

# Research on the Application of Blockchain Technology in Cold Chain Logistics for Agricultural Products

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**Abstract:** With the continuous advancement of science and technology and the advent of the digital era, blockchain technology is increasingly demonstrating its great potential across various industries due to its unique features of decentralization, transparency, and immutability. In particular, in the cold chain logistics of agricultural products, the application of blockchain technology can not only enhance logistics efficiency but also ensure food safety and boost consumer trust<sup>[1]</sup>. This paper first outlines the advantages of blockchain technology in cold chain logistics for agricultural products, and then clarifies the application pathways of blockchain technology in this field, providing a reference for relevant researchers.

**Keywords:** Blockchain technology; Agricultural products; Cold chain logistics; Application

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## 1. Introduction

Cold chain logistics for agricultural products is a method that maintains a consistently low temperature throughout the entire process, from harvesting, processing, and storage to transportation and sales. Its purpose is to ensure the freshness and quality of agricultural products, meeting consumer demand for high-quality produce. Blockchain technology, a decentralized database system known for its immutability, can enable full traceability of cold chain logistics, addressing issues like information asymmetry and food safety while ensuring the security of agricultural product logistics<sup>[2]</sup>.

## 2. Advantages of blockchain technology in agricultural cold chain logistics

### 2.1. Facilitates full process traceability

Blockchain's tamper-resistant nature is one of its key advantages. By installing RFID tags in warehouses, ports,

and transport vehicles, real-time monitoring of humidity and temperature is carried out using GPS. This data is uploaded to the blockchain in real time and can be updated to reflect changes, allowing all participants in the cold chain logistics process to accurately track temperature, humidity, and other relevant information. This improves the efficiency of monitoring and controlling temperature conditions throughout cold chain operations. Moreover, blockchain can store critical information such as the origin, harvest time, and water content of agricultural products, ensuring easy access to original data and transportation records, which enhances the safety of agricultural products <sup>[3]</sup>.

## **2.2. Improves automation in cold chain logistics**

Smart contracts are an essential function of blockchain technology. Agricultural enterprises and cold chain logistics companies can automate tasks such as payments and deliveries through smart contracts. In agricultural cold chain logistics, smart contracts can be applied to various stages, such as raw material procurement for processing plants and product sales between processing plants and dealers. The automatic execution of smart contracts not only enhances transaction efficiency but also reduces the risk of human error and intervention, thereby improving the overall automation of cold chain logistics <sup>[4]</sup>.

## **3. Current application of blockchain technology in cold chain logistics for agricultural products**

With growing global awareness of food safety and increasing consumer demands for high-quality agricultural products, the application of blockchain technology in agricultural cold chain logistics is being steadily promoted <sup>[5]</sup>. Agricultural producers and logistics companies are beginning to integrate blockchain technology into their systems, building traceability frameworks for cold chain logistics. These systems enable the real-time collection of data throughout the entire supply chain, from production and processing to storage, transportation, and sales, allowing for comprehensive monitoring and tracking. Additionally, the traceability systems offer data analysis and visual display functions, allowing enterprises, regulators, and consumers to intuitively understand the cold chain logistics process, identify potential issues, and address them promptly.

However, despite its broad potential, blockchain technology faces several challenges in practical application. First, the technology is not yet fully adopted, and some agricultural and logistics companies lack the necessary technical understanding and support. Second, the costs associated with building and maintaining blockchain infrastructure are relatively high, making it difficult for smaller enterprises to afford. Lastly, data security and privacy protection issues have not received adequate attention from businesses <sup>[6]</sup>.

## **4. Application path of blockchain technology in cold chain logistics of agricultural products**

### **4.1. Issuing guiding policies to promote the development of cold chain logistics**

With the rapid development of information technology, blockchain technology has been widely applied across various sectors. To ensure the effective use of blockchain in the cold chain logistics of agricultural products, government bodies should implement guiding policies that promote the integration of blockchain technology with cold chain logistics. The specifics are as follows:

First, the government should offer preferential policies, lowering the development and application standards

of blockchain technology, and promoting the connection of traditional data sources to blockchain enterprises and research and development organizations. This would help alleviate their financial difficulties <sup>[7]</sup>. Additionally, apart from supporting resource alignment, governments should encourage enterprises to actively develop blockchain-based logistics and agricultural technologies by offering tax reductions and preferential policies.

Second, a legal liability identification system should be established for the blockchain industry. If any violations of laws or regulations are detected, the legal responsibilities should be clarified immediately to protect the interests of all parties involved in the supply chain, ensuring market order is effectively maintained.

Third, from the perspective of “tangible hands,” blockchain technology should be integrated with the unique development characteristics of cold chain logistics for agricultural products in China. Blockchain can be fully utilized to explore new supply chain management models that revolve around blockchain and network logistics. Conducting empirical research in this area will lay the groundwork for promoting the efficient use of blockchain in agricultural cold chain logistics. Additionally, the government should optimize resource allocation by establishing industry incubation parks, facilitating efficient resource clustering within regions, and managing resources effectively in urban development <sup>[8]</sup>.

#### **4.2. Building a comprehensive standard system to promote blockchain technology**

Currently, the blockchain industry lacks uniform standards, particularly in the integration of blockchain technology with the cold chain logistics of agricultural products. This deficiency significantly hinders the transition of blockchain technology from theoretical applications to practical use and impedes the development of blockchain-based agricultural cold chain logistics. To address this, the industry must develop a robust and scientifically sound blockchain application system, as well as establish corresponding industry standards for cold chain logistics in agriculture.

The construction of a standardization system requires collaboration between the government, logistics enterprises, research institutions, and universities. Together, they can create a regional blockchain-based cold chain logistics standardization system for the supply chain. For example, interface standards and digital coding specifications between various platforms should be unified, fostering a conducive industry environment and enabling the seamless integration of agricultural cold chain logistics with blockchain technology. Additionally, by standardizing template management solutions, regional agricultural cold chain logistics can achieve unified oversight and management.

It is worth noting that these efforts should begin with pilot programs in economically developed regions. These areas can first address the challenges in applying blockchain to agricultural cold chain logistics, refine the technology’s applications, and gradually expand its use to other regions across the country <sup>[9]</sup>.

#### **4.3. Using traceable information technology to strengthen the quality and safety of agricultural products**

Blockchain technology is essential for achieving traceability in cold chain logistics. By employing EDI, GPS, and other advanced data acquisition, storage, and transmission technologies, agricultural logistics enterprises can streamline cold chain logistics workflows, ensuring traceability throughout the entire process. A comprehensive monitoring and early warning system can be established to track every step from harvest to home delivery, creating an unbroken chain of information.

Particularly for the “first kilometer” (from the farm) and the “last kilometer” (to the consumer) of logistics,

relevant authorities must collaborate with agricultural logistics enterprises on infrastructure and monitoring system development. Real-time monitoring and accurate recording of crucial data, such as production dates, shelf life, and product freshness, should be integrated into the blockchain system. This allows for seamless oversight of the entire cold chain logistics process.

Once order requirements are confirmed, farmers should harvest the agricultural products and store them in nearby warehouses for cold storage using refrigerated trucks. By attaching a two-dimensional (QR) code to each packaged product, scanning the code can automate the reading and transmission of product information, improving data transmission efficiency. Simultaneously, GPS and GIS positioning systems can track the cold chain truck's location in real time, helping identify any issues and responsible parties quickly<sup>[10]</sup>.

Moreover, the use of intelligent temperature control and blockchain technology ensures that agricultural products remain fresh and at the proper temperature throughout the process. All monitoring data is recorded in the blockchain, enabling users across the chain to share information and visualize the cold chain logistics process. For example, if an anomaly is detected in the temperature data, the blockchain platform can automatically trigger an alarm, helping to reduce potential losses<sup>[11]</sup>.

#### **4.4. Breaking information barriers and sharing real-time logistics information**

First, the information barrier must be addressed. In cold chain logistics for agricultural products, the “cold chain” is central, incorporating upstream and downstream enterprises, suppliers, distributors, banks, financial credit companies, and other social resources. An enterprise alliance can be established through smart contracts to eliminate these information barriers. Blockchain technology, with its inherent traceability, immutability, and unforgeability, provides reliable information to all participants in the cold chain logistics process, facilitating information sharing. Simultaneously, smart contract management within the cold chain logistics supply chain ensures smooth information sharing and circulation among enterprises and departments<sup>[12]</sup>.

Making financial information transparent for all participants in the supply chain reduces the difficulty and cost for suppliers, dealers, and cold chain logistics enterprises in obtaining loans and funds from banks or credit companies. This transparency provides enterprises with financial guarantees and credit lines, ensuring smooth flows and transparency within the entire cold chain logistics supply chain.

Secondly, real-time information sharing is essential. By leveraging the distributed nature of blockchain technology, all nodes on the blockchain maintain equality, security, and independence. Integrating blockchain technology ensures that each link in the cold chain logistics process operates as part of a unified system. Blockchain enables manufacturers, suppliers, distribution enterprises, distributors, and consumers to collaboratively build a distributed cold chain logistics platform, allowing participants to exchange information from multiple directions. This not only enhances the efficiency of information transmission but also helps establish a comprehensive trust-based cooperation system, ensuring the efficient and stable operation of cold chain logistics<sup>[13]</sup>.

#### **4.5. Optimizing talent training and cultivating multidisciplinary expertise**

With the steady progress of globalization, interdisciplinary talents possessing expertise in both agricultural cold chain logistics and blockchain technology will be crucial for the future development of China's logistics industry. Currently, the shortage of professionals in the field of blockchain and cold chain logistics is a bottleneck hindering the growth of agricultural cold chain logistics. To address this, logistics enterprises,

schools, and related departments need to raise their awareness and understanding by organizing peak forums, producing specialized textbooks, and inviting renowned experts for seminars to increase society's overall focus on cultivating blockchain and cold chain logistics talent.

Enterprises should also strengthen technical and strategic cooperation to enhance the synergistic effects of combining blockchain with cold chain logistics. They must encourage employees to engage with blockchain technology, explore issues within agricultural cold chain logistics, and pay attention to the results of this integration. Additionally, forming expert teams specializing in blockchain and cold chain logistics is essential. These teams should conduct comprehensive research on blockchain technology, its development models, and related regulations to significantly enhance the application of blockchain in agricultural cold chain logistics.

Through collaboration between technology-driven enterprises and research institutions, technology development and research teams should be established to foster competition and drive differentiation within agricultural cold chain logistics. Finally, professionals specializing in blockchain must engage in interdisciplinary communication and cooperation to push blockchain from theory to practical implementation, seeking greater breakthroughs. Simultaneously, society should invest heavily in schools, providing the necessary resources to encourage the cultivation of talent with expertise in both blockchain technology and other relevant fields. This will promote the innovative application and development of blockchain technology within agricultural cold chain logistics <sup>[14]</sup>.

## 5. Conclusion

In summary, blockchain technology, as an emerging information technology, holds significant application potential in the cold chain logistics of agricultural products. To foster its development, several key measures can be taken: issuing guiding policies to support cold chain logistics; establishing a robust standard system to effectively promote blockchain technology; utilizing traceability information technology to enhance the quality and safety of agricultural products; breaking down information barriers to enable real-time logistics information sharing; and optimizing talent training methods to cultivate interdisciplinary expertise. These actions can drive the widespread adoption of blockchain technology in agricultural cold chain logistics, ensuring sustainable development and providing strong support for the growth of China's logistics industry <sup>[15]</sup>.

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