their supply chain systems, it isn't easy to expect it to scale up to an operational level. And it is evident from the various successful models that for any technology to be successful, it needs to reach scale and volume thresholds in its adoption. Thus, the obtained results align with the previous research where Khan et al. (2021) suggest a substantial effect of blockchain technology on the circular economy and collaboratively on firm performance. Kouhizadeh et al. (2020) conclude that blockchain capabilities support the circular economy with information transparency and reliability; Welfare (2020) finds that blockchain technology reduces resource consumption with enhanced traceability and transparency and thus helps provide an ecosystem with a trusted set of data and transactions. Specifically, in the agri-food sector adoption of blockchain technology and other digital techniques big data analytics, cloud computing can solve multifarious issues such as productivity enhancement, improving soil and plant health, resource conservation, and environmental sustainability (Sharma et al., 2020). An environmentally and socially sustainable supply chain can only lead to supply chain sustainability over a considerable period (Baliga et al., 2019). Also, disruptive digital technologies support the supply chain and firm performance measurement process (Kamble & Gunasekaran, 2020).

6. Practical Implications

This study emphasizes the need for extensive adoption of blockchain technology to achieve the circular economy goals and resolve sustainability-related issues. There are substantial benefits from blockchain technology for different sectors and the entire economy. At the same time, the challenges in the adoption of blockchain are also massive and need legal and government support to overcome them. The upfront costs are restricting the scalability but undoubtfully, in the coming days to come, the industry will mark the benefits of blockchain technology exceeding the challenges. As most brands these days are focussing on circularity, so blockchain technology is getting embraced by them. Several start-ups in the field of agriculture and food are adopting blockchain to avail tracking and tracing benefits. (Welfare, 2020). For the industry players, blockchain design supports two prominent benefits for the circular economy- "proving the product designs and incentivising positive behavioural change" (Lancelott et al., 2021). Limited adoption in current times by the industry is because presently the economy is in the testing phase; as soon as associated challenges get overcome positively and large scale projects exemplify its value, then automatically mass adoption will happen (Lancelott et al., 2021).

7. Conclusion

In the fourth industrial revolution, technologies are evolving and undergoing rapid change in almost every field of human activity. At present, the rapid pace of evolution of technologies has outpaced their adoption in the food industry in India. The companies operating in the Indian food sector invest in research and development to bring about product innovations. Still, they lag in providing traceability solutions to consumers about the origins of their product and process details on food processing and the related activities. Blockchain technology has shown its proven success in providing traceability solutions and therefore promises food safety to consumers. This study has attempted to understand the challenges perceived by the food industry stakeholders towards blockchain technology adoption in food supply chains. Previous studies on this topic argued that adopting blockchain technology faced challenges from the industry. In the Indian context, 'regulatory structure' emerged as the most significant challenge as per this study. If government support is there for blockchain technology adoption, it may be inferred that underlying challenges like the lack of infrastructure support and the lack of technology can be resolved. Most importantly, government support can create more awareness and develop ICT infrastructure and relevant facilities, which can further help people realize the need for this technology.

Similarly, the lack of skills among stakeholders to execute the blockchain technology and the high costs associated with its implementation can also be resolved. With higher awareness and skilled people combined with the necessary technology and infrastructure support, blockchain technology can promise a safe and trustworthy platform to work with. This study reflects the need for attending to the perceived challenges so that blockchain technology can be scaled up. Indian food supply chains can cater to the needs of the masses much better than at present, and blockchain amalgamation can support this cause. Management of underlying challenges highlighted in this study and previous literature studies can create an ecosystem where the agri-food supply chains will be digitally enabled and sustainable. A circular economy is the need of the hour, and this study highlighted the role of blockchain-enabled agri-food supply chains in achieving the aims of a circular economy. Blockchain-enabled supply chains can be resource-saving, more efficient, have better resilience, flexible, transparent, and sustainable.

8. Limitations and Future Scope

This study focuses on identifying challenges for blockchain technology adoption, and future research may be directed to identify the applications, cost analysis, associated risks, etc., of blockchain technology in the agri-food sector. Studies may also focus on evaluating and validating the current audit and verification system for blockchain implemented by several players. The success and failure case studies so far in the domain can also enhance the learnings for practitioners. Multi-model analysis may be carried out for validation and better decision-making.

Conflict of Interest

The authors declare no conflict of interest in this research study.

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