Journal of Infrastructure, Policy and Development 2024, 8(7), 4987.
https://doi.org/10.24294/jipd.v8i7.4987

Review

Strategies for digital transformation of cold chain logistics of fresh agricultural products based on Internet of things

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CITATION

Wang Y, Pochan J, Panichakarn B, Garin ME. (2024). Strategies for digital transformation of cold chain logistics of fresh agricultural products based on Internet of things. Journal of Infrastructure, Policy and Development. 8(7): 4987. https://doi.org/10.24294/jipd.v8i7.4987

ARTICLE INFO

Received: 4 March 2024
Accepted: 1 April 2024
Available online: 23 July 2024

Abstract: The rapid development of cities and urbanization in China has forced the growth of new channels for buying agricultural products. The purpose of this research is to examine how Internet of Things (IoT's) technologies can digitize a traditional fresh food supply chain. Comparative and descriptive analysis methods are used to highlight the major pain points in the traditional supply chains and assess how digital transformation could help. We delve into every part of digital transformation, which includes establishing an information platform based on IoT and developing smart storage options. Our findings revealed that through end-to-end digital integration, supply chain efficiency is improved with shorter lead times and leaner inventories that yield reduced costs as well as fewer losses while ensuring product quality and traceability. In sum, such an approach would enhance sustainability within the fresh food value chain. As such, our article highlights key aspects of transitioning towards a digital environment in this sector for those planning similar ventures.

Keywords: Internet of Things (IoT's); digital transformation; fresh agricultural products; traceability; intelligent crisper; information platform; cold chain logistics

1. Introduction

The Internet of Things (IoT), Block chain, Big Data (BD), Cloud Computing (CC), 5G and Artificial Intelligence (AI) have completely changed the global economic scenario (French et al., 2021). Based on the findings outlined in the White Paper on the Fourth Industrial Revolution's Influence on Supply Chains, digital transformation has proven to significantly impact various sectors. Manufacturing enterprises experienced a notable 17.6% reduction in costs and a substantial 22.6% increase in revenue. Likewise, logistics service providers had a fall of 34.2% in expenses and an impressive revenue growth of 33.6%. Besides, retail sales had cost cuts of 7.8 % with an astonishing increase in sales that stood at 33.3 % (Amr et al., 2019).

Enterprise performance and market value are believed to be enhanced by digital transformation in recent years (Zhao et al., 2022). The research shows that a high level of digital transformation delivers the best results and makes digital technology more practical (Guo and Xu, 2021). In the case of digital transformation in business, informed decision-making can be facilitated through timely product discovery and proper sales forecasting (Gao, 2022). Zhang, via statistical analysis, scrutinized the significance of diverse components involved in the supply chain of food products, and he discovered that with a perspective on the management of supply chains, every link optimized would render an all-around assurance for the entire circulation process of agricultural produce. It is studied and identified that we shall optimize different factors within the supply chain and should ensure that agricultural products move smoothly (Zhang, 2016). Therefore, this perspective emphasized the needs for better traditional methods of transportation in addition to streamlining the entire logistics in order to make more efficient the process of circulating agricultural production (Ma et al., 2019).

This study utilizes the IoT technology to enable the tracing of location and source for new products. Moreover, it improves digitalization in transportation, storage, circulation and processing of food commodities especially regarding temperature and humidity monitoring along the whole supply chain. This holistic framework enhances communication among cold chain logistics various actors. The cold chain logistics management is a process that involves ensuring that the required temperature is maintained during all stages of perishable goods such as fresh farm products, drugs and some chemicals right from production till they are consumed. It is essential to maintain quality, safety and shelf-life of these items from when they are produce until they are consumed (Han et al., 2021). The cold chain can improved through the reduction of information gaps which ultimately improves the efficiency of cold chains. The main goal of this study is to reduce the delivery time for fresh agricultural produce under cold-chain regimes, eliminate cold-chain disruptions and mitigate losses arising from the management of cold supply chain.

The research starts with a review of the current situation about city fresh agri-food supply chain in China, followed by identification of possible impediments and necessities. Section three provides a brief background of our methodology, while section four critically analyses diverse approaches towards cold supply chain management issues. Sections five and six make suggestions on how to handle fresh agricultural produce within the cold chain and then we wind up with the conclusion's final results.

2. Literature review

The aim of this literature review is to explore the current context of urban fresh agricultural supply chains, in order to recognize some key challenges and issues. These problems include absence of distribution standards, high costs for distribution, huge losses from distribution, intricacies and inefficiencies in the supply chain model alongside digital supply chain solutions' demands increase.

2.1. Current status of fresh agriculture supply in cities

Fresh agricultural products refer to meat, poultry, fruits, vegetables, eggs, milk, aquatic products, other fresh primary products, and agricultural sideline products. Fruits and vegetables, meat, and fish are the main categories under which the agriculture products are grouped (W. Wang, 2021). They are perishable since fresh agricultural products have a strong timeliness which makes them not possible to be stored at constant or high temperature for long time (Han et al., 2021). According to a rough estimate the annual loss of Chinese vegetables in the storage process is 25% to 30%, fruit loss of 20% to 25%, the meat deterioration rate of about 10% to 15%, freshwater fish deterioration rate of more than 30%. Every year, the loss in food products due to spoilage across supply chains and logistics results hundreds of billions yuan (Ye and He, 2018).

Cold chain logistics is a system that is used to prevent food from becoming spoiled and the freshness of farm produce preserved in the process from when it was harvested up to consumption. This comprehensive approach involves maintaining a low-temperature preservation environment utilizing refrigeration technology to safeguard the freshness of the products (Huang et al., 2023). Therefore, if the quality of perishable agricultural products is to be guaranteed; then; efficient cold chain logistics operations are significant (Huang and Guo, 2022). In order to meet the rising demand for logistics, China must improve on its logistic technology and that is why the government has increased support towards technologically equipped intelligent logistic while also coming up with various targeted policies (Pan et al., 2020). With the rapid development of digital technology, new technologies such as the Internet of Things (IoT), Big Data (BD), and Block chain have been widely used in fresh agricultural products, and digital technology has become the core driving force that promotes the development of various industries.

Above discussed digital transformation initiatives in fresh produce logistics cold chain management have been effectively implemented by several companies. Walmart has resorted to use of block chain technology, through which Walmart enhances traceability and transparency. It has enabled the Walmart efficient to recalls the product when quality issues arise (Lacity et al., 2021). As Maersk utilizes IoT sensors fitted on its refrigerated containers, it is able to observe the conditions experienced during transit hence ensuring optimum freshness and quality. For faster last-mile delivery, Amazon invests in drone technology to reduce transit times and spoilage risks. Through data analytics and predictive modeling, Dole maximizes supply chain operations so as to anticipate disruptions and ensure timely delivery. Meanwhile, Del Monte makes use of RFID technology that helps track product movements thereby reducing shrinkage while improving visibility (Street et al., 2009). Examples like these exhibit how digital technologies can improve operational efficiency and sustainability in fresh produce logistics.

2.2. The main problems or hinder in agriculture supply chain

Numerous challenges exist in the fresh agricultural products supply chain management which demands urgent solution. These challenges hinder the seamless flow of products and impact overall supply chain efficiency and profitability. Normally, traditional cold chain logistics systems are not technologically developed enough to guarantee the quality and integrity of perishable goods in their passage from producer to consumer. This leads to an ongoing problem such as spoilage, temperature fluctuations and lack of monitoring which results in huge monetary losses and food safety jeopardy. It is important to look for potential ways such as digital transformation that would use relevant aspects of IoT technologies to make fresh product delivery more effective and transparent and sustainable.

The term digital transformation refers to the incorporation of digital systems and new ideas aimed at making cold chain management operational processes more streamlined, open and enhance their capability (Watanabe, and Shafiq 2023). It includes using tools such as IoT, analytics, AI, block chain, and cloud computing to streamline the storage, freight and distribution of perishable products while ensuring that regulations are adhered to and consumers' expectations are met (Qu et al., 2021). Therefore, some of the major problems of agriculture products are described below.

2.2.1. Lack of distribution standards

China's present development is substantially challenged by the lack of a unified standard system across its upper, middle and lower reaches of fresh agricultural product distribution. (Ping Hua et al., 2018). There is no distribution network which has a standard system in place to hinder logistics and effect the efficiency of cold chain logistics for fresh agriculture products(Ye and He, 2018). Moreover, the diverse rules concerning machinery and tools, temperature regulation as well as standards upheld in various links also lead to low percentages of fresh produce enjoying refrigerated cold chains throughout their supply chain and movement (Ye and He, 2018). This problem can be fixed through the technological transmortation and usage of digital cold chain techniques.

2.2.2. High distribution costs

Cold chain logistics dependence in fresh distribution necessitates substantial initial infrastructure investments that make up for the generally high costs of fresh agricultural products (Shui and Li, 2020). The intricacy of distribution process escalates these expenses thereby emphasizing the need to deal with this issue towards a cheaper and environmentally friendly supply chain (Shui and Li, 2020). So, it is imperative to control the distribution cost through technological transformation.

2.2.3. Serious distribution loss

The perishable nature of fresh products calls for strict adherence to timeliness all throughout the supply chain. Nevertheless, China's cold chain logistics equipment faces difficulties being left behind by developed countries that lead to high rates of distribution loss as a result of spoilage in the circulation process (Wang and Bi, 2022). It is important to fix these technological and infrastructural deficiencies in order to decrease large yearly losses of fresh agricultural produce (Ye and He, 2018).

2.2.4. Complexity and inefficiency in the supply chain model

The current supply chain model has many links in the circulation of agricultural products, causing a weak relationship between them and increasing levels of uncertainty and risk which is also a one of the major hinder agriculture supply chain (Zhou, 2023). Many elements engaged in the movement of farming goods lead to price fluctuations during this process due to the lack of transparency in information because of various interests which harm the rights of farmers (Gu and Yu, 2022; Shen et al., 2022; Imran et al., 2021)). Tardy supply network restricted farmer's ability to control transactions, resulting into unstable prices, thus hampering efficiency and market competitiveness within agricultural products supply chain (Wang et al., 2022; Zhao et al., 2021; Watanabe et al., 2024). Traditional fresh agricultural supply chain is shown in **Figure 1**.

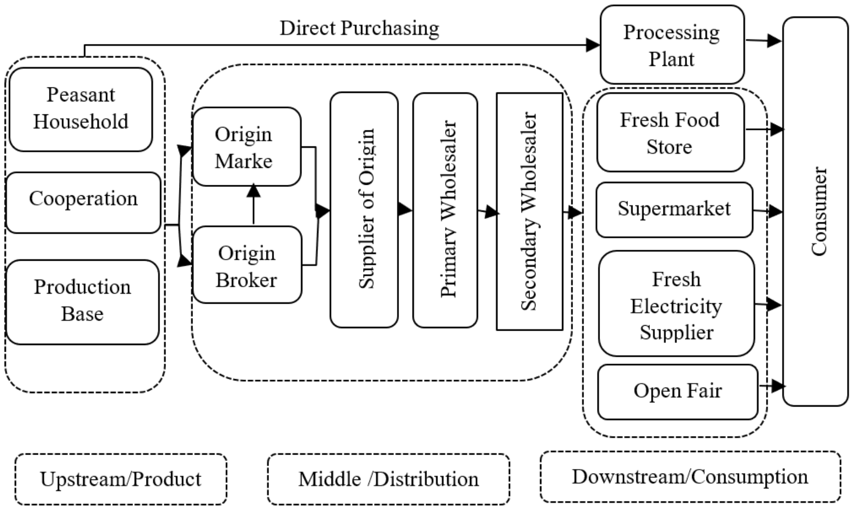

Figure 1. Traditional fresh agricultural supply chain. (Zhang and Yin, 2023).

2.3. Requirements for digital supply chain

The increasing trends of digital technology have been demanded high standards on fresh farm products supply chain management. Some of the basic requirements are mentioned below:

(1) Strong information processing ability: It is the imperative to establish a strong information processing ability in your supply chain because its affects the overall timeliness of fresh agricultural products' distribution network (Wang, 2019). The distribution path is not fully optimized because of the lack of real-time information support in the distribution link. The distribution capacity is not effectively utilized, resulting in low distribution efficiency, which increases the distribution cost to a certain extent and affects consumers' satisfaction with the distribution logistics (Tian et al., 2021). A conceptual model established to promote the strong information processing ability is presented below in **Figure 2**.

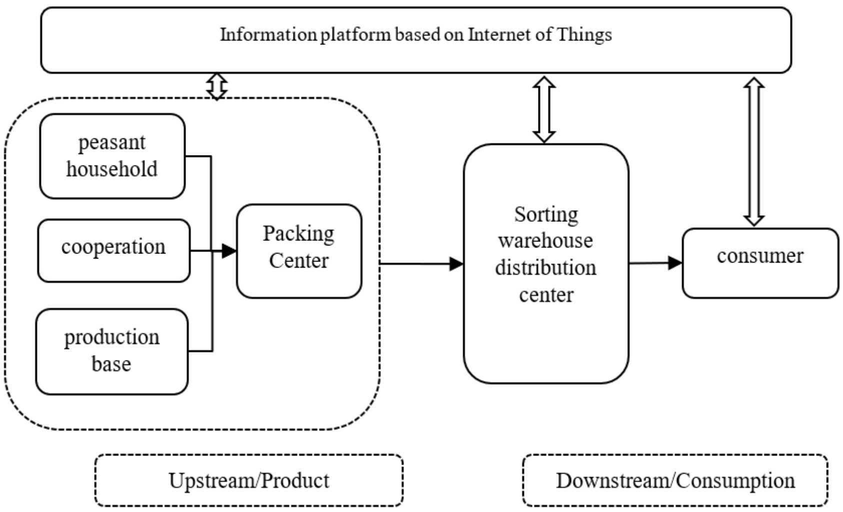

Figure 2. Intelligent fresh agricultural supply chain.

(2) Advanced Cost Control Techniques: It is also necessary to use the advance and accurate cost control techniques because the cold chain accurse a substantial

operational costs. The major junk of cold chain or fresh agricultural products operational costs is refrigeration, cold freezing, packaging, storage and distribution (L. Zhao et al., 2022). Therefore, while providing consumers with satisfactory distribution efficiency, agricultural fresh products supplying enterprises are required to control the early input cost and later operational cost of their fresh agricultural products distribution system to ensure the state of sustainable expansion (Y. Wang, 2021).

(3) Better and advance transport capacity: allocation system for traditional fresh agricultural product distribution, most of which are similar to ordinary distribution (Fu and Yang, 2024). To achieve an agile distribution network for fresh agricultural products in the new normal, it is imperative to resolve the fluctuating transport capacity requirement (Chen et al., 2022).

The Chinese government has already established a national policy direction, which is committed to making all governments at all levels make efforts towards introducing intelligent logistics systems that would promote the delivery of fresh agricultural products and satisfy residents’ daily life needs. This study also looks at possible remedies and ways of constructing a digital supply chain management from the perspective of digital transformation in order to guarantee the supply of fresh agricultural products to urban areas. The purpose is to ensure availability of fresh agri-products from farm to end users within 24 hours and troubleshooting the hinders if any. With this technology, it could be possible for the whole process to be controlled, seen by everyone involved as it happens, and then traced back after accidents for their subsistence needs during daily routine or emergencies. **Figure 2** demonstrates a proposed model for an intelligent fresh agricultural supply chain.

3. Methodology

This study utilizes comparative analysis to look into the key issues of traditional fresh agricultural products’ supply chain and analyzes the developmental stages of China’s fresh food supply chain industry (Della Porta, 2008; Duan et al., 2020). Adopting a descriptive method of analysis, this paper explains how digital technology can be used to integrate all dimensions of the digital traditional raw material sourcing chain that would solve problems like low efficiency, low standardization and the traditional management system of raw materials sourcing chain and hence digitize every aspect of the industry (Attaran, 2020; Holmström and Partanen, 2014; Liu and Ma, 2022; Zook and Pearce, 2018). It includes intelligent refrigerator design based on IoT technology, highly automated packaging centers and sorting centers workflow and at its core is the information sharing platform strategy under government control (Mondejar et al., 2021).

The term “intelligent crisper” normally refers to a fridge or storage unit which utilizes advanced technologies such as sensors, automation and IoT connectivity. It enables the crisper to monitor and control aspects like temperature, humidity and air quality in order to maintain optimal conditions for preserving freshness of perishable items including fruits, vegetables and other farm products.

4. Results and analysis

In this part, the internet and digital strategies that should be followed to promote urban fresh agricultural chain management are given. In this study, we have tried to strengthen and improve the cold chain logistics system for fresh agricultural products. Additionally, it has been aimed at constructing a new model of intelligent cold chain logistics of urban fresh agricultural products in the framework of optimization-based model structure analysis. The present model is used by researcher to construct public information platform for smart cold chain logistics in urban environment focusing on the supply of farm produce. For instance, using advanced technology in sorting center for fresh produce can enhance the cold chain logistics system. By incorporating warehouse robots, temperature sensors, GPS, IoT, and blockchain, an intelligent model is created for urban fresh agricultural products. This digital system monitors and controls the material flow, improving transportation and storage efficiency. Automation and real-time data insights make the cold chain logistics more robust, minimizing waste and ensuring the quality of agricultural products from farm to consumer. All above are imperative to boost the efficient cold chain management and it can be attained through intelligent cold chain distribution which illustrated in below section.

4.1. Intiligent cold chain, distribution map

Using a medium-sized city as a reference, we established small packaging centers in suburban farms for the pre-cooling packaging of fresh agricultural products. Around the city, strategically position sorting, storage, and distribution centers are proposed, as illustrated in **Figure 3**. These centers can handle fresh agricultural products from the packaging center and efficiently deliver them to consumers through organized sorting, storage, and distribution processes facilitated by well-planned locations and routes. Delivery times are carefully managed, typically within a day, ensuring afternoon delivery for products harvested in the morning and morning delivery for those produced in the afternoon. This approach not only ensures that agricultural products are fresh but also reduces the duration and scale of storage, which increases consumer satisfaction and enhances efficiency in cold chain logistics of fresh agricultural products. The map of smart cold chain logistics distribution is shown in **Figure 3**.

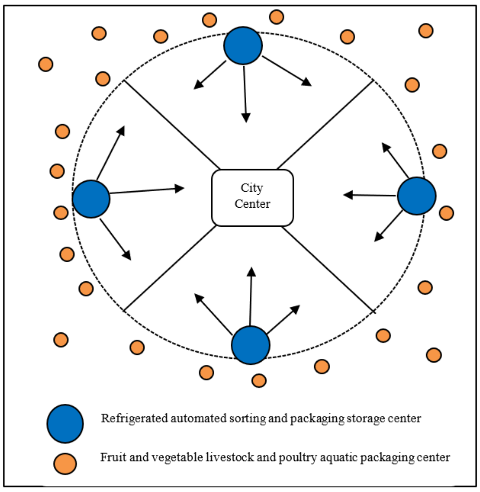

Figure 3. Intelligent cold chain logistics distribution map.

4.2. Intelligent crisper

The intelligent crisper is first a storage box made of transparent and environmentally friendly materials equipped with an intelligent controller based on Internet of Things communication (Zhang et al., 2022). Intelligent crisper is able to sense, monitor record and follow up environmental changes that occur during preservation and transportation of fresh agricultural produce. It further shows the quality and safety in storage and transportation of these fresh agricultural products. On the other hand, this intelligent crisper can give quality and safety information about fresh agricultural products to producers, sellers, and consumers unlike traditional packaging that is crucial in terms of food safety or nutrient content. **Figure 4** below illustrates a block diagram for controller structure as one technology used in smart crispers.

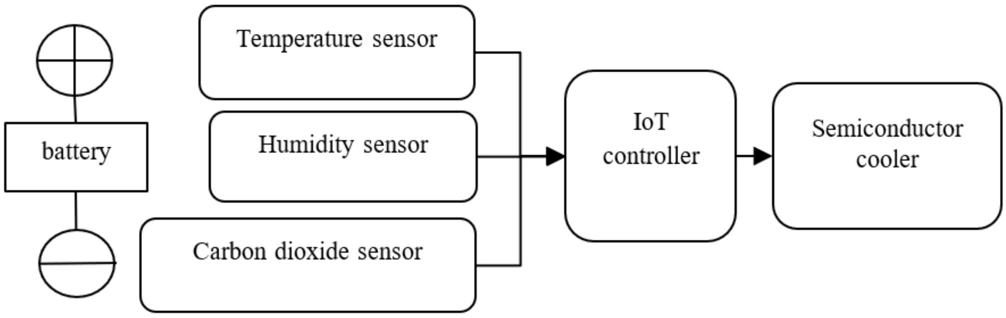

Figure 4. Intelligent crisper control circuit block diagram (Qin, 2018).

4.2.1. Radio frequency identification

Radio Frequency Identification (RFI) is a system which automatically performs the identification. In this system a communication based on radio frequency identification tags is used as intelligent crisper (Baballe and Nababa, 2021). Radio Frequency Identification tags are mainly used to report the whole process of live animals, such as cattle and pigs, from birth to slaughter and storage (Bai et al., 2017). This study is mainly proposed the use of intelligent crisper identification and supply chain management to achieve the purpose of intelligent crisper quality supervision and random inspection.

4.2.2. Sensors

Sensors are devices that sense the information of the measured object through sensitive elements and convert the information into usable signals (such as electrical signals) using conversion elements(Chortos et al., 2016). This study mainly focuses the useage of temperature and humidity sensors and gas fitted based sensors which measures the temperature, humidity, and gas inside the intelligent crisper.

4.2.3. Zigbee technology

The Zigbee is also a low-power consumption intelligent crisper which has local area network protocol developed according to IEEE802.15.4 standards and it is close-range wireless data transmission network communication technology which is highly reliable (Nath et al., 2017). ZigBee can be used in process control and remote control systems that have been incorporated into various gadgets (Qin, 2018). It is therefore important that this research recommends the use of ZigBee technology as an IoT application in digitizing the fresh agricultural supply chain.

4.2.4 Semiconductor cooler

Semiconductor cooler technology is also one of the intelligent crisper which is based on the Peltier effect, which is a new refrigeration method. Its advantages include being easy to operate, low volume, zero pollution, etc. Semiconductor refrigeration technology can be used for food refrigeration. The cooling effect of semiconductor refrigeration technology is good but also energy conservative, which can greatly reduce energy consumption (Pambudi et al., 2022). This study proposes the use a semiconductor cooler as a temporary cooling device for the intelligent crisper, which can be started in transit or other emergency situations.

The intelligent crisper features a backup battery charging system and an intelligent lock function, enabling automated monitoring and refrigeration. It serves as a cornerstone in the digital strategy of the urban fresh agricultural products supply chain. Once fresh agricultural products are placed into the intelligent crisper, they seamlessly enter the cold chain system, facilitating comprehensive cold chain transportation, monitoring, and traceability.

4.3. Analysis of existing system and proposed model for the digital supply chain

To design a cold chain logistics system for fresh agricultural products that can be automated, efficient and convenient as well as observable, the key elements that characterize the smart crisper cold chain for fresh food are analyzed. Fresh produce has a short shelf life and is highly time sensitive hence in packaging, storage, transportation and other aspects of cold chain logistics through the use of digital technology to ensure entire process of fresh produce preservation environment that maintains high efficiency at low cost in freshness of these commodities while guaranteeing product quality (Chen and Zhang, 2020). **Figure 5** presents Chen and Zhang's (2020) model of a digitalized supply chain for fresh produce.

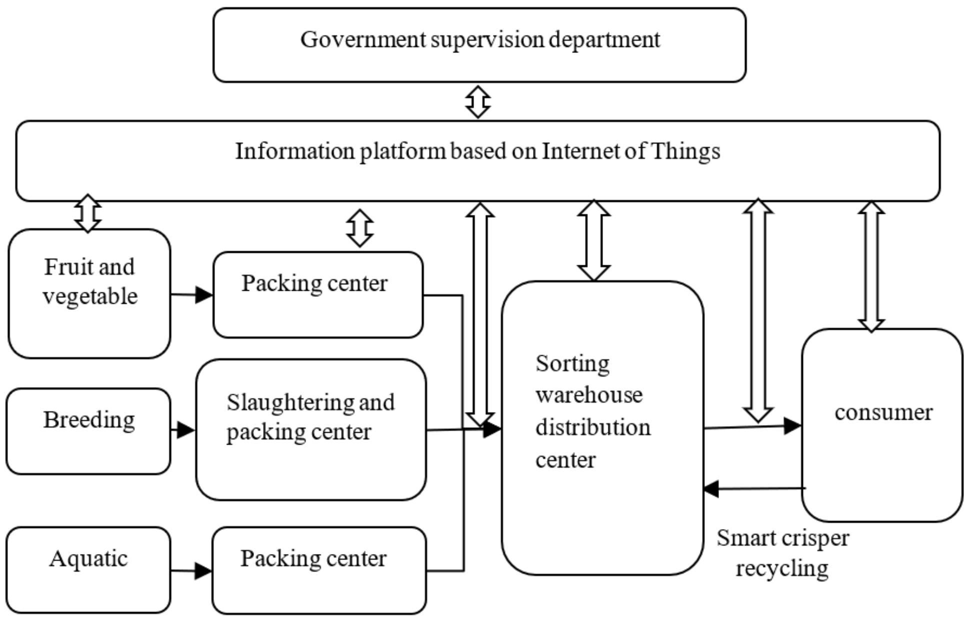

Figure 5. Digital fresh produce supply chain (Chen and Zhang, 2020).

4.3.1. Fresh agricultural products production base

Fresh agricultural products production sites are mostly located in rural and urban suburbs. The fresh agricultural productions in urban suburbs and nearby rural areas make the city's main supply base. Packaging centers are mainly built near these bases, as far as possible, to shorten the distance between the base and the packaging center and ensure that fresh agricultural products enter the cold chain as soon as possible. At the same time, keep the traceability of production base and cold chain supply traceability consistent (Curto and Gaspar, 2021).

4.3.2. Packaging center

The packaging center of fresh agricultural products based on the Internet of Things technology mainly includes picking (slaughtering), sorting, packaging, pre-cooling, loading, and other links. The process is completed primarily by the automatic control system, which collects various information about fresh agricultural products, including origin, product, packaging, employee, and loading information (Chen et al., 2020). Upload all the collected data to the information system of the production enterprise and then upload it to the information platform for subsequent product information query (Zhang et al., 2022). Information can be transmitted in real time, and the entire process can be monitored in real time. The Packaging center workflow is examined and with adaptation of Chen et al. (2020), we have proposed the packaging center workflow as shown in **Figure 6**.

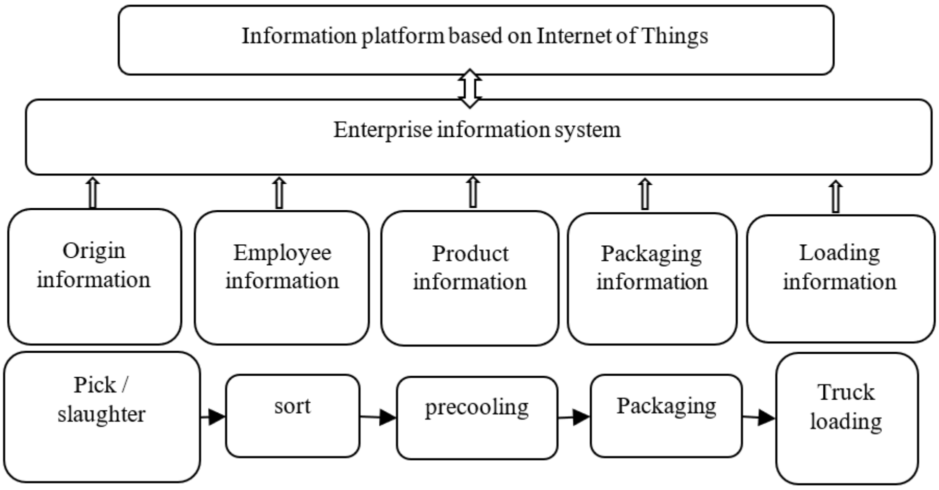

Figure 6. Packaging center workflow (Chen et al., 2020).

4.3.3 Transportation

To keep the products fresh the role of transportation is crucial. We have analyzed the existing transportation system and proposed the intelligent system as explained below. To maintain a complete cold chain during transportation, the intelligent refrigerated trucks can be utilized. Each refrigerated truck shall installed with the Internet of Things data acquisition equipment, positioning system, communication equipment. For example to accurately collect the information of the intelligent fresh-keeping machine and vehicle driving information in the refrigerator and feedback on the temperature and humidity in the refrigerator to the information center through communication technology to monitor the environment inside the refrigerator truck in real time (Gillespie et al., 2023; Li, 2021). The transport vehicle will deliver the recovered intelligent crisper at the time of recycling to enable reuse, reduce costs, and protect the environment.

4.3.4 Sorting warehouse distribution center

The sorting and assembly center at the warehouses and distribution centers also required the automation such as shall equipped with automatic loading and unloading and automatic sorting and repackaging capabilities according to the order. Shall operates seamlessly throughout the process with low-temperature operation and storage functionality. Its primary function is to re-sort products received from fresh produce packaging centers and repackage and distribute them to consumers based on individual customer orders. (Dong, 2022; Joubert, 2019). The sorting and assembly center uploads product information to the platform for easy management and traceability. It also integrates the intelligent crisper's cleaning, disinfection, and charging functions, promoting its reuse. After the analysis of existing sorting assembly centers we have adapted and presented the sorting and assembly center function as shown in **Figure 7**.

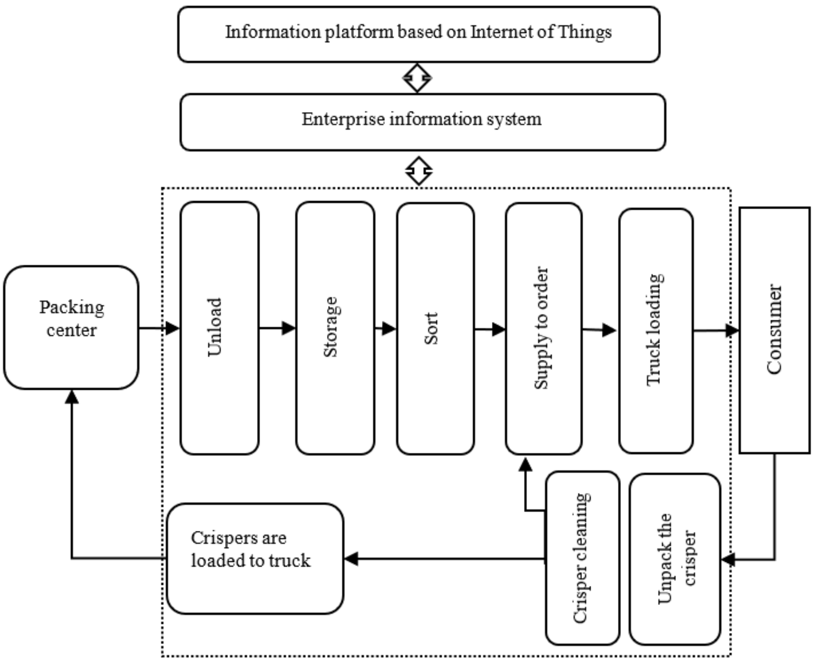

Figure 7. The function of the sorting and assembly center (Dong, 2022).

4.3.5. Cold chain distribution

The distribution of the products is also one of the crucial aspect and shall use the intelligent refrigerated trucks in the distribution process, and the operation of the refrigerated trucks can be monitored in real time throughout the process to ensure the quality of fresh agricultural products in the distribution process as explained in the transportation section (Han et al., 2021). To ensure the convenience of the consumers to receive goods on time, some of the emergency storage stations should be established in the community level which shall be integrated with the intelligent crisper and the distributor shall be capable enough to wait for consumers to receive goods independently. The delivery vehicle can also be used as for the reverse logistics and may deliver the recycled intelligent crisper on its return to enable reuse, reduce costs, and protect the environment.

4.3.6. Consumers

Consumers are the final service objects of fresh agricultural products cold chain logistics, including individual families, restaurants, and canteens (Cheng, 2021). Through online traceability, consumers can understand the fresh produce they want to buy and may place orders online. Traceable consumption patterns, online shopping, and home delivery are also more acceptable to consumers perspectives (Zhang et al., 2020).

5. Recommendations

Based on the above discussion, explorations, comparisons and analysis of the existing cold chain management models and elements we have proposed the below mentiond cold chain stratigies for the Chaina Agriculture products freshness and immediate delivery to save the detoriation of products.

5.1. Establishing the public information center's

The establishment of platforms for public information is a vital element in the cold chain logistics to supply the fresh agricultural products. The platform should consist various government departments, leading cold chain logistic companies, fresh agricultural produce growers and consumers among other stakeholders tasked with building the kind of public information network that the author envisions (Bhat et al., 2021). Its functions would be based on the IoT to achieve agricultural products data collection, information traceability, information sharing, and more.

Government should construct and operate the information platform, with leading enterprises in cold chain logistics takes the lead, employ internet of things to monitor fresh agricultural products from start to finish and use big data platforms for sharing (Yan et al., 2016). Using big data analytics such as cloud computing assists farmers in strategic planting planning, this recommendation is also supported by (Tseng et al., 2019). Use of the IoT for information sharing will enables tracking the quality of agricultural products consumers purchase and facilitates a seamless information query process from the field to the retail terminal, this recommendation is also supported by (Chen et al., 2021; Zhu et al., 2021). The sharing of information in this center will serve to greatly improve consumer demand for agricultural products boldly, it will make the cold chain of fresh agricultural products that is both integral and controllable, maximize the efficiency of operations in cold logistics chains and shall save on costs.

5.2. Development of cold chain infrastructure

The direct effect of cold chain logistics infrastructure development is Cold Chain Logistics Industry's transformation and growth, which has a great importance in terms of government departments' supervision and management over it. It is supported by this suggestion (Bai et al., 2023). It is also recommended that government departments shall increase investment in cold chain logistics infrastructure development in various regions, such as the development of 5G networks, big data centers, intelligent equipment, etc. The development of the extensive use of technologies such as cloud computing, big data, internet of things and artificial intelligence in the cold chain logistics industry will help in transforming and modernizing the traditional cold chain logistics. We based our recommendation on research findings (Ren et al., 2022; Watanabe et al., 2024). The government shall provide a strong guarantee secure investment environment for the development of the intelligent cold chain logistics industry. At the same time, government departments should give more preferential policies, vigorously develop and support leading cold chain logistics enterprises, and drive the development of other cold chain logistics enterprises.

5.3. Ensure the source and traceability

The key actors in the agriculture supply chain are the farmers, processing enterprises, logistics companies, consumers, and government regulatory authorities, so traceability system of the supply chain of agricultural products shall inplaced to the every step, as this recommendation is supported by (Wu and Wang, 2024). A detailed description of each agriculture supply chain actor and the proposed recommendations are given below:

Farmers: Farmers are the initial supply chain actor in the fresh production supply chain they shall use the intelligent transaction contracts. The farmers generate substantial crop volumes, overseeing growth details and managing diverse agricultural activities. The product information shall deemed necessary to be verified and confirmed by farmers, it is crucial for the traceability prior to selling the crops to processing companies, this recommendation is supported by the study of (Javaid et al., 2022; Wang et al., 2021).

Processing enterprises: Processing enterprises play a key role in disinfecting, cleaning, selecting, preserving, waxing, grading, and packaging crops, transforming them into final products. So it is strongly recommended that the processing enterprises shall meticulously record these processes, aggregate the information through digital labels, and subsequently distribute the finished products to distributors (Peters, 2019).

Logistics companies: Logistics companies primarily handle the cold chain logistics of fresh agricultural products as explained in the study of (Wang et al., 2020). It is recommended that utilizing sensors for temperature, humidity, pressure, and GPS systems, we shall record transportation details, time, location, and shipper/consignee information for fresh agricultural products, uploading environmental conditions and driving trajectories, this recommendation is supported by the study of (Y. Zhang et al., 2022).

Distributors: Distributors are mainly divided into two sections first is the whole sale distributors and the second is the retailers. Both are responsible for purchasing finished products from processing enterprises and selling them to consumers (Firouz et al., 2021). When and as the distributors purchase finished products from processing companies and store them in warehouses, shall utilize the sensors and other equipment to monitor storage conditions, time, and basic physiological indicators of fresh produce. Subsequently, they are responsible for distributing these products to consumers with transparent traceability, this recommendation is supported by the study of (Yen and Yang, 2018).

Consumers: Consumers are the end users of agriculture products. It is also an imperative that the consumers shall be able enough to verify the credibility of the quality and safety of fresh agricultural products through the traceability system before purchasing the goods, they may use the bar code scan the information from the central public information center shall be accessible for the consumer, this recommendation is supported by the study of (Prashar et al., 2020).

Government supervision department: To ensure the source and traceability of the product the role of the government department is crucial. As an off-chain entity, the role of the government is primarily to oversees and manages the entire network, handling disputes and supervising the complete process of agricultural product supply chain. This helps in the establishment of quality standards and responsibilities for things like transaction disputes and product fraud which is concerned with fake data, which is supported by (Han et al., 2021).

In conclusion for the traceability and record of the origin and source shall use the centralize information platform and shall keep the all data of fresh agricultural products supply chain from the farmers, processing enterprises, logistics companies, and distributors to the consumers, these recommendations are supported with the studies of (Lezoche et al., 2020;Teng, 2021).

5.4. Implementation of intelligent and smart supply chain

The application of a smart supply chain in the agriculture products industry is recommended strongly to attain the more productive efficiency and effectiveness in the supply chain system and to reduce the detoriation cost, as recommended by (Chen et al., 2019; Kong, 2023). The government should establish a nationwide policy for the intelligent supply chain implications and shall strengthen the policy guidance of smart logistics construction and to present clear goals of smart supply chains of fresh agricultural products, our this recommendation is also supported by the (Liu et al., 2022). As we recommended above there is a huge potential of smart logistics which shall built on the key technologies and shall be capable for the provision of information to the public or users of the products (Song et al., 2020). Through these innovative measures, the fresh agricultural products circulation efficiency will gradually increase; expenses and losses will go down as well as supply chain service innovation capacity and customer experience improving (Zhu and Yin, 2020), an intelligent supply chain model which we adapted from the study of Zhu and Yin (2020) is shown below in **Figure 8**.

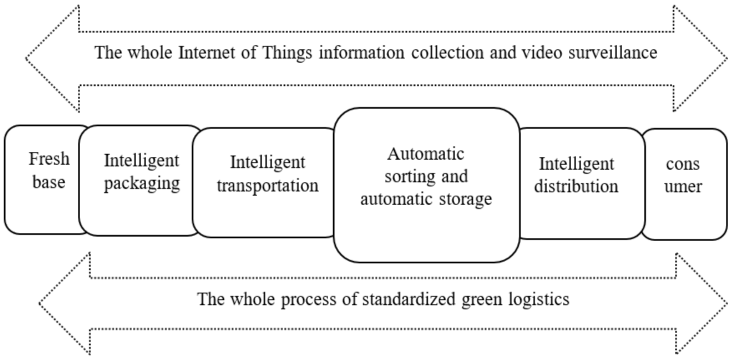

Figure 8. Intelligent supply chain (Zhu and Yin, 2020).

5.4.1. Intelligent packaging

Intelligent packaging is also one of the crucial aspect for the cold supply chain, this strategy can also improves the products shelf life and it will be helpful to maintain the freshness. The intelligent packaging relies on the operation of an automated pre-cooled packaging production line. It is recommended to create the automat inputs which shall helpful to detects crucial information such as size, volume, nature, and quality of the items to be packaged. (Berger et al., 2023). Choose the correct intelligent packaging box from the source “one thing one code” packaging traceable input from the source to achieve the whole process of fresh agricultural products positioning, tracking, control, and traceability information management, this strategy is also supported by the study of (Mao and Zhang, 2023).

5.4.2. Intelligent transportation strategy

It is advisable that the smart transport majorly be employed shown in the mode of real-time monitoring of cold-chain transport vehicle management. This covers real-time sense, monitor and regulate for fresh agricultural product temperature and humidity, as well as continuous monitoring of vehicle driving quality during the transportation process (Tang, 2020). Transport intelligence also offers vehicle-driving path optimization and other services.

5.4.3. Automatic sorting and automatic storage strategy

It is recommended that the enterprises shall use the automatic sorting and automatic storage centers which shall be highly integrated with comprehensive systems. This integration would be the application of the IoT, automation equipment, AI, and so on, a series of using intelligent processes such as warehousing, sorting, storage, and assembly are realized in the automated process, as suggested by (Khan et al., 2022). To promote the transformation and development of traditional static storage to dynamic storage. Automatic sorting and automatic storage centers monitor shall regulate the temperature and humidity of fresh products in real time (Van Geest et al., 2021). To realize order time planning, task time and space optimization matching, dynamic path planning, shelf update optimization adjustment, and other functions shall also be performed through the automated system.

5.4.4. Intelligent distribution strategy

The intelligent distribution link significantly impacts the intelligent cold chain of agricultural products. It is recommend to be sued in the automatic sorting and automatic storage center, and the delivery vehicles shall be arranged uniformly for orders with the same delivery address. The orders with the same delivery period can be automatically plan the delivery path to avoid crowded areas and areas with heavy traffic flow (Kuru et al., 2019). If the consumer cannot receive the goods directly, place them in the self-picking cold storage room and inform the consumer on time. Intelligent distribution also includes the application of intelligent equipment, such as drones and unmanned vehicles, within the distribution link (Mohsan et al., 2023).

5.4.5. Intelligent handling strategy

Intelligent loading and unloading are predominantly evident in the automated management of vehicles within packaging and storage centers, extending across all facets of the fresh agricultural products supply chain. Leveraging technologies such as the Internet of Things and Artificial Intelligence, real-time analysis is conducted throughout the entire process of cold chain transport vehicles entering and leaving the facilities (Goodarzian et al., 2023). This process consists on real-time guidance of cold chain transport vehicles during loading and unloading operations. It includes activities like scheduling, timing and optimising utilization. Besides, it examines the available space for cargo and also the actual unloading rates that enable efficiency and maximization of loading and unloading capacities (Cui, 2021).

5.5. To promote the green supply chain

The main components of the green supply chain strategy has been include green procurement, manufacturing, distribution, and recycling (Sahar et al., 2020; Tashfeen et al., 2023)). Also, a green supply chain strategy usually includes transparent information flow and cooperative relationships that allow different participants of the supply chain to collaborate in order to attain common environmental objectives (Gao, 2024; Nazeer et al., 2024). This research involves an electronic metamorphosis of the classical natural produce supply chain and strongly advocates for green supply chain strategy (Nazeer et al., 2020; Shafiq et al., 2023). Such technological transformation is possible with the implementation of recyclable intelligent crispers.

6. Discussion

The practical implications of this study with respect to digital transformation of cold chain management is necessary and significant. Using the IoT technologies can enable stakeholders to improve cold chain management efficiency, reduce the supply chain wastes and enhance food safety. Real-time monitoring devices with IoT sensors allow the capture of temperature, humidity and other critical parameters during transportation and storage so as to keep perishable goods within optimal conditions from the beginning till end of the whole cold chain. It guarantees that no spoilage or downgrading in quality takes place while at the same time maintaining freshness as well as extending product shelf life such a situation would result into less wastage hence higher profits for farmers, distributors and retailers. Also, this enables people to know more about their own product purchases in terms of traceability and transparency.

This study presents some understanding from our research on the intersection of agriculture industry and technology with a focus on how the IOT can modernize traditional methods for managing cool chains. Such an approach allows researchers to understand how, for instance, digital technologies could address age-long problems like perishability, transport inefficiencies and quality control, etc through examining IoT applications in fresh agricultural produce. Secondly, it illustrates how digital transformation initiatives are customized to specific industrial contexts notably in agribusiness thus differing from previous supply chain management literature which is criticized by this paper for its focus. Therefore, empirical research findings combined with theoretical analysis enrich scholars' knowledge about impacts of IoT adoption in cold chain logistics thereby providing possible areas for future investigation informed by relevant policy interventions towards sustainable farming systems that also have resilience.

7. Conclusion

This paper has thus summarized the main findings of a study on IoT-based strategies for digitizing cold chain logistics for fresh food. This can be achieved by using smart systems and data-oriented approaches to improve preservation, delivery and quality aspects of fresh farm produce. Consequently, some stakeholders may propose to increase efficiency in operations through using IOT based solutions such as smart crisper drawers, packaging stations that are automated and information sharing platforms in reducing waste and protecting perishable goods along the supply chain. Henceforth, it is important for the players in the agriculture sector to embrace strategies for digital transformation that will facilitate taking into account changes in consumer preferences towards more sustainable farming methods that will help meet future demand of healthy food and reduce environmental impact resulting from agriculture. Following the conclusions of this research, a number of important approaches can be identified for the application of Internet of Things (IoT) technology in cold chain logistics of fresh agricultural produce:

7.1. Implementation of smart crispers/coolers

The use of IoT sensors and automation technologies to refrigerators enables real-time monitoring and control over temperature and humidity levels. This ensures that perishable goods are stored under optimal conditions to prevent spoilage and maintain product quality.

7.2. Adoption of automated packaging and sorting centers

Employing IoT devices in machines will simplify the packaging and sorting process. For example, it is possible to accelerate automation thereby reducing remuneration payments and mistakes made by employees.

7.3. Development of information—Sharing platforms

To attain the efficient cold chain management it is necessary to have the centralized platforms where producers, supplies, distributors and retailers shall be able to share information. This will make it possible to share real-time information on stock quantities, shipping schedules, and even quality control initiatives, promoting transparency across all supply chains.

7.4. Integration with predictive analytics

However, it is important to note that in order to achieve efficient resource allocation techniques, companies should study the microscopic fluctuations in temperature along the entire supply chain, this would help them in predicting any possible challenges and putting precautionary measures before any risks occur.

7.5. Compliance with regulatory standards

The most essential thing is conforming to food safety and quality regulations. If there are noncompliance issues, the IOT devices can monitor and document continuous compliance parameters for regulatory compliance as per these sectors' rules leading to customer satisfaction and trust from customers as well as regulators.

Taking such steps will enable firms exploit internet-of-things technology benefits in increasing efficiency, opening up supply chains, cold chains of fresh agricultural produce. The only successfully approach addressing changing problems of agro-supply chain today or tomorrow lies on embracing digital transformation.

Conflict of interest: The authors declare no conflict of interest.

References

Ahmad, M. B., & Nababa, F. A. (2021). A comparative study on radio frequency identification system and its various applications. International Journal of Advances in Applied Sciences, 10(4), 392. https://doi.org/10.11591/ijaas.v10.i4.pp392-398

Amr, M., Ezzat, M., & Kassem, S. (2019). Logistics 4.0: Definition and Historical Background. 2019 Novel Intelligent and Leading Emerging Sciences Conference (NILES). https://doi.org/10.1109/niles.2019.8909314

Attaran, M. (2020). Digital technology enablers and their implications for supply chain management. Supply Chain Forum: An International Journal, 21(3), 158–172. https://doi.org/10.1080/16258312.2020.1751568

Bai, H., Zhou, G., Hu, Y., et al. (2017). Traceability technologies for farm animals and their products in China. Food Control, 79, 35–43. https://doi.org/10.1016/j.foodcont.2017.02.040

Bai, Y., Wu, H., Huang, M., et al. (2023). How to build a cold chain supply chain system for fresh agricultural products through blockchain technology—A study of tripartite evolutionary game theory based on prospect theory. PLOS ONE, 18(11), e0294520. https://doi.org/10.1371/journal.pone.0294520

Berger, L. M., Witte, F., Tomasevic, I., et al. (2023). A review on the relation between grinding process and quality of ground meat. Meat Science, 205, 109320. https://doi.org/10.1016/j.meatsci.2023.109320

Bhat, S. A., Huang, N.-F., Sofi, I. B., et al. (2021). Agriculture-Food Supply Chain Management Based on Blockchain and IoT: A Narrative on Enterprise Blockchain Interoperability. Agriculture, 12(1), 40. https://doi.org/10.3390/agriculture12010040

Chen, J., Huang, Y., Xia, P., et al. (2018). Design and implementation of real-time traceability monitoring system for agricultural products supply chain under Internet of Things architecture. Concurrency and Computation: Practice and Experience, 31(10). Portico. https://doi.org/10.1002/cpe.4766

Chen, M., Chen, C., & Tao, A. (2020). Research on the application of Internet of Things technology in cold chain logistics of fresh agricultural products. Value engineering, 39(20), 129-132. https://doi.org/10.14018/j.cnki.cn13-1085/n.2020.20.056

Chen, T., He, Y., & Lu, J. (2022). Research on the economic development of fresh fruit products under the background of new countryside. Shanxi agricultural economy, 6, 75–77, 121. https://doi.org/10.16675/j.cnki.cn14-1065/f.2022.06.023

Chen, X., Chen, R., & Yang, C. (2021). Research and design of fresh agricultural product distribution service model and framework using IoT technology. Journal of Ambient Intelligence and Humanized Computing. https://doi.org/10.1007/s12652-021-03447-8

Chen Y., Chen CB, T, An. (2020). Research on the application of Internet of Things technology in cold chain logistics of fresh agricultural products. Value engineering, 39(20), 129–132. https://doi.org/10.14018/j.cnki.cn13-1085/n.2020.20.056

Chen, Y., & Zhang, B. (2020). Research on cold chain logistics application of fresh agricultural products based on Internet of Things technology. Logistics engineering and management, 42(7), 94–96.

Cheng, K. (2021). Transformation and upgrading of aquatic products cold chain logistics from the perspective of new and traditional kinetic energy conversion. Journal of Physics: Conference Series, 1972(1), 012076. https://doi.org/10.1088/1742-6596/1972/1/012076

Chortos, A., Liu, J., & Bao, Z. (2016). Pursuing prosthetic electronic skin. Nature Materials, 15(9), 937–950. https://doi.org/10.1038/nmat4671

Cui, H. (2021). Intelligent Coordination Distribution of the Whole Supply Chain Based on the Internet of Things. Complexity, 2021, 1–12. https://doi.org/10.1155/2021/5555264

Curto, J. P., & Gaspar, P. D. (2021). Traceability in food supply chains: Review and SME focused analysis-Part 1. AIMS Agriculture and Food, 6(2), 679–707. https://doi.org/10.3934/agrfood.2021041

Dar IB, Khan MB, Shafiq M, Ali M, (2021). Marketing Analytics Capability and ERP Systems Implementation: Theoretical Framework and Case Stud. Journal of Contemporary Issues in Business and Government, 27, 1.

Dong, M. (2022). Research on optimization of intelligent operation mode of fresh agricultural products supply chain platform [Master's thesis]. Hunan University of Technology.

Duan, J., Zhang, C., Gong, Y., et al. (2020). A Content-Analysis Based Literature Review in Blockchain Adoption within Food Supply Chain. International Journal of Environmental Research and Public Health, 17(5), 1784. https://doi.org/10.3390/ijerph17051784

E-Commerce Supply Chain of Fresh Agricultural Products under the Background of New Retail. (2023). Manufacturing and Service Operations Management, 4(4). https://doi.org/10.23977/msom.2023.040409

French, A., Shim, J. P., Risius, M., et al. (2021). The 4th Industrial Revolution Powered by the Integration of AI, Blockchain, and 5G. Communications of the Association for Information Systems, 49(1), 266–286. https://doi.org/10.17705/1cais.04910

Fu, Y., Yang, L. (2024). Development problems and countermeasures of cold chain logistics of fresh agricultural products under rural revitalization strategy. Logistics technology, 47(03), 141–142, 163. https://doi.org/10.13714/j.cnki.1002-3100.2024.03.033

Gao, X. (2022). Research on the impact of digital transformation on enterprise performance [PhD thesis]. Guangzhou University.

Gao, X. (2024). Discussion on innovative development path of Chinese logistics enterprises from the perspective of green supply chain. Theory of Chinese commerce, 1, 12–15. https://doi.org/10.19699/j.cnki.issn2096-0298.2024.01.012

Gillespie, J., da Costa, T. P., Cama-Moncunill, X., et al. (2023). Real-Time Anomaly Detection in Cold Chain Transportation Using IoT Technology. Sustainability, 15(3), 2255. https://doi.org/10.3390/su15032255

Goodarzian, F., Navaei, A., Ehsani, B., et al. (2022). Designing an integrated responsive-green-cold vaccine supply chain network using Internet-of-Things: artificial intelligence-based solutions. Annals of Operations Research, 328(1), 531–575. https://doi.org/10.1007/s10479-022-04713-4

Guo, L., & Xu, L. (2021). The Effects of Digital Transformation on Firm Performance: Evidence from China's Manufacturing Sector. Sustainability, 13(22), 12844. https://doi.org/10.3390/su132212844

Han, J.-W., Zuo, M., Zhu, W.-Y., et al. (2021). A comprehensive review of cold chain logistics for fresh agricultural products: Current status, challenges, and future trends. Trends in Food Science & Technology, 109, 536–551. https://doi.org/10.1016/j.tifs.2021.01.066

Holmström, J., & Partanen, J. (2014). Digital manufacturing-driven transformations of service supply chains for complex products. Supply Chain Management: An International Journal, 19(4), 421–430. https://doi.org/10.1108/scm-10-2013-0387

Huang, C., & Guo, M. (2022). Research on the construction of intelligent cold chain logistics system of Hunan fresh agricultural products based on AI technology. Logistics engineering and management, 44(08), 87–89. https://doi.org/10.3969/j.issn.1674–4993.2022.08.026

Huang, W., Wang, X., Zhang, J., et al. (2023). Improvement of blueberry freshness prediction based on machine learning and multi-source sensing in the cold chain logistics. Food Control, 145, 109496. https://doi.org/10.1016/j.foodcont.2022.109496

Javaid, M., Haleem, A., Singh, R. P., et al. (2022). Enhancing smart farming through the applications of Agriculture 4.0 technologies. International Journal of Intelligent Networks, 3, 150–164. https://doi.org/10.1016/j.ijin.2022.09.004

Joubert, L. (2019). An investigation to evaluate the impact of quality-controlled logistics on food waste and food quality with the assistance of Internet of Things. Stellenbosch: Stellenbosch University.

Khan, Y., Su'ud, M. B. M., Alam, M. M., et al. (2022). Application of Internet of Things (IoT) in Sustainable Supply Chain Management. Sustainability, 15(1), 694.

Kuru, K., Ansell, D., Khan, W., et al. (2019). Analysis and Optimization of Unmanned Aerial Vehicle Swarms in Logistics: An Intelligent Delivery Platform. IEEE Access, 7, 15804–15831. https://doi.org/10.1109/access.2019.2892716

Lacity, M., Van Hoek, R. (2021). Requiem for reconciliations: DL Freight, a blockchain-enabled solution by Walmart Canada and DLT Labs. University of Arkansas Blockchain Center for Excellence Research White Paper.

Li, G. (2021). Retracted: Development of cold chain logistics transportation system based on 5G network and Internet of things system. Microprocessors and Microsystems, 80, 103565. https://doi.org/10.1016/j.micpro.2020.103565

Liu, C., & Ma, T. (2022). Green logistics management and supply chain system construction based on internet of things technology. Sustainable Computing: Informatics and Systems, 35, 100773. https://doi.org/10.1016/j.suscom.2022.100773

Liu, W., Long, S., & Wei, S. (2022). Correlation mechanism between smart technology and smart supply chain innovation performance: A multi-case study from China's companies with Physical Internet. International Journal of Production Economics, 245, 108394. https://doi.org/10.1016/j.ijpe.2021.108394

Ma, X., Wang, S., Islam, S. M. N., et al. (2019). Coordinating a three-echelon fresh agricultural products supply chain considering freshness-keeping effort with asymmetric information. Applied Mathematical Modelling, 67, 337–356. https://doi.org/10.1016/j.apm.2018.10.028

Mao, Z., & Zhang, Q. (2023). Application Process Design of Digital Quality Monitoring and Traceability System for Fresh Agricultural Products. Digitalization and Management Innovation. https://doi.org/10.3233/faia230005

Mohsan, S. A. H., Othman, N. Q. H., Li, Y., et al. (2023). Unmanned aerial vehicles (UAVs): practical aspects, applications, open challenges, security issues, and future trends. Intelligent Service Robotics. https://doi.org/10.1007/s11370-022-00452-4

Mondejar, M. E., Avtar, R., Diaz, H. L. B., et al. (2021). Digitalization to achieve sustainable development goals: Steps towards a Smart Green Planet. Science of The Total Environment, 794, 148539. https://doi.org/10.1016/j.scitotenv.2021.148539

Nath, S. K., Aznabi, S., Islam, N. T., et al. (2017). Investigation and Performance Analysis of Some Implemented Features of the ZigBee Protocol and IEEE 802.15.4 Mac Specification. International Journal of Online Engineering (IJOE), 13(01), 14. https://doi.org/10.3991/ijoe.v13i01.5984

Nazeer, S., Fuggate, P., & Shafiq, M. (2020). Farm level sustainable cotton supply chain management: an empirical study of Pakistan. International Journal of Logistics Systems and Management, 37(3), 389. https://doi.org/10.1504/ijlsm.2020.111384

Nazeer, S., Saleem, H. M. N., & Shafiq, M. (2024). Examining the Influence of Adoptability, Alignment, and Agility Approaches on the Sustainable Performance of Aviation Industry: An Empirical Investigation of Supply Chain Perspective. International Journal of Aviation, Aeronautics, and Aerospace, 11(1). https://doi.org/10.58940/2374-6793.1898

Pambudi, N. A., Sarifudin, A., Firdaus, R. A., et al. (2022). The immersion cooling technology: Current and future development in energy saving. Alexandria Engineering Journal, 61(12), 9509–9527. https://doi.org/10.1016/j.aej.2022.02.059

Pan, X., Li, M., Wang, M., et al. (2020). The effects of a Smart Logistics policy on carbon emissions in China: A difference-in-differences analysis. Transportation Research Part E: Logistics and Transportation Review, 137, 101939. https://doi.org/10.1016/j.tre.2020.101939

Peters, K., Ramirez, C. (2021). Technology of fruits and vegetable processing. ED-Tech Press.

Porta, D. della. (2008). Comparative analysis: case-oriented versus variable-oriented research. Approaches and Methodologies in the Social Sciences, 198–222. https://doi.org/10.1017/cbo9780511801938.012

Prashar, D., Jha, N., Jha, S., et al. (2020). Blockchain-Based Traceability and Visibility for Agricultural Products: A Decentralized Way of Ensuring Food Safety in India. Sustainability, 12(8), 3497. https://doi.org/10.3390/su12083497

Qin, N. (2018). Design of real-time temperature and humidity monitoring system for cold chain logistics of fresh agricultural products based on ARM9 and ZigBee. Hubei agricultural sciences, 57(18), 98–102. https://doi.org/10.14088/j.cnki.issn0439-8114.2018.18.025

Ren, Q.-S., Fang, K., Yang, X.-T., et al. (2022). Ensuring the quality of meat in cold chain logistics: A comprehensive review. Trends in Food Science & Technology, 119, 133–151. https://doi.org/10.1016/j.tifs.2021.12.006

Sahar, D. P., Afifudin, M. T., & Indah, A. B. R. (2020). Review of green supply chain management in manufacturing: A case study. IOP Conference Series: Earth and Environmental Science, 575(1), 012239. https://doi.org/10.1088/1755-1315/575/1/012239

Shafiq, M., Nazeer, S., & Saleem, M. N. S. M. N. (2023). Investigating the Impact of Entrepreneurial Orientation and Ownership Structure on Firm Supply Chain Management Performance. Logistics & Digital Supply Chain Magazine (Thai language), 1(1), 26–36.

Soltani Firouz, M., Mohi-Alden, K., & Omid, M. (2021). A critical review on intelligent and active packaging in the food industry: Research and development. Food Research International, 141, 110113. https://doi.org/10.1016/j.foodres.2021.110113

Song, Y., Yu, F. R., Zhou, L., et al. (2021). Applications of the Internet of Things (IoT) in Smart Logistics: A Comprehensive Survey. IEEE Internet of Things Journal, 8(6), 4250–4274. https://doi.org/10.1109/jiot.2020.3034385

Street, A., del Monte Tabor, F. S. R. (2009). Static and Dynamic Population Clustering in Personality Diagnosis for Personalized eHealth Services. Personalisation for e-Health Services. Paper presented at the Personalisation for e-Health, Verona, Italy.

Tang, X. (2020). Research on Smart Logistics Model Based on Internet of Things Technology. IEEE Access, 8, 151150–151159. https://doi.org/10.1109/access.2020.3016330

Tashfeen, R., Saleem, I., Ashfaq, M., et al. (2023). How Do Women on Board Reduce a Firm's Risks to Ensure Sustainable Performance during a Crisis? Sustainability, 15(14), 11145. https://doi.org/10.3390/su151411145

Tian, Z., Zhong, R. Y., Vatankhah Barenji, A., et al. (2020). A blockchain-based evaluation approach for customer delivery satisfaction in sustainable urban logistics. International Journal of Production Research, 59(7), 2229–2249. https://doi.org/10.1080/00207543.2020.1809733

Tseng, F.-H., Cho, H.-H., & Wu, H.-T. (2019). Applying Big Data for Intelligent Agriculture-Based Crop Selection Analysis. IEEE Access, 7, 116965–116974. https://doi.org/10.1109/access.2019.2935564

van Geest, M., Tekinerdogan, B., & Catal, C. (2021). Design of a reference architecture for developing smart warehouses in industry 4.0. Computers in Industry, 124, 103343. https://doi.org/10.1016/j.compind.2020.103343

Wang, D., Yuan, Q., & Xiang, F. (2020). Analysis of current situation of joint distribution in cold chain logistics. 2020 International Conference on Urban Engineering and Management Science (ICUEMS). https://doi.org/10.1109/icuems50872.2020.00055

Wang, J. (2019). Informatization and New Agricultural Cold Chain Logistics Mode. Proceedings of the International Academic Conference on Frontiers in Social Sciences and Management Innovation (IAFSM 2018). https://doi.org/10.2991/iafsm-18.2019.44

Wang, L., Xu, L., Zheng, Z., et al. (2021). Smart Contract-Based Agricultural Food Supply Chain Traceability. IEEE Access, 9, 9296–9307. https://doi.org/10.1109/access.2021.3050112

Wang, W. (2021). Research on Development and Pricing of Fresh E-commerce Platform in China-A Case Study of Jingdong Fresh (4 th). International Conference on Global Economy, Finance and Humanities Research.

Wang, Y. (2021). Study on coordination and optimization of supply chain of fresh agricultural products [PhD thesis]. Wuhan University of Technology

Watanabe, W. C., Shafiq, M. (2023). A Study on the Impact of Digital Marketing on Business Practices. Business Review of Digital Revolution. 3(1), 1–10.

Watanabe, W. C., Shafiq, M., Ali, S., et al. (2024). The impact of triple constraints on the project success, a moderating role of organizational support. Journal of Project Management, 9(1), 73–84. https://doi.org/10.5267/j.jpm.2023.8.002

Watanabe, W. C., Shafiq, M., Nawaz, M. J., et al. (2024). The impact of emotional intelligence on project success: Mediating role of team cohesiveness and moderating role of organizational culture. International Journal of Engineering Business Management, 16. https://doi.org/10.1177/18479790241232508

Wu, G., Wang, M. (2024). Design of traceability system for fresh agricultural products based on blockchain technology. Computer technology and development, 34(1), 177–184.

Yan, B., Yan, C., Ke, C., et al. (2016). Information sharing in supply chain of agricultural products based on the Internet of Things. Industrial Management & Data Systems, 116(7), 1397–1416. https://doi.org/10.1108/imds-12-2015-0512

Ye, Y.S., He, M. (2018). Research on the development of fresh e-commerce distribution under the background of new retail -- taking “Hema Fresh” as an example. National circulation economy, 15, 13–15. https://doi.org/10.16834/j.cnki.issn1009-5292.2018.15.006

Yen, G.-F., & Yang, H.-T. (2018). Does Consumer Empathy Influence Consumer Responses to Strategic Corporate Social Responsibility? The Dual Mediation of Moral Identity. Sustainability, 10(6), 1812. https://doi.org/10.3390/su10061812

Zhang, A., Mankad, A., & Ariyawardana, A. (2020). Establishing confidence in food safety: is traceability a solution in consumers’ eyes? Journal of Consumer Protection and Food Safety, 15(2), 99–107. https://doi.org/10.1007/s00003-020-01277-y

Zhang, Q., & Yin, Y. (2023). Iresearch: Insight into China’s raw food supply chain industry in 2023. Available online: https://report.iresearch.cn/content/2023/04/466108.shtml (accessed on 4 January 2024).

Zhang, X., Sun, Y., & Sun, Y. (2022). Research on Cold Chain Logistics Traceability System of Fresh Agricultural Products Based on Blockchain. Computational Intelligence and Neuroscience, 2022, 1–13. https://doi.org/10.1155/2022/1957957

Zhang, Y. (2016). Research on fresh agricultural products circulation based on supply chain management [Master’s thesis]. Central China Normal University.

Zhang, Y., Chen, L., Battino, M., et al. (2022). Blockchain: An emerging novel technology to upgrade the current fresh fruit supply chain. Trends in Food Science & Technology, 124, 1–12. https://doi.org/10.1016/j.tifs.2022.03.030

Zhao, L., Yu, Q., Li, M., et al. (2022). A review of the innovative application of phase change materials to cold-chain logistics for agricultural product storage. Journal of Molecular Liquids, 365, 120088. https://doi.org/10.1016/j.molliq.2022.120088

Zhao, X., Sun, X., Zhao, L., et al. (2022). Can the digital transformation of manufacturing enterprises promote enterprise innovation? Business Process Management Journal, 28(4), 960–982. https://doi.org/10.1108/bpmj-01-2022-0018

Zhu, X., & Yin, L. (2020). Research on the supply chain development of fresh agricultural products in China under the background of intelligent logistics. Preservation and Processing, 20(6), 199–204. doi: 10.3969/j.issn.1009-6221.2020.06.031

Zhu, Z., Bai, Y., Dai, W., et al. (2021). Quality of e-commerce agricultural products and the safety of the ecological environment of the origin based on 5G Internet of Things technology. Environmental Technology & Innovation, 22, 101462. https://doi.org/10.1016/j.eti.2021.101462

Zook, K. L., & Pearce, J. H. (2018). Quantitative Descriptive Analysis. Applied Sensory Analysis of Foods, 43–71. https://doi.org/10.1201/9781315137681-3