

Research Article

Study on Supply-chain of Modern Agricultural Products Based on IOT in Order to Guarantee the Quality and Safety

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Abstract: Modern agriculture features industrialization, marketized industrial structure, intensive production pattern and high digitization; farm produce logistics are characterized by wide range, large quantity, relative independence, consumable as well as value-added processing. In this study, in view of the features of modern agriculture and farm produce logistics, a SCOR model (Supply-Chain Operations Reference-model) of agricultural products based on the Internet of things has been put forward through the improvement of the logistics model of traditional agricultural products. The advantages of this model have also been analyzed.

Keywords: IOT, modern agriculture, supply chain

INTRODUCTION

For food and agricultural products, the whole procedure from production to consumption involves production, processing, packing, transportation, storage, shelf display and consumption. Each link is likely to bring unsafe factors, which mainly include: the inputs of poisonous and harmful material residues during the planting and breeding processes; the effects of environmental pollutants to food hygiene, as pesticide, fertilizer and other environmental pollutants can enter human body through the food chain and then bring damage to health; pollution during the processing, transportation, sales course. As consumers' requirements for the quality and safety of food and agricultural products have been improved continuously, it is urgent for us to do the whole monitoring for food and agricultural products supply chain. The tracking and traceability of the product also become more important (Liu *et al.*, 2007; Xie *et al.*, 2007).

Because the supply chain of food and agricultural production and distribution of space are of wide area, even flow, the traditional wired sensor technology can't meet the needs of the whole monitoring application. In recent years, along with the development of Micro Electromechanical System (MEMS), wireless communications and digital electronics. The IOT (Internet of Things) research has made great progress. It has developed a lot of micro sensor nodes with low cost, low power consumption, awareness, computing and communication capabilities, as well as the relatively mature RFID chips, encapsulation, reading and writing equipment design, manufacturing and system integration technology, which makes the application of Internet of things technology in the food and agricultural products production, processing, logistics, safety supervision

become highlights in many colleges and universities, enterprises and research institutions at home and abroad in the recent years. As to main research at home and abroad, such as Amador installs RFID with temperature sensor in pineapple corrugated carton and plastic turnover box (Some with sensor probe inserted in the pulp), through the experiment from Costa Rica to United States in the long-distance transportation we get the pineapple surface temperature and the pulp temperature changes and the differences in the measurement accuracy of recording method compared with the technology and the traditional method (Amador *et al.*, 2009). Abad with others use RFID sensor with temperature, humidity and light sensor to study the technique of Internet of things' application in an intercontinental transportation of the fresh fish from South Africa to Europe, air-land coordinated transport over a period of 3 days (Abad *et al.*, 2009). Hayes and other researchers set temperature sensors of WSN in two fishing boats and use SMS (text message) through the GSM network to transmit real-time data to Internet server and record it, solving the problems of past method which can only realized single ship monitoring system. The technology can be extended to more fishing boats' wide-area monitoring (Hayes *et al.*, 2005). Wang xiaodong and other experts designed real-time monitoring system based on GPRS technology which is suitable for the food cold chain transporter. The temperature monitoring data can be sent to the server of the control center (Wang *et al.*, 2009). Shan and others studied application feasibility of Bluetooth, Zigbee, artificial intelligence, neural network and fuzzy logic technology in the cold chain transportation and put forward the future application of the Internet of things technology in cold chain transport track and the technical scheme for automatic decision-making ideas

(Shan *et al.*, 2004). Ruiz-Garcia and others studied the application of WSN in fruit multi-transportation and the effectiveness of the sensor nodes in low temperature environment in Zigbee network is verified. He also proposed that we can quickly determine moisture loss in product through monitoring the change of moisture content in air environment (Ruiz-Garcia *et al.*, 2008). Gras found that if we install passive RFID with a temperature sensor in the frozen food packaging, we can quickly acquire and record the actual temperature of the item, to speed up the logistics (Gras, 2006). Many research results show that the Internet of things is more and more widely used in food circulation.

Since traditional agriculture in our country now makes up the greater part, the development of agricultural products logistics is still backward and fails to form standard organization and management. The transport management, which lacks of wholeness and coordination, directly leads to hindered circulation of agricultural products and the increase of cost (Yue and Huang, 2004). The agriculture operations is mainly based upon farmer families and the correlating agricultural products circulating system characterized as "small scale and big group" finds it more and more difficult to meet the demands of modern agricultural products logistics and agricultural industrialization. Therefore, stepping up the development of modern agriculture has become the important strategy towards the building of agricultural power.

ESSENTIAL FEATURES OF MODERN AGRICULTURE

Marketization of agricultural industrial structure: Geared by the market, the modern agriculture meet people's basic consuming demands by adjusting the agricultural industry structure. The marketization of agriculture industry is to pick up the leading product and develop market agriculture that integrates production and marketing, as well as a highly open export-oriented agriculture, in accordance with the supply and demand situation of farm produce market and combining with different economic conditions and natural resources of agriculture.

Intension of the agriculture production mode: As one of the essential features of modern agriculture, intensive production transformed the extensive production form into mechanized, improved, specialized and large scaled production form.

Industrialization of modern agriculture: Modern agriculture is a kind of production operation system, which is integrated with planting, breeding, processing; production, supply and sale; export and import trade; agriculture-industry-commerce; farm, science and education. It is market oriented, benefit focused, centering on pillar industries, making rational allocation

of production factors, practicing regional distribution, specialized production, integrated management, socialized services and entrepreneurial management.

Modern agriculture should be high digital: Modern agriculture should be digitized. Digital agriculture refers to a intensive agro-technique supported by space geo-science and science technology. What counts is to acquired the outputs of farm land crop and the different information of space-time environmental factors. Upon this basis, the analysis of reasons are made and the relevant measures, which should be technically practical and economically effective, are adopted, namely, "prescript farming".

THE PRESENT SITUATION OF AGRICULTURAL PRODUCTS LOGISTICS MANAGEMENT MODE

The characteristics of agricultural products logistics: Agricultural products logistics is a physical economical activity, which aims to satisfy consumers and realize profit, by transforming the material object or information from producers to customers. It contains several links: production, purchase, transportation, storage, load and unload, packing, distribution, circulate process, retail and information activities etc. During this process, the organized goal and increment are achieved. The features of our agricultural products is mainly focused on the following aspects:

- Large scale and wide variety of product logistics
- Relative independence of agricultural products logistics operating. The production of farm produce, circulation and processing, packing methods, storage condition, as well as the technique instrument, all of which are professional, besides, the establishment, equipment and conveyance are characteristic of the relative independence
- The perish-ability of the agricultural products logistics. "Fresh and alive "is where the value at, however; farm produce are perishable, owing to its high moisture content and short period for preservation, thus the agricultural products logistics need badly the green logistics
- Increment in processing. Increase in value, prolong the preservation, improving agricultural products added value are the indispensable parts of agricultural products logistics

Operation mode of agricultural products logistics: The present agricultural products logistics in our country is still on the initial stage, the circulation system is backward, As shown in Fig. 1, The broad lines is the main circulating mode.

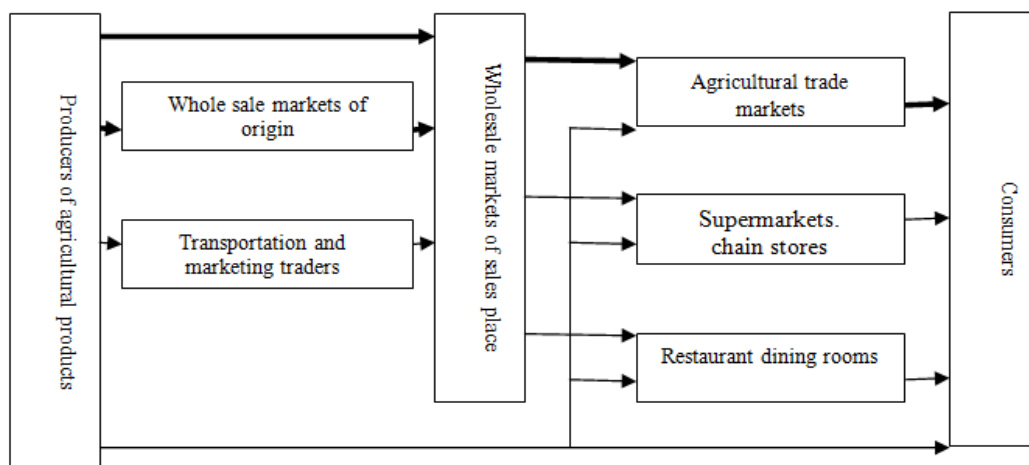


Fig. 1: The present operation mode for modern agricultural products logistics in China

Problems of agricultural products logistics: The existing problems of agricultural products logistics in our country now are mainly as follows.

Disconnection between production and demand: The production of agricultural products, for the most part, fail to get involved in agricultural products logistics and are forced to obey the middlemen or distributors, without accurate data of marketing prospect and demands, the initiative of farm is mainly based on the price once have, especially the previous year, such kind of production of agricultural products often cannot reflect the true demands of market, which cause the blindness of farmer production.

Excessive intermediate link: As shown in above figure, it is find to need several intermediate link, before it reaches the consumers, overmuch intermediate link and laggard trade mode have lowered the trade efficiency and increase the wasting of intermediate link, the unit price of agricultural products and the cost.

Low informationization: Most enterprises in our country now did not realize the significance of informationization to their self development and the units on agricultural products supply chain have no information platform for their information communication, which lead to a lack of necessary understanding between enterprises on the farm produce supply chain and the information of downriver and upriver cannot reach each other smoothly. As to the farmers, the uncertainty of demand information and uncontrollable intendency cause wide price fluctuation in the terminal market, which is detrimental to the equilibrium of supply and demand in agricultural products. For the consumer, the opacity of supply information result in the absence of thorough understanding to the product quality. It is for the same

reason, that the government suffers from inadequate supervisor and exorbitant cost.

Miniature logistics: Although the subject of logistics are pluralistic and large scalar, it is small in size and week in competition. Though the reform and open of several years, there are emerged a lot of subjects of agricultural products logistics, in addition to the traditional logistics such as, state business enterprise, suppliers and so on. There are also the great family of rural production and operation, the leading corporation of agriculture industrialization, professional association and professional logistic company, etc., from which we can see the subject of logistics are develop in the direction of diversification. The logistic corporation is in large quantities and develop in high speed, however; numerous participant individuals and organizations are small scale, discrete, low-organizational, lacking of competition. So it is difficult to deal with the impact from the market and large logistic corporation and let alone compete with large logistic MNC with advanced management and operation method.

Product quality lacking of whole process control: The internationally accepted concept of fully management from farm land to table is to take scientific and standardized quality management measures under the process of choosing, protecting and purifying the farm produce, using the inputs such as, feed, veterinary drugs, chemical fertilizer, agricultural machinery etc., application of normal production regulations, controlling the process and circulation, what 's more, the concept is also extended to the consuming process, holding the highest object of satisfying the ultimate product consumer. The quality supervision of agricultural products which is limited to certain processes, worked out badly due to the imperfection in management system, infrastructure and technical personnel. The case of milk powder is a case in point.

CONSTRUCTION OF THE MODERN AGRICULTURAL PRODUCTS LOGISTICS SUPPLY CHAIN MANAGEMENT MODE BASED ON IOT

Basic features of IOT: Based on Computer Internet, Internet of Things making use of Radio Frequency Identification and wireless data communication technique, constructs a network that cover with everything on the earth. In which things can hold communion with each other without manual intervention. The essence is auto recognizing merchandise and realizing interlink and wide share of information by using RFID. In the conception of IOT, normative and interoperability information are placed in RFIT tag and are acquired automatically to the centre information system though open computer Internet, thereby exchanging and sharing the information though the use of open computer Internet and implementing transparent management.

Mode construction: Centered on the core enterprise, the supply chain is a function nets chain structure that integrates suppliers, manufacturers, distributors, retailers and the final customers. By controlling information flow, logistics and capital flow, the supply chain starts from purchasing raw materials then makes intermediate products and final products and eventually sends product to target consumer via the sales Internet. Generally, the supply chain consists of four processes, materials circulation, commercial circulation, information circulation and cash flow, which have different functions and different circulation directions. To realize the minimum unit cost for agricultural

products from production to consumption and guarantee the products quality, it is required that all the nodal enterprises in the supply chain of agricultural products must operate synchronously and coordinately. Only in this way can all the enterprises be benefited. Therefore, the management of supply chain is based on smooth information flow, Supported by IOT and information technology, the logistics of modern logistics technology are important components of modern logistics system, through the IOT platform and information technology, farmers, suppliers, wholesaler, retailers and consumers are blinded together. The real-time tracking, effective control and whole-process management of each link in agricultural products' logistics are realized, with resources and information shared.

There is no doubt that "IOT" represents the direction of information revolution in the future, To improve the competitive ability of the agricultural products in our country, build famous brands, monitor their quality as well as security and increase farmers' income, our country should carry forward a reform of the traditional logistics management mode for agricultural products in advance and build a modern logistics supply chain management mode based on IOT. A SCOR mode for modern agricultural products based on IOT is presented in Fig. 2.

Advantages of the mode:

The transformation from passive production to active production of agricultural products: The initiative is mainly manifested in two aspects. On one side, the raw materials, technologies and equipments that are needed in the production of agricultural products can be timely and scientifically settled in the

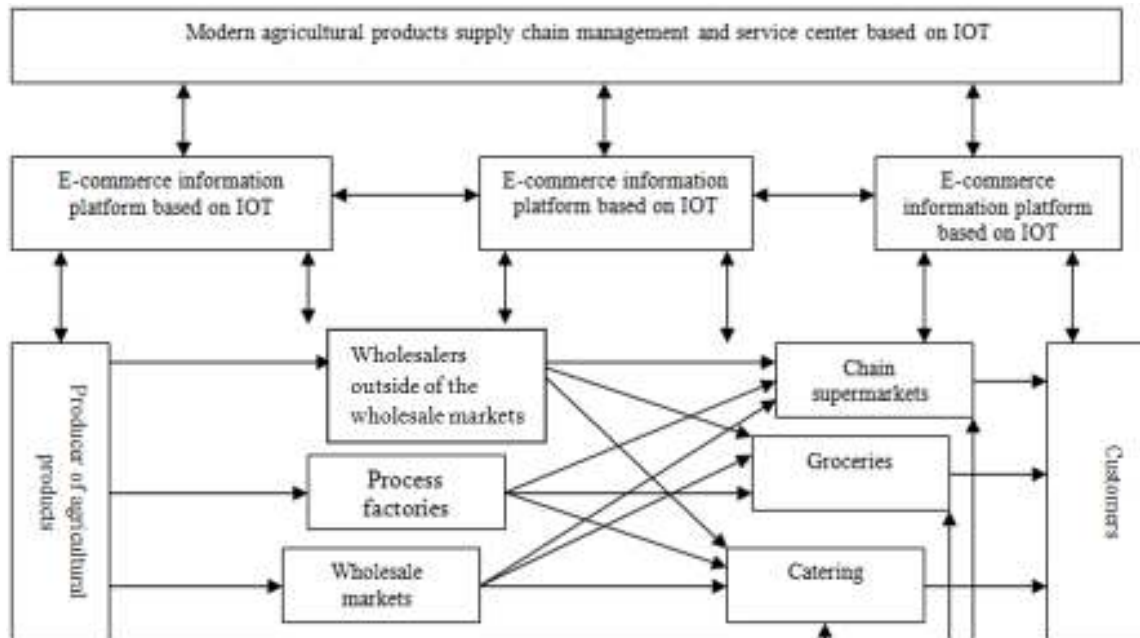


Fig. 2: The operation mode for modern agricultural products supply chain logistics based on IOT

"supply chain management and service center". On the other side, the output of agricultural products can be reasonably controlled according to previous sales data. Thus, the production mode of "manufacturing according to sale" for agricultural products can be realized.

Logistics distribution can be accomplished by the third party that is the specializing logistics company: With the step-by-step socialization and professionalization of modern logistics system, the third party logistics distribution center which is responsible for the logistics distribution of agricultural products supply chain has become the principal method for the logistics distribution for modern agricultural products. Through advanced management and technology, the logistics distribution center makes full use of the information provided by modern agricultural products supply chain management and services center, which makes the whole process of modern agricultural products circulation efficient, coordinate and orderly. Thus, the damage and cost are cut down and the optimum economic and social benefits are gained.

Lowering the dealing cost that occurs in the circulation process of agricultural products: Through coordinating the information flow of the supply chain for agricultural products, the dealing cost that occurs in the circulation process of agricultural products is cut down. By sharing information, each nodal enterprise in the supply chain for agricultural products collaboratively integrates in the whole circulation process and organizes logistics reasonably. Through the one-step check, damage caused by long logistics process of agricultural products is lowered. Besides, the professional third party logistics with rapid speed can help to curtail the distance travelled, shorten the production period of agricultural products, improve dealing efficiency and cut down logistic cost.

Realizing the whole-process management of agricultural products' quality: Modern agricultural products are marked by RFID labels with unique ID number from the first process of production, during the production process, all the correlating information is gathered and recorded. In addition, the related frequency chip management system is applied to deal with the information of producing agricultural products. Moreover, by making records in the whole growth process of individual agricultural product or that in the same lot, we can obtain the seeds needed in the production of agricultural products, information such as the raw materials demanded in growth process, state of illness and treating. Besides, the statistical analysis and management can be conducted. Meanwhile, in the process of transportation, manufacturing, storing and

sales, the whole-process information and intellect management can be realized just like that in the producing process and eventually we can make the whole process management of agricultural products' quality a reality.

THE APPLICATION OF SCOR MODEL IN PIG SUPPLY CHAIN MANAGEMENT

Lower cost, higher efficiency: Based on SCOR model, the pig supply chain management renders higher transparency to all links. Pig and its elaborated products can be traced in real time in the whole supply chain. As reader-writers are installed in breeding companies, slaughterhouses, distribution centre and store shelves, the flow of meat products in the whole supply chain—from breeding to ultimate consumers can be recorded automatically. Hence, lower bullwhip effect, less inventory cost as well as labor cost for logistics centres or distribution centres, higher utilization rate of inventory, more inventory turnover. Informatization, automation and intellectualization are achieved.

Information sharing, supply and demand balance: With the Information sharing mechanism, SCOR model enables all sectors of pork supply chain to check data read by RFID (Radio Frequency Identification) system. When there are inadequate or excessive products, suppliers can get demand Information from SCOR model, then adjust output and deliver goods on time, making the whole supply chain respond in time and avoid unnecessary loss. As the supply chain is able to perceive and response swiftly to the changing consumption direction, pork processors can timely improve or adjust production, distributor and retailers can reduce the amount of stock or stop stocking, thus balancing supply and demand, avoiding inventory backlog and maximizing profits.

Accurate and effective control of supply chain: Because of errors in bar code scanning while checking inventory of goods or artificial errors in identifying damaged bar codes, there are errors in about 30% of detailed lists of logistics management, leading to disrupted the flow of information and logistics and ultimate damage of the interests of merchants and consumers. SCOR mode can improve accuracy and speed of information identification and reduce errors in distribution, storage and transportation of products. Monitoring is conducted in the whole process from breeding, pigs available for slaughter, processed products referrals, in and out of the distributor's warehouse to sales of retailers. Distributors can monitor and control stock and keep reasonable stock levels while retailers are able to monitor sales allowance and replenish goods.

Food safety and recall management: Since food safety has been given priority by government, enterprises and consumers, a traceable information carrier in food supply chain management is needed to present the information about food safety. With the use of Internet of Things technology in pork supply chain, enterprises of breeding and processing can establish effective recall management system and provide information about farms, processors and dates of pork and its processed products to downstream distributors, retailers and consumers. Relevant information can be found through SCOR model with code of RFID of each piece of pork product. Consumers, as buyers and eaters of pork products, can also send the code of RFID to notified bodies to inquire related information, which facilitates the protection of personal health and consumer rights.

To improve the pig supply chain security management:

Building platform for supply chain information to ensure pig supply quality and safety: According to the characteristics of different pig in the supply chain, we have to collect, transmit and deal with information in the course of breeding, production and processing, transportation, storage, sales and other courses and then build fresh pig and pig packaging two traceability information systems. On this basis, we can set up public information platform for pig quality and safety of supply chain based on supply chain integration, realizing traceability regulation for the whole process of food supply chain operation and synchronous information flow, goods flow, workflow among different departments and information sharing, which improve the pertinence and effectiveness of the pig safety management work. Therefore, on one hand, the workload of human input related regulatory data can be decreased and the traceability of product can be ensured, which can improve the quality of the product safety, upgrade the technological content of the enterprise and brand value; On the other hand, supervision efficiency can be enhanced and costs can be reduced, which can ensure the health and safety of food supply.

Building modern pig distribution center: Pig logistics distribution centre is one of the important control nodes for the supply chain of pig quality and safety. First, we can do centralized management for pig in the logistics distribution centre and realize unified procurement, reprocessing and distribution, ensuring the quality and hygiene of pig and safety control for pig; Secondly, we can construct socialized and specialized pig logistics service system and set up professional third party pig logistics enterprises to prevent pig rot and pollution in the process of transportation; Finally, pig logistics distribution centre can put forward reward mechanism for downstream

production operators and give punishment to enterprises with unsafe factors, so as to improve the quality and safety level of production operators.

Strengthening management of pig safety standard:

In recent years, all kinds of pig safety problems are repeatedly appeared both at home and abroad, these problems make consumers lose confidence in pig safety. To this end, we should establish strict, advanced, more scientific system of quality standards. On this issue, we can draw lessons from some western developed countries on quality standards and pig safety control system. Such as EU countries, the EU's quality standards and pig safety control systems have several kinds, some have international standard (such as ISO 9000 series, namely, the international organization for standardization specified pig quality assurance standards), the European Union standard (such as HACCP, namely pig hazard analysis and critical point control), the national standard (such as the BRC, British retailers organized technical standards), the industry standard (such as EUR/GAP, namely the European retailers coalition/high quality agricultural standards). These four categories have different applicable objects and scope without conflicts. Among them, the HACCP system is considered as the most effective way to guarantee pig safety.

Strengthening emergency management and building fast recovery path for harmful pig:

For major pig safety accidents, we shall establish and perfect efficient rescue system and operational mechanism, to standardize and guide the emergency response work and minimize the harm brought by accident, protect public health and life security, maintain social stability. Improve the harmful pig rapidly recycling channel. Once harmful pig is found, the pig supply chain players should be initiative to take responsibility, to recall harmful pig with the fastest speed, reducing losses to the minimum. They should never be like "San lu milk powder" incident. They have to set up the threshold of return. Consumers can handle the return of good only with invoice. Those people who haven't reserve invoices or throw about the harmful milk powder, may cause further environmental pollution.

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