



Research Article

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The application of internet of things in agricultural means of production supply chain management

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ABSTRACT

The aim of this article is to introduce the related technologies of internet of things and tries to build a model of Agricultural Means of Production Supply Chain based on it. Then it analyzes the function and utility of the internet of things applying on the agricultural means of production supply chain. Finally, the article describes the trends and prospects that the technology of internet of things in Agricultural Means of Production Supply Chain. How to improve the agricultural supply chain operation efficiency and competitiveness is the key to the problem of solving. Application of Internet of things in the agricultural supply chain helps to improve the agricultural supply chain information technology level, so that the operating efficiency of the supply chain of agricultural products is improved by enhancing the whole supply chain integration. This paper analyzes the application of IOT in product supply chain business processes, and the driving factor in the adoption of agricultural products supply chain effect in the Internet of things technology are analyzed, to provide a reference for the node enterprises of agricultural products supply chain in the implementation of the Internet of things..

Key words: the internet of things, agricultural means of production, supply chain, TOE model

INTRODUCTION

Agriculture is the foundation of national economy, only the agricultural development is good, the entire national economy can steadily forward. The economic development of our country's history suggests that, only given a great development of agriculture and rural economy, the whole national economy can go to prosperity. At the same time, only agricultural production can provide the second and third industry with raw materials and financial resources, laying the foundation for the modernization of society.

Our country is an agricultural country of production and consumption. Since the reform and opening up, China's agriculture has solved the problem of food and clothing for 1300000000 people, gained great success attracting worldwide attention. Although made such great achievements, the development of agriculture in our country has been the weak link in China's economy [1]. The development and regulatory of agricultural means of production are directly related with the production of food, farmer's income and the order of market [2]. It plays a vital role in ensuring the quality and quantity of agricultural products. But in recent years, the business system of China has investigated tens of thousands of cases of fake cultural materials including many kilograms of substandard seeds and many kilograms of substandard fertilizer. These fake agricultural products will bring enormous loss to the farmers. In China, one of the important reasons why we cannot eliminate the problem of fake and shoddy agricultural products is that China has not established a reasonable sound agricultural supply chain [3]. Existing agricultural supply chain has disadvantages in decentralized management and lacks of convergence. So a safe, efficient, smooth and perfect operation of the network system of agricultural products cannot be established. It is the technology of internet of things that solves the above problem by providing a feasible and efficient solution [4-5]. In our current environment, the internet of things, with its real-time, accurate and shared characteristics, will bring great changes to the agricultural supply chain and provide a critical technology for establishing a smooth flow of agricultural logistics

and supply chain information.

This paper presents the agricultural products supply chain management technology of Internet of things based on three layer framework. In the agricultural information processing and application infrastructure, application of facility agriculture IOT is mainly embodied in the realization of intelligent agricultural production, management, decision-making, therefore on the agricultural production of the key link, need to focus on the applications of the Internet of things technology in crop growth data processing facilities, production of digital management, data sharing, user interface and service intelligent network, intelligent decision-making.

2. RELATED BASIC THEORY

2.1 The concept of internet of things

Now the internet of things is generally defined as a network, which connects everything with the internet by radio frequency identification (RFID), sensors, global positioning systems, laser scanners and other information sensing devices in accordance with the agreed protocol and exchange information in order to achieve intelligent identification, location tracking, monitoring and management [6].

The network can realize the automatic identification of objects and location, track, monitor and trigger the corresponding event [7]. It makes use of RFID technology for scanning and reading EPC tags on the items and achieves automatic identification of goods and information sharing.

At present, the architecture of the Internet of things is divided into three layers: the sensing layer, network layer and application layer. System structure was shown in Figure 1 of the Internet of things.

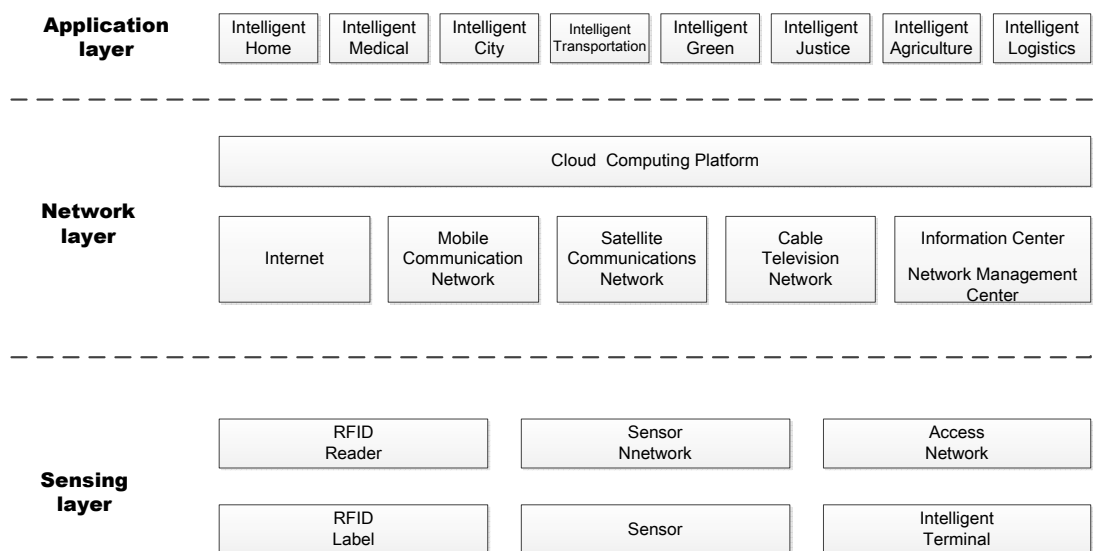


Figure 1. System structure of the three layers

The sensing layer consists of data acquisition layer, self-organizing sensor networks and middleware.

- 1) Acquisition sub layer integrated bar code, sensors, satellite positioning, RFID and multimedia information acquisition technology for data acquisition, access to a variety of data information of all kinds of voice, video and other multimedia data, to mark the physical world.
- 2) Self-organizing sensor network includes digital link coding, modulation, and demodulation technology based on data transmission, networking, traffic management, routing technology based on self interaction, organization and coordination among the nodes.
- 3) Middleware includes embedded middleware, sensor network middleware, application in the sensing layer to solve the problem of equipment management and data management, configuration, calibration, fault detection and data conversion, such as loading. When the data collection is completed, in order to effectively reduce the data redundancy and improve the quality of data, data fusion, compression, clustering, recognition and other information processing technology are also needed.

2.2 The key technology of the internet of things

The internet of things involves a lot of new technologies, whose core technologies include RFID, sensor technology, network communication technology and cloud computing [8].

The Radio Frequency Identification (RFID) is a non-contact automatic identification technology and obtains relevant data by automatically identifying the label (tag) on the objects [9]. It is one of the most critical technologies in the technologies of internet of things.

Sensor technology is mainly responsible for the information collection of internet of things. It is the basis service and application to achieve the perception of real-world. It is the sensor that exchanges changes in the real world into quantitative data and sends these data to specified location through certain techniques.

The technologies of network communication includes a variety of wired and wireless transmission technologies, switching technology, network technology and gateway technology, which is the basis of perceiving and communicating information between objects[10]. The Cloud Computing is a product that combines traditional computer technology with network technology including grid computing, parallel computing, and distributed computing, utility computing, virtualization, network storage, load balancing and other traditional computer technology, network technology and so on. Sensor is a detection device which can feel the measured information and transform the measured information into electric signal or other required information in the form of output.

The RFID system generally consists of three parts: tag, reader and antenna. The label by coupling components and chips, each label is the only electronic coding for recognition of objects; reader for reading the label information; main antenna for emitting radio frequency signals, in order to guarantee the communication quality inspection of the tag and reader.

2.3 The architecture and application system of the internet of things

There is a popular view that the internet of things should be a three-tier system including the layer of perception, the layer of network and the layer of application. The layer of perception includes RFID tags, readers, cameras, sensors, sensor network and so on, which mainly solves the problems of perceiving, recognizing objects and collecting information. The layer of network is a mature part of the internet of things. It is the infrastructure for the internet of things to realize universal service. It will direct towards the combination of the layer of perception and the layer of application in the future. The layer of application is a layer that combines the internet of things with the technology of specific industry. It is the layer of application that realizes the deep integration between the technology of the internet of things and the technology of the industry expertise. The internet of things almost applied in all areas of industry, including precision agriculture, industrial control, building control, vehicle scheduling, environmental testing, remote diagnostics, and smart home and urban management. Among them, agriculture is one of the most extensive areas.

2.4 Organizational level of information technology adoption behavior theory (T-O-E model)

Tornatzky & Fleischer put forward the critical theory of classical diffusion of innovation. They suggest that factors influencing the diffusion of information technologies not only contain the characteristic elements of the technology itself (T), also contain the organization characteristic elements (O), environmental factor (E). The TOE framework is proposed, because of its wide applicability. Many scholars at home and abroad studied TOE framework and the factors contained in this framework. The technical characteristics of technology itself include technical compatibility, complexity. The organizational factors include the size of the organization, high-level support, organizational culture and the environmental factors include external competition pressure, the government policy support and so on.

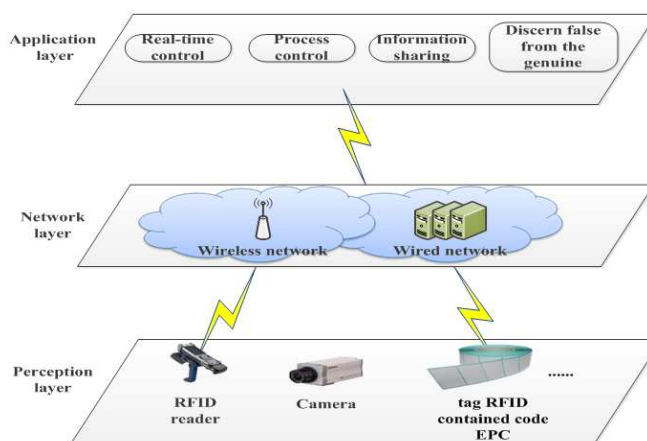


Figure 2. The architecture system of the internet of things for agricultural supply chain

3. ANALYSIS OF AGRICULTURAL SUPPLY CHAIN BASED ON THE INTERNET OF THINGS

3.1 The architecture system of the internet of things for agricultural supply chain

This paper argues that the system architecture of the Internet of Things for agricultural supply chain can also be divided into three layers including the layer of perception, the layer of network and the layer of application. It is shown in Figure 2.

The layer of perception in the internet of things for agricultural supply chain contains the tag EPC, mobile reader RFID, sensor network and other sensing devices. In this layer, we should focus on solving the problem of perceiving and recognizing objects and collecting information. The main technology in this layer involves the technology of RFID, sensing, control and short-range wireless communication. The information on tag EPC of agricultural products will be collected by RFID. Then it will be sent to the next layer, the layer of network.

In the layer of network, the local server sorts and filters code EPC that can be identified by reader RFID in order to send them to the local ONS. The local ONS calculator queries automatically and sends the collated EPC to the specified domain root ONS servers to obtain the required advice. The Second DNS root server sends one or more EPC domain names corresponding to the IP address of PML server back to the local ONS calculator. Then the local ONS calculator sends the IP address back to the local server. At last the local server contacts with the correct PML server according to the correct IP address to obtain the required EPC of agricultural products.

The layer of network will use the processed data from the internet of things to get information about agricultural products, and ultimately achieve real-time monitoring, process control, information sharing and discerning and so on.

3.2 Analysis of the internet of things for agricultural supply chain

In the traditional agricultural product supply chain, the data about the information of agricultural products is mainly collected by means of manual and bar code. This can easily result in delays, errors and lack of information for agricultural supply chain. And it will make logistics and information flow distorted in the transmission process. The application of the internet of things on agricultural supply chain can build a system that can control and trace the quality of agricultural products by combining agricultural supply chain with farmers' purchase.

The technology of RFID and cloud computing integrate the information of production, distribution and safety of quality in the agricultural supply chain effectively. It will ultimately combine the farmers with the internet of things and make transparency of the entire agricultural supply chain process. It is useful to establish a system that monitors and traces the quality of agricultural materials. The agricultural supply chain management based on the internet of things can process the logistics information of every aspect including the production, procurement, storage, transportation and sale. The system can send exact number and right quality of agricultural products such as pesticides, fertilizers and seeds to appropriate places for meeting the needs of farmers in right price at the right time.

3.3 Analysis of the process in agricultural supply chain based on the internet of things

3.3.1 Production stage

Agricultural products are sent to the farmers mainly through production, transportation, storage, sales and other stages. In the production process of agricultural products, the entire items in product line including raw materials, products, semi-finished products and finished products should be identified and tracked to achieve a balanced and steady production. Each agricultural product is labeled with RFID tag encoded with the EPC. The EPC code contains the information of product such as product name, manufacturer, grade (classification), and place of origin, net weight, batch number, production date, and shelf life and so on. Storage management business process was shown in Figure 3.

When the processing plant products are shipped after storage, RFID/EPC tag information in fixed locations RFID can be read into the wagon inside the product variety and quantity information. People can order this information, once found error, return the working personnel and processing factory communication; if shipment is correct, then classify products. Each batch of agricultural products will be stacked together and it is convenient for storing and linking goods.

3.3.2 Transportation stage

In the transportation stage of agricultural products, installing GPS positioning system on the vehicles enables the managers to know the location and state of the vehicles that transport the agricultural products and adjust driving direction timely in an emergency. At the same time, installing wireless data acquisition system on the vehicles can not only learn the basic information and quantity of the goods, but also detect and prevent the lost and stolen goods during the transportation.

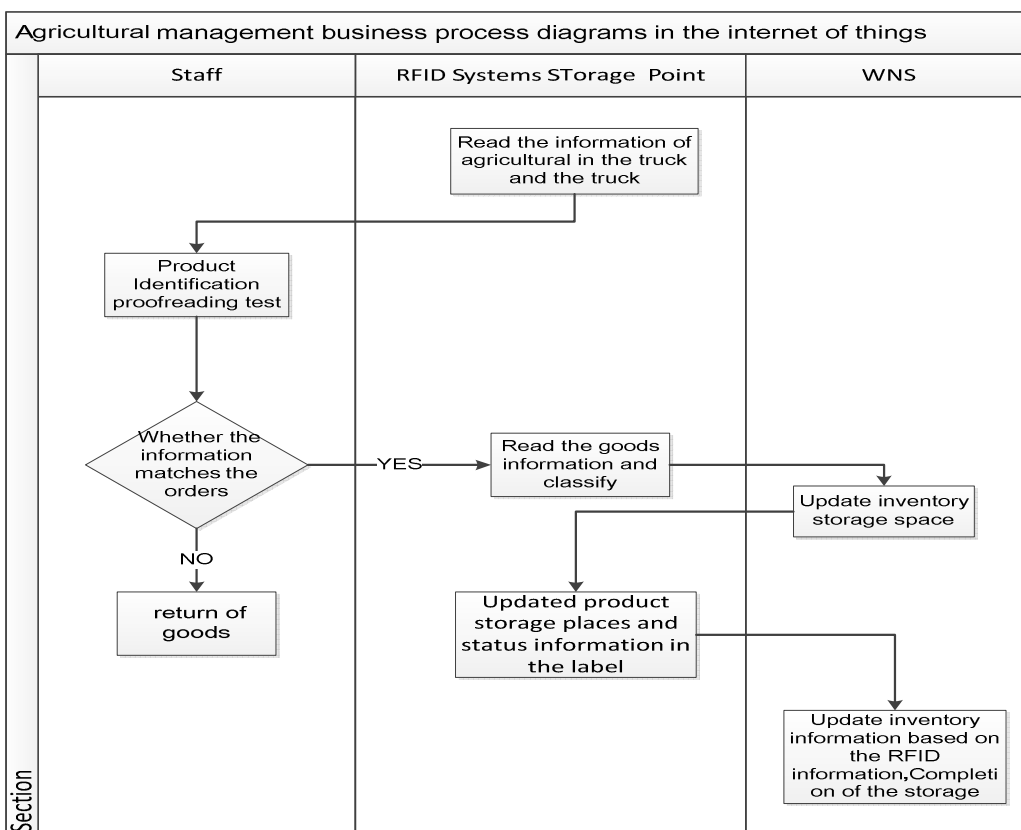


Figure 3. Storage management business process

The network structure of agricultural product supply chain management system of the Internet of things was shown in Figure 4. The system mainly consists of four network center including farms, processing plants, distribution centers, distributors and the supply chain management information center. The node network layouts of Breeding base, processing plants, distribution centers and retailers are roughly the same, mainly include the RFID/EPC tag, RFID reader with a temperature sensor, PDA, ONS server, EPCIS server, database, workstation, the intra node communication equipment through the internal LAN, RFID/EPC tags and temperature sensor information to nodes within the database through a wireless network. Supply chain management information center includes the workstations, switches, the central processor, GIS server, ONS server, database server and other components, its interior communication is also through the LAN. The processing plant, distribution center, retailer and supply chain management information center are connected to other users through the high speed Ethernet connection .

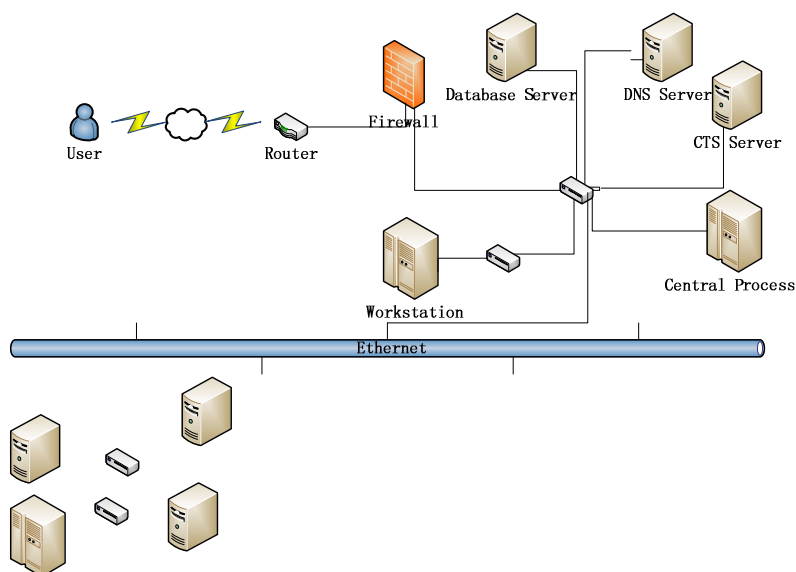


Figure 4. The network structure of agricultural product supply chain management system

3.3.3 The system function design

Database about agricultural products should be established and set product code as its key information. It will not only help the enterprises improve storage utilization, reduce inventory and save costs, but also help the enterprises well aware of the business inventory and make a scientific and accurate decisions during ordering and production. Agricultural production management system infrastructure (Figure 5) consisted environmental monitoring subsystem, greenhouse facilities and digital management subsystem and so on.

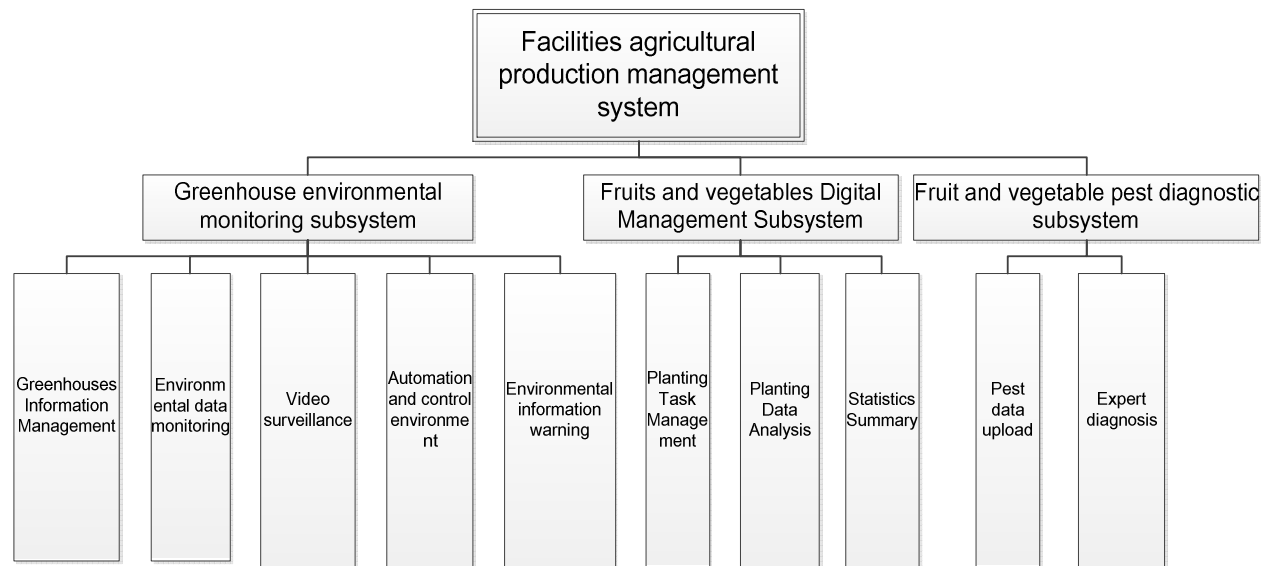


Figure 5. Agricultural production management system infrastructure

3.3.4 Sale stage

The application of the internet of things in the stage of agricultural products' sale can be reflected in the statistics, security and validity monitoring forms. Farmers can determine whether the agricultural product is expired according to the production date EPC tags and then judge its quality. When the accident occurred in agricultural products, manufacturers, distributors, or farmers can find the final consumer by traceability system and find the places that occurred problems. This will help form a chain of efficient management and query.

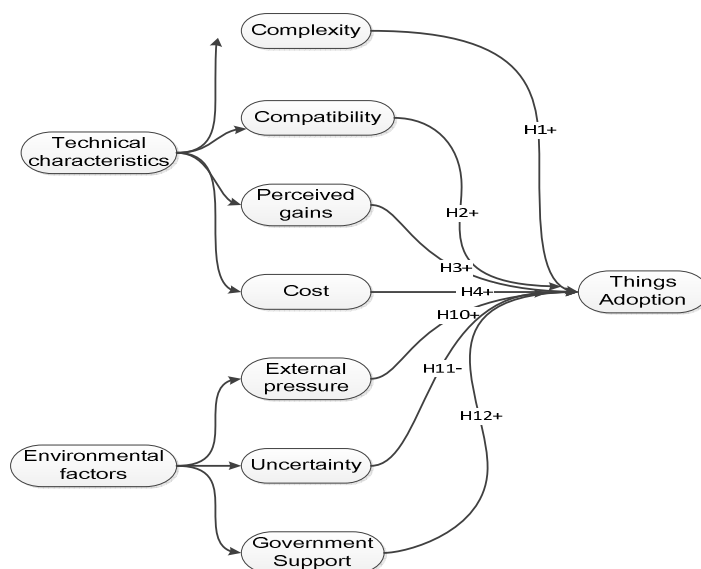


Figure 6. The model adopted by this study

4. THE ROLE OF THE INTERNET OF THINGS IN THE AGRICULTURAL SUPPLY CHAIN

4.1 Purify agricultural material market

The agricultural supply chain based on the technology of the internet of things is a chain of setting production,

storage, distribution and retail in one to provide a traceable RFID carrier to confirm the authenticity of the agricultural products. Relevant information about agricultural products can be found from tag RFID. This will face the producers directly and eliminate the fake products completely. It will strengthen quality control and purify agricultural market by controlling the import and export channels. The Internet of things technology adopted model of this study was shown in Figure 6. Factors shown in the figure are classified according to the T-O-E model. Diagram '+' said positive influence factors on the Internet of things technology adoption, '-' said factors network reverse influence technology adoption.

4.2 Reduce the burden on farmers

The agricultural supply chain based on the technology of the internet of things makes each step of the supply chain improve the transparency greatly. Tag RFID can automatically record the entire supply chain of agricultural products in the flow - from production to final farmers. It can not only greatly reduce the "bullwhip effect", inventory costs and labor costs in logistics center, but also improve inventory utilization. And then it will lower agricultural products price to give benefits to farmers and reduce their burdens.

4.3 Serve the agriculture, rural areas and farmers better

The agricultural supply chain based on the technology of the internet of things can guarantee the supply of cultural materials and serve every link of agricultural production well. It will improve the efficiency of agricultural supplies and meet the needs of agricultural products by adopting advanced management concepts, management tools and distribution methods of agricultural products.

Business process analysis framework and network provides a good way for enterprises based on network, as the networking technology application in the agricultural supply chain provides a reference guide; adoption of agricultural enterprises of Internet of things technology. Analysis on driving factors of adoption of Internet of things technology, can make agricultural enterprises to understand what are the key factors affecting the adoption of Internet of things technology, can focus on these factors in the process of technology adoption, make things better, faster to implement in the agricultural products supply chain.

CONCLUSION

In the fierce global competition environment, our country agriculture highlights the low level of industrialization, the low value chain level, low management level, low level of information. In order to solve the above problem, the application of new technology is a feasible method. In this paper, the applications of the Internet of things technology to the agricultural products supply chain, in order to improve the operation efficiency of the supply chain of agricultural products, promote the development of agriculture in our country. Of course, there are many factors affecting the adoption of agricultural products supply chain of the Internet of things. There is still a long run for the internet of things to enter into the practical stage of agricultural supply chain. There are also many problems for the internet of things to solve, which include how to reduce costs, carry on the R&D of core technology, develop industry standards, protect the privacy and so on. But the internet of things based on RFID technology has been integrated into all aspects of supply chain management and it will has a significant impact on the development of supply chain management.

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