

# Research on the Security of Cold-Chain Logistics

Guojun Ji, Rong Guo

**Abstract**—In this paper, the definition of cold-chain logistics and security features are analyzed. Based on overview of China's cold-chain logistics, cold chain, through the status quo at home and abroad contrast, we present some of China's food chain problems. With security control system of thought, and risk management theory, the establishment of a more comprehensive evaluation of cold chain logistics system, through a cold-chain business case analysis, put forward suggestions to solve a few cold-chain logistics security strategy.

**Index Terms**—Cold-chain logistics; Temperature control Security; Strategy

## I. INTRODUCTION

IN the State Bureau of Technical Supervision issued the "People's Republic of China National Standard Logistics term", the cold-chain [1] is defined as maintaining the fresh food and frozen foods, such as the quality of its production to consumption from the process, always in low-temperature state with the logistics network of specialized equipment. The scope of the cold chain is the primary agricultural products, processed foods and special products (such as drugs). Cold-chain, including low-temperature processing, low-temperature transport and distribution, low temperature storage, low-temperature four aspects of marketing. Food collected in the origin, after cooling, processing, storage, packaging, transport to the sale terminals, and finally sold to the end consumer (Gao Xuling, *et al.*, 2006). The cold-chain framework is shown in Figure 1.

Cold-chain logistics system, also known as low-temperature logistics system, mainly refers to the food cold chain logistics system. In cold-chain logistics in every link is vital that any omission to make the cold chain logistics will come to naught. And narrow cold-chain logistics system only sales logistics, state at low temperatures, through the flow of processing, transportation, storage, packing, loading and unloading for transportation, the organic integration of information in order to create value, improve the level of logistics services to meet the needs of society as the goal of an organic whole. At present

Guojun Ji, professor, School of Management, Xiamen University, Xiamen Fujian, 361005, China (phone: 86592-2181717; fax: 86592-2187289; e-mail: jiking@xmu.edu.cn).

Rong Guo was a graduate student, School of Management, Xiamen University, Xiamen Fujian, 361005, China (e-mail: silly042010@yahoo.com.cn).

most of the cold-chain logistics mainly refers to the narrow cold-chain logistics.

Cold-chain logistics has the following three main features:

- (1) the construction of large investment and large and complex systems;
- (2) timeliness requirements of the various sectors of higher organizational coordination;
- (3) effective control of operating costs and food are closely related to the development of cold chain.

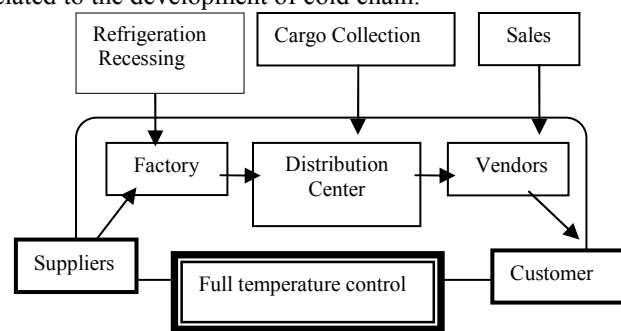


Fig.1 Cold-chain framework

### A. An overview of cold-chain logistics

According to statistical data of national statistical offices, the entire frozen and refrigerated food industry currently has a production scale of 15 million tons and is 15% per annum growth rate (Fang Xin, 2004).

China's cold chain industry report shows that China is now only 15% of perishable products refrigerated trucks transport, in developed countries this ratio close to 90%. The consequences are: China's vegetables, fruits, etc. The resulting annual loss of up to 8.9 billion U.S. dollars, accounting for 30% of annual production of fruits and vegetables, and in other developed countries, this loss rate was only 5%.

### B. Comparison of cold-chain status quo at home and abroad

The United States, Japan, Germany and other developed countries during transport refrigerated trucks full trial or refrigerated containers, and with EDI systems and other advanced information technologies, the use of railways, highways, waterways, such as multimodal transport, including the establishment of production, processing, storage, transport, sale items, including fresh frozen cold chain. In accordance with international standards, food logistics cost should not exceed the maximum total food costs by 50%. Refrigerated road transport due to low efficiency, high food losses, and China's logistics costs throughout the food costs accounted for

about 70% ( Li Zhijun, 2007). Specific data are shown in Table 1 as follows.

**Tab. 1 Cold supply chain at home and abroad compared with the analysis of the status quo**

Content	Domestic situation	Foreign status
Pre-cooling	30%	Europe and the United States for 80% -100%
Refrigeration capacity	7 million T	The world's total to 80 million T
After the loss rate of Fruits and Vegetables	20%-40%	5%
Refrigerated transport capacity	6792 train refrigeration, cold storage more than 30,004 automotive vehicles	American refrigerated and insulated vehicles 200,000;Japan 120000
Refrigerated transport rate	The total transport rate was less than 50%	Europe, America and Japan: 80% -90%
Refrigerated Transport Management	Refrigerated goods circulation long and complex, cold storage technology was not common	European and American developed countries has been basically to establish a highly efficient cold chain

*C. China's cold-chain problems*

Firstly, complete an independent food cold chain system is still not formed. Secondly, food cold chain infrastructure imperfect hardware. Thirdly, the food chain of market-oriented, slow development of third-party logistics. Logistics and distribution business for most of them from manufacturers and dealers completed, food cold chain is very lagging behind the development of third-party logistics service network and information systems are not sound enough, greatly affected the logistics of in-transit food quality, accuracy and timeliness. Fourthly, China's food chain on the lower reaches of the lack of overall planning and integration [5]. Cold chain is often interrupted, in the management of flow will give more consideration to frozen processing and business process itself, but the upper reaches of the negligence of the cold chain logistics procurement environment and link. Fifthly, the enormous investment in the food chain, in industrial policy is not specific business needs limited circumstances.

This paper is organized as follows: Firstly, the cold-chain security system is discussed, and an evaluation model is presented. Finally, a case study is illustrated our conclusions.

**II. COLD-CHAIN SECURITY SYSTEM**

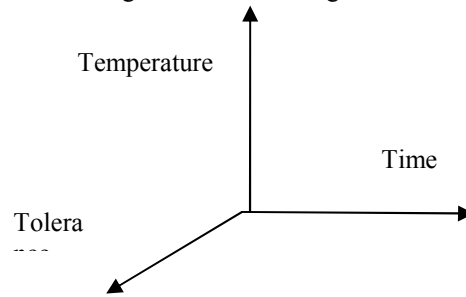
In 2004, the International Association of cold-chain performance measurement standards of the cold chain (CCQI).

HACCP (Hazard Analysis Critical Control Point) management system is the world's most authoritative quality and safety of one of the protection system (Tang Xiaofang, 2003). Cold-chain logistics in agricultural products HACCP management system, to carry out the quality and safety tracking

and positioning of monitoring the cold chain logistics management system HACCP Optimize HACCP through the cold-chain logistics management systems integration management, not only can achieve the rationalization of the allocation of resources, but also effectively improve the cold chain logistics efficiency and service levels.

System reliability theory, Security systems engineering theory and Risk management thinking is a major security risk control based on sources and methods (Qiu Zhuqiang, Xie Ruhe, Gui Shouping, 2008).

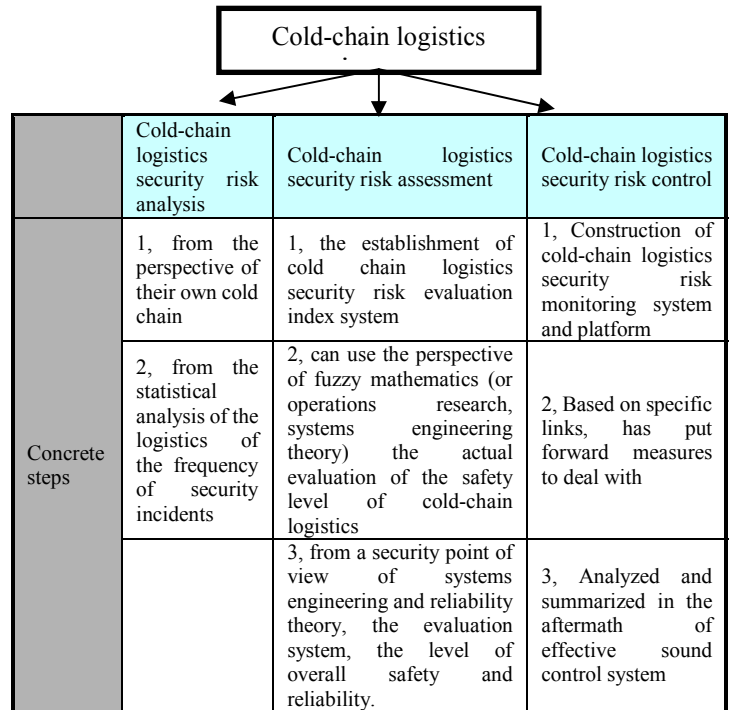
According to a large number of experimental data as the basis, ARSDEL elaborated on the quality of frozen foods and frozen and refrigerated to allow the relationship that exists between the temperatures. TTT-called principle, namely: time (Time), temperature (Temperature) and storability (Tolerance). Three-dimensional figure is shown in Figure 2.



**Fig. 2 TTT of three-dimensional map**

*A. Construction of model*

Logistics of food safety control process can be divided into security risk analysis, evaluation and control of three basic steps. Security of cold-chain logistics system is shown in Figure 3.



**Fig. 3 Security of cold-chain logistics system**

1) Risk Assessment of cold chain logistics security

Construction of Safety Evaluation of cold-chain logistics system, the perspective of fuzzy mathematics can be used (or operations research, systems engineering theory) and so on. Normally cold-chain logistics and means of transport, carrying objects and the environment form an interrelated system. If these four factors can form a harmonious entity, the system can safely run, otherwise, would lead to accidents. Specifically, Cold-chain transport security evaluation systems are shown in Figure 4.

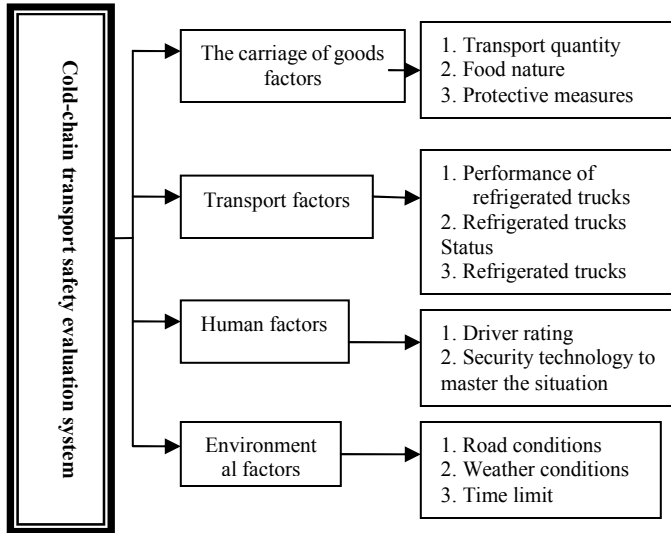


Fig. 4 Cold-chain transport security evaluation systems

To the above system, the Fuzzy Comprehensive Evaluation:

(1) To establish the evaluation factor set F object. For example, Carrying material factors are shown in Table 2.

Tab.2 Various indicators on the evaluation of levels of Membership degree

Evaluation factors	Linguistic variables	Various indicators on the evaluation of levels of Membership degree				
		Very dangerous	More dangerous	General	Safer	Very safe
Quantity	Overloading	0.2	0.8		0.3	0.7
	Not overloaded					
The risk coefficient	0-10	0.3	0.4	0.3	0.2	0.8
	10-20					
Protective measures	20-40	0.1	0.1	0.2	0.3	0.7
	Good					
	General					
	Poor	0.1	0.9		0.3	

(2) The establishment of the reviews of the various factors set:  $P = \{P_1, P_2, P_3, P_4, P_5\} = \{\text{Equal, More important, Important, Very important, Important}\}$ .

(3) Used AHP to determine weights of evaluation matrix:  $A = \{a_1, a_2, \dots, a_n\}$ .

(4) Evaluation Matrix R

The performance factors used to set the matrix F and reviews a collection of fuzzy relations between P.

$$R = \begin{bmatrix} R_1 \\ R_2 \\ \vdots \\ R_n \end{bmatrix} = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ r_{12} & \cdots & r_{2n} \\ \vdots & \vdots & \vdots \\ r_{n1} & \cdots & r_{nn} \end{bmatrix} \quad (1)$$

(5) Comprehensive Evaluation

According to the weight matrix and factors evaluation matrix, for computing the synthetic evaluation of the membership factor B, namely:

$$B = A \times R,$$

$$B = (b_1 \quad b_2 \quad \cdots \quad b_n) \quad (2)$$

$$= (a_1 \quad a_2 \quad \cdots \quad a_n) \begin{pmatrix} r_{11} & \cdots & r_{1n} \\ r_{21} & \cdots & r_{2n} \\ \vdots & \vdots & \vdots \\ r_{n1} & \cdots & r_{nn} \end{pmatrix}$$

(6) Calculation of the indicators of the safety index Z.

Grade standards-based assessment of the value of the collection of vector used to express C:  $C = \{C_1, C_2, \dots, C_n\}$ .

C is the evaluation of the fuzzy set P subset. Make Maximum risk for one. There are:  $1 \geq C_1 > C_2 > \dots > C_n \geq 0$ .

To b as weights, the evaluation of set P subset of C can be weighted by the evaluation of the safety value:

$$Z = B \times C^T \quad (3)$$

Finally, in accordance with the principle of the largest degree of membership to determine the outcome of the each evaluation target.

2) Safety Monitoring Mode -Key points to monitor

Temperature (time) management for the center to HACCP (Hazard Analysis and Critical Control Point) as the standard time (temperature) and the target reservoir of resistance (tolerance) for the reference point to establish a well-established cold chain management system.

In the storage and transportation, in order to guarantee product quality, first of all, attention to the temperature of storage and transportation. Second, control the entire chain of cold-chain. This is mainly reflected in the convergence of cold-chain, the product from the cold plate to the cold storage on board, will go through a transition room, making the movement of products at room temperature, the process did not expose the space, a reduction of product damage metamorphism.

Finally, attention is necessary, cold-chain to do well in the preceding, if the end of the cold chain will ultimately affect consumers get the product quality; it should also rely on distributors and customers to control the end of the cold chain (Xi Xiangde, 2007).

III. CASE STUDY

HAVI (HAVI) Food Company (Jin Tao, 2008), was founded in 1974, is a McDonald's in the global logistics provider. McDonald's where the shop, will HAVI their cold-chain

distribution system where coverage. HAVI with McDonald's in 1981 opened its first store in Hong Kong and into China. Today, the company provides logistics services for more than 800 McDonald's restaurants.

The 55 million investment to establish the capacity to reach 12,000 square meters of cold storage in North China near the McDonald's chain, the vast majority of 300 required distribution of raw materials. HAVI have their own refrigerated fleet; will be regularly sent to the Product here to the McDonald's distribution in various stores.

2008 Olympic Games in Beijing adopted a strict standard of cold-chain logistics system. HAVI in the cold chain in all aspects of its own strict set of standards, because such a high degree of professionalism, HAVI becomes the first batch of cold-chain Logistics Company of the 2008 Olympic Games. In order to meet the requirements of the Olympic Games, and their equipment, the only changes made is that installation of cold storage at a number of video equipment in order to be able to monitor the whole process.

In fact, the beginning, faced with substandard HAVI warehouses, dilapidated trucks and the lack of refrigerated trucks. Because do not have their own cold storage, HAVI only leasing of state-owned enterprises cold. After 1998, HAVI has invested set up their own cold storage, followed by more advanced facilities for lease to the United States a set of hardware and software experience to China.

HAVI of each refrigerated trucks are equipped with temperature measuring instrument, you can monitor the whole process temperature changes. Regardless of loading or unloading, HAVI have strict rules of time and the order of discharge on the transfer of process control, temperature control, goods storage conditions standards strictly enforced.

In fact, HAVI real advantage lies not only in hardware, but also the logistics center in the background support systems, through a software package composed of a number of background support systems, not only can be analyzed HAVI McDonald's orders, inventory, deployment of vehicles, to achieve optimal network configuration, you can monitor temperature changes inside the refrigerator. Through the system software, enter the store location and the latest road conditions, the system will give one of the most optimized routes. Through these measures, the quasi-point HAVI distribution rate of more than 98%. A logistics company, in the face of hundreds of kilometers in radius of hundreds of stores, has reached such a quasi-point rate are staggering.

#### IV. CONCLUSIONS

In this paper, based on our discussion, some of Cold-chain logistics security solution specific strategies are as follows:

##### A. Encourage food companies to cooperate with the 3 PL

To achieve fast-track and frozen cold chain, cold chain preservation of the use of technology through a third party logistics outsourcing, and standardize "vacuum pre-cooling standards" and "clean vegetables packaging standards" and other standards (Yao Xiaohui, Wang Shan, Wang Tong, 2005), the development of corporate brand and improve the competitiveness of enterprises. For example, Unilever and the

way the snow cold-chain logistics are frozen to hire professional logistics companies to operate.

##### B. Government support

Government to provide the appropriate policy support and financial support, through the common laws and regulations to improve food logistics and system, the establishment of a comprehensive food supply chain quality management system, can be poisoning, rotten food, such as the phenomenon to a minimum. Government departments in the development of cold chain standards also accelerated. 2007 "perishable foods cold-chain transportation requirements of motor vehicles" to declare the project has been approved by National Committee for Standardization, refrigeration equipment standards, such as cold storage standards have also begun a number of important criteria for a comprehensive revision.

##### C. Standardize the equipment is particularly important

Firstly, build a modern cold storage. At present, the refrigerated product varieties, patterns on the increase. This requires the modernization of cold storage should have a wide range of temperature regulation, to be used in a distributed refrigeration system capable of storing a wide range of refrigerated products. With the continuous development of automation and modernization of cold storage refrigeration, equipment is implemented automatic control (Bao Changsheng, 2007).

Secondly, to vigorously develop the road transport and refrigeration, "amphibious" refrigerated container transport. The use of modern technology and management, realize high-value goods appropriate boxes ready, and gradually improve the cold chain for perishable foods. At the same time, should increase its existing refrigerated transportation management system reform, for the refrigerated transportation industry to create large-scale development relaxed external environment, the establishment of railways, highways, waterways, multi-channel, multi-layered pattern of refrigerated transport.

Thirdly, make full use of information technology. Food transport, logistics and distribution links, the use of GPS positioning system, GIS, RFID electronic sign system and the closure temperature sensing devices real-time monitoring, to ensure food safety during the transportation. For example: At present, the refrigeration system, intelligent control, mainly through intelligent use of frozen and refrigerated temperature Miriam car GPS systems seamless docking, and with a temperature acquisition function, GPS can be refrigerated transport vehicles of the information in the network computer terminals( Jim Thompson, 1998).

Fourthly, development and manufacturing a new generation of antimicrobial materials and energy saving and environmental protection of cold storage facilities.

#### ACKNOWLEDGMENT

This work is supported by the following projects: New Century Outstanding Talent Plan in Fujian (2007, No.35), Green Supply Chain Analysis and Operation Study of the National Nature Science Foundation (2008, No.70802052).

## REFERENCES

- [1] People's Republic of China National standard terminology logistics [J], China storage and Transportation 2001, (3):40-43.
- [2] Gao Xuling, *et al.* E-commerce environment of cold-chain logistics study [J]. Logistics Technology,2006, (4):11-13.
- [3] Fang Xin. [J]. Logistics Technology and Application, 2004, (11):56-60.
- [4] Li Zhijun. Watch the cold chain from the food safety technology [N]. Modern logistics is reported in 2007.
- [5] Chinese cold chain logistics in 2008 research report [R].2008.
- [6]Tang Xiaofang. HACCP food safety management system set up and implementation [M]. Beijing: China Metrology Press, 2003: 130-133.
- [7] Qiu Zhuqiang, Xie Ruhe, Gui Shouping. Perishable agricultural products logistics security control mechanism [J] .2008, (9):23-25.
- [8] Xi Xiangde. Fragile cold chain [J].Global Entrepreneur. <http://www.gemag.com.cn/gemag/new/> 2007,12(146).
- [9] Jin Tao. High standards for the operation of cold milk Raiders logistics [J]. Logistics Technology and Application, 2008, (8) :62-64.
- [10]Yao Xiaohui, Wang Shan, Wang Tong. Road transport of dangerous chemicals and the cause of the accident frequency study [J]. Safety, 2005, (5): 37-38.
- [11]Bao Changsheng. Cold-chain logistics system, system of food safety protection [J]. Modern management science, 2007, (9):66-67.
- [12]Jim Thompson. Strength Weak Links in the Cold Chain Asia-Pacific Refrigerated Trade 98 Conferences. 1998,(3):4-6.