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A study on opmtimizing the cold chain logistic system in China

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A STUDY ON OPMTIMIZING THE COLD CHAIN LOGISTIC SYSTEM IN CHINA

(With a case – LRP distribution problem solving of Tiankelong supermarket)

By

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China

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DECLARATION

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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Abstract

Title of research paper: **A Study on Optimizing the Cold Chain Logistic System in China (With a Case – LRP distribution problem solving of Tiankelong supermarket)**

Degree: **MSc**

Cold chain logistic, as a new means of supply chain, since the 1960s originated in United States, within the last few decades in the rapid development of the economic and technology, has played an important role in logistic industry, especailly in some developed countries such as United States, Europe countries and Japan. However, the concept of logistics has been introduced in China recent year, the development of cold chain logistics in China is just started.

This article consulted a number of researches by experts and scholars, and discussed the special features of cold chain systems and the development of cold chain logistic systems both in China and developed countries which have advanced technical facilities and experience of management. After that, due to the weak foundation of cold chain logistic system in China, the author put forward some suitable strategies to improve the Chinese cold chain logistic system in the future. Moreover, this paper found a viable valuable method and concept to improve the distribution pattern of cold chain logistic system and establish a optimal logistic cost model to help cold chain logistic companies to control the cold chain logistic cost in condition of right – time delivery for the product in the cold chain transport are usually perishable food which will be devalued seriously if it cannot be delivered right in time.

After build the mathematical model of LRP, the author solves a real transport problem of a supermarket by applying LRP model. Finally, in the chapter of conclusion, the author raises some suggestions and comments on using the established model in this paper and the direction of develop the Chinese cold chain logistic system.

KEYWORD: Cold chain logistics, LRP model, China

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LIST OF ABBREVIATIONS

LRP	**Location – Routing Problem**	**21**
3T	**Time, Temperature, Tolerance**	**12**
FIFO	**First In First Out**	**15**
JIT	**Just In Time**	**12**
SFC	**Space Filling Curve**	**28**
SDLRP	**Single – Depot Location**	**28**
HACCP	**Hazard Analyses Critical Control Point**	**5**

CHAPTER 1 INTRODUCTION

1.1 The background of the topic

A cold chain is a temperature-controlled supply chain. An unbroken cold chain is an uninterrupted series of storage and distribution activities which maintain a given temperature range. It is used to extend and to help ensure the shelf life of products such as chemicals, foods and drugs.

A well developed and efficiently organized cold chain reduces wastage, spoilage and helps keeps the perishables intact thereby helping to maintain the quality of the Use the "Insert Citation" button to add citations to this document.harvested food products ultimately making the whole system cost effective to the suppliers and end customers.

The cold chain logistics is a typical modern logistics industry, and started late in China. At present, China’s cold chain is still in its infancy, the hardware and software facilities lagging behind. With the urbanization process, deepening the rural reform, progress of modern society, the demand of fresh and perishable food are rising. As the protection of food safety, cold chain logistics become a industry which matters the social security and people’s quality of life.

China faces an acute problem of large amounts of food wasted away due to the lack of a proper cold storage, cold chain and frozen food distribution system. If only this was in place, huge amounts of food could have been processed into some kind of value added food and sold both locally and abroad. If there were cold storage systems, efficient cold chain, logistics and distribution companies, it could have been possible to process these primary products into newer, secondary products and resold to consumers locally and internationally. A strategy needs to be carved out for the growth of this industry and a lot of investment action is yet to see some real action.

1.2 Methodology

Since distribution of cold chain transport system is a weak point of Chinese cold chain system, the author would like to build a LRP (Location-Routing Problem) model to optimize the transport route to minimize the logistic cost. Because in the cold chain transportation, the most product are perishable food or some other high – temperature - required product, which needed to be delivered right in time or it will lose its value dramatically. When build the LRP model, the author introduce two objectives, one is to obtain a lowest cost while the other is the product has to be delivered at the required time.

In chapter 5, the author would introduce a case study of distribute problem of a supermarket by applying the LRP model. There are a lot of ways to solve the LRP problem, in this dissertation, the author would use heuristic algorithm to solve the SDLRP problem, namely solving the localization – assignment problem first, and then the route arrangement problem.

1.3 The framework and content of dissertation

The aim of this dissertation is to utilize the LRP model to optimize the distribution pattern in the cold chain logistic system. There are four chapters in the main body of the dissertation. Chapter 2 is a literature review, in this chapter, the author analyses the advanced experience in some developed countries which have developed and researched on cold chain system for decades. At the end of this chapter, the author raises the main problem unsolved in cold chain logistic in China. In chapter 3, the author brings an overview of the cold chain system, including features, definitions and so on. Also, there is a comparison of situation of cold chain logistic system between China and developed countries. After that, the strategy to improve and optimize the Chinese cold chain logistic system has been put forward. In chapter four, the author would build a multi – objective LRP model which can optimize the distribution system and fulfill the task with the lowest logistic cost. In chapter five, the author utilize the LRP model built in the former chapter to solve a case of optimizing the distribution pattern of a supermarket. Therefore through the above study, the

reader should have a rough understanding of the situation of Chinese cold chain development and the conception and application of LRP model.

Chapter 2 LITERATURE REVIEW

Vegetables, fruit, meats, aquatic product and other agricultural products (live, fresh and perishable agricultural product for short) need to be put into a low temperature circulation in able to maintain its fresh, luster, flavor and nutrition. Cold chain logistics arises as this needs required. Cold chain logistics, which also knows as Low Temperature Logistics, is a system which keeps food in a good condition under a low temperature during production, storing, transportation, consumption etc. before bring to the customers.

These days, countries as US, Canada, Germany, Italy, Australia, Japan and South Korea had already have formed an integrity agricultural product cold chain logistics system. Some countries' saint perishable agricultural product cold chain circulation (count by value) is already 50% of the total sales, and is still growing.

Developed countries have lots of precious experiences in this aspect. After investigation and study, the author summarizes some main points in the aspect of the developed countries' agricultural product cold chain logistics procedure and experience, and hoped it can provides reference for our nation's cold chain logistics' development.

2.1 The Contribution and Advanced Experience of Cold Chain Logistic System Management

2.1.1 The core of the development of cold-chain logistics: a "from field to fork" series of system

Governments of those developed countries attach great importance to the quality and safety of cold-chain logistic system, have developed a series of related to agricultural production, processing, distribution, packaging, transportation, storage, labeling, quality grade, containers and packaging, Import and export of agricultural products also have a strict testing and certification system, has a strong cold operational and test line. Such as the Canadian Food Inspection Agency (CFIA) as

the federal food safety regulatory agencies, in accordance with international practices and the Hazard Analysis Critical Control Point (HACCP) principle of the development of food safety supervision plan (FSEP). CFIA and COFFSP of FSEP participation reflects the continuous improvement of its commitment to food safety from primary production to final retail products of the multi-sectoral, cross-sectoral collaboration in food safety, and ultimately from the field to fork, including the whole process of cold-chain logistics food safety control and management.

2.1.2 Key step in developing cold chain logistics: utilize the market mechanism by following the leading enterprise

Leading enterprise has played a very important role in the cold chain logistics in different countries. Take Canada as an example, it has three main cold chain logistics pattern. It benefits both to the best North American rail transport enterprises National Railway Company (CN) and Canada's largest source of cauliflower Melvin Farms processing of cold-chain logistics for the main mode (production processing mode), but also to North America's largest wholesale market of agricultural products Ontarion Food Terminal Board and Canada's largest distribution center of the Sobeys chain logistics for the main mode (mode of distribution centers and wholesale markets), as well as to Canada's largest third-party logistics enterprise of the Thomson Group as the main chain logistic model (third-party logistics mode).

2.1.3 To promote the development of cold-chain logistic support: to increase the government input to create a good operating environment

Governments have increased funding to promote the agricultural development of cold-chain logistics. Firstly, the government adopted preferential policies and financial support. Secondly, through the development of laws and regulations, national standards and inspection and supervision of law enforcement, standardize agricultural products logistics industry and make cold chain system work healthy and orderly. Japan's local governments benefit from the central government attaching great importance to the logistics of planning and construction industry and provide a certain degree of preferential policies. Such as 1997's "integrated logistics policy framework", it is the main logistics infrastructure to provide strong financial support.

2.1.4 Encourage technological innovation and adopt advanced technology management

Those advanced states rely on cold-chain logistics technology innovation to improve the overall level of the logistics industry, technological innovation in the body in all aspects of cold-chain logistics.

A, in the storage technology and equipment, the active use of automation in cold storage technologies, including automated storage technology, high-density power storage (HDDS) for electronic data exchange and treasury management system, the storage of refrigerated shelf life than ordinary extension of 1-2-fold. Controlled Atmosphere Storage is one of the most widely used advanced technology in fruit storage.

B, In the transport technology and equipment, refrigeration transport technology has undergone development from road transport refrigeration, railway transport refrigeration, marine transport refrigerated to multimodal transport refrigerated containers. European transport network is with fast and flexible road transport, use model of small segments of loading and unloading to reduce the shipment of the wear and tear, can offer "door-to-door" services. Canada's largest third-party logistics companies in addition to large capacity Thomson Group a high degree of automation of refrigeration facilities, also has the world's most advanced power supply of the mandatory (PT0)-driven, automatic temperature control and recording, satellite monitoring of the "three-step" refrigerated truck can be transported at the same time three different temperature requirements of the goods.

C, Speaking of information technology, an effective food cold-chain logistics operations, rely on accurate real-time data transmission and high-quality information-sharing. In order to ensure all aspects of cold chain logistics operations quickly and accurately, it is the requirement of the modernization of advanced information systems to transfer data and share information resources. According to their own needs, using HDWMS (Warehouse Management System), HDTMS

(Vehicle Management System), RMS (Reverse Logistics Management System) and CAPS (computer-aided selection system), RFID (radio frequency identification technology), to achieve the entire cold-chain logistics operating paperless, real-time information exchange and networking. In addition, the construction of information systems hardware and software focus on the effective integration, which greatly improve the overall supply chain management and collaboration of all parties. Such as in temperature control technology, mainly through automatic remote monitoring system, the operation of remote monitoring systems, parameter adjustment, remote alarm, remote fault diagnosis and other functions to ensure effective control of temperature. High-tech and advanced management tools effectively promoted agricultural countries the rapid development of cold-chain logistics.

2.1.5 To establish a standardized system

Modern logistics is based on the premise of standardization, which is also important in cold chain logistic system. The development in the developed countries of the logistics of the process of globalization, logistics standardization system has played a significant role. Legal standard of vegetables in the United States is established under the authority of a matching, integrity and maneuverability. As long as the computer identified the name of a vegetable, its identification could be released on standards, quality standards, grading standards and some other series of supporting standards. Standards in the logistic infrastructure, such as packaging Standards, transportation standards, are an convergence of all aspects to achieve reunification. In fruit and vegetable grading, packaging, measurement, even in the logo on the outer packaging has a unified standard. Not only provides detailed interface between facilities, and strict to laws and regulations of the form. Therefore, effectively enhance the standardization of logistics efficiency, lower costs, more convenient transaction of goods more competitive in the marketplace.

2.2 Unsolved Problems in China

2.2.1. The chain has not fully formed yet as a whole. No matter from the view of national economic or consuming capacity, the gap is obvious between China and

developed countries. The food industry required further improvements in cold chain logistics systems.

2.2.2 There is a very limited number of professional third-party logistic companies in China now. Most domestic cold chain transport are operated by the suppliers. Since the cold chain logistic service network and information systems are less-developed, the quality of product and the cost of distribution as well as the accuracy and timeliness cannot be satisfied by customers.

2.2.3 The hardware facilities of the food chain are relatively backward. There are 30,000 refrigerated trucks in China, the number only takes up 1/7 that of US, and 1/4 of Japan. In addition, most of these refrigerated trucks are of old style.

2.2.4 The upstream and downstream of cold chain is lack of overall planning and integration. In the supply chain of perishable food and primary agricultural products, the problem of lacking of professionals operator and coordination is serious.

2.3 Conclusion

After analyse the advanced experience of developed countries, the author found that there is a gap between Chinese cold chain logistic system development and which of developed countries. Distance is existing in all aspects of cold chain system, such as regulation, technology, concept of ‘chain’ and investment made by government and so on. Among these problems, the author would like to emphasize on the problem of logistic distribution and establishment of the ‘chain’.

CHAPTER 3 AN ANALYSIS ON CHINESE COLD CHAIN LOGISTICS AND STRATEGIES TO IMPROVE CHINESE COLD CHAIN LOGISTIC SYSTEM

3.1 The Overview of Cold Chain System

As the economy continues to develop, people's living standard is improving continuously, People's consumption patterns of food have changed from single and traditional ones to the "multi-variety, small quantity, to safety reliable", which has put forward the food industry higher requirement, it has to provide customers the services with better quality, greater flexibility, more choice, higher prices and lower price. In this case, the food industry in order to remain rivalrousness, we must continue to reduce the development time, improve products' quality, reduce production costs and shorten the delivery cycle. This requires the construction of Chinese food industry, to make it become modern logistics platform will change the basis of the traditional food supply chain logistics to logistics transformation.

3.1.1 Definition of cold chain

Chinese State Bureau of Technical Supervision issued the "People's Republic of China national standard terms of logistics", the cold chain is defined as maintaining the quality of fresh food and frozen food for the whole process from producing area to consumption area, by making use of keep the product in a condition of low-temperature state of the logistics net of specialized equipments. The scope of the cold chain including primary agricultural products, processed foods and special commodities, such as drugs. Cold-chain logistics including low-temperature processing, transportation, distribution, storage and sales. Cold chain system flows as following processes: collectting of food at the place of production and cooling, processing, storage and packaging at this place, then transport them to the distribution center, and finally they are sold to the final consumers. A typical cold supply chain processes is shown in the Chart 1:

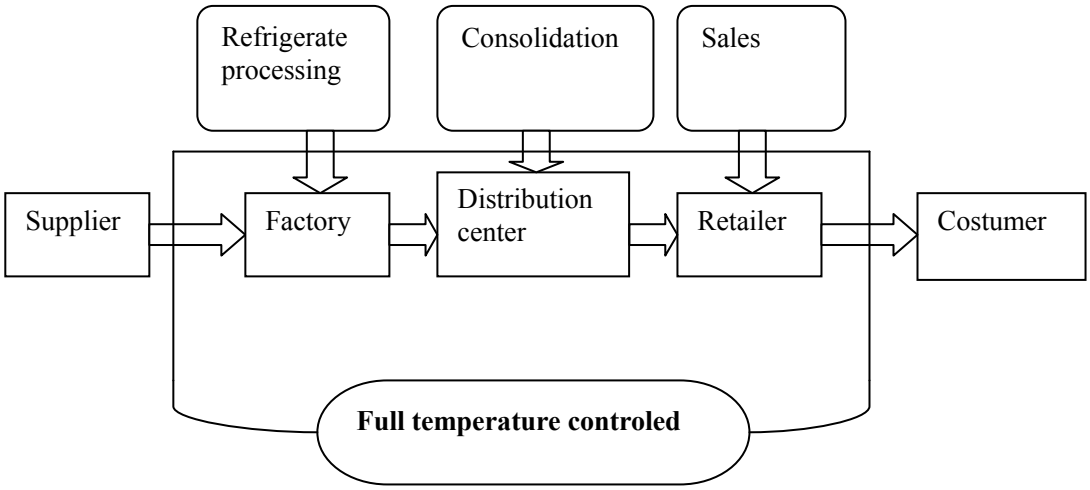

Chart 1: a typical cold supply chain processes

Cold-chain logistics (also known as low-temperature logistics) is a special form of logistics, the main target of it is perishable foods (including raw materials and products). Refrigerated cold-chain logistics are technology-based, by means of artificial refrigeration technology to the production and circulation for the convergence in order to achieve well-maintained food quality and security for the purpose of a systems engineering. It requires considering the production, transport, sale, and other economic and technical elements of the relationship between co-ordination to ensure that perishable fresh foods in the processing, transportation and sales process and increase their value. Therefore, the cold-chain logistics has to be followed "3t principle", namely the Time, Temperature and the possession of resistance (Tolerance). Due to the own characteristics of sensitiveness of outside environment and strictly timing requirement of perishable food, management of cold-chain logistics has to consider storability of the product, and to make use of special transportation such as refrigerated vehicles, and strictly control the course of delivery, transport time, transport patterns.

3.1.2 The main features of cold chain logistic system

We must have a series technical indicator of temperature control and economic storage time for monitoring different goods and different quality of goods. Low temperature food logistics should be standardized, so the level of technical services as well as the quality of food sales played a decisive impact. Cold-chain logistics systems have more dominant features compare with other types of logistics systems, the special features are mainly lie in the harsh construction of cold-chain logistics and stringent environmental requirements. Cold-chain logistics systems generally have the characteristics as follows:

3.1.2.1. Stringent cold environmental requirements.

Cold-chain logistics in general is a relatively constant temperature operation, it's divided into refrigerated and frozen logistics. Refrigerated logistics' temperature should keep between 0 ℃-5 ℃, freezing Logistics temperature should be at -15 ℃. So the temperature of cold chain logistics is extremely difficult to grasp for the variable environmental factors.

3.1.2.2. The condition of construction of cold chain system is harsh.

From the point of construction of cold-chain logistics system, the environment, infrastructure, delivery systems, storage systems, packaging systems and marketing system have a highly standard to be built. For example, raw fish in the cold-chain logistics requires a low-temperature at -50 ℃, fresh fish requires low temperature of between -2 ℃ and 1 2 ℃. Distribution is only a part of the whole process, in addition, the process of storage, transportation and loading is also have to be .connected well.

3.1.2.3. Huge investment required.

In order to ensure that the perishable foods in the various segments of the flow of logistics has always been necessary in low - temperature environment, temperature - controlled facilities must be installed, such as procurement refrigerator car or cold storage. To improve the operational efficiency of the logistics required for the use of advanced information systems, the additional investment lead to low-temperature

logistics a high cost industry. The investment of room temperature logistics compared with which of cold-chain logistics systems, the investment of cold chain logistics system is usually 5 – 10 times that of normal temperature, Or even more. Accordingly, return periods of cold-chain logistics system and the rate of return is higher. Room – temperature logistics industry is extremely competitive and the it does not have a very special feature, on the country, cold-chain logistics system is not only a large – investment industry but also has a high technical requirements. Thus, cold chain logistics system is now a key part of the core competition.

3.1.2.4. Zero inventory requirement.

The character of cold-chain product determines the cold chain distribution inventory must be guaranteed. If the time of production, distribution provisions of the quantity and quality of goods cannot be assured, shortage or loss of stock will happen. Shortage means lost sales, overtime or expired metamorphism caused by distribution means the loss of goods. Product in cold chain is different from normal commodities since the inventory in the distribution means loss, that is why the cold chain distribution has to adopt JIT delivery.

3.1.3 The requirements of implement of cold chain transportation

Cold-chain logistics should follow "3T principle": the quality of the product will depend on the cold-chain storage and circulation time (time), temperature (temperature) and product of the Tibetan resistance (tolerance). The 3T theory is that: (1) Of each frozen degrees F, the decline of the quality occurred in the food have a certain relationship with the experienced time of the food, the quality of the most of frozen food’s stability is reduced as the temperature of food and the relationship between increased exponentially; (2) freezing of foods in storage and transportation process, due to the experience of time and temperature caused by the accumulation of lower quality and is not reversible, but the order experienced had nothing to do.

"3T principle" point out that the quality of frozen food to maintain the time and products to allow the relationship that exists between the temperature. As a result of

frozen food in the circulation due to changes in temperature caused by the accumulation of lower quality and non-reversible, so different products of different varieties and quality products are the corresponding time control and storage of technical and economic indicators.

In addition, "3P" conditions (that is, the quality of agricultural raw materials, processing technology, packaging of goods), "3C" conditions (that is, throughout the processing, and distribution process, the care for agricultural products, and maintain clean conditions, as well as the low-temperature environment), "3Q" conditions (that is, the number of cold-chain co-ordination of equipment, equipment of the same quality standards as well as the operation of fast) and "3M" conditions (that is, tools and means of preservation, preservation methods and management measures).

3.2 The Comparison of Cold Chain System Development Between China and Developed Countries

3.2.1 The matured situation of cold chain logistic in developed countries

As the leading country in the cold chain industry, Europe, Japan and US has a significant impact on the cold chain development of other countries for their well-developed cold chain conception and system. Due to various cultural backgrounds, these countries have different emphases and understanding on the development of cold chain

The definition of cold chain in Europe is emphasize the standardization of operation. This is because the different inter-country logistics activities in the concrete operation is the most difficult to achieve compare with the technics and management. At the same time, operational standardization is also a special emphasis on objectives, through the development of a series of standards on cold chain regulate to a certain extent the operation of the process reflects the importance of interface management.

The cold chain in Japan has been considered as a circulation system, which is emphases on the use of cold chain technology such as frozen, refrigerated and low

temperature storage. Also, Japan focus on the introduction of the new flow approach – in order to improve added value of fresh agricultural products, Japan established a high degree of automatic three-dimensional warehouse and handling the use of advanced loading and unloading facilities.

The cold chain definition in United States embodied with the thought of supply chain. they emphasize the application of concept of chain in the integration management of cold chain system.

Developed countries like Europe, the United States and Japan now has formed a complete cold chain system. The United States in the 60s of nineteenth century had been developed and well used the cold chain technology. Japan since the sixties of nineteenth century began to study the circulation of clod chain technology, completion of a nationwide modernization of cold chain systems in the eighties. They use refrigerated trucks and containers of the whole process of multi-transportation of railways, highways and waterways combined the use with EDI to track and tracing. They has established the cold chain in the whole process of production, processing, storage, transportation and sales, etc. So that the rate of refrigerated fresh product transport has greatly improved and quality of fresh product is guaranteed.

3.2.2 The situation of cold chain logistic in China

According to London, "Maritime Asia", an article reported that due to the weak situation of road construction, modernization and frozen storage and transportation infrastructure, in food transit in China each year, deterioration of perishable fruits, vegetables, dairy products and other perishable food, the total loss is 750 billion RMB. If the money used to buy food, will allow 200 million people do not get hungry. Experts believe that China's lack of well-trained food logistics and cold chain management, as well as the modernization of cold storage and transportation infrastructure. These are the tens of millions of dollars waste because of Chinese food every year. A logistics expert from the European study of China in the cold-chain management and logistics service supply chain hold a view that if ignore the quality of food at its origins, he pointed out that if in accordance with European standards

and norms to operate, among the current China's food circulation, 80% of the total amount of fruits, vegetables, frozen foods and dairy products such as fresh foods will be refused by consignee on arrival at destination.

The existence of the above-mentioned problems, from respects of historical, economic, technical and some other reasons, are not simply the issue of logistics. Cold-chain management is a temperature - controlled facilities and equipment, including technology, product research and preservation of insulation, temperature tracking technology, product management and marketing supervision chain, such as a series of management system.

Taken together, the current situation of Chinese cold-chain system management has the following characteristics:

A. The refrigerated supply chain has not been built and worked smoothly. Refrigerated goods, because of its special characteristics of the low temperature requirements, are in a flow of the process more orderly, rhythmic, and smooth. FIFO is strict and orderly, according to volume, there are records to track the problem. Rhythmic plan is in strict accordance with the transport and storage. Which Is not smooth because the storage and transportation problems occur stop the flow of link congestion. Smooth formation of circulation of commodities need to chain manufacturers, wholesale companies at all levels, merchandise sales, etc. there are more close and constant cooperation between the business or. And our original plans as a result of changes in circulation system, the new distribution system is taking shape, the scattered acts of commodity trading and circulation of refrigerated full circulation of commodities markets. Started from the 50's for the protection of urban meat, eggs, milk supply refrigerated warehouse are scattered in the market rent, and there are manufacturing enterprises leasing, business leasing, but scattered among the majority of wholesalers lease. Production, transportation, transmission, storage, wholesale, many aspects of sales can not be connected to form an effective, first because there is no reason a group can influence the commercial refrigeration market enterprises, and the other is the Government of the circulation of refrigerated goods market there is no effective means of monitoring. The flow of refrigerated

goods, there is no effective organic chain, but cut into a paragraph. Disorder so that the flow of goods, quality control difficult.

B. There is a big gap between the Infrastructure we use right now and the modern cold chain management. At present, the refrigerated warehouses are mostly built in the last century 50's to 70's. The construction ideas are far behind the modern requirements of the logistics of goods. Take Beijing, under the management of business systems of 1 20,000 square meters of refrigerated warehouse and three-ring in between the Second Ring, transport, Treasury form, scale, all with modern equipment and logistics requirements of urban planning falls far short of the Treasury mess does not meet food hygiene requirements; not efficient unloading and loading platform are not satisfied with the rapid modern logistics requirements; high energy inefficient refrigeration equipment of the modern enterprise can not meet the operational requirements of efficient and safe. In short, the existing infrastructure has been frozen frozen chain management as a constraint of the obstacles to modernization.

C. The problems caused by Low-price competition. Low-price competition in the logistics market is a common phenomenon, this is even worse at low temperature logistics, resulting in greater harm. The prices of transport frozen goods will be generally 2-113 times of dry goods. Transport market reality only by means of low prices, the pressure of prices is harsh against each other, resulted in the quality of transport of goods difficult to ensure. As the existing warehouse property and the depreciation period has been completed, the cold warehouse rental market generally indicate a low price. To the existing cold storage rental market price estimates, the new cold it is difficult to establish. To the author's point of view, the existing cold storage resources has become a new cold storage building as an obstacle. Cold flow of products without the formation of the commodity chain as a result of an effective monitoring system, the disorderly flow of cold products, the business to pursue their own immediate short-term participation in a vicious market competition, resulting in refrigerated logistics management products out of control is very difficult to avoid.

D. The synergistic relationship between logistic-company-associations is weak. In

developed countries, the role of trade associations is very obvious. The purpose of business is to pursue the maximization of profits; the role of government laws and regulations by the executive to restrict the conduct of business development of the market balance; the role of trade associations to protect the industry from the perspective of long-term development proposals, to develop rules to prevent individual enterprises violations harm the interests of other enterprises. At present, our country's trade association has not played its due role, or just in its infancy, the role was not obvious.

3.3 The Strategies of Improving Chinese Cold Chain System

The development of Chinese cold chain logistic in the future and construction of cold-chain process, the following aspects should be clear and breakthrough:

3.1.1 Carry out joint distribution.

Due to the pattern and problems existing of cold chain development in China, we should develop a suitable joint distribution model which can optimize allocation of resources to solve these issues. To establish the regional core distribution center and a full integration of the existing cold chain resources is needed. Joint distribution model can be worked as a third-party logistics companies serve a number of customers, or a couple of distribution companies to conduct a joint distribution, as well as some commercial enterprises jointly invest in the construction of cold chain logistics facilities. It can be considered as a sharing of distribution task, logistic resources and facilities, as well as the logistic management. As a new trend of development of logistics, joint distribution has been applicable successfully in some developed countries. Undoubtedly, a joint distribution is a optimal choice for developing the Chinese cold chain logistic system.

3.1.2 Application of JIT

During the entire manufacturing process, JIT method can significantly reduce the inventory levels, improve the quality of product and at the same tine, reduce the cost.

JIT has a strong competitiveness in the resource shortage industry like cold chain logistic industry in China.

3.3.3 To enhance China's overall food supply chain planning, establish institution, industry organizations and related businesses linkage mechanism.

A country's food security system of cold-chain, are difficult to rely solely on any of the parties to promote effective, it requires government, industry and business co-operation organizations. It should be combined with China's national conditions, draw on the experience of developed countries, improvement of technical management tools and regulatory measures: the Government should develop a food chain development policy environment and incentives, to enhance planning and guide the direction. Trade organizations should play a role in communication and coordination to develop and overall planning of the implementation of trade and industry norms: the relevant enterprises should be based on the specific operation of the rules of the market, to promote the progressive development of the food cold chain by joint forces.

3.3.4 Promote the establishment of multi-modality food cold chain system.

There are two matured models in the current international food cold chain: First, with enterprises as the mainstay of the food chain system, this model is popular in United States, Japan and Western Europe, ‘7-1l’ in Japan is one of representatives; Second one is a large number of food products to ensure that the general quality, reduce wear and tear in the way of price and quality model for the developing countries in general.

Chinese food cold chain logistics in accordance with the development of the status quo, should promote the development of a variety of cold-chain model, on the one hand relying on the leading agricultural enterprises and large-scale food enterprises to develop the core enterprise of the food chain as the axis system, upstream and downstream supply chain series, cover classification and gradually form a food security system in the cold chain industry: the construction of agricultural products in

the green on the other hand, a major thoroughfare on the basis of the building connecting the main producing areas and consumption of agricultural products to the food cold chain logistics backbone network to improve the logistics of large quantities of food security level.

3.3.5 Establish information systems of food quality monitor of cold-chain logistics.

As the food chain modernization and development of food security. Through the food chain of the cold chain logistics information system for providing accurate information on market dynamics and communication, as well as verification of food safety information to provide traceability support.

3.3.6 Promote the intensification of co-distribution

The logistics of distribution are mainly the following several ways: factory direct delivery, general delivery, a common distribution. Logistics and distribution strategy, the main objective is to improve service levels and lower distribution costs. At present, more food logistics shift variety, small batches of transport has become an inevitable trend. Distribution costs from the point of view, a more common distribution factory direct delivery, a more general distribution of economic, so-called co-distribution, in accordance with the Japanese Industrial Standards (JIS) above: it is to improve the logistics efficiency of many businesses with the means to carry out distribution. A common distribution vehicle loading rate increased, reaching the size of the effect is more ideal choice. Of China's current food manufacturers and food wholesale businesses, some small, self-distribution center in financial difficulties, therefore, a number of food enterprises to build a distribution center is an optional program, in particular, a number of manufacturers concerted common distribution - distribution of the common intensive logistics cost savings is more useful.

3.3.7 The construction of cold-chain distribution center

The physical distribution center’s appearance and forms is the social product development and the social division of labor refinement result. Firstly, food cold chain

logistics in the process of the emergence of the first distribution center is to meet the requirements to reduce logistics costs. Distribution center for the flow of goods, cost savings, in order to meet the customer service provided a platform; The second is to meet the dramatically increases of cargo requirements in logistics and cold food products. Distribution center can speed up the transfer speed of goods for goods transport and the volume of orders to provide a path of rapid response; Thirdly, the huge change of the mode of transport refrigeration and transport. Cold-chain logistics center to meet the various means of transportation between the conversion; Fourthly, a lot of experience is the emergence of trade situation. Cold-chain logistics center is still the main service targets businesses to occupy a large proportion. Fifth, the needs of urban functions. In order to meet a large number of urban food supply, multi-level distribution of the circulation of commodities demand, cold-chain logistics center is an essential form of.

CHAPTER 4 AN OPTIMAL MODEL OF COLD CHAIN LOGISTIC SYSTEM TO MINIMIZE DISTRIBUTE COST IN CONDITION OF RIGHT – TIME DELIVERY

4.1 The Introduction of LRP model

LRP can be defined as solving the following three sub-problems at the same time: location one or more plants and from selected depots to assigned customers to minimize the cost of the supply network. Then, to make further improvements in the network, it is proposed to integrate an inventory model under the fixed interval orer policy to the LRP.

Since the last century, domestic and foreign scholars have started certain researches in optimization of the physical distribution network system, and have constructed some models to solve actual problems. Researches in LRP may trace back to the 1870s. For example: Cooper summarized a localization problem of transportation, the purpose of which was to optimize the goods supply position and reduce the transportation cost; Tapiero introduced time complexity into ordinary transportation localization model;

In the mid 1870s, Watson-Gandy and Dohrn combined transport vehicle characteristics with localization transportation network in their research. After that, Bookbinder and Reece defined three layers multi-commodities allocation system, established the non-linear mix integer programming model, and decomposes the question into two parts: rational localization and transportation. In recent years, the growing demand of logistics unceasingly requests the enhancement of logistic service. With the arrival of new technology, logistic company should extend its service area to include logistic related services, and reconstruct its logistic process. Nowadays, customer demand of logistic service emphasizes economic: the product should be delivered to the assigned the place at the assigned time by the most economic way. And this in fact is a problem of multi-objective LRP. In most cases,

reduction of arrival time often means increase in logistic cost. Therefore, reasonable cost control to meet the requested timeframe is more practical compared to the pure cost control.

Until now, many LRP researches stayed in the abstract level, and most of which studied single target model. At present, some domestic scholars also constructed the multi-objective LRP model, in which the majority of main objectives were to achieve lowest total cost. After analyzing both domestic and foreign research findings, this article establishes a model of multi-objective localization ------- transportation route arrangement problem (LRP). The main difference between this model and previous LRP models is that punctuality rather than lowest total cost is the main objective of this new multi-objective system.

4.2 Build the LRP model

4.2.1 Objective of LRP

Before analyzes the mathematical model of LRP, we need to define the objective system of city logistics delivery system. Here punctuality and lowest total cost are the two goals in this objective system.

(1) Punctuality: Namely defers to improvement of logistic service by delivering goods within requested timeframe. Customers specify cargo arrival time and demand punctually because they often tailor products to their specific needs. Therefore it is consider the primary goal of a logistic system to be able to deliver cargo punctually.

(2) Lowest cost: To achieve profit, logistic company must seek the lowest total cost and optimize the transportation plan.

The above two goals are independence, but at the same time have complex internal relations. Therefore, the LRP problem of city logistics delivery system is a problem of multi-objective integer programming. In this objective system, punctuality is more important than achieving lowest total cost.

4.2.2 Basic assumption

Before building the LRP model, some assumptions have to be made:

(1) Several distribution centers, each of which has some vehicles of different models. The capacity of each single vehicle is larger than customers' total demand for the route. Each vehicle can delivery more than one customer's cargo;

(2) Goods are not delivered from all distribution centers, but from one or some of them;

(3) Cargo of one customers is deliver by only one vehicle;

(4) Each vehicle embarks from a distribution center, and returns to the starting point after completing all the delivery tasks along the route.

(5) A timeframe is applied on the cargo arrival time and customer requires punctual delivery.

4.2.3 Build the model

4.2.3.1 The meanings of parameters in the model

$H\{h_m / m = 1,2,...,\ \mathrm{M}\}$ Set of distribution centers, in which 1,2，…M are the codes of the distribution centers

$A_m = \{a_{m1},\ a_{m2},...,\ a_{mk_m}\}$ corresponding to the distribution center h_m.The sub-set of K_m number of vehicles (i.e. the that park in the distribution center);

$V = \{1,2,...N\}$: Set of customer, in which 1,2, ，Ⅳ is customer code;

Loading expense per unit of vehicles a_{mk}; h_m K_m;

C_{ijmk}: Average transportation cost from i to j of vehicle a_{mk};

Distance from i to j;

q_j: average quantity of cargo Customer j demands $(j \in V)$

Q_{mk}: capacity of vehicle a_{mk};

T_j time at which the vehicle reach customer j

Customer requests cargo to be delivered within a certain time slot. The permitted earliest arrival time is ET_j, while the permitted latest arrival time is LT_j, namely [ET_j, LT_j].So, we requests $ET_j \le T_j \le LT_j$.If the cargo arrives to the customer j at a time that is earlier than ET_j,the vehicle has to wait at point j.If later than LT_j, then the delivery service for customer j is delayed.

4.2.3.2 Decision Variance in the Model

$$x_{ijmk} = \begin{cases} 1, \text{if vehicle} a_{mk} \text{ of distribution center} h_m \text{ from i to j;} \\ 0, \text{if false} \end{cases}$$

$$y_{ijmk} = \begin{cases} 1, \text{ if vehicle } a_{mk} \text{ finish the task of point i;} \\ 0, \text{ if false} \end{cases}$$

$$z_{ijmk} = \begin{cases} 1, \text{ if distribution center h}_{\text{m}} \text{ open} \forall m \in H; \\ 0, \text{ if false} \end{cases}$$

4.2.3.3 Model establishment

$$\min f_1 = \sum_{j=1}^{N} \{Max[(ET_j - T_j), 0] + Max[(T_j - LT_j), 0]\}$$

$$\min f_2 = \sum_{\text{m=1}}^{M} \sum_{\text{k=1}}^{K_m} \sum_{\text{i=1}}^{N+M} \sum_{\text{j=1}}^{N+M} C_{ijmk}\ x_{ijmk}\ d_{ij} + \sum_{\text{m=1}}^{M} \sum_{\text{k=1}}^{K_m} x_{ijmk}\ q_j$$

Subject to :

$$\sum_{\text{m=1}}^{M} \sum_{\text{k=1}}^{K_m} y_{imk} = 1, \quad \forall \text{i} \in V$$

$$\sum_{\text{i=1}}^{N} x_{ijmk} = y_{imk}, \quad \forall \text{j} \in (H \bigcup V); \quad \forall m; \quad \forall k$$

$$\sum_{j=1}^{N} x_{ijmk} = y_{imk}, \quad \forall j \in (H \bigcup V); \quad \forall m; \quad \forall k$$

$$\sum_{j=1}^{N} y_{imk}\, q_j \le Q_{mk}, \quad \forall m; \quad \forall k$$

$$\sum_{i \in R} \sum_{j \in R} x_{ijmk} \le |R| - 1, \quad R \subseteq \{1,2,..., \quad N\}, \forall m; \quad \forall k$$

$$\sum_{i=1}^{N+M} x_{ipmk} - \sum_{j=1}^{N+M} x_{pjmk} = 0, \forall m; \quad \forall k; \quad \forall p \in (H \bigcup V);$$

$$\sum_{r \in H} \sum_{j \in V} x_{rjmk} \le 1, \quad \forall m; \quad \forall k;$$

$$\sum_{m=1}^{M} \sum_{k=1}^{K_m} \sum_{j=1}^{N} x_{rjmk} - Z_r \ge 0, \quad \forall r \in H;$$

$$\sum_{j=1}^{N} x_{rjmk} - Z_r \le 0, \quad \forall m; \quad \forall k; \quad \forall r \in H;$$

$$\sum_{m=1}^{M} \sum_{k=1}^{K_m} x_{rjmk} + Z_r + Z_j \le 2, \quad \forall r; \quad j \in H;$$

$$\sum_{o=1}^{M} \sum_{p=1}^{N} x_{opmk} + \sum_{u=1}^{M} \sum_{v=1}^{N} x_{uvmk} \le 1 \quad \forall m; \quad \forall k$$

$$x_{ipmk}(T_j - T_i) \ge 0, \forall i; \quad j \in V; \quad \forall m; \quad \forall k$$

Brief explanation of the above functions:

(1) An objective function indicates that the vehicle arrives punctually within customer requested time slot;

(2) An objective function indicates the lowest total cost, in which the first item is the transportation cost, and the second item is loading cost of the vehicles in the distribution center;

(3) Indicates each task must be completed by only one vehicle;

(4) Arrive at a customer point once;

(5) Indicates each vehicle can only start from a receive point once;

(6) Indicates that the total demand of the customers on the route can not exceed the fixed load-carrying capacity of the vehicle;
(7) Indicates elimination of solution on incomplete route;
(8) Maintains restraint of completeness of the route;
(9) Each vehicle belongs to only one distribution center;
(10), (11) Guarantees each distribution center has vehicles to send out as long as it opens;
(12) Guarantee arbitrarily two distribution centers are not connected;
(13) Guarantee arbitrarily two distribution centers are not on the same route;
(14) Guarantee the chronological order of delivery route.

4.3 The Suggestion of Applying LRP Model and Mathematical Solutions

LRP may define for is assigning a series of customers and the latent facility hits the mark determined the facility position and the number simultaneously determined how the vehicles arrangement and does cause the cargo from each facility to each customer transit route which this system the cost lowest customer position and its demand are known either may estimate by or many facilities supplies each customer only to receive comes from a facility cargo latent facility position known question goal is chooses the facility organization transportation to cause the system total expense to be smallest.

LRP has already been proved as a NP - hard problem. Many domestic and foreign scholars have conducted massive research in methods of solving LRP problems. There ‘re mainly two kinds of methods: precise algorithm and heuristic algorithm. The precise algorithm may be divided into fractional algorithm, dynamic programming, integer programming, and nonlinear programming. The heuristic algorithm has two ways: solves the localization-assignment problem first, and then the route arrangement problem, or the other way round. Search method is not allowed in two stage.

This article will adopt the heuristic algorithm to solve the LRP model in the case of next chapter.

CHAPTER 5 A REAL CASE OF APPLYING LRP MODEL TO OPTIMIZE COLD CHAIN TRANSPORT SYSTEM OF TIANKELONG CHAIN SUPERMARKET

5.1 The Introduction of Tiankelong Supermarket

Beijing Tiankelong CO. LTD was established in 1995. Now, it has 10 chain supermarkets in Beijing, 5 supermarkets in Shijiazhuang of Hebei Province, Tangshan, Handan and Huhhot of Inner Mongolian, and 1 supermarket in Macau. The company manage more than 10,000 kinds of commodity. It has 3000 employees and a total business area of more than 100000 square meters.

Tiankelong is one of the first company to adopt chain supermarket management in China. Since it was established, a new chain commercial entity was form, in which reformation and innovation became the lifeline of enterprise. The company broke through the traditional commercial management system and has adopted the advanced supermarket management technology. It has 3 delivery centers with strong capacity. It unified delivery and implements cross region purchase to reduce cost. It hired a new group of highly educated commercial administrative personnel and servicer to sharpen the enterprise's competitive ability in order to adapt the development of market economy.

5.2 The Problems faced by Tiankelong Supermarket in Cold Chain Distribution

Tiankelong supermarket now has three distribution centers, all of them are operating both normal – temperature transportation and cold chain transportation. The complicated situation and poorly management often causes delay or temperature control error, even wrong delivery. Thus, the

directorate decided to reintegrate them to make one cold chain distribution center and two normal – temperature distribution center. To build one into professional cold chain distribution center is aim to lower the error probability of wrong delivery and build a professional fleet of refrigeration vehicles to improve the level of service quality. Also, this decision will lower the operation cost.

The directorate will chose one of the three distribution centers, which located at Baiyun road, Zhanlan road and Zhong guan cun, to be the cold chain distribution center. In next paragraph, the author will use XY reference frame to locate the three spots in the SFC to find the best cold chain distribution center.

5.3 Solving the Problem by Applying LRP Model Established

This article proposed one kind of heuristic algorithm to solve the SDLRP problem, namely solving the localization-assignment problem first, and then the route arrangement problem. First, we construct a route that can connect every customer and latent facility position through SFC (spatial packing curve) to determine the location of chosen facilities. Then we divide the route in a optimum way to form several route. At last, we make some improvements to these routes and obtain the satisfactory solution.

5.3.1 The computation of needed primary data

Chart 2: primary data of customer and latent facility location

Customer	X	Y	Demand	Customer	X	Y	Demand
1	0.46	0.83	5	8	0.85	0.23	5
2	0.56	0.12	1	9	0.23	0.18	7
3	0.94	0.44	6	10	0.76	0.82	5
4	0.30	0.75	3	latent	X	Y	

				facility location			
5	0.18	0.31	9	1	0.47	0.53	-
6	0.76	0.77	1	2	0.36	0.42	-
7	0.20	0.55	3	3	0.71	0.31	-

Chart 3: SFC value of customer and latent facility location

Customer	SFC value	Customer	SFC value
1	0.325789	8	0.722255
2	0.817392	9	0.971523
3	0.685553	10	0.471591
4	0.344669	latent facility location	SFC value
5	0.037091	1	0.374513
6	0.468896	2	0.116576
7	0.173713	3	0.654498

5.3.2 Method for Calculation

1. The Construction of Initial Solution

The most important thing for a calculation method is that it can quickly find the way to an optimal initial solution. SFC, which can quickly generate a high quality initial solution, has such superiority. SFC may transform a unit space problem into a unit interval problem, which is much more easier. The biggest merit of SFC is that it retained proximity of points: if 2 spots were close to each other in the space, they’re close when translated onto the plane. Another merit of SFC is that it can calculate the position of a given fixed-point simply and quickly.

In this article, we first distribute the latent facility and customer evenly on the unit square, and calculate their spatial relative position using SFC. Because only one facility can be chosen at a time, we choose the one which is closest to the center,

and draw a big closed curve with all other customers to construct a big TSP return route. After that we can sort the customers according to their relative position.

2. Based on the initial solution, we divide a TSP route into several routes which can satisfy the conditions. This problem can be described as: Assume there are n customers, whose corresponding order are 1,2,…, n. Define the break point as the end of a division of TSP route, and the node behind this break point is the beginning of another route. The goal is to seek K break points, which can minimize the cost of breaking up the initial TSP route and contruct K feasible routes. The condition is to meet the limitation of vehicle capacity.

5.3.3 Results

The results of dynamic programming optimization method are shown in Table 3. After the dynamic division, we got the vehicles route quantity: K=3, the corresponding route is:

Route one: 0, 5, 7, 0;

Route two: 0, 1, 4, 6, 10, 0;

Route three: 3, 8, 2, 9, 0.

Total cost of the objective function is 104,052RMB.

Chart 4: Results of Dynamic programming optimization method

Customer j	Cost added e_j	Demand q_j	Accumultated completed demand	Optimum number of customers d_k^*	Total cost of SDLRP
5	0.394	9	9	$d_1^* = 2$ $d_2^* = 4$ $d_3^* = 4$	104,052
7	0.189	3	12		
1	0.399	5	17		
4	0.194	3	20		
6	0.737	1	21		
10	0.468	5	26		
3	0.734	6	32		
8	0.594	5	37		

2	0.509	1	38		
9	0.649	7	45		

5.3.4 CONCLUSION

Compare with the cold chain distribute cost 110,521RMB, which is the figure before build the cold chain distribution center. It is obviously a feasible decision to reintegrate the distribution center system for a long run. But in this case, the author did not consider the fixed cost which used to build a new cold chain distribution center.

CHAPTER 6 CONCLUSION

As China's rapid economic development in recent years, the weakness of the cold chain logistics has been noticed by the government and most transport companies, manufactures and supermarkets who closely related to transportation and distribution. They have realized that the weakness of cold chain system would seriously risk the safety of the product and they will loss money for that. But the Chinese cold supply chain has not been fully formed, there are a lot of improvement to have to be made, such as to improve the hardware facilities, to use the advanced management system to control the cold chain logistics, to build the information system to track the product, to regulate the cold chain market to achieve the standardization.

In this dissertation, the author has suggested some strategies to optimize the cold chain logistic system, the important ones are apply the conception of JIT, carry out the joint distribution and establish the distribution center. To establish the regional core distribution center and a full integration of the existing cold chain resources is needed. As a new trend of development of logistics, joint distribution model can optimize allocation of resources and it is an undoubtedly wise choice for developing the Chinese cold chain logistic system. JIT method can significantly reduce the inventory levels, improve the quality of product and reduce the cost, it also meet the high requirement of the perishable product which is transported in cold chain systems of being delivered in time.

Also, the author introduces the LRP model to solve the distribution problem in order to deliver the product in time with the lowest cost. Then the model has been tested by solving a real problem using heruistic algorithm.

All in all, this is a slight study on optimal Chinese cold chain logistic system which focuses on the distribution problem. There are still a number of existing problem need to be analyse and solved.

List of bibliography

Liang, Z. J. (2006). Research on Constructing Food Stuff Cold Chain in China. School of Economics and Administration, Southwestern University of Finance and Economics, Chengdu, Sichuan, China.

Zhao, X. P. (2008). Optimization model for the Food Cold Chain Logistic costs of Beijing Olympic Games. Logistics Management Dept, city DLUT, Dalian, Liaoning，China.

Li, F; Luo, Q. M; Ye, C. M. (2007). The Analyses on Application of JIT Modal in the Distribution of Cold Chain Logistics. Industry Technology. Vol. 26, No.1 page 99-101.

Kuang, Y. Zhang, C. (2008). Comparative Research of Developing Situation between Chinese and Overseas Low Temperature Logistics. Science Technology and Industry. Vol.8, No.8 , Aug.,2008 page 47-52. Information Management College of Wuhan University, Wuhan, China.

Zhao, Y. G.. (2008), Cold Chain Logistics, the Focus Lies in the Construction of “Chain”. The Technology of Logistics. Vol. 27, No. 10, 2008, page52-66.

Wen, X. W. Da, Q. L. (2008), The optimal Choice of Modal of Cold Chain Logistic Distribution in China. Management of Morden Science, No.3, 2008. page 13-14.

Xiao, J. Zhang, D. J. (2008), Research on Construction of Our Country
Food Cold Chain Logistics Management System. Aguiculture Research. No.7, 2008. page 13-17

Sun, J. Si, J. C. Lan, H. J. (2008), Stucy on Food Cold Chain Logistics System for 2008 Olympic Games. Science of Food, Vol.29, No. 07, 2008, page 470-478.

Shen, Z. L. Lin, D. S. (2008), China’s Food Cold Chain Logistics Bottleneck

Breakthrough Research. Storage Transportation & Preservation of Commodities. Vol. 30, No. 4, 2008. page 32-34.

Sun, M. Y. Lan, H. J. Huang, F. Q. (2008), Analyses on Cold Chain Definition. School of Economics & Management, Beijing, Jiaotong University, China.

Liu, B. Wang, X. S. (2008), A Study on Innovation for the Pattern of Cold Chain Logistics Management and Control in Retail Enterprise. Storage Transportation & Preservation of Commodities. Vol. 30, No. 3, 2008, page 34-37.

Tang, X. Y. Qian, Y. Z. (2008), Situation of Meat Cold Chain Logistics in China and Development Countermeasures. Science of Food. Vol. 29, No. 10, 2008 page 656-660.

S.J.James, C.James, J.A.Evans. (2006). Modelling of Food Transportation Systems – a Review. *International Journal of Refrigeration*, 29, (2006), 947 – 957

Stephen C.H. Leung, Wan-lung Ng, (2007). A Goal Programming Model for Production Planning of Perishable Products with Postponement. *Computers & Industrial Engineering*. 53, (2007), 531 – 541

Rob A.C.M.Broekmenl, Karel H. Van Donselaar, (2009), A Heuristic to Manage Perishable Inventory with Batch Ordering, Positive Lead – times, and Time – varying Demand, *Computers & Operations Research*, 36, (2009), 3013 – 3018

S.K.Goyal, B.C. Giri, (2001), Invited Review Recent Trends in Modeling of Deteriorating Inventory, European Journal of Operational Research, 134, (2001), 1 – 16