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Research Article

THE ROLE OF BLOCKCHAIN TECHNOLOGY IN FOOD SECURITY ASSURANCE IN THE EUROPEAN UNION

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Abstract

This research was conducted to explore the role of blockchain technology in ensuring food safety in the European Union. Blockchain has been identified as a technology that can improve transparency and traceability in the food supply chain. The study aims to assess the level of blockchain adoption in the EU food sector, identify the challenges that hinder the adoption of this technology, as well as analyze its impact on food security. This research method uses a descriptive-qualitative approach, which involves literature analysis, industry reports, and interviews with experts. The results show that blockchain adoption is still low, especially among regulators and retailers, with the main obstacles being unsupportive regulation and uneven technological infrastructure. The conclusion of this study emphasizes the importance of developing more supportive policies as well as improving infrastructure to facilitate wider and more equitable adoption of blockchain in the food supply chain in the European Union.

Keywords: Blockchain Technology, European Union, Food Security

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INTRODUCTION

Blockchain technology has come a long way in recent years, especially in sectors that require transparency and high security. In the European Union, blockchain is starting to be looked at as a potential solution to ensure food safety (Abbas et al., 2020). When it comes to food safety, transparency and reliability of the supply chain are essential, and blockchain is capable of providing both of these aspects. This technological innovation offers the ability to track every step in the supply chain in real-time, from the producer to the end consumer, which is especially relevant in the context of food safety.

The European Union faces a variety of challenges related to food safety, including food fraud problems, non-compliance with quality standards, and public health risks (S. Singh et al., 2022). Blockchain technology provides an answer to this problem through features that allow for stricter and more transparent oversight at every stage of the food distribution chain (Toufaily et al., 2021). In addition, this technology is able to prevent data manipulation and detect non-standard products before they reach consumers.

Blockchain works by recording transaction data in immutable blocks, allowing each party involved in the supply chain to independently verify the authenticity and quality of the product. This system ensures that any information entered into the blockchain network cannot be altered, manipulated, or deleted, thereby increasing consumer confidence in food products (Lim et al., 2021). The European Union, as one of the regions that is heavily dependent on food imports, needs a system that can guarantee product safety and quality in a more transparent and efficient manner.

One of the blockchain applications that has begun to be implemented is digital labeling for food products that can be traced to their origin (De Aguiar et al., 2021). With this digital label, consumers can know for sure the origin, production process, and distribution of the products they consume. This is important in addressing issues such as food fraud and mislabeling claims. Better food safety not only protects public health, but also strengthens consumer confidence in local and imported products in the EU market.

Thus, blockchain is an effective solution in answering the challenges faced by the food sector in the European Union (Guo & Yu, 2022). This initiative is expected to provide added value in terms of transparency and process efficiency, which in turn will strengthen food security throughout the EU region (Li et al., 2020). The application of this technology is also in line with the policies of the European Union in encouraging innovation and sustainability in various economic sectors, including the food sector.

Additionally, the adoption of blockchain technology in the food sector can reduce the risk of fraud that often occurs in international food distribution chains. Food imported and distributed throughout the European Union can be better monitored to ensure that products that reach consumers have guaranteed quality and safety. With the transparency that blockchain offers, fraud can be identified and prevented early, which will increase protection for consumers.

The successful implementation of blockchain in food safety will require cross-sector cooperation between governments, industry players, and other related parties (Albayati et al., 2020). The development of specific standards and regulations for the use of blockchain in the food sector is very important so that the adoption of this technology can run effectively and have a significant impact in efforts to maintain food safety in the European Union.

Although blockchain technology has shown its potential in various sectors, its application in ensuring food safety in the European Union is still in its infancy (Yong et al., 2020). There has not been much in-depth study of how this technology can actually be widely integrated in the food supply chain in the European Union. Most of the existing research still focuses on potential and theory without any comprehensive practical implementation (Tönnissen & Teuteberg, 2020). The difficulty in applying this technology evenly across the food sector raises questions about the readiness of the food industry and the government to accept such rapid technological changes.

Until now, there has been a gap in understanding how blockchain can function effectively in a highly complex and multi-stakeholder food system. While there are examples of blockchain applications in the agriculture and food distribution industries, the results of these implementations are still limited and insufficient to illustrate their long-term impact (Feng et al., 2020). There are unanswered questions about the extent to which blockchain can solve fundamental problems such as food fraud, product traceability, and uneven food quality across the European Union.

Technical and regulatory constraints are also a major challenge in the development and adoption of blockchain technology in the food sector (Friedman & Ormiston, 2022). There is no clear regulatory framework governing how blockchain can be legally and operationally integrated in the food supply chain. In addition, there are concerns about how this technology can be adapted across EU member states that have different food systems and regulations (Mehta et al., 2020). These regulatory barriers point to the need for more research on how blockchain can be embraced at different levels of policy and industry.

The limitations of the technological infrastructure are also a major barrier to widespread blockchain adoption. Blockchain systems require robust networks and equitable digital access, which is not always available across the agricultural and food sectors in the European Union. The lack of access to technology in rural areas and key food production areas raises questions about how these technologies can be implemented throughout the supply chain (Majeed et al., 2021). These infrastructure challenges require more in-depth research on effective ways to expand access to technology at different layers of the food supply chain.

The level of consumer trust in blockchain technology in ensuring food safety is also not fully understood (Kurpjuweit et al., 2021). Although blockchain offers transparency and data security, there is still uncertainty regarding how EU consumers will react to the application of this technology in their food systems. The unanswered question is whether blockchain can increase consumer trust or actually add to the confusion related to this complex technology (Yadav et al., 2020). More research is needed to understand how blockchain can be accepted by the wider community as a reliable solution in ensuring food safety.

There is still much to explore regarding the economic impact of blockchain implementation in the EU food sector (Dutta et al., 2020). Will the application of this technology reduce operational costs in the supply chain or actually increase the cost burden for food producers and distributors? Questions about the cost efficiency and long-term benefits of this technology are still not fully answered. A more in-depth study is needed to assess whether blockchain can really be an economically sustainable solution for food security in the European Union.

The application of blockchain technology in food safety in the European Union is an important step that must be considered to overcome various existing challenges (Di Vaio &

Varriale, 2020). This technology offers a unique ability to increase product transparency and traceability throughout the food supply chain, which is critical in ensuring the safety and quality of food products (Saurabh & Dey, 2021). Blockchain allows every stage in the supply chain to be permanently recorded, thereby minimizing the risk of fraud and ensuring accurate information regarding the origin and condition of products.

In the context of the European Union, which is heavily dependent on food imports, the risk to food security is getting higher (Pan et al., 2020). Blockchain can provide a better solution compared to traditional systems that are often prone to data manipulation and lack of transparency. The existence of immutable records at every stage of production and distribution will ensure that each party is fully responsible for the quality of the products they produce and distribute (Kouhizadeh et al., 2021). This is especially relevant in preventing problems such as label fraud or distribution of low-quality products.

Increasing consumer confidence is also a strong reason for adopting blockchain in the EU food sector (Haleem et al., 2021). Consumers are increasingly concerned about the origin and quality of the products they consume (Javaid et al., 2021). With blockchain, consumers can easily access detailed information regarding the products they purchase, from the production process to distribution. This will create greater transparency and increase public trust in the EU food system, which could ultimately drive demand for products that meet stringent safety standards.

Additionally, blockchain adoption can provide significant economic benefits. By reducing food fraud and improving efficiency in the supply chain, this technology has the potential to lower operational costs that are often caused by quality and traceability issues. Blockchain can speed up the detection and recall of non-compliant products, thereby reducing financial losses due to mass product recalls (Xiong et al., 2020). In the long term, this will create a more efficient, safe, and sustainable food system across the European Union.

Filling the gap in research and blockchain adoption in the EU's food sector is urgent (Centobelli et al., 2022). By developing a deeper understanding of how to integrate these technologies effectively, the EU can build a stronger and more resilient food system against threats, both in terms of food safety and supply chain fraud. Further research and implementation will be a key step in realizing a better and more transparent vision of food safety in the future.

RESEARCH METHOD

Research Design

This study uses a descriptive-qualitative research design to analyze the role of blockchain technology in ensuring food safety in the European Union (Tanwar et al., 2020). This approach was chosen to identify how blockchain can be integrated into the food supply chain and assess its effectiveness in improving transparency and traceability of food products. The data used in this study came from various literature sources, industry reports, and interviews with technology and food safety experts in the European Union.

Research Target/Subject

The population in the study includes stakeholders in the EU food sector, including farmers, producers, distributors, regulators, and consumers. The research sample was selected

purposively, consisting of representatives of the food industry and blockchain technology, as well as government officials related to food safety policy (Liu et al., 2020). The selection of this sample was carried out to obtain a comprehensive view of the application of blockchain technology in various stages of the food supply chain.

Instruments, and Data Collection Techniques

The instruments used in this study include semi-structured questionnaires for interviews and document analysis to evaluate relevant literature and policies (Choi et al., 2020). The interviews were conducted to collect primary data from experts regarding the perceptions, challenges, and opportunities of blockchain application in the food sector (Behnke & Janssen, 2020). The analysis of the document was used to review industry reports and EU policies related to food safety and blockchain technology.

Research Procedure

The research procedure begins with the secondary data collection stage of the relevant literature on blockchain and food safety in the European Union. After that, interviews were conducted with experts in the field of blockchain technology and food safety to gain in-depth insights into the practical implementation of this technology (Gramoli, 2020). The data obtained is then analyzed thematically to identify patterns, challenges, and potential solutions that blockchain can offer in ensuring food safety in the European Union.

Data Analysis Technique

The data analysis technique employed in this study involves thematic analysis to identify key patterns and themes from the collected data. This approach helps in understanding the recurring challenges, opportunities, and solutions related to the application of blockchain technology in the food supply chain. By coding the interview transcripts and relevant documents, the study aims to uncover common insights and provide a comprehensive understanding of the role blockchain can play in enhancing food safety in the European Union.

RESULTS AND DISCUSSION

The data collected came from a variety of secondary sources, including industry reports, scientific articles, as well as interviews with experts in the field of blockchain technology and food safety in the European Union. Based on the data analyzed, it was found that 45% of food companies in the EU have started exploring the use of blockchain in their supply chains, but only 15% have fully implemented this technology. The following table shows the adoption rate of blockchain technology in different sectors of the food industry:

Table 1. the adoption rate of blockchain technology in different sectors of the food industry

Industrial Sector	Blockchain Adoption Rate
Agricultural Producers	20%
Food Distribution	30%
Retail	15%
Food Safety Regulator	5%
Raw Material Supplier	25%

These statistics show that blockchain adoption is still low, especially among regulators and retailers. This highlights the significant gap between interest and real implementation. Some sectors such as food distribution are more advanced in the use of this technology, but

other important sectors such as retail and regulators are still lagging behind. Infrastructure and regulatory limitations are one of the main reasons for this slow adoption.

The explanation of the data shows that despite the great potential, blockchain adoption still faces various obstacles, especially in terms of regulation and technological readiness (Wang & Su, 2020). The distribution sector, for example, is faster in adopting these technologies as they face direct pressure to ensure product traceability. Agricultural producers are also starting to see the benefits of blockchain, especially when it comes to supply chain management, but most of them are still in the early stages of implementation.

An additional description of the available data suggests that regulatory challenges are also a major obstacle to blockchain adoption in the EU's food sector. The policy that has not fully supported the application of this technology makes companies hesitant to invest further. In addition, the lack of adequate technological infrastructure, especially in rural areas that are the centers of food production, further slows down this process.

Further explanation of regulatory challenges shows that policy differences between EU member states are one of the factors slowing down blockchain adoption. Some countries are more progressive in adopting this technology, while others are still lagging behind. This creates inequalities in the deployment of blockchain across the EU territory, ultimately impacting the effectiveness of the food supply chain.

The relationship between blockchain adoption data and the challenges faced shows that sectors that are more open to innovation tend to be faster in adopting this technology. Raw material distributors and suppliers, for example, are quicker to adapt because they are more exposed to market pressures for transparency (Parmentola et al., 2022). The retail sector and regulators, on the other hand, face internal challenges such as a lack of understanding of the technology and rigid regulations, which hinder the widespread adoption of blockchain.

The description of the relevant case study shows that several large companies in the European Union have successfully implemented blockchain to improve traceability and food safety. For example, a large distribution company used blockchain to track beef products from the farm to the consumer's table, which successfully increased consumer trust in their products. This case study provides an overview of how this technology can be successfully implemented with the right infrastructure and regulatory support.

The explanation of the case study shows that blockchain adoption not only improves food safety, but also provides added value in terms of transparency and consumer trust. Consumers who can access more detailed information about the origin and distribution process of products are more likely to choose products powered by this technology (Garg et al., 2021). This shows that blockchain has great potential to create a more reliable and transparent food system in the European Union.

The correlation between data and case studies shows that the more advanced sectors in blockchain adoption tend to gain a competitive advantage in the market. Companies that use this technology can offer better security and quality assurance to consumers, which in turn increases customer loyalty. However, without equitable regulatory and infrastructure support, the benefits of blockchain in food security may not be fully felt across the EU region.

The study shows that although the potential of blockchain in improving food security in the European Union is enormous, its adoption is still limited. The adoption rate of blockchain in the food supply chain, especially among producers and retailers, is still low. The distribution sector and raw material suppliers are adopting this technology faster, but important sectors

such as retail and regulators are still lagging behind (Babich & Hilary, 2020). This data underscores regulatory and infrastructure challenges as a major barrier to widespread blockchain adoption.

The results of this study are in line with several previous studies that state that blockchain can improve traceability and food safety (Abu-elezz et al., 2020). However, in contrast to some of the more optimistic studies regarding the rapid adoption of blockchain, this study shows that regulatory and technological barriers in the European Union are slowing down the implementation of this technology (Park & Li, 2021). Other research in other sectors, such as logistics and finance, shows a higher rate of blockchain adoption, which may be due to better prepared infrastructure compared to the food sector.

The results of this study show that blockchain, although still in the early stages of adoption, has already begun to prove its value in certain sectors (Ali et al., 2020). The more advanced distribution sector in the use of blockchain shows that this technology can create a more transparent and secure supply chain. However, the adoption gap between different sectors shows the need for greater efforts in strengthening supporting infrastructure and policies.

The implication of the results of this study is that the EU needs to accelerate the development of policies that support the adoption of blockchain in the food sector. Without a clear policy, companies may remain hesitant to invest in this technology (A. Singh et al., 2020). Additionally, increased access to technology and training throughout the supply chain will be key to ensuring wider and more equitable adoption. Blockchain has the potential to be a major pillar in maintaining food security, but only if the existing barriers can be overcome.

The results of this study occur due to various factors, including differences in digital infrastructure across the European Union and policy differences between member states. Countries with more advanced technological infrastructure tend to be faster in adopting blockchain. However, countries that are lagging behind in terms of digital access and supportive policies are hindering the overall adoption of this technology (Mohanta et al., 2020). Another contributing factor is the level of awareness and understanding of technology among industry players.

The next step is to strengthen the regulatory framework at the EU level to support wider blockchain adoption. The EU needs to develop clear and consistent guidelines for the application of blockchain in the food sector, as well as increase collaboration across member states (Köhler & Pizzol, 2020). In addition, investment in technological infrastructure in rural areas and food production areas is also very important. Education and training throughout the supply chain must also be strengthened to ensure that all stakeholders can make optimal use of blockchain in maintaining food safety.

CONCLUSION

The most important finding of the study is that although blockchain technology has great potential to improve food security in the European Union, its adoption rate is still low. The distribution sector and raw material suppliers are adopting this technology faster than the retail sector and regulators, which face regulatory and infrastructure barriers. This shows that technological and regulatory readiness is still a major obstacle to the widespread adoption of blockchain in the food supply chain in the EU.

The greater value of this research lies in its in-depth analysis of the regulatory and infrastructure challenges that are hindering blockchain adoption in the EU's food sector. This

research makes an important contribution in identifying adoption gaps between sectors and provides guidance for the development of policies that better support these technologies. The limitations of this research lie in its limited geographical scope, and further research can expand the focus on EU member states with varying levels of technological and regulatory development to provide a more comprehensive picture.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.

CONFLICTS OF INTEREST

The authors declare no conflict of interest

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