Proceedings of the 28th SMART-iSTEAMS
Interteriary Multidisciplinary Conference
American International University West Africa
The Gambia

Conceptual Research Paper

An Evaluation of Blockchain-Based Technologies In The Food Supply Chain

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ABSTRACT

Beyond the financial sector, the use of blockchain in supply chain traceability is extremely important, although the trade-offs between implementation difficulties and attainable effect are uncertain. Six components of blockchain-based technologies in the food supply chain were examined in this research using a technology elvaluation methodology that differentiates between six distinct components of a technology: technique, knowledge, organization, innovation, environment and product. The research aims to offer fresh crucial insights into how blockchain-based technologies may be applied in the food supply chain, as well as to further the debate on blockchain-based technologies' social and environmental implications. The findings show that blockchain is not a stand-alone technology, but rather one component in a larger system of technologies. While blockchain-based technologies are anticipated to have a wide range of effects, only a few are directly related to the blockchain: Change management and external pressure, Complexity of integrating different systems, Lack of knowledge and expertise, high investment are the impediment and constraints affecting full adoption of block chain based technologies. More study is required to establish if blockchain-based technologies enhance the sustainability of agricultural supply chains as anticipated.

Keywords: Micropolar-Casson fluid; Magnetohydrodynamic, Variable viscosity; Variable thermal conductivity; Viscous dissipation

Proceedings Reference Format
Adegbenro, D.R., Longe, O.B., Dawodu, A.A., Abdulrahman, M. & Omonayin, E.T (2021): An Evaluation of Blockchain-Based Technologies in the Food Supply Chain. Proceedings of the 28th iSTEAMS Intertertiary Multidisciplinary Conference. American Int University West Africa, The Gambia. October, 2021. Pp 113-126 www.isteams.net/gambia2021.
DOI - https://doi.org/ 10.22624/AIMS/iSTEAMS-2021/V28N2P8

1. INTRODUCTION

Many contemporary supply chains span several countries and include a number of different actors, making it more difficult to identify where a product originated and how it was produced from its inception. It is common for companies to have little or no awareness about their second and third-tier vendors. When it comes to exchanging information with consumers and verifying the authenticity of a product, this may be an issue for certain businesses. As supply chains get more complex, consumers are expecting more information on product safety, quality, and long-term sustainability from manufacturers.

This is true in particular for the food industry. This is true in particular for the food industry. According to a 2016 survey, 94 percent of consumers want to know how their food is produced and where it comes from. Food adulteration and mislabeling, which can include anything from purposeful substitution, dilution, counterfeiting, misrepresentation of food, ingredients, or packaging to incorrect or misleading comments about the product, has eroded consumer confidence in food labels and weakened consumer confidence in the food industry. It is estimated that this will cost $30 to $40 billion each year (World Economic Forum, 2019).

Today's customers want products that are healthy, safe, and of consistently high quality. They want guarantees about the quality of the food they're buying, as well as openness about any problems that may arise. Consider the recent EHEC-bacteria outbreak in Germany as evidence for this claim. Customer demands also include a year-round supply of a broad variety of products in an affordable price range. National and international food quality and safety regulations and legislation, as well as trade law reforms (WTO) that have led to more open markets, all contribute to these needs. With increasing levels of uncertainty, supply chains become more vulnerable.

Figure 1: Supply Chain Management Components
Source: https://www.michiganstateuniversityonline.com/resources/supply-chain/what-is-supply-chain-management/

This vulnerability is exacerbated even more if businesses have grown dependent on other organizations as a consequence of the practice of outsourcing. Increased supply and demand uncertainty, globalization of the market, shorter product and technology life cycles, and increased use of manufacturing, distribution, and logistics partners, resulting in complex international supply network relationships, have all contributed to increased supply chain risk exposure in the past decade or more.

As the food trade has grown more international, the food supply chain has gotten more complex, increasing the possibility of food fraud. As a consequence, trust between supply chain partners has been eroded, and consumer worries about food safety have increased significantly (Tahir et al., 2020). The global food safety issues of recent years include the 2013 horse meat scandal in Europe, which was caused by food labeling fraud (Bechtsis, Tsolakis, Bizakis, & Vlachos, 2019), the 2017 multi-state Salmonella outbreak in the United States, which was caused by Maradol papayas (Menson 2018), and the 2017 contaminated egg scandal in Switzerland, Hong Kong, and 15 EU member states (Saurabh & Dey, 2021a). These food safety concerns not only threaten people's health, but they also have an impact on customers' perceptions of the food industry as a whole.

In order to overcome the existing constraints of food supply chain management, blockchain technologies, which enhance transparency, security, and durability of supply chains, have the potential to become more widely used (Antonucci et al., 2019). Blockchain technology allows all parties in a supply chain network to permanently store and retain data, which improves transparency and trust in complicated supply chains (Stoyanova, Nikoloudakis, Panagiotakis, Pallis, & Markakis, 2020). By linking foodborne outbreaks to their causative food vehicle, blockchains make it feasible to reduce the number of disease outbreaks and casualties in catastrophe situations. Also beneficial is the fact that blockchain allows for a more thorough investigation into the underlying reason of an out-break, which is beneficial for future preventive efforts (Papa, 2017).

Fig 2: Components of Blockchain Technologies
Source: https://www.inc.com/drew-hendricks/blockchain-the-new-technology-of-trust.html

Blockchain technology may be used by governments to enable multi-party control of food markets, according to the World Bank. Using a system that collects information about food market transactions, food supervision issues may be more effectively addressed and addressed more effectively (Helo & Hao, 2019).The use of blockchain technology will make it simpler for businesses to verify the origins, manufacturing times, and production locations of raw materials in order to ensure that they are of high quality.

2. REVIEW OF RELEVANT LITERATURES

Agri-food companies may utilize blockchain technology to improve process transparency and efficiency, promote trustworthiness, and remove unnecessary middlemen from the supply chain. This can also raise consumer confidence in traceable food products, according to (Papa, 2017). Despite the potential role of blockchain technology integrated information and communication technologies (ICTs) in the agri-food supply chain, there is a significant knowledge gap between blockchain adoption and new ICTs that may be used. It is still unclear how actors evaluate the relative significance of different factors for technology adoption, or to what degree such elements affect their decision-making processes when deciding whether or not to embrace a technology. Many individuals nowadays think that the blockchain was created only for the purpose of storing financial information. However, by using a decentralized approach, operating structure, it can be applied to various domains. In this context, we chose to investigate the possibilities of blockchain in food chain supply.

However, it has not yet been determined how actors assess the relative significance of various variables for technology adoption, or to what degree such aspects affect their decision-making processes regarding technology adoption intentions. Aspects of the current study that are particularly noteworthy are the feasible design and processes of blockchain technology architecture in the context of agri-food supply-chain management (Kouhizadeh & Sarkis, 2018). Despite this, it has not given much attention to the desires of supply chain actors when it comes to blockchain adoption. It is necessary to determine the most essential characteristics of the agri-based supply chain, as well as the optimum mix of this restricted number of attributes that are the most authoritative on supply chain users' choice or decision-making.

By investigating determinants or factors of technology adoption and proposing scalable, traceable, trackable, interoperable, and resilient blockchain architecture for sustainable agricultural and food supply chain practices, we hope to make a contribution to this potential research gap in the literature. In addition to contributing to the economic and environmental dimensions of sustainability (Malik, Kanhere, & Jurdak, 2018) blockchain technology can help to achieve an inclusive agri-food supply chain by embracing collaborative networks (Antonucci et al., 2019), community-based ownership of resources, democratic governance, and a decentralized digital technology platform. With the use of the Interpretative Structural Modeling (ISM) and Decision-making Trial and Evaluation Laboratory, (Management & Journal, 2019) identified and assessed thirteen enablers (DEMATEL). They discovered the most important enablers, which were traceability, auditability, immutability, and provenance, among other things. These enablers are divided into groups depending on their driving power and their reliance on certain power levels (or values).

The findings of the research are limited to the interrelationships between blockchain characteristics in the agricultural supply chain. However, determining the appropriate amount of each parameter as well as the optimal supply chain design is essential to meeting the user's requirements while also taking the price into consideration in the model. The study of (Hald & Kinra, 2019) does not offer such an insight.

Furthermore, in order to make the most of blockchain technology, we should combine it with other current or upcoming ICTs such as the Internet of Things, RFID, sensor devices, cloud computing, and machine learning to maximize its potential. The research conducted by (Astill et al., 2019) suffers from the lack of consideration for such an integrated strategy. We also contend that decision-makers must be aware of the value of information systems architecture. Additionally, they must recognize the importance of the key drivers of technology adoption, as well as the impact of their levels, which may have an impact on sustainable supply chain operations and the overall performance of the organization (Helo & Hao, 2019) . (Bechtsis et al., 2019) created a conceptual framework for food Supply chain digitization, in which the connections between major possibilities and obstacles are hypothesized and discussed. While there have been few research and advice on blockchain in developing nations and companies of varying sizes, they have been unable to address the technological dynamic effect (Kamilaris, Fonts, & Prenafeta-Boldú, 2019).

Previous research has looked at blockchain-based technologies, particularly those used in the food supply chain, and found them to be promising (Krzysztof & Agnieszka, 2020). In these studies, blockchain-based technologies are described in detail at different deployment levels, and the benefits and disadvantages of incorporating them into the supply chain are identified. Most of these studies refer to 'blockchain' as a technology in and of itself, but they do not provide a clear breakdown of the components of blockchain-based technologies from a systemic viewpoint. As a result, the critical function of blockchain is not clearly distinguished from the roles of other components, making it impossible to determine the true scope of its effect. Consequently, the research gap that this study seeks to close is the absence of a comprehensive knowledge of blockchain-based technologies on a systemic level. Furthermore, bridging this gap should allow for the advancement of the discussion of what the social and environmental impacts of blockchain-based technologies are, a discussion that, as noted by (Yadav, Misra, & Goundar, 2020), remains open and unresolved at the time of this publication.

3. TECHNOLOGY ADOPTION THEORIES

Adoption theory describes how a single party in an ecosystem accepts a change; diffusion theory, on the other hand, defines a group phenomenon, which indicates how an invention spreads across the ecosystem through time from a macro-perspective (Bayramova, Edwards, & Roberts, 2021). Integration of these two ideas aids in the understanding of how a new technology will be accepted and disseminated in an industry, since acceptance will almost always result in diffusion of the new technology. IT adoption theories at the company level that are often used include DOI (Diffusion of Innovation) theory as well as the TOE (Technology, Organization, and Environment) framework (Wamba & Queiroz, 2020).

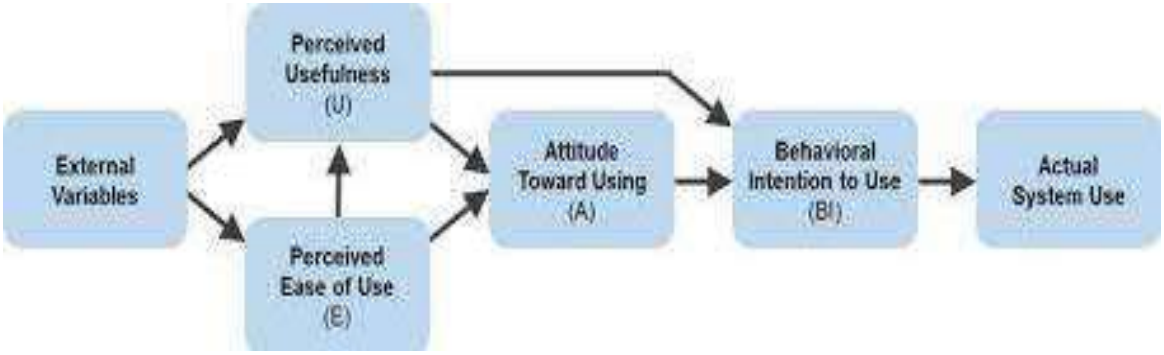

Fig 3: Technology Acceptance Model

DOI (Diffusion of Innovation) theory and the TOE (Technology, Organization, and Environment) framework are the most widely used information technology adoption theories (Chang, Iakovou, & Shi, 2020). Both theories have looked at the variables that affect an organization's ability to innovate in the field of technology. Technological innovation, according to DOI theory, is linked to the invention itself as well as to communication channels, time, and social systems (Chen, Liu, Yan, Hu, & Shi, 2020). The TOE framework places a strong emphasis on technological innovation decision-making, which is influenced by a variety of variables, including the external task environment, the availability and features of technology, and the characteristics of the organizations involved (Köhler & Pizzol, 2020). To evaluate technological innovation in the TOE framework, the environmental context is regarded a novel and significant component of the analysis of technological innovation (Kshetri, 2021)

However, although both theories examine the variables that influence technological innovation, they place a strong emphasis on the decision-making process, with little attention paid to the technological innovation processes themselves. Following the Individual Innovativeness (DOI) hypothesis, five adopter categories are defined, each based on the level of individual innovativeness: innovators, early adopters, early majority, late majority, and laggards (Saurabh & Dey, 2021b). The process of technological adoption is investigated in previous research, with an emphasis on the initiation phase rather than the implementation process. The implementation process at the business level, on the other hand, includes a huge number of stakeholders, each of whom has a role to play in the decision-making process, making the whole process more difficult to manage (Ali, Chung, Kumar, Zailani, & Tan, 2021)

Prior research have placed a strong emphasis on the study of factors associated with technology adoption (Della Valle & Oliver, 2021). Using DOI theory, for example, (Jabbar, Lloyd, Hammoudeh, Adebisi, & Raza, 2021)were able to identify the many reasons why families should use solar water disinfection equipment. Only a few studies, on the other hand, have looked at the consequences of adopting new technologies. Following (Bayramova et al., 2021), the effects of innovations may be divided into three categories: 'pleasant or unwanted consequences,' "direct or indirect consequences, and "expected vs unforeseen consequences." 'Desirable vs unwanted' refers to the fact that an invention may be useful to a system while having a negative impact on certain specific people inside the system.

As a result of the distinction between direct and indirect consequences, it is recognized that the adopter in a system may suffer direct consequences as soon as an invention is accepted, and that this consequence may result in indirect implications for other people in the system (Vu, Ghadge, & Bourlakis, 2021). The uncertainty element of innovations, which may arise from the technology itself or from change agents, is included in the comparison of expected and unforeseen outcomes. Both the participants in the system and the change agents have difficulty anticipating whether or not the innovation will be implemented. All three aspects, in general, provide some advice on management in companies after the introduction of new technologies.

Finally, the DOI theory and TOE framework have identified a number of variables that affect technology adoption as well as the repercussions of technological innovations. These considerations serve as the foundation for this study's examination of the benefits, difficulties, and procedures associated with blockchain implementation in food supply chains. Blockchain technology has the potential to be a game-changing innovation in the field of supply chain management (Saurabh & Dey, 2021b). Before blockchain-based food supply chains, the majority of the study focused on how to get started with the usage of blockchains, including both theoretical and practical investigations. Few studies, on the other hand, have examined and assessed adoption procedures in order to aid in the improvement of blockchain adoption in food supply chains. This study examines the use of blockchain technology in food supply networks. It is also important to highlight the difficulties and advantages that businesses may reap from implementing blockchain technology in order to aid them in their transition from a conventional food supply chain to a blockchain-powered food supply chain(Nurgazina, Pakdeetrakulwong, Moser, & Reiner, 2021).

3.1 Theoretical Framework

The development of a holistic and ontological universal definition of technology would be a first step in decolonizing the notion of technology. What is required is an open-ended technology conception that allows us to understand the relationships between technical and social development, as well as develop inter-disciplinary techniques for identifying and solving technological transformation issues. McLoughlin has a good explanation of various meanings of technology (Hald & Kinra, 2019). The interdependence of supply chain players for technology adoption must be understood in order to build a theoretical framework. Technology digital platform developers, Agro-ICTs organizations and blockchain start-ups, for example, have several opportunities to learn what supply chain actors value most for the chain configuration and how they can be assisted to further re-engineer the attributes of platform-based application services (Hald & Kinra, 2019).

Note that a variety of players play their roles in the supply chain such as input providers. complexity and prices of processing technologies all have a role in how well players coordinate and how much power imbalance there is (Kshetri, 2021). Each component in the model has a reason, which is later outlined in this research. In the supply chain architecture, level refers to how strong or intense a characteristic is preferred by the players in the chain or its users.

3.2 Conceptual Framework

New theories and conceptual frameworks have emerged in development research during the last several decades, although they have primarily been found in the social and political sciences, which tend to be Eurocentric. Too far, the notion of "technology" as such has not been seriously questioned. Technique and technology are frequently used interchangeably, and few, if any, development scholars explicitly define technology. But most development literature makes no such difference, but instead uses basic comparisons. People use technology to reproduce and improve their living circumstances. Technology has four elements: technique, knowledge, organization, and product.

Any technology has the four elements as inseparable parts. Consequently, all components and their interrelationships must be included in a thorough study of a specific technology. Of course, each individual element or component may be described and analyzed on their own. A technological analysis is composed of many areas, each of which may be used as an entrance point. The four elements may be seen as the most important interacting factors in technological development. All of these must thus be considered when it comes not just to the analysis but also to the implementation of technological change.

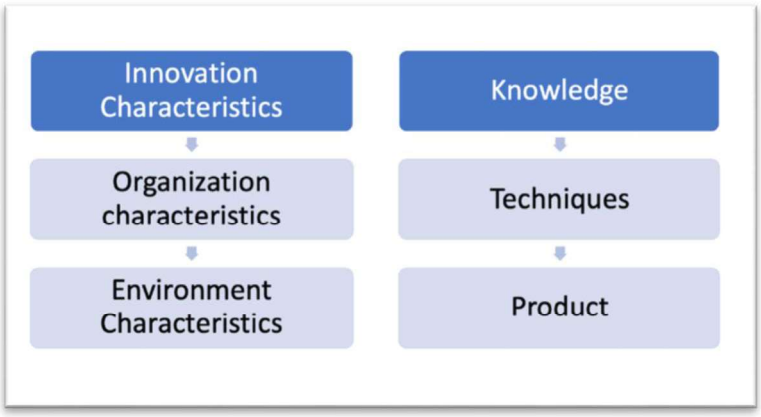

Fig 4: CConceptual Framework - haracteristic Mapping

4. TECHNIQUE COMPONENT

Blockchain technology, tracking technology, data input, data administration, data storage, and data transfer, as well as tokenized incentives, are all parts of the method element. Anyone can view all transactions on a completely open blockchain. Combining public and private blockchains creates a more flexible system that can be customized to suit specific needs. For token transactions and traceability, (Köhler & Pizzol, 2020) proposes using both a public and a private blockchain.

IBM Food Trust is built on Hyperledger Fabric, a private blockchain that limits access to data to only those with the appropriate rights (Malik et al., 2018). All blockchains utilize a peer-to-peer network to guarantee decentralization.

4.1 Knowledge Component

To deploy blockchain-based technology in the food supply chain, software developers, supply chain players, and other stakeholders need specialized expertise. Software developers need to master new languages like Solidity for Ethereum. They should also be familiar with blockchain architecture, off-chain storage alternatives, cryptography, smart contracts, and IoT device integration. Because the blockchain landscape is rapidly evolving, these players must constantly evaluate whether new components should be tested and deployed. They must also explain the benefits of their particular implementation to others.

Actors in the supply chain must be able to utilize the platform, record a harvest or catch, transfer asset ownership, update assets, and, if feasible, connect their current software to blockchain-based technology. The platform's usability may be a critical element in the adoption of blockchain-based technologies in the food supply chain. Only when the platform is simple to use will all types of users be able to take full benefit of what it has to offer. New asset registration can also be handled in a variety of ways depending on the situation.

4.2 Product Component

The information supplied on the management dashboard of their blockchain-based software system is the product for the businesses. It has the potential to provide businesses with near-real-time access to product information. Data accessibility for businesses may therefore aid in the optimization of current operations.

4.3 Innovation Characteristics

The features of the invention under consideration that may have an impact on the adoption choice and the way the adoption process develops are referred to as innovation characteristics (Papa, 2017). In this particular instance, the Blockchain applications cluster contains information on the usage and potential of Blockchain, as well as information on system-related obstacles, which indicates the limitations of the technology. For example, before assessing the viability of using Blockchain, businesses must first identify the particular goal of the project, such as product traceability, and then understand the existing technological limitations/challenges of Blockchain.

4.4 Organization Characteristics

Organizational features refer to certain qualities of the adopter that may have an effect on the adoption process (Bechtsis et al., 2019). Intra-organizational motivations, such as the benefits companies expect from adopting Blockchain, and various intra-organizational obstacles, such as a lack of competence or a fear of losing privacy, may both be considered features of an organization. These variables may have a significant effect on various phases of implementation, as previously discovered in research analyzing various technical innovations (Vu et al., 2021). For instance, it is discovered that a barrier such as a lack of IT capacity has an effect on the initiation and adoption stages.

5. CHALLENGES OF BLOCKCHAIN ADOPTION IN FOOD SUPPLY CHAIN: IMPLEMENTATION BARRIER

In the literature on innovation uptake, technology complexity has long been a central theme (Hayati et al., 2020).According to research, companies choose innovative products that are easy to use, helpful, and provide comparative benefits. Small and medium-sized businesses are having a hard time embracing blockchain technology (Kamilaris et al., 2019; Wong et al., 2020). Blockchain technologies (Zhao et al., 2019) need highly specialized understanding of IT and equipment, which is uncommon among halal food SMEs. Additionally, all Supply players engaged in data input into the network chain must have access to digital devices (Kamble et al., 2020). SMEs, on the other hand, are still utilizing pen and paper to capture data. Case C, for example, involves personally inspecting every incoming material.

Firms may also rely on halal certification and labeling to ensure their products are kosher. Moreover, since the manufacturing materials are conventional and uniform, switching from traditional paper and pen to digital devices may be prohibitively expensive (Antonucci et al., 2019). In all instances, home-made systems are utilized for monitoring and controlling. As can be seen, each of the five systems is distinct, making it difficult to transfer data to a blockchain (Nash, 2018). It follows therefore that halal food SME companies' preparedness for the full adoption and application of the food SC's blockchain technology is dubious.

5.1 Change management and external pressure

The food Supply chain is often unaware of or lacks expertise in blockchain (Zhao et al., 2019). However, blockchain specialists and professionals who can educate the food SC are few and are still learning (Papa, 2017). This study's cases all knew about blockchain technology. However, owing to insufficient references and advice on blockchain deployment in reality, the food SC still understands blockchain technology conceptually (Nurgazina et al., 2021). SMEs often have flatter structures and centralized decision-making. The adoption of blockchain is dependent on top management's understanding. A comprehensive knowledge of the architecture and setup required to enable blockchain technology adoption and deployment inside a business is required. Firms' current infrastructure and support systems are probably obsolete and not compatible with blockchain technology. Some company models and activities may not be compatible with blockchain technology, requiring a new business model (Astill et al., 2019). Change management will be impacted by a company adopting blockchain. Employers must persuade workers to embrace blockchain technology, which is a major problem (Krzysztof & Agnieszka, 2020).

5.2 Complexity of integrating different systems

Data quality is critical for the success of blockchain-based solutions. To launch a blockchain-based system, all providers must participate. If suppliers refuse to cooperate, some data may be lost, making food monitoring more difficult (Antonucci et al., 2019) .Furthermore, since blockchain technology should be used in food manufacturing, some suppliers may be reluctant to give their data (BMI Research , 2018b).To encourage information exchange among supply chain firms, a strong business environment is required. However, it is difficult to execute since the ecosystem requires amicable collaboration and efficient information exchange while not all businesses in the supply chain have similar rights.

Aside from that, certain goods may include sensitive data, making system integration more challenging. It's difficult to combine secrecy with openness.

5.3 Lack of knowledge and expertise

The fact that not enough people understand Blockchain technology and how it works is a source of concern for many businesses. There are several factors to consider before beginning the implementation of a Blockchain system. This includes the availability of the necessary infrastructure, know-how, and technical capacity.

5.4 High investment on blockchain

To integrate all businesses into the blockchain-based system, financial assistance and infrastructure expenditures are required. Another factor to consider is that time consumption is critical for small providers. A potential option is for the government to make money and equipment investments. At the moment, the majority of companies use blockchain to monitor food, but the expense of tracking food exceeds the worth of the item itself. The high expense of food traceability, particularly for some agricultural goods, must also be considered.

6. THEORETICAL CONTRIBUTION

The findings of this study have benefited theory in a variety of ways. To begin, the suggested paradigm fills in the study gap identified by Tieman et al. in the halal food SC literature about the scarcity of studies examining blockchain (Kshetri, 2021). Practitioners may use the suggested conceptual framework to review problems and possibilities that have arisen since the adoption of blockchain technology. This research tackles the paucity of empirical blockchain studies, particularly with regard to halal food, by using the case study approach (Bayramova et al., 2021) . Due to the involvement of five SMEs in this study, an in-depth explanation and rationale for the spread of blockchain technology could be provided. Third, this study responds to the request made by (Nurgazina et al., 2021) for a real-life examination into the adoption of blockchain and its use in the halal sector. Fourth, as proposed by (Krzysztof & Agnieszka, 2020) this research focuses on unresolved non-technical problems surrounding blockchain (2019). Fifth, this study expands Wong et al research.'s by focusing on SMEs as the primary debate point.

To begin, managers may utilize the findings of this study as a roadmap to better understand the connection between the possibilities and difficulties associated with blockchain implementation. Additionally, companies with characteristics comparable to those of the instances examined in this study may discover that using blockchain in their Supply chain poses similar difficulties. As a result, companies should be more proactive and ready when planning for potential blockchain use. In addition, the findings of this study shed light on the difficulties faced by halal food SMEs in practice. This study provides essential information for governmental policy formulation via a thorough examination and debate of the blockchain's possibilities and problems.

7. DISCUSSION AND CONCLUSIONS

In this study, six cases of blockchain-based technologies in the food supply chain were analyzed using a technology assessment framework. Findings were used to provide a deeper understanding of the state-of-the-art role of these technologies in food supply chains. The study contributes to build a foundation for further analysis and discussion of the social and environmental implications. A technological evaluation methodology was used to evaluate six blockchain-based food supply chain solutions. The evaluation looked at four components: method, knowledge, organization, and product. The results helped researchers better understand how blockchain-based technologies are utilized in food supply chains today. As a result of the research, we have a better understanding of the current status of blockchain-based technology in food supply chains.

More study is required to determine the long-term effects of blockchain-based technologies in the food supply chain and establish whether they will bring about the beneficial change anticipated. The major issue here is the scarcity of recent literature and the lack of systematic monitoring or quantification of the direct and indirect social and environmental benefits associated with the technology. As a result, long-term research using blockchain-based technology in the food supply chain may be very helpful in closing this gap. It would also be beneficial to examine the differences in effect between long and short supply chains, for example.

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