A blockchain-based quality management framework for fresh product in the context of digitization

Jingyi Song

School of Business Administration, Liaoning Technical University, Fuxin, China

Alexsoong_email@126.com

Abstract. In the context of digital transformation, enterprises are undergoing rapid industrial transformation and upgrading, leading to an increasing emphasis on information sharing and data security. This is particularly crucial in the fresh agricultural products industry, which directly impacts human health and well-being. Simultaneously ensuring data security while facilitating information sharing is of paramount importance to control costs. However, with the emergence and application of blockchain technology, the importance of data information sharing and traceability has become even more pronounced. Currently, applying blockchain technology to the operational management of fresh agricultural products is considered an effective solution, attracting attention and exploration in terms of relevant policies and theoretical research. Therefore, this paper first analyzes the potential of digital technology in the fresh agricultural product supply chain, elucidates the feasibility of utilizing blockchain technology for sharing and tracing data information, and proposes a framework for quality management of fresh agricultural products based on blockchain technology. Furthermore, a comprehensive analysis is conducted on the operational processes of stakeholders in the fresh agricultural product supply chain under this framework, followed by a summary of the benefits and future research directions of implementing this framework.

Keywords: digital transformation; blockchain; fresh product; quality management

1 Introduction

Currently, digital transformation of enterprises has become a widely advocated trend, influencing the development direction of various industries [1]. Among them, agriculture is one of the industries that benefits most from digital technologies [2]. For example, by utilizing technologies like artificial intelligence, the growth status of crops can be monitored and analyzed in real time, thereby improving crop yield and quality. During the pandemic, many farmers have utilized internet live streaming and other methods to sell agricultural products, fully demonstrating the innovative role of digital technologies in the industry [3-4]. As an industry directly related to human survival and well-

B. K. Kandel et al. (eds.), *Proceedings of the 2023 3rd International Conference on Business Administration and Data Science (BADS 2023)*, Atlantis Highlights in Computer Sciences 19,
https://doi.org/10.2991/978-94-6463-326-9_20

being, the process of digital transformation in the agricultural sector needs to fully consider the perishability of its products [5-6]. It also relies on digital technologies to ensure transparency and reliability of data throughout the entire process of agricultural production, processing, and transportation, thereby enhancing product quality and safety.

Blockchain is a distributed ledger technology that has gained significant attention due to its characteristics of immutability, decentralization, and transparency. It arranges transaction records in blocks in chronological order and utilizes cryptographic techniques to encrypt them, forming an immutable chain structure. Blockchain technology has features such as decentralization, security, traceability, and programmability, making it applicable in various fields such as finance, healthcare, logistics, and energy [7]. Particularly, its immutability and traceability provide natural advantages in the field of logistics. Given the current inadequate state of supply chain technology in the agricultural industry, blockchain technology also holds great potential for application [8]. The agricultural sector involves the production, circulation, and sale of agricultural products, requiring end-to-end traceability and supervision. Blockchain technology can establish a traceability chain for agricultural products, enabling comprehensive traceability from production to sale. It helps monitor the quality and safety of agricultural products, promptly identify and address potential risks, improve the quality and security assurance of agricultural products, and increase consumer trust.

Currently, numerous scholars have been exploring the application of blockchain technology in the agricultural field [9]. Scholar Wang, K. believes that the use of blockchain technology can greatly help in reducing fraudulent activities in the supply chain [10]. In the construction of smart climate agriculture systems, blockchain sensors are utilized to collect real-time data such as temperature, soil moisture, light intensity, and humidity, achieving the goal of intelligent cultivation [11]. Furthermore, during the COVID-19 pandemic, scholars, based on Pakistan's rice export data, have pointed out that blockchain systems can help alleviate the rigidification of the global food supply chain caused by the viral outbreak [12].

Based on the literature review, it is found that, in the context of digitization, more research has focused on technological innovations and hardware implementation. There has been relatively little research combining the advantages of blockchain with the perishable nature of fresh agricultural products and their impact on health. Therefore, based on the traceability of blockchain, this paper focuses on humidity detection during the transportation process of agricultural products. It proposes the construction of a blockchain-based framework for quality management of fresh agricultural products.

The remainder of this paper is arranged as follows. Section 2 elaborates on the principles of constructing the system and user profiles. Section 3 analyzes the application value of this framework in the agricultural supply chain. Section 4 summarizes the characteristics and advantages of the framework and proposes future research.

2 A Blockchain-based Quality Management Framework for Fresh Product

Considering the challenges posed by the perishability of agricultural products in ensuring food safety during transportation, this section proposes a blockchain-based framework for quality management of fresh agricultural products as shown in Fig.1. This framework can provide comprehensive traceability and regulatory services for the entire agricultural supply chain, thereby ensuring the final food safety and quality of agricultural products. The framework consists of five layers: data collection layer, data transmission layer, data analysis layer, blockchain network layer, and application layer.

(1) Data Collection Layer: the data collection layer serves as the foundation of the framework and is responsible for collecting relevant data during the production, processing, transportation, and sale of agricultural products. To effectively gather data, the data collection layer employs various digital technologies, including WiFi, QR codes, barcodes, and RFID, to achieve comprehensive supervision and management of the entire supply chain. By utilizing these data collection mediums, interference from human factors in transportation data can be avoided, ensuring accurate monitoring and recording of product quality and transportation environment. The specific data collected includes indicators such as temperature, humidity, light intensity, carbon dioxide concentration, weight, dimensions, as well as transportation information such as product origin, production date, processing date, transportation time, and sales channels.

(2) Data Transmission Layer: the data transmission layer takes the information collected by the collection layer and inputs it into the blockchain network through communication technologies such as Bluetooth and 5G. This layer has efficient classification and encryption functions, which are applied to the interaction between various stages, forming an efficient and secure digital management technology. The depicted communication technologies enable real-time tracking of information at various stages of agricultural product collection, transportation, storage, and sales. This layer aims to track the information throughout the entire process of agricultural product transportation and comprehensively monitor the transportation process, enabling digital technology management of various stages in the agricultural supply chain.

(3) Data Analysis Layer: the data analysis layer is primarily responsible for analyzing and mining the data collected by the collection layer and transmission layer to better understand the operation of the entire supply chain. The data analysis in this layer allows for rapid and accurate analysis and processing of the collected data. This section attempts to establish consensus clauses for quality supervision of agricultural products in various stages of the supply chain and standardize the management processes.

(4) Blockchain network Layer: the blockchain network Layer layer plays a crucial role by utilizing a decentralized distributed database to record transactions and events in the transportation of agricultural products. To ensure the immutability and integrity of transportation data, each transportation handover event in the agricultural supply chain is assigned a unique hash value and linked to the previous and next handover events. This linking relationship forms a data chain in the blockchain, which helps ensure the integrity and trustworthiness of the data, and enables verification of data au-

thenticity using the data chain. Through this framework, all parties involved in the agricultural supply chain can record and trace transportation information of the products in real-time, enhancing data credibility and transparency, thus ensuring the quality and safety of agricultural products.

(5) Application Layer: based on the applications of the data collection layer, data transmission layer, data analysis layer, and core business layer, an information traceability platform can be established among farmers, agricultural transportation companies, suppliers, distributors, consumers, and government agencies. This platform enables end-to-end tracking and traceability of agricultural products, facilitating information sharing among all stakeholders. In the top application layer, from the start of agricultural product production, every step of the production information can be recorded and transmitted in real-time to the system platform. During transportation, each transportation event by agricultural transportation companies is fully recorded, including transportation time, location, vehicle information, driver information, etc., and can be updated in real-time in the system. Distributors can trace each sales link back to the previous supplier and the transportation method and route of the previous link. In case of food safety issues encountered by consumers after purchase, the responsibility can be quickly traced back to the responsible party based on the sub-layers, thus improving the efficiency of problem resolution. Consumer feedback can be forwarded to relevant government departments to ensure effective supervision and management of the entire process of agricultural products from production to consumption.

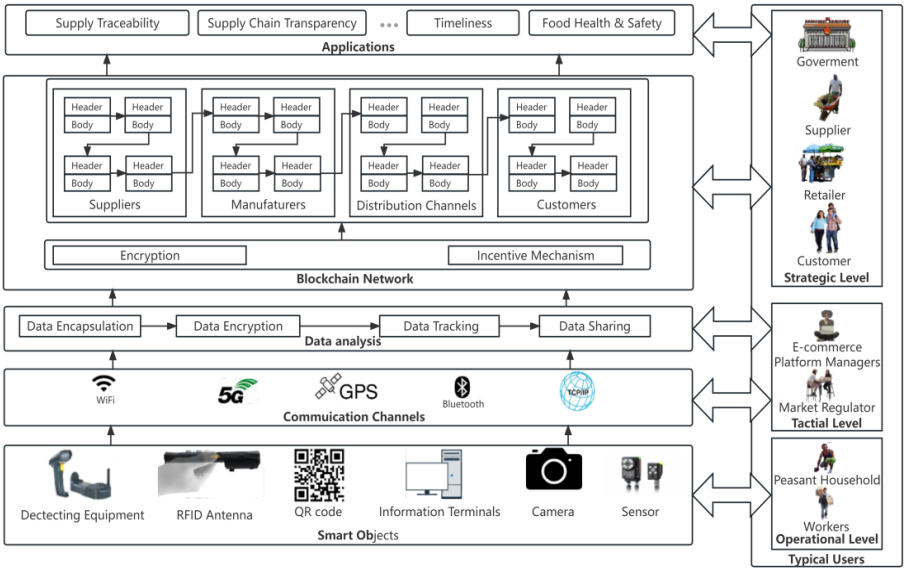

Fig. 1. Blockchain-based Quality Management Framework for Fresh Product

3 The Key Process of Agricultural Product Supply Chain Stakeholders' Operations

This section depicts the operational logic among various entity stakeholders in the framework of a blockchain-based fresh agricultural product quality management framework. It provides a clearer description of the end-to-end traceability of agricultural products enabled by the blockchain network, as shown in Fig. 2.

Farmer household, as the agricultural product producers at the forefront of the supply chain, are unable to directly interact with the end consumers of their products. Therefore, farmers expect to showcase their produced agricultural products on this platform to expand sales channels and enhance brand visibility. Through blockchain technology, farmers can record production information, quality indicators, cultivation methods, and other data of their agricultural products in immutable blocks, providing a trusted source of information and enhancing consumer trust in the agricultural products.

Suppliers play a crucial role in the entire fresh agricultural product quality management system, as they are responsible for collecting and clustering agricultural products and selling them to the retail market. Through the proposed framework of the fresh agricultural product quality management framework in this paper, the supply chain can monitor product quality in real-time and have access to important information such as the production and transportation locations of the products. By leveraging this confidential data for risk control, the agricultural product supply chain can be better coordinated, reducing economic risks associated with product spoilage and improving overall efficiency and reliability of the supply chain.

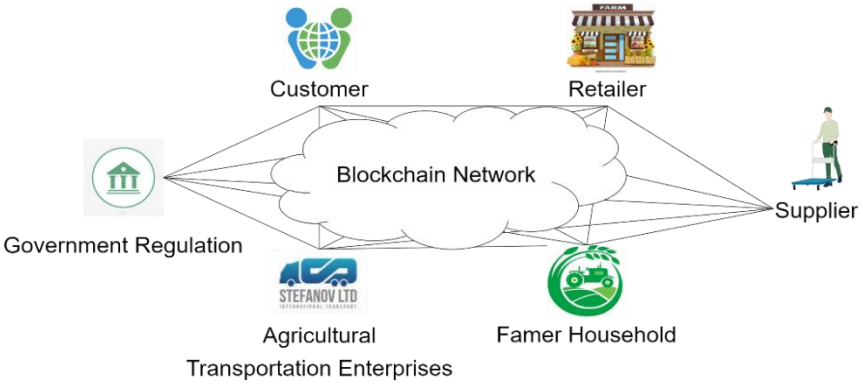

Fig. 2. Process of Agricultural Product Supply Chain Stakeholders' Operations

As a crucial link in the supply chain that directly interacts with consumers, retailers utilize the blockchain network to receive agricultural products supplied by upstream vendors and provide traceability services to consumers. By leveraging this system, retailers can accurately identify responsible parties in the event of food safety issues, thereby enhancing customer satisfaction and increasing supply chain resilience.

As the end customers of the supply chain, consumers can benefit from the framework proposed in this paper. They can access real-time information about the entire lifecycle

of agricultural products, including their sources, production processes, transportation conditions, and quality certifications. Based on this information, consumers can gain a better understanding of the quality and safety characteristics of agricultural products, enabling them to make informed choices that align with their needs and health management. Furthermore, consumers can hold all parties involved accountable in real-time through blockchain, encouraging agricultural product suppliers and retailers to prioritize agricultural product quality and food safety.

For agricultural product transportation companies, this framework can assist in scheduling and planning transportation vehicles, reducing transportation time, and saving fuel costs. Transportation companies can access real-time order demands and delivery dates, allowing them to efficiently arrange transportation routes and allocate transportation resources, thereby improving transportation efficiency.

Government regulation plays a supervisory and management role in this framework. Through the framework, they can understand the operations of various market segments, monitor agricultural product quality, and address safety issues. They can also timely release targeted policies to support the agricultural product industry in achieving green, healthy, and sustainable development.

The framework proposed in this paper represents a comprehensive system where various entities collaborate to advance the improvement of agricultural product quality management. This framework aims to provide consumers with safer and more reliable agricultural products, injecting new vitality into the sustainable development of the agricultural product industry.

4 Conclusions

This paper takes the issue of digitalized agricultural product quality management based on information data sharing as its starting point and systematically constructs a framework for the quality management of fresh agricultural products enabled by blockchain technology. By fully leveraging the advantages of blockchain, including immutability, decentralization, anonymity, and transparency, it can effectively monitor the information data management and transaction supervision of agricultural products throughout the entire process from production to consumers' tables, thereby improving transparency and operational efficiency in the fresh agricultural product industry. Compared to the traditional centralized management approach for fresh agricultural products, the decentralized nature and immutability of blockchain technology help reduce the risks of information leakage and loss. It also enables precise identification of responsible parties, avoiding situations where various stakeholders in the supply chain shift responsibilities, thus enhancing the reliability of information and improving the satisfaction of all stakeholders in the fresh agricultural product supply chain. The research findings of this article are not only of significant scientific importance in the field of information management but also have practical implications in addressing the issue of quality supervision in fresh agricultural products. Furthermore, they have the potential to provide more secure and trustworthy solutions for operations and management in other fields. Future plans involve leveraging smart contracts related to blockchain technology and

their programmability to achieve automatic triggering of smart contracts without the need for third-party intermediaries. This will facilitate the design of a more versatile framework, allowing users to customize and expand asset management while ensuring data integrity. These advancements will empower various industries in the digital era to upgrade and thrive.

Reference

1. Andriushchenko, K. et al. (2020) 'Peculiarities of sustainable development of enterprises in the context of digital transformation', Entrepreneurship and Sustainability Issues, 7(3), 2255–2270.
2. Liu, X.-Y. (2021) 'Agricultural Products Intelligent Marketing Technology Innovation in big data era', Procedia Computer Science, 183, 648–654.
3. Yu, Z. and Zhang, K. (2022) 'The determinants of purchase intention on agricultural products via public-interest live streaming for farmers during COVID-19 pandemic', Sustainability, 14(21), 13921.
4. Tan, B. Q., Wang, F., Liu, J., Kang, K., & Costa, F. (2020). A blockchain-based framework for green logistics in supply chains. Sustainability, 12(11), 4656.
5. Venkatesh, V. G., Kang, K., Wang, B., Zhong, R. Y., & Zhang, A. (2020). System architecture for blockchain based transparency of supply chain social sustainability. Robotics and Computer-Integrated Manufacturing, 63, 101896.
6. Nakandala, D., Lau, H. and Zhang, J. (2016) 'Cost-optimization modelling for Fresh Food Quality and transportation', Industrial Management & Data Systems, 116(3), 564–583.
7. Nofer, M. et al. (2017) 'Blockchain', Business & Information Systems Engineering, 59(3), pp. 183–187. doi:10.1007/s12599-017-0467-3.
8. Dutta, P. et al. (2020) 'Blockchain technology in Supply Chain Operations: Applications, challenges and research opportunities', Transportation Research Part E: Logistics and Transportation Review, 142, 102067.
9. L.B., K. (2022) 'Survey on the applications of Blockchain in Agriculture', Agriculture, 12(9), 1333.
10. Wang, K., Yan, X. and Fu, K. (2020) 'Research on risk management of agricultural products supply chain based on Blockchain technology', Open Journal of Business and Management, 08(06), 2493–2503.
11. Ting, L. et al. (2022) 'A secure framework for IOT-based smart climate agriculture system: Toward Blockchain and edge computing', Journal of Intelligent Systems, 31(1), 221–236.
12. Khan, H.H. et al. (2022) 'Blockchain technology for agricultural supply chains during the COVID-19 pandemic: Benefits and cleaner solutions', Journal of Cleaner Production, 347. 131268.