Chapter 8

Supply Chain Innovation with IoT

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Additional information is available at the end of the chapter

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Abstract

In this chapter, we first describe and analyze the evolution of supply chain and the history of IoT technologies' development briefly. And then, we conduct a systematic research on the characteristics of supply chain system in IoT context and analyze how to realize the innovation of supply chain system in IoT context in detail, and on this basis, we propose the architecture of cold chain traceability system. Furthermore, through the decision-making process model for supply chain disruption and establishment of knowledge management system in IoT environment, the competences needed for improving supply chain resilience is reinforced. In the end, a case study is conducted to illustrate the availability and robustness of traceability system in the food supply chan.

Keywords: supply chain innovation, IoT, decision-making process model, traceability system, cold chain

1. Introduction

One obvious characteristic of contemporary social and economic development is the competition, being more intense, and the development of technological progress, being more rapid, prompting enterprises to make a series of changes in the field of logistics and purchasing and more companies to adopt the thoughts and methods of supply chain management (SCM), which not only can reduce the operating costs of enterprises, raise the speed of response to market demand, but also can improve the competitiveness of enterprises in market competition. Nevertheless, there are still certain issues of concern in the operation of supply chain management, such as the low level of intelligentization of SCM, poor visual management, high degree of uncertainty, low automation of certain industries, frequent manual errors, serious industry losses, difficulties in tracing products after sales, etc. The research and development of Internet of Things (IoT) bring new opportunities to the innovation of SCM.

After the advent of computer, Internet, and mobile communications, IoT is another revolutionary development of information industry. From perceptual layer, network layer to application layer, IoT involves a wide range of fields including standards, core technologies, and products, as well as the integration and collaboration among various technologies, systems, products, networks, and applications. With its long industrial chain and wide application, it is indeed omnipresent and all embracing. Therefore, research of IoT has been highlighted in recent years, and its related research and development have also drawn great attention of a variety of countries.

1.1. Research of IoT

In 2005, in "ITU Internet Report 2005: Internet of Things" released by International Telecommunication Union, the concept of Internet of Things is mentioned [1]. According to the report, goal of information and communication technology has developed from connecting anyone with anytime and anywhere to the phase of connecting anything, and the connection of everything forms Internet of Things. In September 2009, the EU Group released the "IoT Strategic Research Roadmap," which considers Internet of Things as an integral part of the future Internet [2]. In 2011, in "Building the Internet of Things using RFID: The RFID ecosystem experience," Welbourne Evan proposed the idea of establishing IoT through RFID, pointing out the importance of RFID in constructing IoT [3].

In 2014, when energy crisis being more and more severe, Roselli explored how to apply IoT technology in the field of energy and develop RFID technology, wireless power transmission, and green electronic products to conserve energy, this can be also referred to in the application of IoT technology in other fields [4]. As network technologies are being applied in more and more ranges, through comparing the security of IoT with traditional network, Jing makes an exploratory analysis on solutions to security issues of IoT, and at the same time, warns the applications of IoT technology, emphasizing that security issues and problems of IoT technology should also be focused [5].

1.2. The evolution of supply chain

The development process of supply chain concept has gone through three phases, which are logistics management phase, value chain phase, and supply chain network phase (see **Figure 1**). With the changes of supply and demand context and continuous advance of information technology, emphasis of supply chain concept has been varied at different stages, and this concept is gradually improved. As shown in **Figure 1**, in this chapter, we use the definition of supply chain network phase, defining supply chain as a value added chain that comprises all the participating node enterprises in supply chain, starting from the supply of raw materials, the manufacturing process, product sales, and to end users. Logistics, information flow, and cash flow are all covered [6].

SCM is to use integrated resource integration concept, advanced information technology, and control technology to manage and coordinate the supply chain network commencing from original supplier to ultimate customer so as to satisfy supply chain members, enhance the efficiency of the whole supply chain, follow the cost-effectiveness principle to the greatest extent, and meet customer demands.

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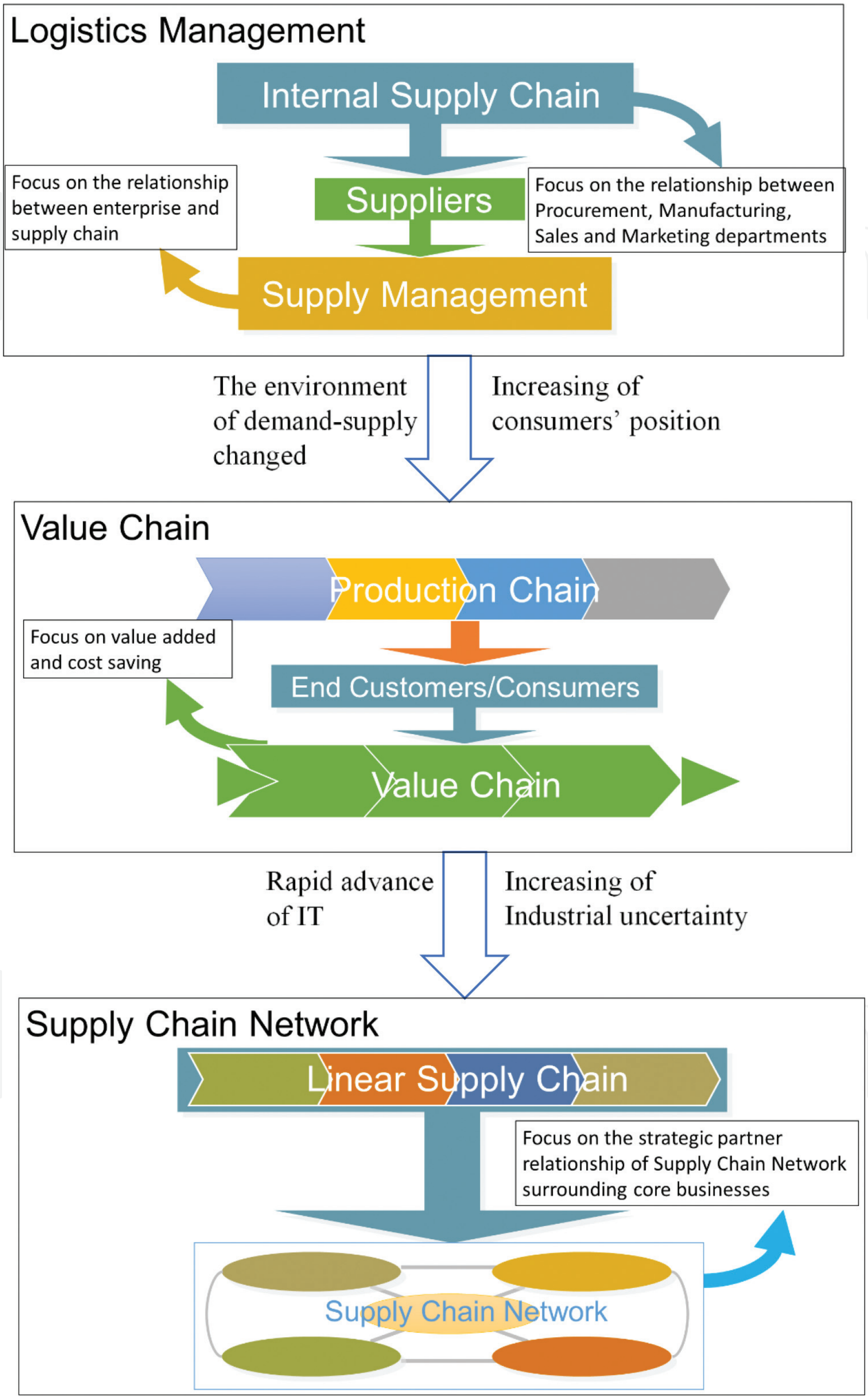

Figure 1. Three phases of supply chain evolution.

The rapid development of new technologies and the emergence of Internet-based e-commerce vitalize supply chain. Enterprises in supply chain start to focus on the improvement of overall performance of the entire supply chain so as to actualize close coordination and seamless connection of node enterprises. With its characteristic endowed by information age, this supply chain enhances the coordination level of supply chain, thereby so-called “collaborative supply chain management” is also paid attention recently [7].

Collaborative supply chain model synthesizes the theoretical research results generated since the birth of the concept of supply chain, and comprehensively reveals the network chain function of supply chain, which comprises all the aspects of product production, including the procurement of raw materials, production and processing, logistics, and sales. The model is an integrated supply chain that manages the synergy of multiple companies.

2. Characteristics of supply chain system in IoT context

IoT, which is also called the third wave of information technology, has induced various new opportunities and changes to SCM and a variety of industries. In especial, it boosts the extension of the function of supply chain; specifically speaking, it provides technical support for enhancing the visualization and stability of supply chain and realizing intelligent management of supply chain.

2.1. Enhancing the visualization of supply chain

One of the main goals of IoT is to improve human perception ability and intelligent processing ability. IoT is able to provide the connection of various objects at any time and any place, and also the status and related information of any object at any time and any location. The perception layer, as the foundation of Inter of Things, is also the basis of IoT-based SCM system in IoT context. For the agricultural supply chain, the introduction of IoT technology intellectual brings new opportunities and changes to intelligent agriculture.

The adoption of RFID tags, wireless sensors, and transmission equipment enables the tracing and visual digital management of single or packaged agricultural products and food. Throughout the entire process, from the production of agricultural products and food to sales, in detail, from the production site to warehouses, from warehouses to tables, intelligent management is able to monitor and realize the digitized and visualized logistics and management of agricultural products and food, improving their quality [8]. In terms of retail supply chain, the application of RFID technology and wireless sensors can provide accurate information regarding the variety, quantity, customer, location, and other related details of products to decision makers in supply chain, enhancing the level of transparency, and visualization throughout the entire process, and more importantly, the whole supply chain (see **Figure 2**). Decision-making entities are able to be aware of the real-time operation progress and make better coordination; accordingly, the efficiency of supply chain is raised to a great extent.

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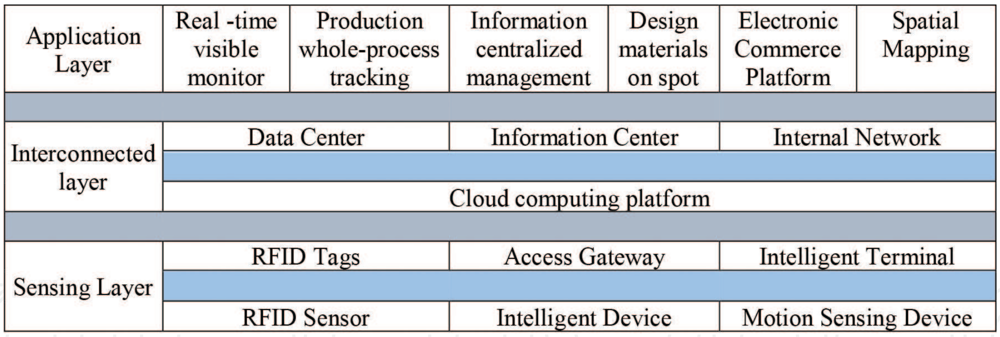

Figure 2. Layer architecture of supply chain system in IoT context.

2.2. Enhancing the robustness of supply chains

Enhancing the robustness of supply chains and lessening the uncertainty of supply chain is one of the important factors to be considered in the establishment of supply chain system [9]. The advent and the development of IoT technology assist in enhancing the robustness of supply chain and lessening its uncertainty. Based on IoT technology, decision-making entities in supply chain can dig and gather data with more accuracy and obtain more precise information, shortening the lead time of expected demand for products or inventory.

At the same time, the application of IoT technology also provides information sharing mechanism to decision-making entities in supply chain, thereby minimizing the bullwhip effect and uncertainty of supply chain, enhancing the robustness of supply chains. In the IoT context, applying IoT technology can make real-time monitoring and decision-making of the whole supply chain throughout the process of supply chains, meanwhile, precise management of the quantity, variety, quality, and batch information of raw materials can be also realized, with accurate information regarding the storage location of raw materials or spare parts being provided. Accordingly, timely replenishment of inventory is performed; hence, shortening of production cycle, decrease of cost, inventory, capital occupation, and eventually supply chain uncertainty can be realized.

Warehouse management plays an important role in supply chains. With the application of IoT technology, the management process of warehouse is simplified. The collection process of information including warehousing, storage location, and quantity is prompt, accurate, and complete, reflecting the real-time inventory status. Furthermore, with the correspondent improvement of space utilization and decrease of cost, management efficiency is raised, thereby the robustness of supply chains is enhanced.

2.3. Realizing supply chain intelligent management

The realization of supply chain intelligent management is an important subject of the supply chain system based on IoT and one of the major changes in supply chain function. To realize the intelligent management of IoT, intelligent platform, which is based on IoT, is significant. The development of IoT technology provides technical support for intelligent management of supply chain. Perception layer is the foundation of IoT. Through the sensor devices of perception layer, the IoT-based supply chain system can continuously obtain information of nodes in supply chain, and dig, classify, integrate, and store relevant data with IoT data processing technology [10]. Eventually, extract useful knowledge and provide timely information regarding supply chain operation status and tendency, and hence realize intelligent decision-making.

First of all, through the installation and application of a variety of sensing devices (such as RFID, sensors, etc.), real-time supply chain operation status can be sensed; when the environment changes, sensed information can be provided to supply chain system timely. Second, the development of wired and wireless network technologies and their integration with internet technologies link the various modules in supply chain system, laying the foundation for prompt and secure transmission of information. Third, the further development of mass data storage technology, data fusion technology, and data mining technology of IoT creates favorable conditions for the development of intelligent decision-making and intelligent control technology, and has turned into an effective guarantee for intelligent management of supply chain. Enhancing the visualization and robustness of supply chain and realizing the intelligent management of supply chain are significant improvements that differentiate supply chain system based on the IoT from traditional supply chain system.

3. Innovation of supply chain system in IoT context

Innovation of supply chain system under the IoT context mainly includes two aspects: innovation of supply chain function and innovation of supply chain process. Along with the continuous development of IoT technology, the function of IoT-based supply chain system has transformed significantly.

In detail, the main functions of traditional supply chain include planning, organizing, coordinating, control, etc. In the context of the IoT, the functions adjust accordingly. In correspondence with this change, supply chain process also needs to adjust. In general, supply chain processes include procurement, production and processing, logistics, sales, and after-sales service process, which also need to be improved accordingly.

3.1. Innovation of supply chain functions in IoT context

3.1.1. Innovations in the planning function

Planning is the basis for the determination of organizational goals. To achieve the goal of supply chain in the context of IoT, in detail, and to improve the level of visualization, transparency, and stability of supply chain, the planning function must be adjusted. In the context of IoT, the application of sensing devices, such as RFID tags and wireless sensors, the integration and adoption of wired and wireless technology and Internet, and the advancement of mass data mining technology can provide information for planning with better precision and speed, thus greatly improving the accuracy of planning.

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On the other hand, the advent of big data perplexes the internal and external environment of supply chain system, greatly amplifying the difficulty in making medium and long-term plan for decision makers in supply chain, decreasing the robustness of supply chain. Accordingly, the planning function needs to be adjusted. In the first place, it is imperative that relevant decision makers in supply chain possess good foreseeability for the development of IoT technology and seize development tendency of IoT accurately. Second, decision makers in supply chain need to dig and collect information to the utmost, so the medium- and long-term plan can be in accordance with the ever developing IoT technology.

3.1.2. Innovation of organizing function

Traditional organizing functions are mainly performed through oral form, written form, telephone, etc. With IoT technology, a variety of new forms can be adopted. For example, with the development of artificial intelligence technology, intelligent robots, as a new type of workforce, are quietly affecting and changing the labor working pattern in manufacturing. The current people-orientated production system will gradually be replaced by intelligent robot-orientated system, which has attracted extensive attention with its advantages such as high efficiency and low cost.

Pattern of this new system transfers from the traditional people-oriented pattern to a new one, which is orientated by intelligent machine, predominantly, and supplemented by manual operation. In the meantime, in the traditional context, organizing function is mainly exerted through the communication or information change among people. While in the context of IoT, the exertion of organizing function not only involves the organizational relationship among people, but also includes the cooperation between people and machines and the coordination of machines. In this way, we can realize the transformation of supply chain functions in the context of IoT.

3.1.3. Innovations of coordinating function

Coordinating function is to promote the consistency of operations through the negotiation and cooperation of all the objects in organization. The fundamental goal of supply chain is to maximize the benefit of the entire chain. Nevertheless, in supply chains, there are always certain conflicts of interests among members of supply chain, impeding the realization of the fundamental goal of supply chains.

According to some scholars, adopting appropriate mechanism design to solve problems, such as asymmetric of information and irrationality of cooperation mechanism among supply chain members, is significant in the realization of fundamental goal of supply chain. IoT technology provide technical support for the maximization of the benefit of the entire supply chain, realizing visual management, and intelligent management throughout the entire supply chain and enhancing the transparency of supply chain, and enabling information sharing among members of supply chain. Accordingly, the resolution of conflicts among the members in supply chain is greatly eased.

Meanwhile, the application of IoT technology also leads to new problems and conflicts of interests among the members of supply chain. For example, uneven investment cost on IoT from decision makers in supply chain, hidden security problems, and issues related privacy protection, which entail ceaseless coordination among members in supply chain and better mechanism design, so the new problem and conflicts of interest appearing in the process of supply chain can be resolved.

3.1.4. Innovations of control function

The essence of control function is to make comparison on the basis of the implementation results with the intended objectives, and then make correspondent adjustments in the light of feedback results continuously. The advent and development of IoT enable the intelligent control, automatic control, and precise control of supply chain. For instance, in the emergency handling system of IoT, robots handling nuclear leakage on site enter designated locations according to instructions, measure parameters related to nuclear leakage through the sensors, and transmit the data to command center. This example indicates that IoT technology has realized extreme perception and control over system processing, providing potent technical support for intelligent control, automatic control, and precise control.

3.2. Innovation of supply chain process in IoT context

In the context of the IoT, with the application of IoT technology (such as RFID, sensor, etc.), accurate information of the whole process including procurement, logistics, production and processing, sales, and after-sales services of goods can be obtained. Meanwhile, cost of procurement, production, storage, and transport and the waste aroused from the procedure can be minimized. The entire logistics process is precisely controlled by information flow. Accordingly, efficiency and profits are maximized.

3.2.1. Innovations in procurement

With IoT technology, intelligent procurement can be realized. In detail, with the acquisition of real-time and accurate delivery information, the waste of fund and time that may result in procurement is greatly decreased, and the stability of procurement is dramatically raised. For example, RFID system can manage the delivery quantity, model, and information of quality provided by raw material suppliers or parts suppliers, and can precisely manage the variety, model number, and batch and production date of raw materials or components. So, replenishment can be conducted in time, and overstock and cash-flow problems are effectively averted.

3.2.2. Innovations in logistics

With the application of IoT, logistics section has changed from the traditional one to intelligent logistics. Basically, the characteristics of intelligent logistics are precise, coordinated, and intelligent. Adopting IoT technology can realize real-time monitoring of the entire process and timely decision-making, inducing the automation and intelligentization of the whole operation process that concludes from procurement, production, and transportation of raw materials.

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Monitoring of warehousing, transfer, distribution, and transportation is actualized through IoT technology. Accordingly, logistics costs such as inventory and transportation, costs are minimized, and waste in links is diminished to a great extent. There is no doubt that the adoption of information streams precisely control the logistics process, thereby maximizing the profit.

3.2.3. Innovations in production and processing

Innovations in this process are mainly reflected in the management of manufacturing equipment, personnel, etc., by means of automatic acquisition technology and intelligent processing technology. Consequently, automation, intelligence, and transparency of production and processing are realized. Especially, in the case of operation of special materials, real-time tracing, and inspecting on operations in extraordinary circumstances. IoT technology enables more precise operation on special materials; while in the meantime, reduces manual errors. And in extraordinary and harsh production and processing circumstances, IoT technology can automate and intelligentize the process, decreasing the hazard caused by manual operations.

In addition, IoT technology allows intelligent and transparent production and real-time monitor on manufacturing information at key positions. Once there is flaw or problem at key position, correction can be made promptly, thereby ensuring product quality.

With the raise of product variety, quantity, and circulation speed, instead of depending on how many goods are stacked, storage efficiency is mainly dependent on precisely seizing the variety, quantity, customer, and stored location information of the stock. IoT technology not only raises the speed of warehousing, delivery of cargo from storage and stock count, but also enhances the level of transparency and visualization of the entire cargo movement process, diminishing or even averting errors in operation, and realizing efficient utilization of storage space, thereby decreasing the cost of storage management and improving the efficiency of storage.

3.2.4. Innovations in sales and marketing

Adopting IoT technology into sales process provides customers with convenient and unusual services. Customers can scan the barcode on shopping cart with their mobile phone to find out the store they are in. Furthermore, they can check the store map and search the products they want with mobile phone.

The application of IoT technology in sales also leads to the emergence of various checkout methods. In detail, cashier can use smart cash register for checkout, and instead of checking and scanning goods one by one for settlement, RFID reader can quickly and automatically read and display the total price of the goods in smart shopping cart. Payment methods for customers to choose from include cash payment, bank card payment, check payment, mobile payment, fingerprint payment, and others. Obviously, automated or intelligent transactions reduce the occurrence of manual errors and related transactional problems. In the meantime, loss of goods that caused by theft etc., can be also reduced; in accordance with it, retail consumption rate is greatly decreased.

3.2.5. Innovations in after-sales service

The adoption of IoT technology in after-sales part contributes to better services provision of enterprises, assists in government regulation, and guarantees the protection of consumers' interests. On one hand, with the information recorded in RFID tag, enterprise can search sold products' manufacturing information such as its time of production, operator, inspector, batch number, serial numbers, etc., so as to resolve after-sale problems and provide better service to customers.

On the other hand, the application of IoT technology guarantees the establishment of a robust product tracing system, which traces from top to bottom. In detail, tracing along raw material suppliers, production and processing companies, logistics companies, vendors or retailers, and finally, the customers. Once problem occurs, problematic link can be found out timely. Government can also perform better regulation. If a consumer purchases defective products, tracing from bottom to top will be conducted for the protection of consumer rights and interests.

3.3. Innovation of supply chain resilience in IoT context

In 2011, Thailand suffered a severe flooding which occurs once in 50 years. Its traditional industrial base—Ayutthaya Industrial Park—was flooded, and nearly 200 factories were closed down. In the same year, Japan's 311 Kanto Earthquake also caused serious losses to the manufacturing industry and numerous supply chain companies in Japan. And recently, scandals involving data falsification in automotive, steel, and carbon fiber have caused great impact on a large number of related supply chain companies, and they are faced with the dilemma of supply chain disruption. In China, Sanlu Milk Powder Incident and Shanghai Fuxi Incident caused by the fact that information on manufacturer's irregular and unethical behavior was not shared with other enterprises in the supply chain in time, giving rise to serious losses to supply chain companies and leading to public's distrust.

In this context, establishing an IoT-based knowledge management system across the supply chain is most essential for improving supply chain resilience. In the following part, adopting a series of procedures undertaken by a supply chain firm of electronic industry when knowledge management system of contingency is started as instance, I briefly introduce in decision-making procedure of different levels, how knowledge management system of contingency operates and supports prompt and accurate decision-making for enterprises when contingency occurs (see **Figure 3**).

3.3.1. Innovations in decision-making process for supply chain disruption

First, according to overall Phronesis of organization proposed by Nonaka, when emergency occurs, knowledge management system of contingency should be launched in different levels of organization [11].

After the occurrence of emergency in Field site phase, staff should go to the scent to investigate and find out the loss, and transfer first-hand data promptly to the administrative phase of the

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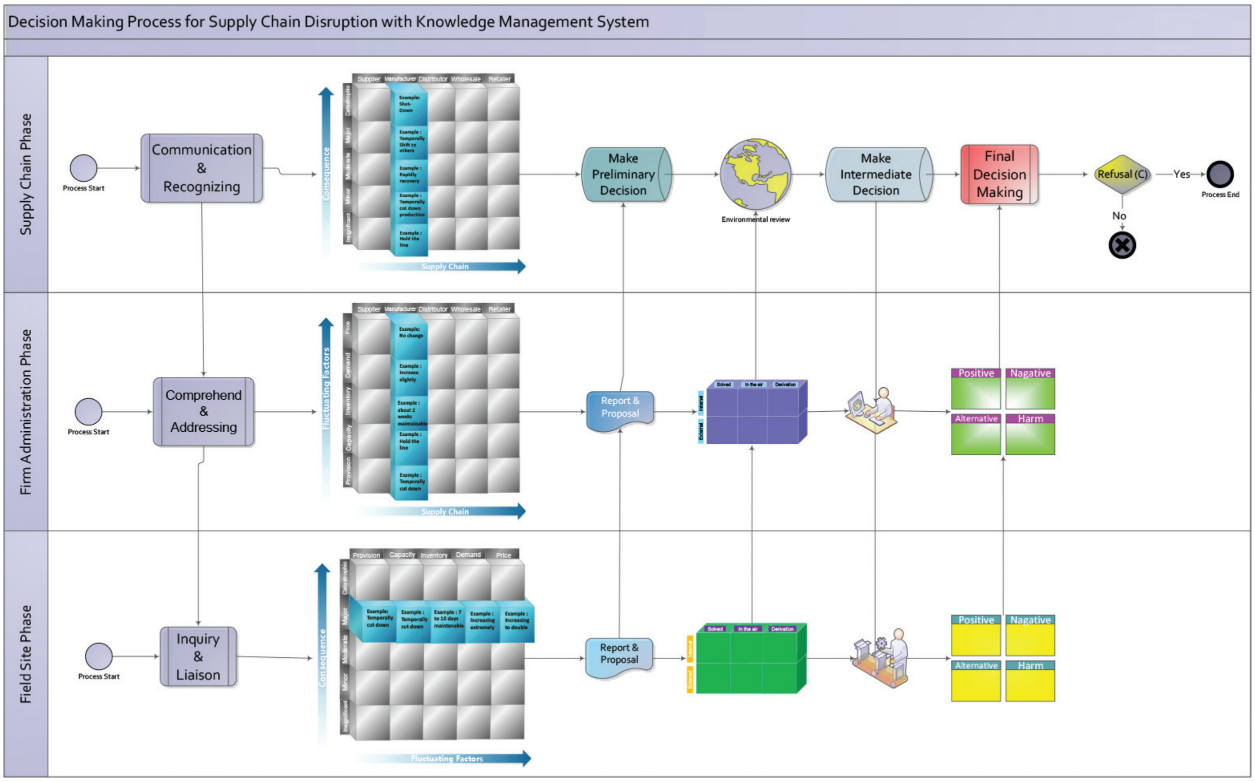

Figure 3. Decision-making process for supply chain disruption.

firm. And after receiving on-site report and being aware of the situation, managers of the administrative phase must manage to resolve the trickiest problems.

On the other hand, the main function of supply chain phase is to actively share first-hand and primary information from the scene. And, in the ever-changing surrounding, recognize the overall situation and make integrated and appropriate arrangement.

3.3.2. Emergency knowledge base system

Nevertheless, to realize the above-mentioned, with the grasp of current situation and swift imagination is far from enough. What we have to establish in advance includes a knowledge base for emergency management (see **Figure 4**).

In this base, previous unexpected incidents and solutions for contingency are stored. For instance, in correspondence with the need of on-site staff, knowledge base can comprehend previous changes of various key factors (provision, capacity, inventory, demand, and price) in different periods through the criticality of incidents (insignificant, minor, moderate, major, and catastrophic). With searching and referring to experience and data, on-site staff can find out the key of problem and make more appropriate predictions.

After making the preliminary decision, various phases successively transfer unsolved problems, make immediate report, and share of problems in the air and problems of derivation. With the summary of entire supply chain and change factors of surroundings and market, intermediate decision is made. Finally, through the conduction of various phases, we

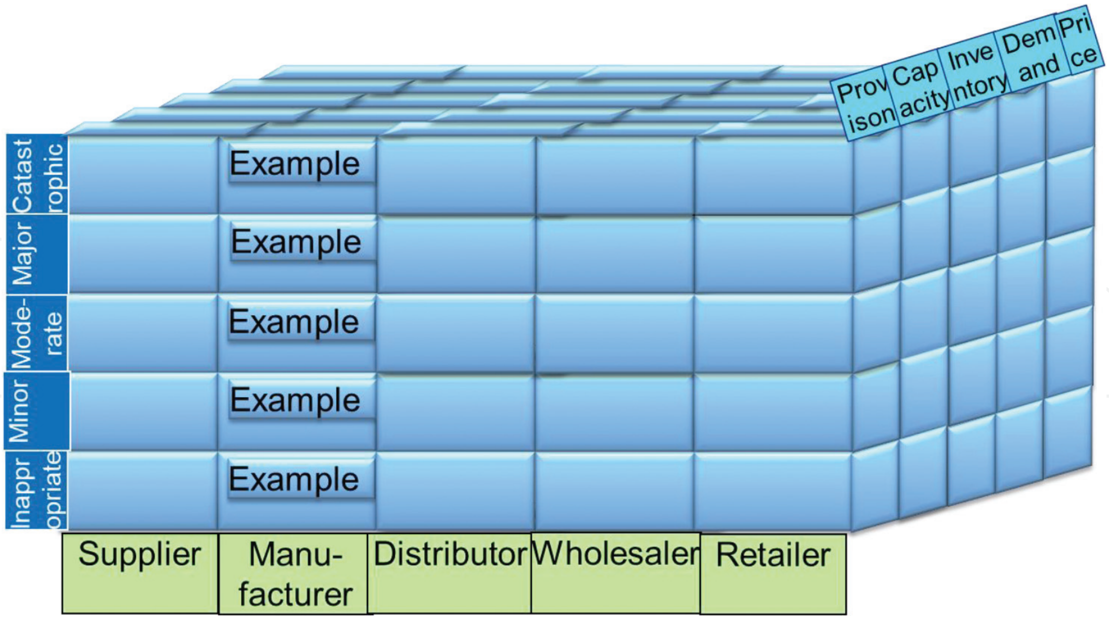

Figure 4. Conceptual scheme of the resilient knowledge-based system.

comprehend and summarize positive, negative, alternative, and harm points, accordingly, the final decision is made.

4. IoT-based food supply chain innovation

The prospect of IoT technology in agricultural industry is extensive. In recent years, IoT and big data has become the pillar of smart agriculture. The application of IoT technology improves the visualization and transparency of food supply chain, reducing the uncertainty of supply chain. Consequently, intelligent degree of supply chains is enhanced.

Food safety has become an issue concerned by the public. Due to the characteristics of fresh food, various chemical and physical changes occur during its circulation process, and any problem in the process may incur issue of food safety. Therefore, one of the most important conditions for ensuring quality and safety of fresh food is to construct a cold chain traceability system.

4.1. Implementation of cold chain traceability system

Cold chain is a special food supply chain, in which temperature is always under control throughout the process from raw materials and resources acquisition, storage, transportation, processing to product sales, and consumption so as to make sure food safety [12, 13]. Food supply chain aims at global resource and raw materials acquisition, global manufacturing, and global sales. Therefore, the carrier of the information must also be globalized (see **Figure 5**).

A set of internationally uniform tracing codes are imperative for food supply and demand network. If all the cold chain enterprises joining in food supply and demand network adopt this set of codes, communication among these enterprises will become smoother, contradictions

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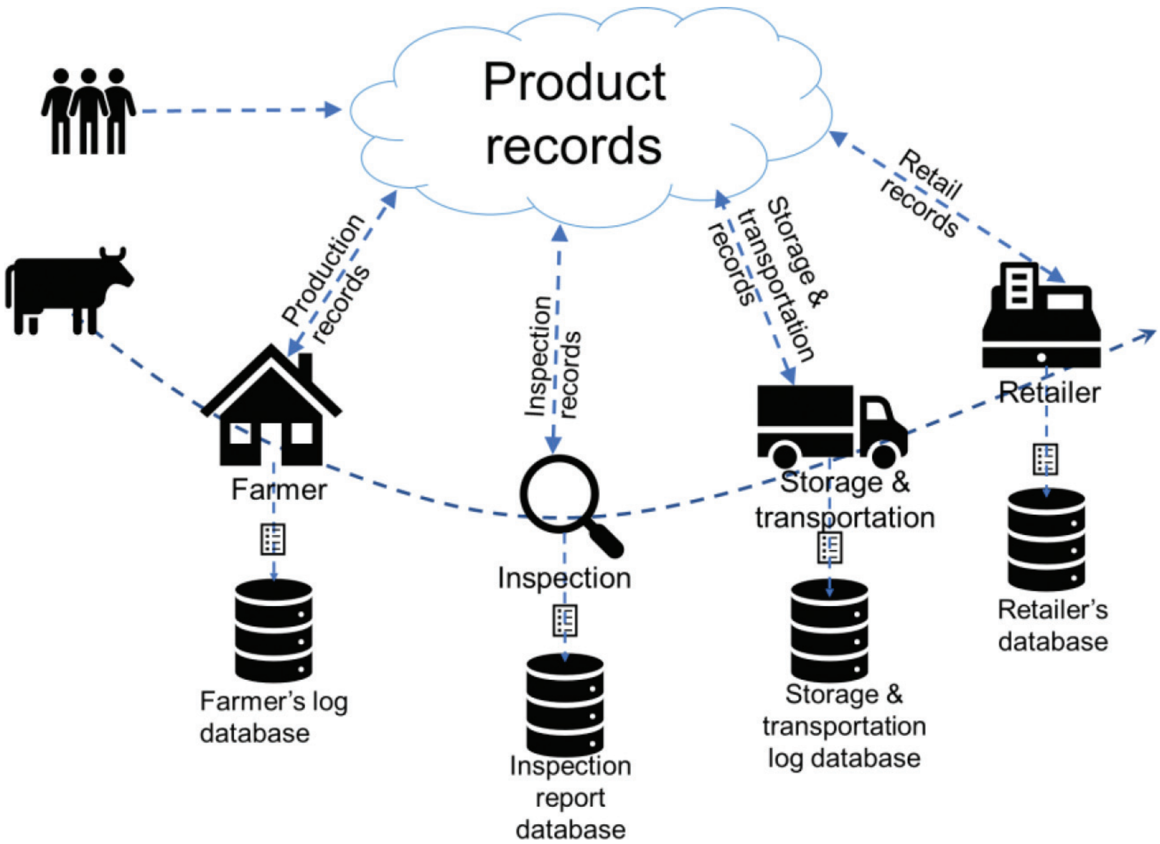

Figure 5. An architecture of cold chain traceability system.

caused by different standards will be reduced; accordingly, tracing efficiency can be improved and tracing cost can be decreased, which also reflects the connectivity and openness of food supply and demand network.

4.1.1. Information system of cold chain traceability system

The establishment of cold chain traceability system is systematical, requiring the integration of information from all the enterprises in cold chain. In this complicated system, information regarding the producers and suppliers of raw materials, producing process, logistics, and consumers are all concluded.

For alliance enterprises in food supply chain, all product information for a single firm is stored in the firm's information system. Moreover, a public cold chain data platform is built for information sharing in the alliance. Once a problem occurs in one enterprise, the source of the problem can be tracked through product information. Meanwhile, other alliance companies can also track the product information to assist the problematic company.

4.1.2. Information system of cold chain traceability system

In food supply chain, a node is an enterprise. Enterprises are connected to each other, representing food supply chain network. Once a part of the supply chain is disconnected, it can be linked through other companies, reflecting the dynamic stability of food supply chain.

What circulate in the circulation line is not only objects, but also the technology, capital, information, management, and human resources, reflecting the versatility of food supply chain. Enterprises of all sizes are welcomed in this network, so the resources will be more abundant and the structure will be more stable, which reflects the openness of food supply chain.

4.2. A case study of cold chain

4.2.1. Cold chain of Xianyi supply chain

Founded in April 2009, Henan Xianyi Supply Chain Co. Ltd., is a temperature control supply chain company in China. Its main business scope include: logistics services, freight forwarding, transit of goods, general cargo, and special transport of goods (containers and refrigeration). In recent years, as the cold chain market evolves continuously, accordingly, the consumers' demand for cold chain products and quality requirement for cold and fresh products also expand constantly. On the other hand, when Xianyi reviews the implementation of China's traceable cold chain system, they find out three main problems: First, information is broken and asymmetric. Second, standards for cold chain are not uniform, with industry standards playing main role, and regulations and constraints are insufficient. Third, cost of traceability is too high. Small and medium enterprises cannot afford the expensive logistics costs, while logistics resources of leading enterprise are vacant in the meantime (see **Figure 6**).

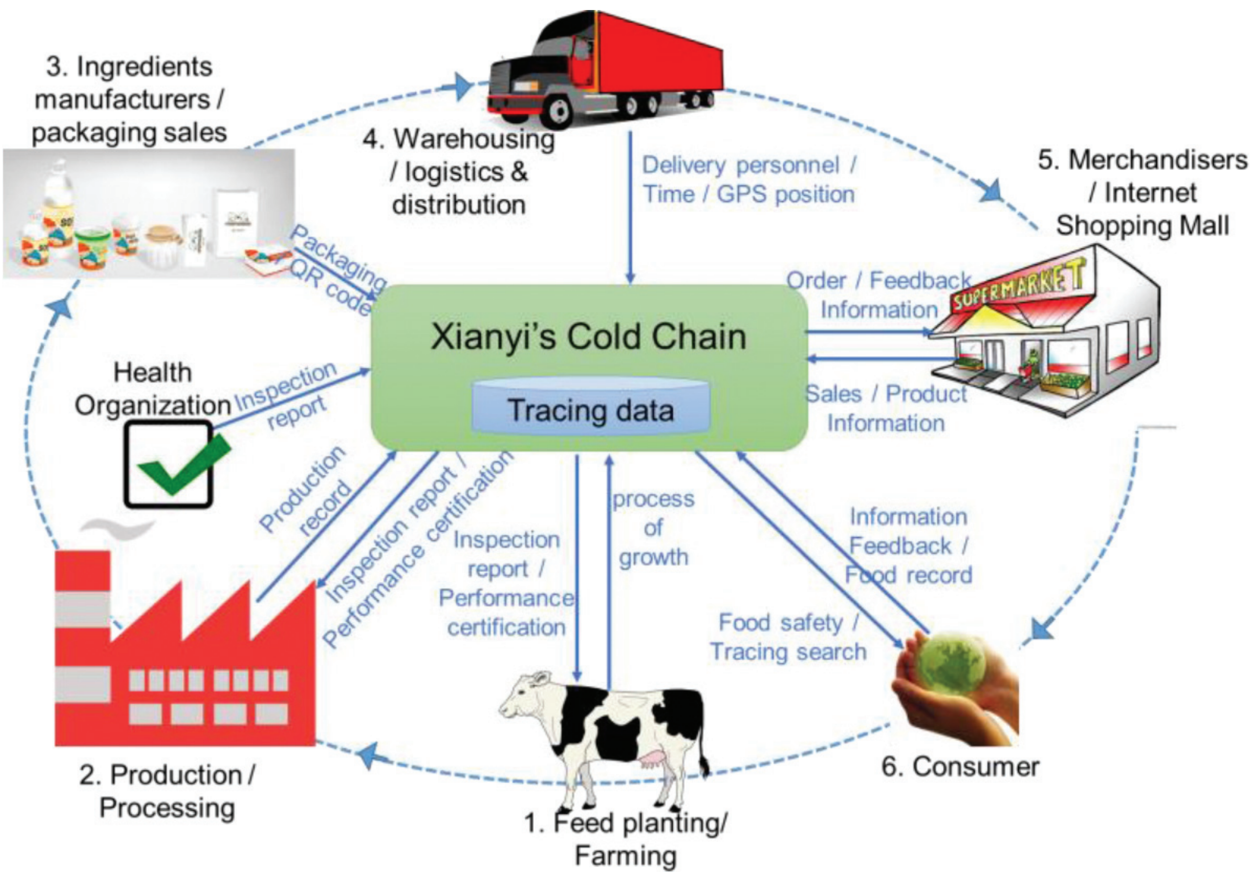

Figure 6. Cold chain of Xianyi supply chain.

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4.2.2. Building smart food supply chain

Xianyi supply chain, which has committed to cold chain logistics for years, with its whole chain and networked temperature control supply chain service system building in the country, accurately capture the demands of various clients and provide customized supply chain service solutions for clients from industrial channels, supermarket channels, food and beverage channels, e-commerce channels, and import channels. With its pointed assistance for customers to optimize their supply chains, efficiency and added value are both enhanced.

With the frequent releases of national policies and the consumers' growing demand for high quality fresh products, Xianyi supply chain actualizes traceable food supply chain service and temperature control visualization of the whole process through in-depth integration of IoT and PaaS information service platform. The company has built a scientific operation management system, established a smart storage and transport system, applied IoT technologies such as RFID tag, GPS, temperature sensor, and driver application to timely monitor the status of fresh products in circulation, including temperature, cargo status and GPS positioning information, food status, and quality information.

5. Conclusions

In this paper, we first describe and analyze the evolution of supply chain and the history of IoT technologies' development briefly. And then, we conduct a systematic research on the characteristics of supply chain system in IoT context and analyze how to realize the innovation of supply chain system in IoT context in detail. And on this basis, we propose an architecture of cold chain traceability system. Moreover, a case study is conducted to illustrate the availability and robustness of traceability system in the food supply chan.

Furthermore, through the depiction and analysis of the decision-making model of how supply chain firms adopt knowledge management system of contingency to make appropriate correspondences when unexpected incidents occur. In this system, knowledge database is the key of contingency management of firms in IoT environment. Therefore, it is necessary to update and improve it unceasingly, and we also need to activate related links and staff of supply chain in share and inspiration so as to truly enhance the key capabilities of supply chain resilience.

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