Research on Agricultural Product Cold Chain Logistics Management Based on Supply Chain Network Structure

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Abstract. The thesis first analyzes the supply chain network structure for the establishment of a new agricultural product supply chain system. This article is to construct a new agricultural product supply chain construction plan, establishes an innovative idea, the business process is urban fresh agricultural product e-commerce, and builds an urban standard distribution model A data-based cold chain integrated distribution model is proposed. This research is mainly to realize the joint operation and management of cold chain logistics and fresh products, and it is necessary to strengthen the coordination of demand-oriented agricultural industry organizations, the coordination of technological innovation of circulation enterprises, and the coordination of the implementation of innovative supply. As a result, the safety mechanism construction of the new agricultural product supply chain, including dynamic monitoring, detection modules and emergency handling systems, has guiding significance for the efficiency of agricultural cold chain logistics circulation.

1. Introduction
With the development of the Chinese social economy, people's living standards are improving day by day, and at the same time, the demand for types of agricultural products is also increasing. Affected by the Chinese natural and social environment, agricultural products' logistics has become a massive obstacle to develop the rural economy. The circulation of agricultural products can look at the quantity and has high requirements in terms of quality. The state has also introduced some policies; the construction of chain logistics has risen to the focus of national economic development construction projects.

The logistics models centered on the supply chain include the third-party logistics integration model, the strategic alliance logistics operation model, the regional logistics distribution center model based on the integration of supply chain logistics, etc. The low-temperature storage requirements of by-products, fruits, and vegetables. We should adopt a logistics model based on third-party logistics and integration of social resources, which can provide for the time cost and capital cost in the logistics and transportation process, as well as the payment of accounts and the ability to preserve freshness. Judging from the current transportation process of fresh agricultural products in China, certain defects are still unavoidable, such as high corrosion rate, low cold chain rate, and high logistics costs [1]. The problems mentioned above are mainly caused by the new agricultural product supply chain problems in China. As a result, the supply chain of fresh agricultural products should be improved from the overall perspective.
2. The concept of agricultural cold chain logistics
The cold chain logistics of agricultural products consist of frozen processing, frozen storage, refrigerated transportation and distribution, and frozen sales. Cold chain logistics needs to comprehensively consider various factors such as production, transportation, sales, economics, and technology, and coordinate the relationship between the factors to ensure that perishable and fresh foods maintain and increase their value during processing, transportation, and sales. The food range applicable to the cold chain includes vegetables, meat, aquatic products, dairy products, and quick-frozen foods [2].

3. Problems in the cold chain logistics system of fresh agricultural products

3.1. There are no specific applicable policies, regulations and industry standards
Policies, regulations, and industry standards are the institutional guarantee for the healthy development of an industry. There are only rules and regulations formulated by some functional departments and industry associations. Such as the "Fresh Agricultural Products Cold Chain System, Agricultural Product Distribution Center Project Construction Contents and Standards" formulated by the Ministry of Commerce, and the "Logistics Terminology" drafted and formulated by the China Federation of Logistics and Purchasing. This puts the entire industry in a state where it is impossible to rely on. Related companies are operating following their respective applicable regulations and standards. It is difficult to achieve a compelling connection between the industry chain nodes, resulting in difficult quality monitoring and effective sharing of information. Many problems.

3.2. Amazing waste of resources
So far, more than 90% of Chinese meat and more than 80% of aquatic products, vegetables, and fruits are still transported and sold under natural conditions without cold chain guarantees, and a complete and independent food cold chain system has not yet been formed. Due to the backward processing and circulation facilities of agricultural products such as fruits and vegetables, the annual loss of fruit rot in the country is nearly 12 million tons, and the loss of vegetable rot exceeds 130 million tons. Calculated at 1 yuan/kg, the economic loss exceeds 100 billion yuan. RMB. Agricultural products have suffered severe losses due to decay and deterioration, and the logistics costs have increased, resulting in tremendous losses and waste.

3.3. Insufficient integration of the entire supply chain of the cold chain and more chain disconnections
In this process, the core role of the agricultural product wholesale market is insufficient. Each cold chain node company operates independently, rarely conducts information sharing and exchanges, has many broken links, and frequent conflicts of interest. This leads to the formation of many non-cooperative games and zero-sum games during the operation of the cold chain, resulting in low efficiency and waste of resources in the entire supply chain.

3.4. The low penetration rate of logistics standardization and low-carbon technology
The small scope and low application rate of logistics standardization and unification have increased carbon emissions in the agricultural product supply chain to a certain extent. As shown in Figure 1, the grapes are first packaged once after being picked. When transported to the wholesale market in the place of origin, they will be packaged twice to facilitate long-distance transportation and loading and unloading [3]. After the goods reach the wholesale market in the place of sale, they will be packaged again. Because of the difference in the transportation environment and customer needs, it will be changed again. The low applicability of standardized logistics packaging and logistics operations has led to repeated packaging and frequent loading and unloading vehicles in the cold chain process. Due to the high cost of energy-saving and emission-reduction technologies, and the country has not yet given detailed implementation rules for carbon trading, most cold chain logistics service providers for agricultural products have not applied emission reductions, low-temperature storage, and low-
temperature transportation, which have high carbon emissions. Technology, refrigerated warehouses with high energy consumption and low cooling effect, and mechanical refrigeration vehicles in cold chain logistics have led to a large amount of greenhouse gas emissions.

4. Network structure design of fresh agricultural product supply chain

From the perspective of the stability and timeliness of urban fresh product consumption demand in recent years, per capita consumption demand such as fresh vegetables, beef, sheep and pork, fresh eggs, aquatic products, and fresh fruits and vegetables has been stable, as shown in Table 1. From 2016 to 2020, urban residents' per capita purchase volume increased steadily, and the national population increased from 2016 to 2020. Although the per capita purchase volume of urban residents decreased slightly, the total demand was relatively stable. This fully shows that to meet the stable demand for daily necessities and the timeliness of purchase, fresh food e-commerce, and offline cold chain logistics companies must respond quickly.

Table.1  Per capita purchases of primary agricultural products by Chinese urban residents from 2016 to 2020

| years | Fresh vegetables | pork | Beef and lamb | Fresh eggs | Aquatic products | Fresh fruit | total  |
|-------|------------------|------|---------------|------------|------------------|-------------|--------|
| 2016  | 1123             | 212  | 37            | 105        | 152              | 561         | 2190   |
| 2017  | 1001             | 204  | 33            | 94         | 140              | 476         | 1948   |
| 2018  | 1001             | 208  | 34            | 98         | 144              | 481         | 1966   |
| 2019  | 1002             | 207  | 39            | 105        | 147              | 499         | 1999   |
| 2020  | 1176             | 200  | 38            | 104        | 130              | 602         | 2250   |

The innovative supply chain network structure of fresh agricultural products is a social consumption network composed of multiple businesses and commercial relationships. The network can realize three essential physical movement functions in physical form, market intermediary, and consumer demand. According to the end consumer's preferences or buying methods, buying behavior, and the guidance of buying fashion, and then adjust the content and form of fresh products, creatively meet the needs and desires of consumers (including Ali, JD. Supermarket, the new retail model). The innovative supply chain network structure of fresh agricultural products is shown in Figure 1.

Figure.1  Innovative supply chain network structure of fresh agricultural products

5. Design of Monitoring and Management Platform for Agricultural Products Cold Chain Supply Chain

5.1. Demand analysis

Cold chain logistics require that select items, such as food and medicine, be kept at the specified temperature and humidity in all logistics links such as production, procurement, distribution, warehousing, sales, recall, and recycling, to reduce the loss of items in the logistics link. The survey shows that not all companies engaged in cold chain logistics can provide temperature monitoring and control records at this stage, and there are still problems such as poor temperature control in the cold chain transportation process. Because there is no temperature control record, once a particular logistics link "broken," it is difficult to investigate which link has the problem. Therefore, logistics companies engaged in the cold chain of agricultural products must be included in the mandatory supervision of GSP, and electronic files of the cold chain supply chain monitoring system must be established.
nationwide to manage the information of the temperature, humidity, transportation, and storage conditions of the entire supply chain. Based on the above problems, a unified data information platform must be established to trace cold chain logistics products [4]. The traceability links include raw material procurement, production, distribution, warehousing, sales, recall, recycling, and other logistics links. Consumers and regulatory authorities access the electronic archives of the cold chain logistics management system through the computer system to understand the product purchase, production, distribution, warehousing, sales, recall, and recycling information on time, and grasp the number and location of products in the cold chain logistics, thereby improving Supply chain performance of cold chain logistics. Simultaneously, access to the cold chain supply chain's electronic archives can conduct comprehensive dynamic monitoring of various cold chain logistics vehicles and provide traceable information support for a food safety review.

5.2. Cold chain logistics product label design based on RFID technology
To realize the design of a real-time monitoring system for cold chain logistics based on GPRS, RFID technology is used for label design and information mining of cold chain logistics products. The label identification process of cold chain logistics products based on RFID technology is shown in Figure 2.

![Figure 2: Cold chain logistics product label identification process](image)

5.3. Design and implementation of a real-time monitoring system

5.3.1. Forward tracking design of cold chain logistics based on GPRS
To realize the design of a real-time monitoring system for cold chain logistics, the forward tracking design of cold chain logistics is based on GPRS technology. Enterprise managers and employees trigger the internal tracking process. Chain logistics products are different from industrial products. GPRS technology is used for information communication. The identification technology used in the cold chain logistics real-time monitoring system mainly includes UHF RFID and GPRS communication identification technology. The forward tracking process of chain logistics is composed of readers, electronic tags, and application software. The establishment of cold chain logistics product supply chain information management system should be based on information systems [5]. Realize the internal tracking of high organization, high order, high standardization, and high modernization. The forward tracking process of cold chain logistics based on GPRS is shown in Figure 3.
5.3.2. Instance data analysis of cold chain logistics monitoring and identification

Based on the GPRS-based forward tracking design of cold chain logistics, the label recognition algorithm calculates the instance data of cold chain logistics monitoring and identification. In the process of tag batch reading, the recognition probability of cold chain logistics forward tracking is

\[ P(1) = (1 - L^{-1})^{m-1} \]

When the production capacity of enterprise B is defined as \( k \), the identification probability of the logistics distribution center for cold chain logistics monitoring is:

\[ P(k) = P(1)(1 - P(1))^{k-1} \tag{1} \]

The average value of the search depth of products from company A, B to the logistics distribution center is:

\[ E(k) = \sum_{i=1}^{k} (1 - P(1))^i = \frac{1}{1 - (1 - P(1))} \tag{2} \]

Assuming that the number of suppliers is \( m-1 \), the mode of transportation is batch transportation of recycling materials, and the product freight from the logistics distribution center to the customer is:

\[ T_{l-ar} E(k) L = \frac{L}{(1 - 1/L)^{m-1}} \tag{3} \]

The reverse tracking process of cold chain logistics takes the information feedback demand of the logistics distribution center as the trigger, and the average number of time slots for cold chain logistics reverse tracking is:

\[ T_{r-ar} E(k) L = \frac{2}{(1 - 1/2)^{m-1}} \tag{4} \]

5.3.3. System framework design

The system mainly includes ARM main control module, ZigBee wireless sensor network module, GPS module, GPRS module, PC server module, and Android mobile phone positioning monitoring module. As shown in Figure 4, the overall system framework diagram of the system, The ZigBee module conducts wireless networking, collects the temperature and humidity information in the carriage in real-time, and then communicates with the ARM master control module through the ZigBee coordinator node to communicate with the ARM master control module through the serial port (serial port 1), and transmit the temperature and humidity information to the ARM; the GPS module and the ARM at the same time The main control module communicates with the serial port (serial port 2) to obtain real-time
latitude and longitude information. Finally, the integrated temperature, humidity, latitude, and longitude information is sent to the remote PC server through the GPRS module using the UDP protocol, and the server transmits the received information stored in the MySQL database.

5.3.4. Design of wireless sensor network
ZigBee is a short-range wireless communication technology standard formulated for the construction of personal local area networks. Its physical layer and medium access control layer protocol is defined following the IEEE802.15.4 standard specification, which has the characteristics of low power consumption, low cost, and self-organizing network. It has very strong practicability in the Internet of Things, such as wireless sensor networks, industrial control, smart home, building automation, etc.

![Star network](image)

Figure 4 Star network

5.3.5. Realization results
To test the performance of the GPRS-based cold chain logistics real-time monitoring system designed in this paper, the system simulation test analysis is carried out, the performance result is shown in Figure 6.

![Performance test analysis](image)

Figure 5 Performance test analysis

6. Conclusion
With the rapid development of the urban fresh product logistics industry and the progress of collaborative logistics and distribution technology, a large number of cold chain logistics enterprises rely on innovative supply chain technology innovation to succeed. Cold chain logistics enterprises are the carriers to ensure the economic growth and economic development of the logistics industry, modern agricultural product supply chain innovation, agricultural product industry organizational development methods, technical levels, and collaborative operation levels directly determine the competitiveness of enterprises, and they play an essential fundamental role in the development of the entire agriculture and logistics industry.

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