

World Maritime University

The Maritime Commons: Digital Repository of the World Maritime University

World Maritime University Dissertations

Dissertations

2006

Research on cold chain in food industry in China

Xuan Li

World Maritime University

Follow this and additional works at: https://commons.wmu.se/all_dissertations

This Dissertation is brought to you courtesy of Maritime Commons. Open Access items may be downloaded for non-commercial, fair use academic purposes. No items may be hosted on another server or web site without express written permission from the World Maritime University. For more information, please contact library@wmu.se.



WORLD MARITIME UNIVERSITY

Shanghai, China

**RESEARCH ON COLD CHAIN IN FOOD
INDUSTRY IN CHINA**

By

LI Xuan

China

A research paper submitted to the World Maritime University in partial
Fulfillment of the requirements for the award of the degree of

MASTER OF SCIENCE

(INTERNATIONAL TRANSPORT AND LOGISTICS)

August 2006

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 research paper reflect my own personal views, and are not necessarily endorsed by the University.

.....

.....

Supervised by

Associate Professor Li Yuru

Shanghai Maritime University

Assessor

Associate Professor Gunnar Stefansson

Charlmers University

Co-Assessor

Professor Zong Beihua

Shanghai Maritime University

ACKNOWLEDGEMENT

Cordial thanks go to my tutor, Associate professor Li Yuru for his insightful guidance and earnest help all through the data collection, analysis and paper-writing stages.

Also, I'd like to thank General Zhu Jianmin, Director Li Denian and Dai Xiaochun in Orient International Logistics Company for giving me the chance to do the real practice in logistics and giving me much help in data collection.

Besides, I want to extend my sincere thanks to my parents who are always beside me and encourage me.

ABSTRACTS

Title of Research Paper: **Research on Cold Chain in Food Industry in China**

Degree: **MSc**

Cold chain is an important part in connecting the consumers and suppliers, it makes sure that the supply chain of freezing and frozen foods are in good qualities. But now in China, the condition of cold chain is still under a bad condition: poor equipment, lack of professionals is the main problems that hamper the development of cold chain. What shall we do to help this infant industry? Is there any problem we may come across when dealing with the issue? In the article, these problems will be analyzed. Moreover, some cases of cold chain in other countries will be investigated to see the characteristics of their cold chain and what we can learn from them. And then, cold chain logistics in China will be mainly studied. Its development, conditions, characteristics will be showed through some cases. Future development and opportunities of cold chain in China will be discussed according to the classifications. Difference analysis will be used here to compare cold chain in food industry in China and in other developed countries. Besides, quantitative analysis will be taken to analyze the optimization of cold chain logistics in China. Finally, some suggestions will be given to settle with the problems that we may encounter when dealing with the issue.

KEYWORDS: Cold chain, Food industry, Supply chain

TABLE OF CONTENTS

| | |
|---|-----------|
| Declaration | ii |
| Acknowledgement | iii |
| Abstracts | iv |
| Table of Contents | v |
| List of Tables | vii |
| List of Figures | viii |
| List of Abbreviations | ix |
| | |
| 1 Introduction | 1 |
| 1.1 Introduction of the dissertation | 1 |
| 1.2 Literature review | 3 |
| | |
| 2 Conception about cold chain & necessity of the research | 7 |
| 2.1 Conception, definition of cold chain | 7 |
| 2.1.1 Cases of bird flu that influence selling of chicken in supermarket | 7 |
| 2.1.2 Conception, definition and classification of cold chain | 8 |
| 2.1.3 Characteristics of cold chain logistics | 9 |
| 2.1.4 The evolution of cold chain logistics in China | 10 |
| 2.2 The feasibility of the further development on cold chain logistics | 11 |
| 2.2.1 Change of consuming style of citizens | 11 |
| 2.2.2 New pattern in retail industry enter the cold chain field | 12 |
| 2.2.3 Other factors that affect | 13 |
| | |
| 3 Status quo of cold chain logistics in developed countries and in China | 14 |
| 3.1 Execution of cold chain logistics in developed countries | 14 |
| 3.1.1 Some statistics and characteristics | 14 |
| 3.1.2 Experience | 16 |
| 3.2 Status quo of cold chain logistics in China | 18 |
| 3.2.1 Lack of an influential 3 rd party logistics leader | 19 |
| 3.2.2 Low efficiency of distribution, poor basic facilities | 21 |
| 3.2.3 Lack of professionals | 23 |
| 3.2.4 Lack of operational experience | 24 |
| 3.2.5 High logistics cost | 24 |
| 3.3 Actions that have been taken by government and enterprises | 25 |

| | | |
|----------|---|-----------|
| 3.3.1 | Government set up regulations | 26 |
| 3.3.2 | Logistics enterprises enter into cold chain logistics | 27 |
| 4 | Developing prospect and opportunities of cold chain logistics in China | 29 |
| 4.1 | Analyze by classification of refrigerated food | 29 |
| 4.1.1 | Cold drink logistics | 29 |
| 4.1.2 | Meat cold logistics | 33 |
| 4.1.3 | Quick frozen food cold logistics | 34 |
| 4.1.4 | Dairy product cold logistics | 36 |
| 4.2 | Business opportunities of cold chain logistics in rural areas in China | 39 |
| 5 | Rationalization analysis of cold chain logistics in China | 40 |
| 5.1 | Management part | 40 |
| 5.1.1 | Set up cold chain standard for food stuffs | 40 |
| 5.1.2 | Cultivate more professionals in cold chain logistics | 43 |
| 5.1.3 | Set up professional cold logistics management system | 44 |
| 5.1.3.1 | JIT strategic management | 45 |
| 5.1.3.2 | Continuous replenishment and midway tracing strategy | 46 |
| 5.1.3.3 | Value-added service strategy | 47 |
| 5.2 | Organizing part | 49 |
| 5.2.1 | Pay more attention to 3 rd party logistics in cold chain | 49 |
| 5.2.2 | Set up alliances | 50 |
| 5.2.2.1 | Set alliance with producers | 50 |
| 5.2.2.2 | Set alliance with other logistics companies | 51 |
| 5.2.2.3 | Set alliance with business companies such as chain stores | 52 |
| 5.3 | Technology part | 53 |
| 5.3.1 | Bring in information system to reduce logistics cost | 53 |
| 5.3.2 | Increase investment in developing science and technology | 57 |
| 6 | Some quantitative analysis method in reducing logistics cost | 60 |
| 6.1 | Use NPV method in purchasing facilities | 60 |
| 6.2 | Use spreadsheet to solve the covering problem | 62 |
| 7 | Some suggestions | 68 |
| 7.1 | Balance the relationship between cost and service level | 68 |
| 7.2 | Green logistics and recovery logistics | 69 |
| 7.3 | Risks and energy development | 72 |
| 7.4 | Can't copy the western model | 73 |
| 7.5 | Avoid reduplicated construction | 74 |
| 8 | Conclusions | 75 |
| | References | 77 |

LIST OF TABLES

| | | |
|---------|--|----|
| Table 1 | Scale and Structure of Annual Logistics Cost in America | 16 |
| Table 2 | Cold Chain in Advanced Countries and in China | 18 |
| Table 3 | Yearly Growth of Consumption of Different Fresh Foods | 29 |
| Table 4 | Developing Situation of Dairy Product Industry in China | 37 |
| Table 5 | Calculation of Operating Cash Flow in Each Year | 62 |
| Table 6 | The Spreadsheet Model of the Covering Problem of DC | 65 |
| Table 7 | The Formula of Spreadsheet Model of the Covering Problem of DC | 66 |
| Table 8 | Use Solver to Get the Answer | 66 |

LIST OF FIGURES

| | | |
|-----------|---|----|
| Figure 1 | The Development of Cold Chain Logistics Industry | 10 |
| Figure 2 | Processes Americans Take After the Vegetables be Picked | 17 |
| Figure 3 | Chinese Refrigerator Ownership by Province | 22 |
| Figure 4 | Forecast of Cold Drinks Production in China | 30 |
| Figure 5 | Consumption of Cold Drinks Market in China | 30 |
| Figure 6 | Cold Drinks Consumption of China and Other Countries | 31 |
| Figure 7 | Ice-cream Consumption of China and Other Countries | 31 |
| Figure 8 | Forecast of Manufactured Meat Consumption | 33 |
| Figure 9 | Manufactured Meat Takes Up in Total Meat Production | 34 |
| Figure 10 | Production of Dairy Products in China | 36 |
| Figure 11 | Average Consumption of Dairy Products in Different Areas | 38 |
| Figure 12 | Personal Disposable Income in Both Urban and Rural Areas | 39 |
| Figure 13 | Average Consumption of Dairy Products in Rural Areas in China | 39 |
| Figure 14 | Governmental Support Price | 43 |
| Figure 15 | Cold Supply Chain Flow Chart | 45 |
| Figure 16 | Information and Transportation Process in Fresh Food Transportation | 46 |
| Figure 17 | Set Alliance with Producers | 51 |
| Figure 18 | Set Alliance with Other Logistics Companies | 52 |
| Figure 19 | Set Alliance with Chain Stores | 53 |
| Figure 20 | On-board Info Platform & Web Info Shared Platform | 56 |
| Figure 21 | Map of Shanghai | 63 |

LIST OF ABBREVIATIONS

| | |
|-------|--|
| WFLO | World Food Logistics Organization |
| GDP | Gross Domestic Product |
| FEFO | First Expiration, First Out |
| CA | Controlled Atmosphere |
| RPS | Renewable Portfolio Standard |
| JIT | Just In Time |
| GPRS | General Packet Radio Service |
| CDMA | Code Division Multiple Access |
| INA | Ice Nucleation Active Bacteria |
| CAS | Cell Alive System |
| NPV | Net Present Value |
| PVIFA | Present Value Interest Factor of Annuity |
| PVIF | Present Value Interest Factor |
| DC | Distribution Center |

1. Introduction

1.1 Introduction of the dissertation

Nowadays, cold chain plays a more and more important role in our daily life, especially in food industry. The requirement for cold chain logistics is higher and higher. However, the development status of cold chain logistics in China is still awfully lagged behind. Cold chain in food industry in China today is just on its first step, there are still many problems. Then there comes a question: how to solve these problems and higher the cold chain logistics level in food industry? Thus, in this dissertation, I will study on the cold chain logistics in food industry in China and find out some practical and effective ways to improve the poor condition. Meanwhile many suggestions on the problems that we may come across when tackling with the issue will be given.

In the second chapter of the dissertation, a case of bird flu will be used to propose the conception, classification, characteristics and evolution of cold chain in China. And then the feasibility of the further development on cold chain logistics will be analyzed to show the necessity of the research.

And then it will be followed by the status quo of cold chain logistics in both of developed countries and in China. In this chapter, a methodology of comparison will be used. Execution of cold chain logistics in developed countries will be

analyzed and I will also find out some experience from their development to see what we can learn from their experience. Afterwards, status quo of cold chain logistics in China will be studied on. And what result in the poor conditions, what the reasons are will be analyzed. Some of the actions that have been taken by government and enterprises will also be talked about.

Next chapter is a connecting link between the preceding and the following chapters, which not only analyzes the refrigerated food by classification, or talks about the status quo of different kinds of perishable foods, but also analyzes their developing prospects and opportunities.

The following chapters are the core of the dissertation. Rationalization analysis of cold chain logistics in food in China will be analyzed. In this chapter, I will propose many effective and practical methods to higher the cold chain logistics level in China which is also the objective and aim of the dissertation. Analysis will be given from three aspects: management, organization and technology. In these aspects, many advices such as set up cold chain standard for food stuffs set up professional cold logistics management systems, set up alliances, bring in information systems are proposed to the government as well as logistics companies.

Then, in allusion to some problems we may come across in the real cold chain logistics practice, such as bring in new facilities, set up distribution centers reasonably, quantitative methods are used in solving those issues, which can really help a lot in real practices.

Of course, whenever we are tackling with whatever kinds of issues, we may come across various kinds of problems in the process. Thus, here in the final part of

dissertation, I also propose many problems that needs concentrate on, such as the relationship between cost and service level, green logistics, energy development and so on.

Finally, conclusions are summarized.

1.2 Literature review

At present, the requirement for cold chain logistics in China is higher and higher in China. There are several reasons for this: many of the youngsters who take a large part of the consumers are under high education, they want to save “kitchen time”, which enlarge the requirement of the food under low temperature. The appearance of some new type of retail style like supermarket makes sure that the cold chain could be integrated in a modern way.

However, cold chain in China is just on its first step, there are many problems still. For instance, Zhen Hailang, in How Freezing Industry Optimize Cold Chain Logistics tells us some statistics on problems: every year, almost 1,000,000 ton fruits go bad or sold at a very low price, about 400,000 ton fish caught go deteriorate. The wastage of those foods that are easy to be perished every year in China, is up to more than 10 billion. About 20% to 25% of fruits and 30% of vegetables get perished during the process of transferring transportation and storage.

Comparing with the world level, cold chain logistics in China has extremely been lagged behind. Cold chain technology was popularized in 1960s in America; Japan began its research of cold chain circulating technology since 1960s, and finished the construction of modern supply chain system around the whole country in 1980s.

Cold chain circulating and processing technology is now prevalent in developed countries, but in our country, it's just an infant industry. Although the low-temperature technology has been applied in many fields, areas and steps of freezing and frozen food logistics, but it's still a long way to a complete cold chain operating system. By summarizing the files, we can get a conclusion that main problems are listed as follows:

First, cold chain logistics is still on its infant step; market is not large, lack of an influential 3rd party logistics leader. Second, Middle-class and small enterprises welled up, but they can't reach an operation of economic of scale. Third, short of basic equipments. Refrigerator car in China nowadays is about 30,000; while in America there are about 200,000, and 120,000 in Japan. Refrigerator cars in China accounts for only 0.3% of automobile carriers, while in U.K, the rate is 2.5% to 2.8%, 0.8% to 1% in U.S, 2% to 3% in Germany. Because of the shortage of these basic equipments, it's difficult to provide proper low temperature for those foods that can easily go perished. Thus attribute to a large sum of wastage of the foods, especially in the process of transportation, the high wastage has make the logistics cost 70% of the total cost, while according to the international standard, logistics cost of easily go perished food should not exceed 50% of the total cost. Finally, China rarely has any regulations on cold chain or on the standard on the condition or temperature in the transportation, but in U.S., it has set up a cold chain union in 2002, which was composed by air company, automobile carrier, transferring company and equipment producing company, mainly dealt with the problem related to goods which are easily go perished, and is the guideline f the standardization of the transportation of goods' temperature control. And in the year 2004, U.S. Cold Chain Union issued Cold Chain Quality Index and announced that this index can be used to test the reliability, quality and proficiency of those enterprises that transport, dispose and store

putrescible food.

Thus many of the researchers and scholars apply themselves in solving the problem and try to find some effective ways to improve the conditions of cold chain in China.

We can classify them into 2 catalogs, from the aspect of government and the enterprise themselves. In the aspect of government, Wang Zilin, points out in Cold chain faces 4 important problems that the government should better pay more attention on cold chain and set up a series of standard of freezing/chilled food and set some other departments to supervise every step of the operation of cold chain.

As for the enterprise part, many of these articles are focusing on the technical part, they put much energy in using new type of tools, new kinds of facilities and analyze the usage. For instance, thicker the heat insulation part of the protection structure. In Wang Zilin's article, it said that it's important to put HACCP control in practice to assure the quality of freezing food in every step of cold chain. While in Francisco Artés's article, Refrigeration for Preserving the Quality and Enhancing the Safety of Plant Foods, he also emphasis this idea. And Li Xuejun in Building cold chain logistics in our food industry emphasize that we integrate distribution, circulation and processing to enhance the ability of keeping fresh of the freezing/chilled food.

Meanwhile, they hold the idea of inviting information system into operation, for example, RFID, which can help us to know where the production is and how is the condition, what's the temperature there now, help with the continuous replenishment program, know when do we need to replenish the goods and get it there in time under a good condition.

Besides, Su Xiujin, in Research on Logistics Planning of Food Cold Chain, shows us the idea of improving logistics programming from 4 aspects: transportation system, logistics service level, stock and supply, storage and positioning of warehouse.

Till now, in our country, there are about 2500 or more meat factories, producing 60,000,000 ton fresh meat, which is increasing at a rate of 5% annually; about 2000 deep freezing factories, produce more than 8,500,000 ton in one year; cold drink factories exceed 4000 (among them 194 has exceeded a certain size), producing 1,500,000 ton every year, which is increasing at a rate of 7% annually; dairy farming is about 1500, produce 8,000,000 ton annually and increasing at a rate of 30%; aquatic product's annual production is 44,000,000 ton and is growing at the rate of 4%. In the year of 2003, total production of fresh food is about 0.7 billion, consumption is about 0.24 billion ton, the expenditures spend on fresh food occupies 51% of citizen's total food expenditure. And the number is still increasing, thus we can predicate how large is a developing room waiting for us. All of these statistics are provided in Wang Zilin, points out in Cold chain faces 4 important problems.

We forecast that in the future, the technology of freezing and chill will be highly enhanced; an efficiency temperature control system will be put into use, operators and managers of the cold chain logistics will be well educated to deal with the supply chain. Besides of those, there may come forth some big companies that can lead the cold chain logistics industry, to do the outsourcing of transportation of those putrescible foods.

2. Conception about cold chain & necessity of the research

2.1 Conception, definition of cold chain

2.1.1 Cases of bird flu that influence selling of chicken in supermarket

Since the bird flu turned up for the first time in the world in 2003, it spread to Guangxi province in China, and then many other provinces, such as Anhui, Liaoning, Hunan, Taiwan and so on, human turn pale at the mention of bird flu. The upstream and downstream of the supply chain of supermarket, acting as main channels of connecting bird flu, chicken and consumers, stand in the breach of strike brought by bird flu.

However, in some areas, because of the shortage of supplying of chicken and eggs, the price of eggs is becoming higher, sometimes it takes on a condition of breaking off of eggs in supermarket. On 16th Nov. 2005, the price of eggs in a supermarket, Wumei, in Beijing has increased from ¥2.48/500g on 15th Nov. to ¥2.95/500g. And this supermarket always sells the eggs in a low price, the former price of eggs is ¥2.38/500g, almost ¥0.6/500g cheaper. (Yan Yongli, 2005, p.62) The consumers who came to buy eggs were discussing around the egg baskets which have already half sold out. There forms a queue of almost 10 persons who wanted to buy eggs in only a few seconds. One consumer said that it was because Beijing rejected eggs

from other provinces by reason of bird flu so that the number of eggs is limited and so expensive. Instead of appreciating, the price of meat decreased a lot.

But in some other parts of China, especially in northern China, like Shenyang, bird flu influences a lot. Some supermarket can't even accomplish the quantity of booking of chicken. It will surely cause some damage to the supplier, but they can hardly do anything to change the sad situation at the moment. If we consider the bird flu as an act of God, the broken of cold chain in selling those freezing and frozen food can then be treated as a disaster caused by human ourselves. What we should do is to take some activities in controlling the quality of foodstuffs instead of taking the emergent actions passively.

2.1.2 Conception, definition and classification of cold chain

Cold chain logistics is a systematic project that assures the quality of food and lessens the spoilage and wastage of food. It acquires that the freezing and frozen food are always kept under a low temperature when producing, storing, transporting, selling, and every other steps before consumption. (Wang zilin, 2005, pp. 18-20)

Cold chain is applicable under the following areas: primary agricultural products: vegetables, fruits; meat, chicken, eggs; aquatic products, flowers. Artifactitious foods: deep freezing food, packing cooked food of chicken, meat, aquatic products and so on, ice cream, dairy products; raw materials for short order. Special goods: medicine. (Wang zilin, 2005, p. 18)

2.1.3 Characteristics of cold chain logistics

It's because freezing and frozen food has strict requirement on environment and time that made the cold chain logistics has following characteristics:

First of all, the final quality of freezing and frozen food rests with three Ts: temperature controlling, time of cold chain and tolerance of product. Thus, transportation service matters a lot with the quality of freezing and frozen food even in the final selling to consumers. (Su Xiujin, 2005, p. 31)

Second, in order to ensure the food which can be easily perished are placed under the necessary low temperature during each step, many facilities and equipment are needed, such as the temperature controlling system, refrigerator car and so on. Moreover, for the sake of enhancing logistics operating efficiency, some advanced information systems are required. All of these are obviously higher the cost of cold chain logistics. Therefore, there is a close relationship between cold chain logistics cost and the whole operation of the cold chain logistics.

Third, cold chain logistics is a complex system that pays much attention on temperature. For example, if there's a tiny mistake in any process of transportation, the food may go bad. The whole cold chain of the food is broken. Thus, the harmony among every segment is important in keeping safety of food in the process of processing, transportation as well as selling. It's a low temperature system with high technology.

2.1.4 The evolution of cold chain logistics in China

Food cold chain is established based on the development of science technology and refrigeration technology. Cold chain in China comes into being in early 50s in 20th century's foreign trade, especially export, and some of heat preservation vehicles are refitted. In 1982, The Regulation of Sanitation of Food promotes the growing pace of cold chain in food. During about recent 20 years, food cold chain in China is developing. Some food processing companies, including foreign trade companies, had set up a system of cold chain logistics. Although the system is not that complete, it's gradually improved.

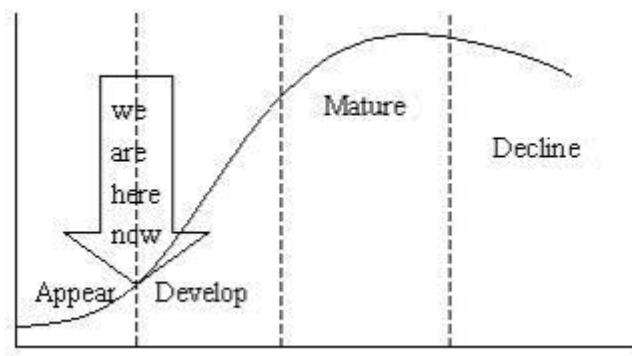


Figure 1: The Development of Cold Chain Logistics Industry

Source: Yan Yongli. Analysis on Cold Chain Logistics in Logistics Company.

Cold chain logistics in China, as can be forecasted, is a new industry with high demand of technology and operation level. Moreover, the profit is also considerable. With the further development of economics in China, cold chain logistics will surely be highly needed. Thus, as an industry of high investment and high technology, enter into the industry will become difficult. Some enterprises of middle or small size can hardly enter the industry although they are awfully desirous to. But facing the high initial investment of facilities, high expenses on training

professionals, they can hardly afford.

However, on the other side, it's absolutely a great opportunity for those large companies who can pay for the investment and have the ability to operate such a large system. These companies may become a great 3rd party leader tomorrow. And now, cold chain logistics industry is coming into a period of high development. It offers a huge room for those large enterprises. With the continuous entry of those large companies, I never suspect that the spring of cold chain logistics industry is coming.

2.2 The feasibility of the further development on cold chain logistics

In China, rapid development of economics also brings in booming in many industries, including the cold chain industry. Although it's still an infant industry, there are many conditions promoting to the development of it.

2.2.1 Change of consuming style of citizens

Nowadays, youngsters take up a high rate in all consumers. The quick pace of life and work attribute to their limited time in kitchen, they are always busy working, doing other things and thus have little time in enjoying life, so those freezing and frozen food are the best choice for them in kitchen. It saves time!

Moreover, they had higher requirement on those kinds of food than their parents, they want these food contains higher added value. For example, they may want the freezing/frozen food be well prepared, is clean enough and waiting for them to eat as long as they put them into the microwave oven. Or, they may choose the food that

have already be arranged in groups, they don't need to wait to thaw the meat or vegetables and then cut them into pieces, add some flavoring like pepper or tomato sauces into them, all of which have extremely strong demand for cold chain logistics but putting forward a more complicated case onto the food cold chain logistics.

2.2.2 New pattern in retail industry enter the cold chain field

Some new patterns in retail industry appear, such as supermarket, mall, which makes it possible for organizational integration of those freezing/frozen foods. They require the suppliers change their way of distributing goods.

Before, these suppliers always transport the goods which each retailer needs one by one, as soon as they got the information that the retailer needs some kinds of goods, they will delivery the goods to them directly. Then a problem appears, maybe about 200 branch supermarkets may ask the same supplier 2 to 3 times a week for the supply of goods, then the supplier will deliver about 600 times for the goods. However, these branch supermarkets don't ask for the supply at the same time. Maybe the one which they pass by today don't have the requirement today, but they send out their requirement the next day. This is because the difficulty in forecasting the selling capacity. But all of these reduce the service level of supplier. They may have difficulty in delivering the goods in time or to assure the quality of the goods transported.

Fortunately, now, they changed their way of distribution. First, the subsidiary companies collect the selling information of each net spot to see what kind of goods they need separately. And then, those subsidiary companies transfer this information to the distribution center. After that, the distribution center matches

goods. Finally, trucks deliver these goods to each supermarket. In this way, the distribution center saves a lot of time in dealing with the requirement of different supermarket and has enough time in checking, thus ensure the quality of transportation. The new organizational pattern of supermarket makes the cold chain logistics more feasible.

2.2.3 Other factors that affect

There are some other factors that make the implement of cold chain logistics becomes possible. For instance, the application of computer technology which makes the transfer of information becomes quicker and nicety. With the internet, suppliers and supermarket or subsidiary companies can communicate with a certain kind of software or system on the selling information, let the suppliers know exactly what kind of goods they need, when they will need it, and how many they need.

Another factor is the fierce competition in the market. More and more supermarkets well up in the market, consumers have many more choices. They are free to choose whichever they want in any supermarket, and supermarkets are trying every means to attract new customers besides to retain the old ones. The quality, of course, becomes an important standard except price. So the managers of supermarket will surely pay more attention on how to improve the quality of goods, especially those freezing/frozen foods that easily go perished. Thus, cold chain logistics becomes necessary.

Now that the cold chain logistics is so important, how is the cold chain logistics in developed countries and in China at present?

3. Status quo of cold chain logistics in developed countries and in China

3.1 Execution of cold chain logistics in developed countries

3.1.1 Some statistics and characteristics

Cold chain originated from the invention of chilling machine in the upper half of 19th century. With the appearance of refrigerator, many kinds of foods that need to be kept fresh and chilling poured into market and families. And food cold chain system had been primarily set up until 1930s. But unfortunately, cold chain in Europe had been destroyed during the World War II in 1940s. Luckily, it recovered soon after war. And now, a complete food cold chain system has formed in the developed countries in both Europe and America.

World Food Logistics Organization (WFLO), founded in 1943, was highly effective in improving refrigerator technology in storage and processing, professional training, information communication, research and development. Furthermore, it upgrades into a thorough logistics service especially in perishable foods.

U.S.A set up a Cold Chain Association in 2002. The association, which mainly tackles with the problems relating to those perishable goods, contains airways, forwarding agent, transportation parties inland and equipment producers. They also set up standardized guideline for the transportation of temperature controlling goods.

In the year 2004, America Cold Chain Association issued Cold Chain Quality Index, and announced that this standard can be used to test the reliability, quality and proficiency of the enterprises that transport, process and deposit perishable goods. Moreover, it will lay the foundation for the attestation of the whole supply chain of perishable goods without any doubt (It's Important for Alliance to Support Cold Chain Logistics, 2005, pp. 45-46). Now, developed countries are evaluating about how the food service industry satisfy the requirement of consumers, how is the performance of logistics service companies. Besides that, they pay much attention on the relationship between freezing/frozen food industry and environment as well as the legislation about the cryogen used in food transportation.

America now owns about 180,000 refrigerator cars and insulated vans. The number in Japan is about 150,000, while in Germany, France, it's about 50,000. However, there are only 30,000 or so in China. 83%-90% of perishable goods are delivered by refrigerated transport in Europe, America and Japan. Moreover, the rate of transportation of perishable goods on highway achieves 65%-85% in developed countries. (Lu Gang, 2005, pp. 50-52)

Meanwhile, because of the free economic policy in America, the logistics business is booming and forms logistics structure characteristics of several channels and forms. During the recent 10 years, logistics industry in America grows up at a rate of 20% annually. In the year 2003, business of American logistics industry is about 936 billion USD, 26 billion more than that in 2002 but takes up about 8.5% of GDP in America, which is 0.2% lower than that in the year 2002. (Song Liang, 2005, p.18)

Table 1: Scale and Structure of Annual Logistics Cost in America

| Item | Cost (0.1 billion) | | | | |
|--|--------------------|--------------|--------------|--------------|--------------|
| | Year 1999 | Year 2000 | Year 2001 | Year 2002 | Year 2003 |
| Cost of stock | 3330 | 3740 | 3390 | 2980 | 3000 |
| Transportation cost | 5540 | 5900 | 5810 | 5770 | 6000 |
| Logistics administrative management cost | 350 | 390 | 370 | 350 | 360 |
| Total | 9220 | 10030 | 9570 | 9100 | 9360 |
| Annual growing rate | 4.3 | 8.8 | -4.6 | -4.9 | 2.9 |
| Proportion in GDP | 10 | 10.2 | 9.5 | 8.7 | 8.5 |

Source: Armstrong & Associates Inc

3.1.2 Experience

To ensure the quality and lower the loss, America focuses on the processes after the vegetables be picked. They usually take the process as Figure 2.

Thus, through the process and techniques as above, there will be merely any broken of the cold chain in the whole transportation process. With every detail be carefully tackled with, loss caused during transportation in America is only 1% to 2%. (Lu Gang, 2005, p.62)

Techniques in those advanced countries are also much better. For instance, in Japan,

when they are transporting agricultural and sideline products, their refrigeration system is to provide electronic power in train or container. They put the refrigerate facilities onto the train to maintain the low temperature and fresh. When the foods are loaded on the ground, they also use the electronic power there to keep the function of refrigerator facilities. In this way, they assure the necessary low temperature in the whole process: from the transportation of the original material, until they get to the consumers.

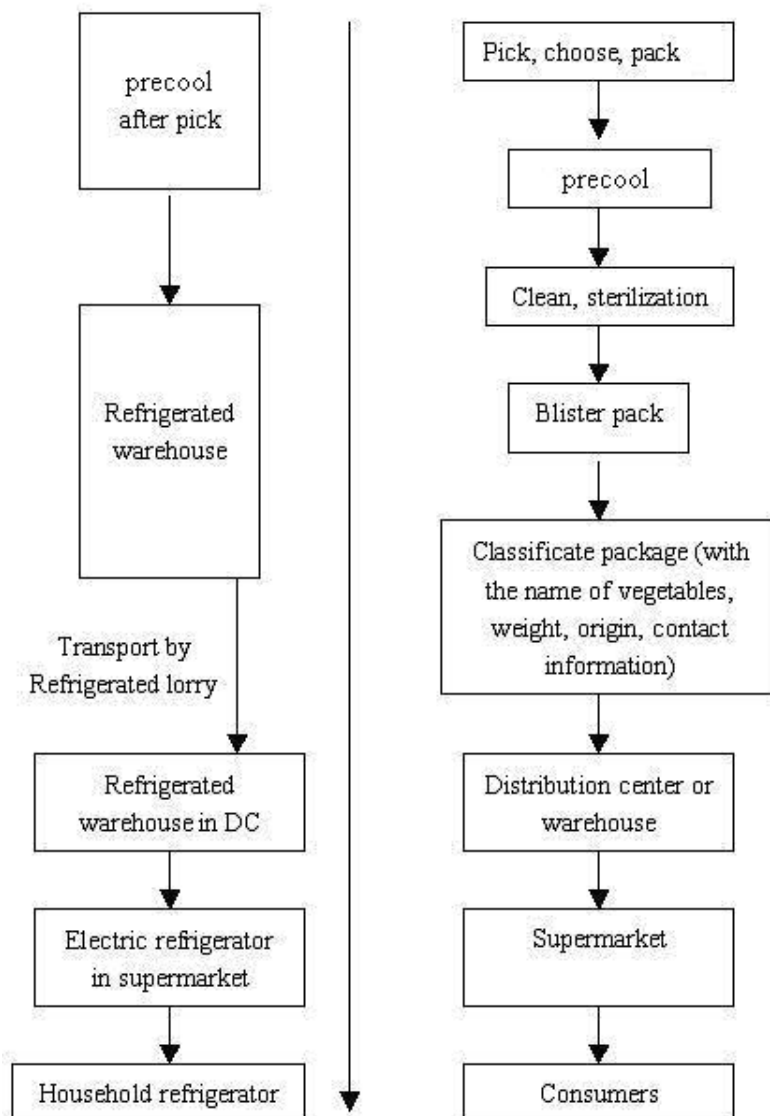


Figure 2: Processes Americans Take After the Vegetables be Picked

3.2 Status quo of cold chain logistics in China

Nowadays, cold chain logistics system in China is still not complete, no matter comparing with economical development or with consumption of advanced countries, there is still a long way for China to go. For example, the annual foodstuff in China valued \$300 billion USD in total, in which 20% was wasted in the process of transportation. Only 20% of foodstuff undergoes the processing of cold storage, while the figure in western countries is 90%. The wastage of cold chain in China is more than 60% while it is no more than 30% in other advanced countries. (Song Liang, 2005, pp. 18-20) The phenomenon of breaking up of cold chain is serious also.

Table 2: Cold Chain in Advanced Countries and in China

| Contents | Advanced countries | China |
|-------------------------------------|----------------------------------|--|
| Precooling rate | U.S. and Europe: 80%-100% | 30% or so |
| Lose rate after picking | 5% | 20%-40% |
| Refrigerated transportation ability | U.S.: 160,000 refrigerated truck | 30000 refrigerated truck, 6792 refrigerated train |
| Refrigerated transportation rate | 80%-90% | Less than 50% in all |
| Refrigerated ability | 80 million in all | 7 million |
| Cold chain management | Efficient | Process is complex |

Source: Yang Bo, Zhao Gang. Cold Chain: Lagged Chain and Its Rebuilding

Maybe the cold chain is quite ok until it get to the free market, however, because of the food stuffs are sold separately and some of the foods which need to be refrigerated can't be transported to the refrigerated house of supermarket, thus reflect on the broken of cold chain. What attribute to these terrible conditions? I classify the reasons as following:

3.2.1 Lack of an influential 3rd party logistics leader

Comparing with logistics development in advanced countries, logistics in China is still on its first step. But in recent few years, logistics industry is developing in an extremely fast pace. However, there is still hardly any large companies which can act as the leader in 3rd party logistics industry.

There are two reasons for this: In 1990s, the definition of logistics came into China, and then many small companies which mainly dealt with transportation business transferred to logistics industry. Most of these companies are still transportation companies instead of logistics companies. With small scale, unprofessional workers, poor equipments, they can't deal with any complex problems. Actually, they are still traditional transportation companies, but just change their title.

Second, as a real 3rd party cold chain logistics, what they need is not only professional and experienced workers, but also abundant capital for the equipment and facilities, such as the refrigerator trucks, temperature controlling system, large warehouses, sound distribution centers and so on. Meanwhile, they need capital to train the workers for some advanced operational and theoretical knowledge. Take Bright Dairy & Food Co., Ltd as an example: they do their business according to three channels. One is from the factory to some supermarket and convenience

stores and promises a distribution of “365*24”, one is directly to the consumers, and the other one is introducing their products into separate communities. All of their distributions are done under a freezing environment (0-4°C) and keeps the cold chain unbroken. Even in the hot July, the temperature is as high as 35°C or more; you can still feel the cool pour forth from the warehouse when you are near the door of their warehouse. As soon as the dairy is squeezed out, it's cooled and put into the truck and transported to the factory for the processing. When the products are finished, they are put into the refrigerator warehouse in logistics distribution center and then sent directly to the supermarket. In order to assure the close connection of cold chain, in Bright, they have a special design of porch, the temperature of which is kept at 0°C to 10°C. When the refrigerator trucks come to warehouse to pick the products, they first drive into the porch. To keep the cold chain unbroken even in the last minute, Bright Company invested as much as 5 million RMB to perfect the refrigerator house in communities to assure that the temperature is kept until it reached consumer's hands. Even more, they brought in many information systems, such as WMS. In the project of setting up a logistics distribution center, they invested about 170 million, a large amount of money is put into the exploration of information. Now in the whole East China, Bright Company has over 10 thousands networks, which covers more than 20 cities. Their daily traffic volume is at about 5,000 tons, distance is about 100,000 kilometers, amount to the distance of 40 rounds between Shanghai and Beijing. (Li Weihua, 2004, p.62) Another typical example is Yum! Brands, Inc. They have a distribution center of 5736 square meters, which contains 3002 square meters' warehouse for dry goods and 1400 square meters of warehouse for frozen goods while 400 square meters for freezing foods. The center storage and transportation department operate 24 hours continuously everyday to provide logistics service for over 250 KFC and Pizza Hut spots. They distribute an

amount of 5 million boxes every year with a distance of 3.5 million kilometers. When it comes to the managing aspect, they also take the international standard of FEFO (first expiration, first out) that ensures the quality as well as safety of foodstuff. (Li Weihua, 2004, p.62) Thus, the high entry requirement hampers many companies from doing the business. That's why hardly any companies can be said as a top leader in 3rd party cold chain logistics.

3.2.2 Low efficiency of distribution, poor basic facilities

There are more than 2500 meat-processing factories in China, which produce 60 million tons of meat per year; 2500 processing factories of fast frozen food which produce 10 million tons or more fast frozen foods. Besides that, 1500 cold drink producing companies produce 10 million tons cold drinks. And there are more than 50 million tons aquatic products. All of those products are supposed to be transported through refrigerated transportation. (Lu Gang, 2005, pp. 50-52)

On the whole, refrigerated technology and facilities in China are keeping following the international pace. 20 years ago, most of the chilling processing equipment in freezing industry are mainly refrigeration compressor, direct expansion air cooler, evaporation pump, brine ice-making and so on. Processing measures are limited, with high intensity of work but low level of product, which also consumes much energy. After mid 1980s, many of our self-research and developed technology and equipment were brought forward. Many of advanced technology on ice-making technology, deep freezing technology, modern roboticized equipments in refrigerated warehouse are highly used in freezing and frozen industries in China, such as: forced-aircooling, differential pressure cooling, vacuum cooling, controlled atmosphere (CA) and so on.

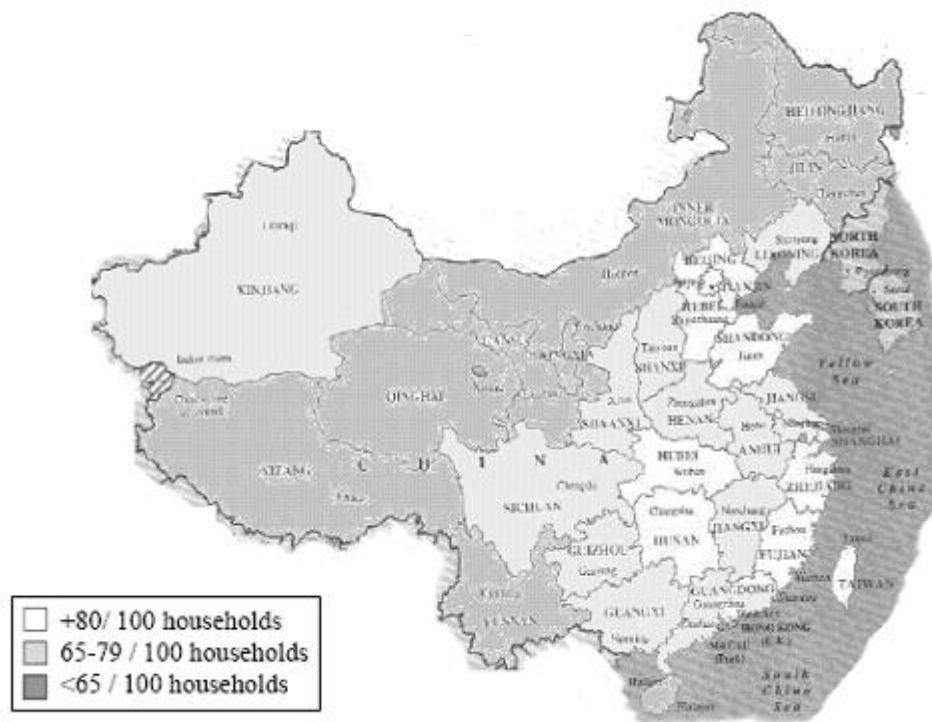


Figure 3: Chinese Refrigerator Ownership by Province

Source: Carmi A. Lyon and Catherine A. Durham¹. Refrigeration and Food Demand in China

However, there are still many serious problems in the development of cold chain logistics in China. Although the capacity of refrigerated warehouse is increasing year by year, still, in some other areas, because of the lagged behind technology of refrigerated warehouse, the quantity of food stuff isn't go up with the capacity of warehouse. At present, it is quite good if the storing quantity can reach 70%, the storage of a refrigerated warehouse can be only 20% to 30% of its capacity, some even less than 10%. The slow development of cold chain logistics incarnate not only on the high vacancy rate of warehouse, but also on the poor freezing/frozen technology. Some technologies in some of areas are just behaved as about the

technological level of 1980s in other countries. Actually, unbalance of cold chain logistics in China is outstanding. In some poor areas or in some free markets of agricultural products, they have their own self-made cold chain, that is to put some ice in the foam box, and then put those fresh fruits on the ice to achieve the function of heat preservation.

The poor cold chain facilities and equipment result in the following results: first, it brings a high waste rate of foodstuffs. Comparing with some advanced countries, the consumption of those foods which are easily go perished is not high, but attribute to the poor technology and low efficiency of insulated transportation, the rate of perishing remains at a high position. Every year, more than 1 million tons of fruit go perished or sold at a low price, and about 400,000 tons of fish go bad. There are about 30,000 insulated trucks in China while there are more than 200,000 in U.S.. Meanwhile, the rate of refrigerated transportation for those perishable foodstuffs is only 15% to 20%, while the number in developed countries is as high as 80% to 90%. (Li Xu, 2004, p.8) What's more, the poor equipment also brings in some hidden danger of those foods.

3.2.3 Lack of professionals

There's a famous Chinese saying goes as 'Modern competition is a competition on talents and professionals'. China is a country with abundant labor; there are many workers in the cold chain logistics field. However, what most of these workers do are easy jobs, like drivers, storekeepers and so on. When it comes to the managing level, there are few professionals. Some of the managers are still on their way of studying and had little experience. Moreover, because cold chain logistics is an industry which needs advanced technology, those professionals who knows well

about the technology and management of cold chain, or skillful in operation of cold chain logistics are highly needed. Nevertheless, to solve this problem, we still have a long way to go.

3.2.4 Lack of operational experience

Due to the specialty of cold chain logistics business, the requirement of operational quality is extremely high. Many logistics companies, however, just transferred from transportation companies, most of their businesses are relating with cold chain transportation, which is only a part of cold chain logistics. They seldom have any complete cold supply chain management or technology index system, and lack of integrate operational experience on cold chain logistics, which also bring on the difficulties in doing some complex business and can hardly achieve the standard.

Moreover, the specialty of cold chain logistics requires a high standard for the quality control on products, most of the fresh food producing enterprises suspicious on outsourcing the logistics, they prefer doing the logistics themselves. Besides that, most of the target customers are assembled in a certain area; it's easy to form specificity as well as exclusivity in those suppliers that have already existed.

3.2.5 High logistics cost

China has an awfully high logistics cost comparing with those advanced countries. It is reported that logistics cost in U.S. takes up only 9% of the whole operational cost while the logistics cost in China takes up about 20%. From the perspective of storage, the turn around time of products in Chinese enterprises is about 35 to 45 days, however, the inventory time of products in developed countries' enterprises is

less than 10 days. In addition, Chinese enterprises prefer to use their own fleet, but the vacancy ratio is up to 37%. Meanwhile, the loss of products caused because of poor package is 15 billion RMB per year, loss of cargo transportation is 50 billion RMB every year. (Xu Bonian, 2004, p.8) What's a large number! Then what's the origin of this poor situation?

According to Professor Wang, Zhitai, a famous logistics specialist, the high logistics cost influence not only the competitiveness of enterprises and products, but also lower the level of general operational standard of national economy. He pointed out in an interview that there are many reasons for the high logistics cost, but the most important factor is the separation of logistics basis that lies in system construction in China and caused low efficiency of logistics. (Huang Zhu, 2003, pp. 12-14) Many logistics basic platform such as railway, airway, highway and water transportation are separated in China, they always doing their own business and controlled by different departments of government. For instance, railway container is an independent system, separated from international seaway transportation and the procedure can be loaded down with trivial details. However, one of logistics characteristics is that they can't just rely on only one mode of transportation, those transportation modes need to be connected closely, that is multimodal transportation. For example, we may transport some containers to railway by trucks and then transfer those containers to one port to transport by vessels, and finally transported by trucks to the final warehouses. During the whole process, if the transferring in any circle is not efficient, the total logistics cost will be much higher.

3.3 Actions that have been taken by government and enterprises

Facing the continuous developing Chinese economy and increasing customers'

demand for freezing and frozen food, cold chain logistics is more and more important in modern societies. Government takes a lot of actions in standardizing the regulations of cold chain as well as controlling of food safety. As cold chain logistics is the developing trend for logistics, and the future of cold chain logistics will be bright without any doubt, many enterprises are also trying every means to enter into this new industry. Those who had already entered into the field are attempting in finding new ways to improve the conditions they are in now.

3.3.1 Government set up regulations

Early in 1986, Key Point of Communications and Transportation Policy in China, which is announced by State Department had pointed out clearly that in China, we should put much energy in develop freezing and frozen transportation to meet the increasing requirement of fresh food consumption.

Besides that, ministry of communications issued a Program of Traffic Transportation Development during 2001 and 2010. In the program, it pointed out that we should put more energy on the construction of container transportation, and promote the specialization, modernization and scaled management of fresh and chilling foodstuff transportation.

In the year 2004, Chinese State Department announced in Suggestions of Policies in Improving Village Work and Increase International Agriculture Producing Ability that every province should pay attention to the construction of agricultural cold chain that focus mainly on chilling and low temperature.

In February 2005, the Ministry of Communications in China announced to the public

that at the end of 2005, we would build a green network for fresh agricultural products, which is the first low cost transportation network for fresh agricultural products. This network will be 27,000 kilometers long, covers more than 30 capital cities and 71 prefecture-level cities. (Wang Zilin, 2005, p.18)

After the horrible bird flu appears, on 25th October 2005, Chinese Grocery Industry Association draw up a Standard on the Environment of Supermarket. It specified in detail on the display of equipments and processing, mainly focus on the cleaning and temperature. Such as: equipment that displays should keep clean, no water accumulation or besmirch on the floor, fix date for cleaning, and keep related record. The area which used to store fresh food and materials should be equipped with low temperature storage facilities, contains freezing and frozen warehouse. The temperature for freezing warehouse should be between -2°C and 5°C while the temperature of frozen warehouse should be under -18°C . This standard, aims not only at bird flu, but also aims at the foodstuff safety environment. It will promote the standardized operation of supermarket and improve the environment, and improve the cold chain level in a certain way as well.

3.3.2 Logistics enterprises enter into cold chain logistics

With a high regard of government, and high development of cold chain logistics, as well as the increasing needs of chilling foods, more and more enterprises become to realize that cold chain logistics will be a challenging and profitable industry. Thus, the prosperity of cold chain logistics abstracts numerous logistics enterprises to enter into cold chain logistics market. There are several examples for this.

On February 21st, 2005, DHL announced to own 60% of Shanghai Yuhe Refrigerated Express's stock ownership by the way of tender offers. Originated owned by Fujian Zhangzhou Yuhe Corporation, the name of Shanghai Yuhe Refrigerated Express will be changed to DHL Yuhe Low Temperature Logistics Co., Ltd, which means that DHL is entering into the refrigeration market of low temperature logistics.

Besides that, Shanghai Food Co., Ltd, which is owned by Jinjiang Group, is also a pioneer on this. They thought, Shanghai food market put out almost 67 million tons of fresh food every day, yearly consumption grows at a rate of 8%. (Li Weihua, 2004, pp. 62-63) In the supermarket, cold chain food stuffs takes up more than 20% that shows a prosperous future. Especially that Shanghai Food Co., Ltd owns 18 refrigerated warehouses in and out of the city, with a total storage of 138,000 tons, which is an absolute advantage for the company. Based on this, they set up a joint venture called Shanghai Xintiantian Dazhong Cold Logistics Co., Ltd with Dazhong Communications Co., Ltd and a Japanese company---Mitsui Co., Ltd.

4. Developing prospect and opportunities of cold chain logistics in China

According to the prosperous industry, we can imagine how the cold chain logistics industry in China will develop, and whether there are any special opportunities and potential chances. In China, there is a high consumption of fresh food. In 2003, 700 million tons of fresh foods were produced and 240 million tons were consumed. Fresh food cost takes up 51% of urban residents' total cost of food. (Su Xiujin, 2005, p. 31) And the percentage is still growing.

Table 3: Yearly Growth of Consumption of Different Fresh Foods

| | Meat | Fruit | Vegetables | Aquatic products | Dairy products |
|---------------|------|-------|------------|------------------|----------------|
| Yearly growth | 11% | 25.8% | 12% | 24% | 7.8% |

Source: Su Xiujin. Research on Logistics Planning of Food Cold Chain

4.1 Analyze by classification of refrigerated food

4.1.1 Cold drink logistics

Cold drink market in our country is keeping growing. Total consumption grew to 1.47 million tons in 2002 from 0.55 million tons in 1990. (Su Xiujin, 2005, p.26) There's now slight difference of seasonal reasons in consumption. We can see

many people, especially girls and children still love those cold drinks even in chilling winter. And we can always buy them in fast stores at any time in the year. At present, there are more than 4000 ice-cream producing companies in our country. In the year 2003, the production of cold drinks is up to 1.6 million tons, 7% more than the figure in the year 2002. Although it's reported that the consumption of cold drinks in China is just one fifth of that in western countries, the potential of this market is huge.

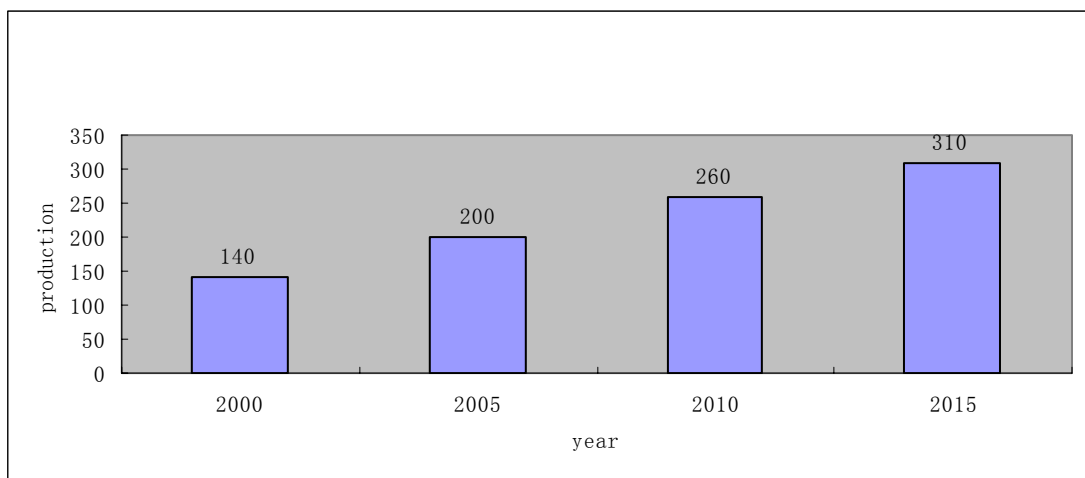


Figure 4: Forecast of Cold Drinks Production in China (Unit: 10,000 tons)

Source: Yan Yongli. Logistics Companies Do Business Analysis on Cold Logistics

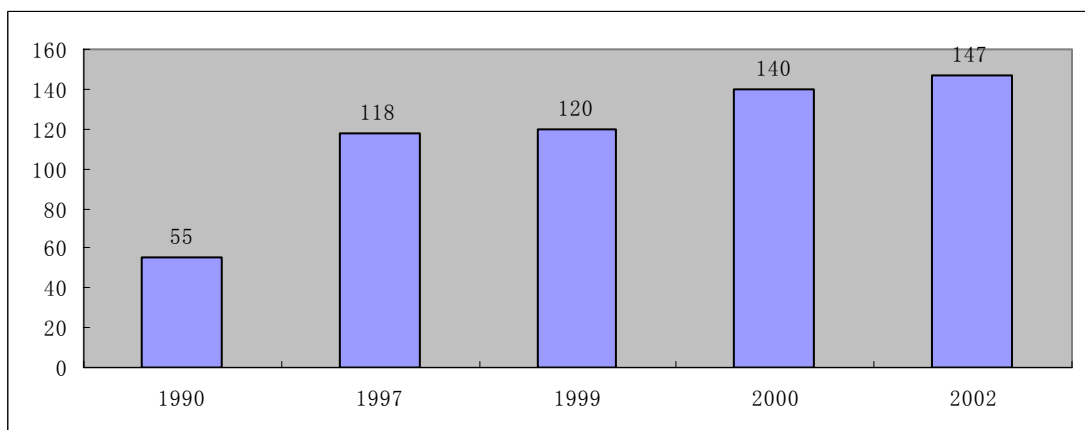


Figure 5: Consumption of Cold Drinks Market in China (Unit: 10,000 tons)

Source: Yan Yongli. Logistics Companies Do Business Analysis on Cold Logistics

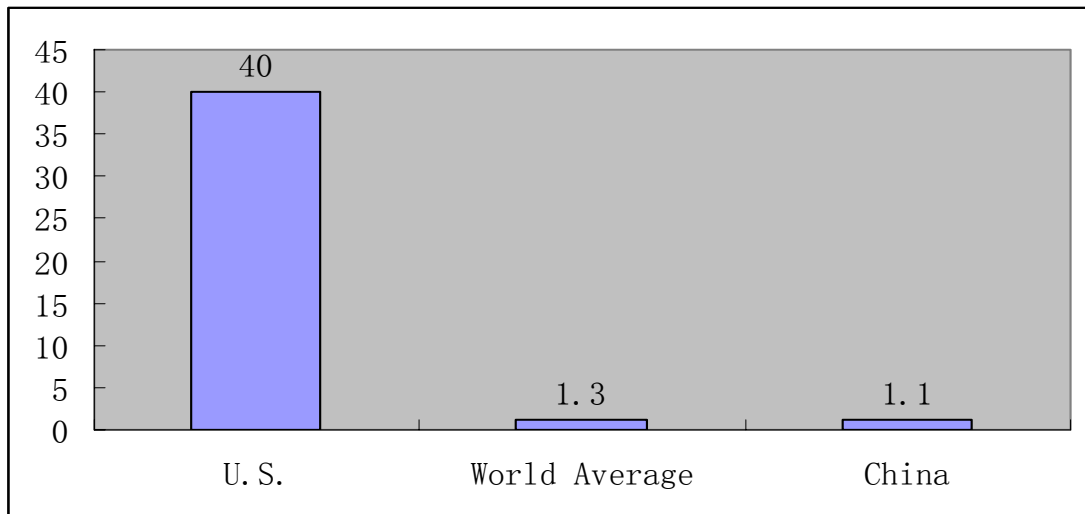


Figure 6: Cold Drinks Consumption of China and Other Countries
(Unit: Kg/Person*Year)

Source: Yan Yongli. Logistics Companies Do Business Analysis on Cold Logistics

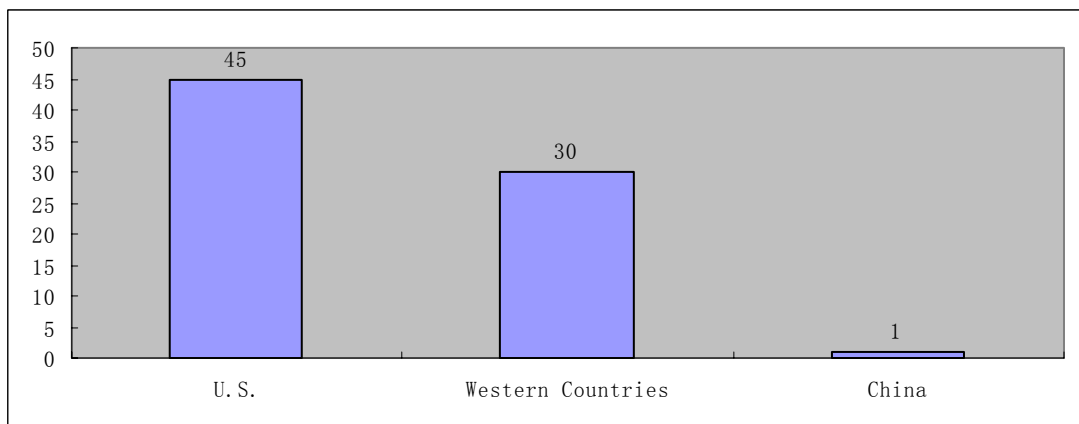


Figure 7: Ice-cream Consumption of China and Other Countries
(Unit: Kg/Person*Year)

Take ice cream for example, during the recent years, the production of ice cream is growing. The production of ice cream in the recent 3 years is keeping at 1.2 million tons and is about 1.4 in last year. The production of ice cream between January and April in the year 2005 increased 30% comparing with the number in 2004. The

highest figure is 50%. (Yan Yongli, 2004, p.19) However, it is also reported that there isn't much change in the term of transportation.

In some western countries, consumption is about 30 kg/person in one year and the number is even up to 45 in U.S., while the figure is only 1 in China. (Yan Yongli, 2004, p.19) We can get a conclusion from the figure that there's still large room for the growth of consumption of ice cream. With the continuous change of consumers' consuming habit for cold drinks and the increasing of income, enlargement of consumers as well as the development of urbanization, the production and consumption of cold drinks will take on an upwards trend.

At present, Guangdong, Beijing, Shanghai, Northeast are the most centralized areas of cold drinks producing and selling, the number of cold drinks producing companies is growing. In 2002, there were only 9 large enterprises that sold more than an amount of 100 million RMB, except for 18 middle-size companies. (Zhen Hailang, 2004, p.9) Some of the brands such as Bright, Yili, Mengniu take up more than 80% of the market. There is a fierce competition on the market share, which brings a war of price. Except for developing new style of cold drinks, many companies are trying to lower the price of their products to attract more consumers. However, the cold drinks industry is an industry with limited profit. Thus, what these enterprises should do is to lower the cost, especially logistics cost.

Cold chain logistics in cold drinks is comparably easy. The technology is not very difficult and the business operation is simple. The logistics demand is increasing and there are already some basic facilities, experience and customer channels. However, there's another problem for the cold drinks logistics party: how can they take advantage of transportation resources when the consumption of cold drinks is

relatively small.

4.1.2 Meat cold logistics

There are more than 3000 meat-processing companies in China in 2005, with a capital of \$10 billion. In 2004, meat production in China is 72.45 million tons, 4.5% more than that in 2003, and becomes the biggest meat producing country. However, the production of manufactured meat is about 2 million tons per year, less than 4% of the total meat production, while the figure in advanced countries is as high as 40% to 70%. (Yan Yongli, 2004, p.26) Assuming that the production gets to 30%, the needs for manufactured meat will be 18 million tons. There is still a developing room for 16 million tons. Thus, we can see from the increasing requirement for total meat consumption and manufactured meat, there is huge potential for manufactured meat.

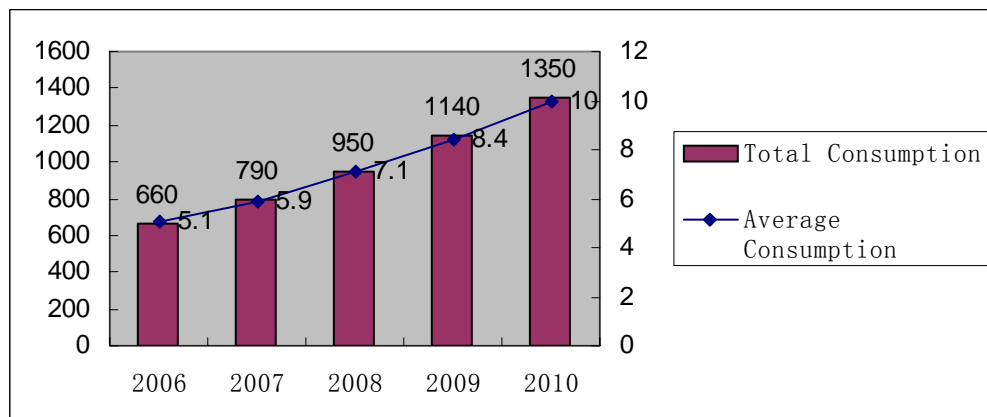


Figure 8: Forecast of Manufactured Meat Consumption

Source: Yan Yongli. Logistics Companies Do Business Analysis on Cold Logistics

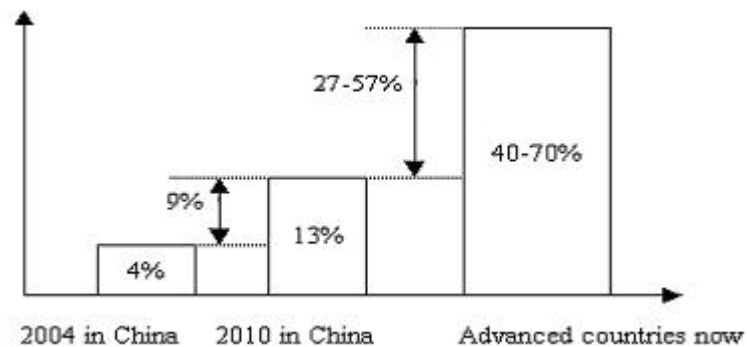


Figure 9: Manufactured Meat Takes Up in Total Meat Production

Besides the consumption in cities, the consumption of meat will also grow in rural areas. With the development of rural areas, the income will grow and then the consumption of meat. It is forecasted that in the year 2010, the average consumption of manufactured meat in China will grow to 10 kg/person. Moreover, meat manufactured industry is now in the developing period, that is: number of consumers grows rapidly, production and selling amount grows continuously.

In doing the manufactured meat logistics, the advantages are that many enterprises are likely to outsource the logistics part to focus on their own core business. There are many kinds of value-added services in the logistics and is profitable. Meanwhile, as the demand of meat will keep at a high level in the following years, the risk is low. Although the value-added services require a certain initial investment and operation experience, the business in this area is still very attractive.

4.1.3 Quick frozen food cold logistics

Quick frozen food are those fresh food, which are quickly frozen and then put under the temperature of -18°C , and can be eaten after the simple thaw, heating or cooking,

like quick frozen dumplings.

Investigation shows that more than half of citizens like quick frozen food and 60% of families have bought the quick frozen food in the recent half-year. According to the statistics, in the year between 1999 and 2001, quick frozen food sells best among all the necessities in supermarkets. From 1995, the quick frozen food in China increases at a rate of 20%, and became the quickest growing food processing industry in 1990s. Its yearly production is about 10 million tons. In the recent years, the consumption grows at a rate of 10% to 30%. There are almost 2,000 all kinds of quick frozen food producing factories that makes a sales amount of 10 billion RMB. (Xu Bonian, 2004, p.34) During these years, many large enterprises appeared in coastal province and cities, especially in East China and Pearl River Delta. Data also shows that in advanced countries, average consumption of quick frozen food is above 20 kg, and grows at a rate of 30%.

Many of companies grow up in this situation and keep developing. Youcan Food Group is one of a successful example. Its core products are cold drinks, dairy products, frozen instant foods and now develops many new types such as boiled dumplings, boiled rice dumplings, special snack, glutinous rice dumplings and so on. Meanwhile, it set up a strategic cooperation with a famous Singapore Food Invest Operation Group and is now growing as an international food making enterprise and food group with frozen industry as its core business. In 2006, Youcan group is programming to promote the national market and intends to build a world-famous brand in 2 or 3 years.

In quick frozen food cold logistics, there are many kinds of value-added services, such as packing by different types, picking out the small ones which are not suitable

and so on. What's more, the demand for quick frozen food is increasing, which ask for a sound logistics system. As a quick developing industry, the risk is relatively small when doing the logistics business but with huge potential.

4.1.4 Dairy product cold logistics

During the last few years, dairy product industry grows very fast. Many of the bases are newly built and enlarged; technologies are obviously better than before and reached a world advanced level.

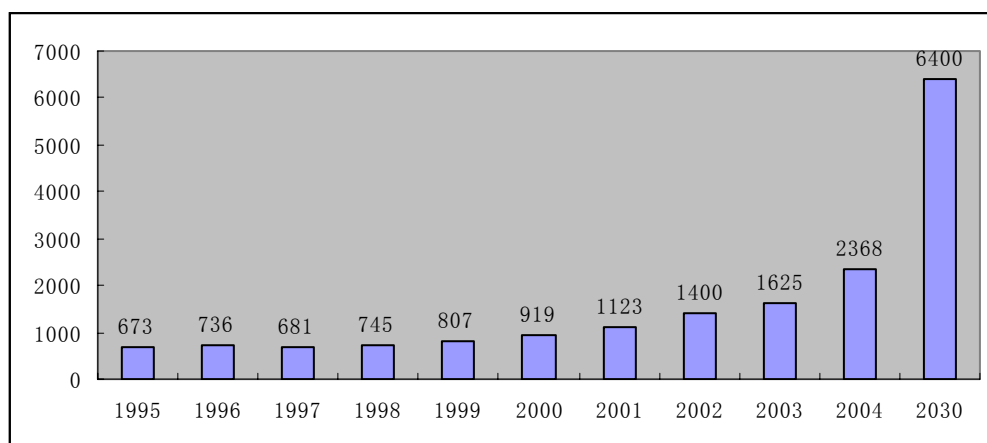


Figure 10: Production of Dairy Products in China (Unit: 10,000 tons)

Source: Yan Yongli. Logistics Companies Do Business Analysis on Cold Logistics

In 1995, the production of dairy products is only 6.73 million tons, but this number quickly grows to 23.68 million tons in 2004, 18.2 kg per person in average. It's estimated that in 2030, the production will reach 64 million tons. In 2005, the average consumption of dairy products in urban areas is ¥124.7, three times more than that in ten years ago. It is estimated that in the following five to ten years, dairy product in China will grow at a speed of 10%, and in 2015, the average production of dairy products will grow to 30 kg, 2.5 times of 8.5 kg in 2000. (Yan

Yongli, 2004, p.27)

When we compare the consumption of dairy products in China with the number of the world, we can see clearly that dairy products in China still have huge room of development. The average consumption in world is 100 kg. The figure in advanced countries is 200 kg and 30 kg in developing countries. The number in Asia is 40 kg, however, the figure in China is only 19 kg. (See figure 11)

Table 4: Developing Situation of Dairy Product Industry in China

| | 2002 | 2003 | Growth | 2004 | Growth |
|---|------|------|--------|------|--------|
| Liquid milk production (Unit: 10,000 tons) | 364 | 583 | 60.2% | 806 | 38.3% |
| Solid dairy production (Unit: 10,000 tons) | 106 | 141 | 33.0% | 142 | 0.7% |
| Income (Unit: ¥100 million) | 355 | 478 | 34.6% | 663 | 38.7% |
| Total profit (Unit: ¥100 million) | 24 | 30 | 25% | 34 | 13.3% |
| Profit margin | 6.8% | 6.3% | -7.4% | 5.1% | -19.0% |

Source: Yan Yongli. Logistics Companies Do Business Analysis on Cold Logistics

Because most of the milk are from north China such as Inner Mongolia and Hei Longjiang, a large amount of milk in the market now in south are transported from northern China. The consumption of dairy products in urban areas takes up more than 80% of market share while the average consumption in rural areas was only

3.62 kg in 2004, only 14% of which in urban. (Zhao Zhijun, 2005, p.5) However, with the increasing income, the developing of economics as well as the change of consumption ideas of people, the consumption will be higher in near future. After the fierce competition, Yili, Mengniu and Bright Company take up about half of the liquid milk market share. However, there are still more than 1500 dairy enterprises, most of which are middle or small sized companies.

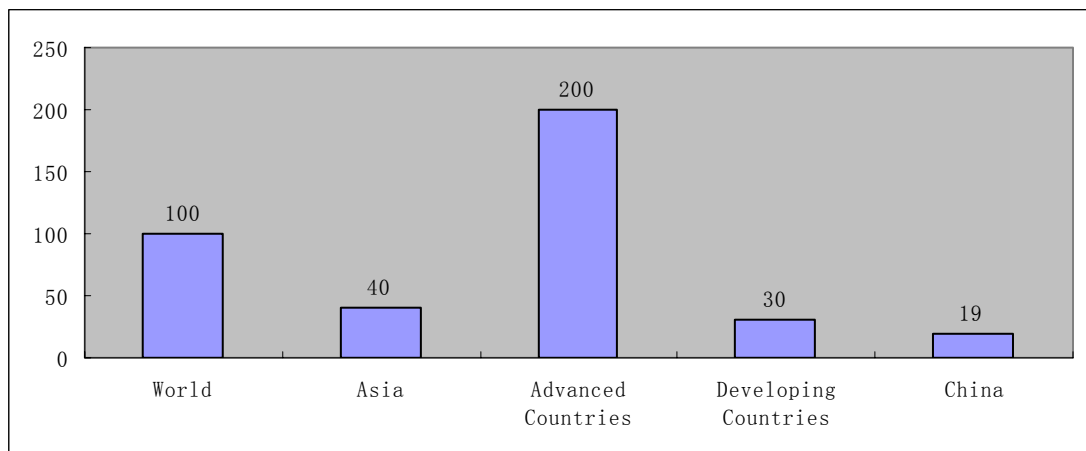


Figure 11: Average Consumption of Dairy Products in Different Areas (Unit: Kg)

Besides that, there is a high requirement for the transportation of dairy products. The fresh milk needs to be transported to milk company for processing and need to be distributed every day. In order to avoid the milk from perishing, especially in hot summer, the milk always be transported in early morning or late evening. And to keep the milk from pollution, the milk should be filled up to avoid the high temperature brought by rolling. From the conditions above, we can get a conclusion that as a logistics company in this industry, as long as we build a sound transportation system to assure the quality of the dairy products, and transport the product in a right route and in time, a bright future is waiting for us.

4.2 Business opportunities of cold chain logistics in rural areas in China

Residents in rural areas take up a large part of total population in China. There are about 880 million rural residents in China, which accounts for about 70% of the total population. However, in the total social retail sale of consumer goods, only one forth of it is from rural areas. Luckily, with the abundant resources in rural areas like animal husbandry, the growing income and the change of consuming attitude, the market in rural areas will boom soon.

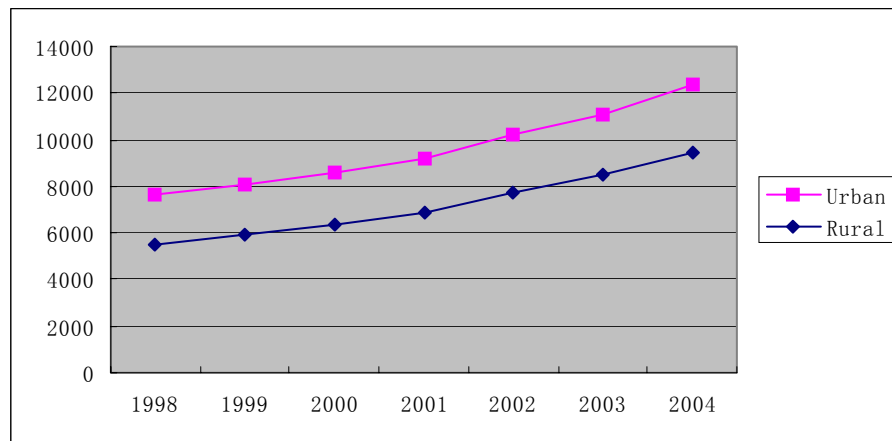


Figure 12: Personal Disposable Income in Both Urban and Rural Areas (Unit: RMB)

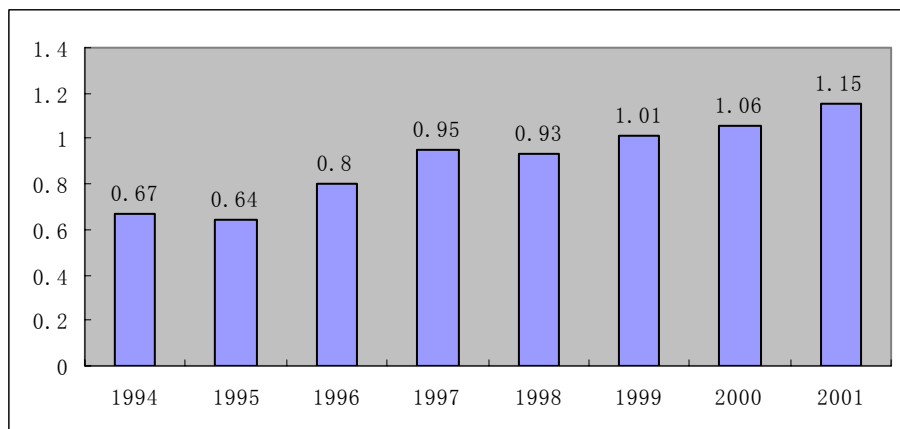


Figure 13: Average Consumption of Dairy Products in Rural Areas in China
(Unit: Kg/Person)

Source: Yan Yongli. Logistics Companies Do Business Analysis on Cold Logistics

5 Rationalization analysis of cold chain logistics in China

5.1 Management part

In order to higher the level of cold chain logistics in China, there are several means we could do. As a government, facing the increasing requirement for cold chain logistics and to ensure of safety of foodstuffs, there are several managing ways they could follow.

5.1.1 Set up cold chain standard for food stuffs

There's no specific standard for food stuffs cold chain standard at present, many of the operations are not canonical, and may bring the problem to the quality of food stuffs. Thus, it's necessary for the government to set up a feasible policy and effective supervision system to closely supervise the operation conditions of fresh food in each step of the cold chain. More over, it's important for the government to set up some policies to restrict and force the producing, processing and transportation companies to use complete cold chain logistics. For example, the government may implement a tax policy that the government charge environmental fee for the rubbishes produced by perishable foods. (Li Xuejun and Wang Jian, 2002, p. 26) The rubbishes may be brought by never using cold chain during the transportation.

Besides that, the government may set aside a certain sum of money in helping some

important enterprises with building a complete and effective cold chain logistics system. However, it may be a large sum of expenditure for the government. Thus, the government should better find out the weakest circle of the cold chain logistics. Take the dairy products for example. We all know that the supply chain of dairy products should not be too long or else the products will be out of date and go perished. Thus many dairy enterprises mainly concentrate on the origin of dairy and set up milk production basis in dominative consumption cities. However, is it useful? Let's see what's hiding under the dairy secret: the origin of those dairy products is farmers, who are the production body that is composed mainly by individual families. Although "decentralized cultivation, centralized acquisition" becomes the only choice, this kind of independent and decentralized unit is far different from what is need in modern producing enterprises. It can't stand fire of competition. And because that the dairy farmers in China can't become shareholders of dairy enterprises like in many Northern European countries, so that dairy farmers become the weakest circle of the cold chain. Also, there's contradiction between dairy enterprises and farmers. However difficult it is to get the dairy products, the procurement price just keeps unchanged. And the selling channel of dairy farmers is very limited; they can only sell their products to the enterprises. Those big dairy enterprises take control of milk and price and never form a coordinate relationship with the poor dairy farmers. Actually in the whole supply chain of dairy products, the profit rate of producing, processing and selling is 1:3.5:5.5, dairy farmers are the poorest but with the highest risk.

Because the specialty of dairy products, the preservation condition of products is very strict, however, the building of cold chain cost much and need to invest a large sum of money. Thus many dairy enterprises just ensure the cold chain investment in the process of selling, for the upstream processes, they will only extend to the

procurement of dairy products, and the preserve circle between decentralized cultivate and centralized acquisition will be ignored in the market. However, it's a circle that is easily broken. The dairy farmers can't ensure the selling amount of their products and all of this is decided by the dairy enterprises. If they require for more, they can sell more, if they limit their volume of purchasing, their milk will be wasted without any choice. Thus, those poor farmers won't be willing to put much money in preservation of milk or to build a cold chain for the safety of dairy products.

Then it comes to the problem of government. How to solve the problem and drive the farmers to follow a cold chain logistics? In order to abstain the farmers from fearing the trouble back at home, the government of Canada and Australia take in the policy of renewable portfolios standard in purchasing milk to assure the milk selling of farmers, the part that exceeds the RPS takes the market price. In U.S., when the purchasing price is less than a certain amount, the government will take a price support policy, which is to say, the government will purchase a large amount of dairy products to ensure the purchasing price of dairy products at a high price level. As the figure showed below, the surplus part between supply and demand are bought by the government.

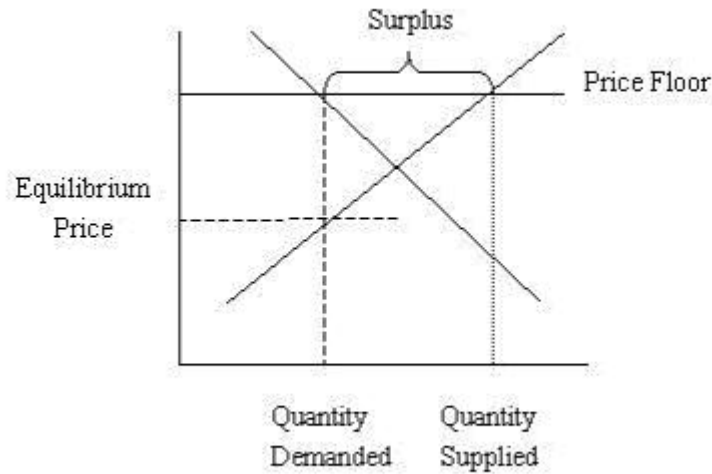


Figure 14: Governmental Support Price

5.1.2 Cultivate more professionals in cold chain logistics

As a newly developing industry, professionals are awfully needed. A cold chain logistics company needs professionals not only have theoretical background but also real practice. Besides, the logistics professionals needed should know not only about warehouse management or one kind of transportation tool or with single knowledge structure but with thorough logistics operation and management knowledge. With which, they can improve and optimize the task under any condition. Logistics service is dynamic and continuous. The improvement is the basis of development of enterprises. To transport cargo from one place to another in time and need to assure the quality of cargo, especially those perishable foodstuffs, the transportation process need to be designed carefully, strictly and scientifically. As a professional, one needs to know exactly about the transportation network, choose a proper tool, a best route and the lowest cost. Any problem in any circle will bring lost for the whole company. Thus, the professionals need to have precise

thinking mode as well as thorough knowledge.

Moreover, as a professional in cold chain logistics, a sound team spirit is important. There are several network points in the whole supply chain; any problem in any point will break the chain. So during the work, the workers should perform well not only on their own work but also the work related with harmonizing the upstream and downstream.

Another important quality is the ability of learning and application ability of information technology. More and more competition in modern logistics enterprises especially cold logistics enterprises now focus on the research and development of information technology. It's also a process of information flow. During the process, suppliers and customers send out much information about cargoes, and get to know the conditions of cargoes when they are on their way or in the warehouse, and logistics companies need to have the ability of processing the information in time. How is the temperature, how about the conditions of the fresh cargo, whether there are any problems or not and how to tackle with it.

At present, logistics in China is facing a shortage of professionals. It is investigated that professionals in logistics is one of the most needed talents in China. About 600,000 professionals are needed now and even in Shanghai, 200,000 are needed. Thus, the cultivation for professionals is strongly needed.

5.1.3 Set up professional cold logistics management system

It's important to set up some professional cold chain logistics management system and advanced cold logistics temperature control operation management system for

the information communication between each step.

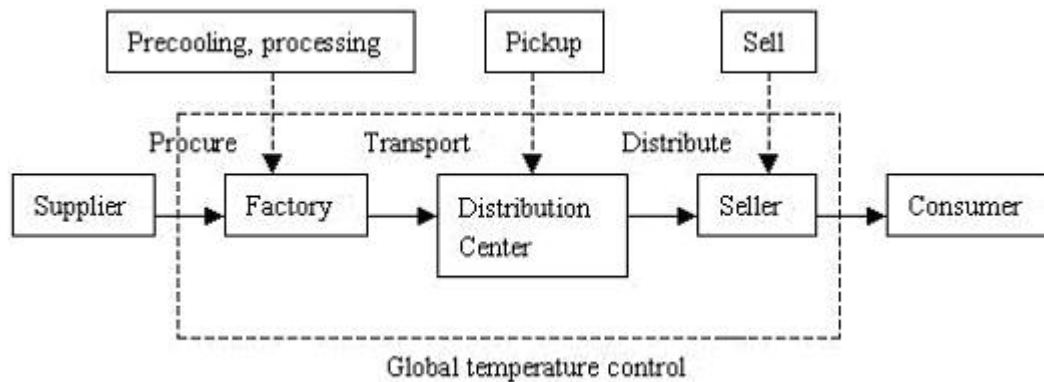


Figure 15: Cold Supply Chain Flow Chart

Source: Su, Xiujin. Research on Logistics Planning of Food Cold Chain

5.1.3.1 JIT strategic management

Transportation of fresh foodstuffs is different, because those fresh foods are easily going perished. Thus, JIT is a suitable strategic for the transportation. JIT in food logistics mainly points to transportation or distribution materials. However, JIT is now frequently used in manufacturing industry but seldom in fresh food as most of the upstream of suppliers are individuals or farmers, which are not shareholders of the enterprises and can hardly be held in. Accordingly, it's important for the enterprises to involve the upstream farmers in the complete supply chain.

We can collect information from the experience in supermarkets or retailers that how much fresh foods may be needed by consumers and then feedback the information to the distribution center and wholesaler, and they will know how much materials they need to ask the farmers to prepare and exactly that amount. More than that amount

will be a waste, less than that amount will bring a shortage to the supermarket and retailer and influence the sales volume and profit.

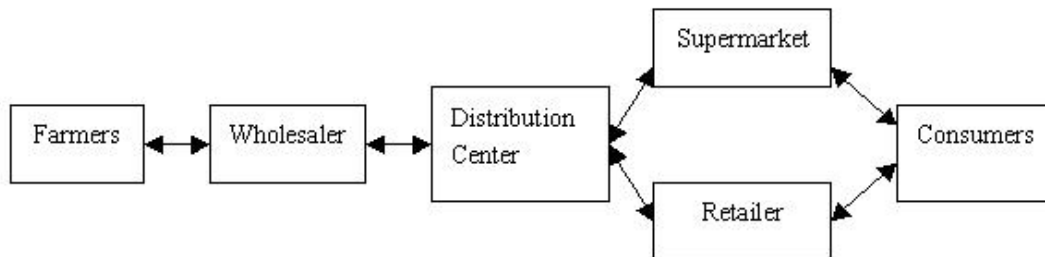


Figure 16: Information and Transportation Process in Fresh Food Transportation

For instance, in Macdonald's, in a stock cycle of a week, the manager need to estimate the safety stock in advance, and contact with distribution and selling center in Tuesday to book the refrigerated foods. After the order form is accepted, foods will be got in Wednesday and Friday. Booking team needs to check and finish a storage report including quantities, names and so on. And everyday, managers will check the quantity ordered and stock cycle, once there's a difference, they will take emergency action.

5.1.3.2 Continuous replenishment and midway tracing strategy

To avoid the shortage of foodstuffs, continuous replenishment strategy is needed. A successful case in application of continuous replenishment strategy is "P&G---Wal-Mart's cooperation commerce pattern". P&G developed a continuous replenishment system and installed it for Wal-Mart. This system can help P&G watch the selling and storage conditions of its own product in Wal-Mart's branch stores, and then adjust its producing and replenishment plan. Attributing to this system, the customer service level increased quickly while the storage decreased.

Storage, transportation, distribution are important steps in cold chain logistics. Any problem in these steps will bring the broken of chain. Temperature control is important during the process. But how can we know exactly the condition at a certain time? Macdonald's can tell us about their midway tracing strategy. How can the logistics manager who sits in the office know how the condition of food is when the truck is still on its way? Are they frozen? Involving in the fierce competition in market, it's reasonable to worry about this. A cooler of a 8 tons standard refrigeration truck values ¥480,000, a heavy repair is needed after every 500 hours' operation. Many enterprises try to omit this step. From Beijing to Shanghai, only the first and the last cooler are working and those in middle are closed. But with the temperature tracing and cargo tracing, everything can be clear. The logistics company of MacDonald's---Havi Food Service Company didn't use expensive tracing tools but something like the black bag used in airplanes. It can record the position of trucks precisely and can record the condition of them. All of the data about beginning time and stop time of truck, the change of temperature will be recorded.

5.1.3.3 Value-added service strategy

The consumption level of fresh food is increasing, which causes customers' high requirement on the value-added services. As for the primary products such as vegetables, fruits and dairy products, which need refrigerated transportation, value-added services are more important in increasing logistics level.

There are several ways to implement value-added service strategy. First, the value-added service could be realized on classification and package of different kinds

of primary products. Second is proper processing of the primary products. Then the value-added services can come from the distribution. Finally, value-added service can be used in some special kinds of primary products. However, many of the enterprises just focus their value-added services on basic construction, such as simple classify, pack, label and so on which are far away from the requirement of modern logistics. Nongfa green food company does well in this field. Primarily, they packed fresh green Chinese onion, green flower vegetables, broccoli and exported them, now they process semi-manufactured dried turnip, preserved szechuan pickle and enlarge the variety of products and processing ability. They set up a mode of company-base-farmers and a vegetable cooperation that share the profit and risk. The farmers become members. They plant under the requirement of company and seed, plant, use pesticides and pick according to the company's requirement, to assure the quality of farm products on one hand and induct other farmer's plants under requirement. The company assemble those incompact farmers and standardize the production, through which they make a sells profit of ¥ 6.85 million in only 4 months.

In some advanced countries like U.S., value-added service is highly adopted in agriculture. Some traditional modes contains simply transform configuration of primary products like meat processing, grind flour, bazaar trade of primary products or transportation that takes advantages of time, clime differences. Nowadays, more innovating value-added services are taken in agriculture in advanced countries. For example, they improve related technology to transform grain into feed, abstract diesel oil from bean oil, or use modern producing technology to produce new types of food which are more convenient, with more nutrition, and much more delicious. Moreover, they can gain more profit though value-added services.

5.2 Organizing part

5.2.1 Pay more attention to 3rd party logistics in cold chain

There are many 3rd party logistics companies in China at present. However, they are not perfect. Actually, there are not any perfect 3rd party logistics companies that can do logistics very well in every field. That needs a large sum of capital. And the disperse investment in different field will bring the result that they can't do any job well as it's impossible for them to focus on every field. Thus, the specialization of 3rd party logistics company is the inevitable developing trend. To develop a 3rd party logistics in cold chain will be a good opportunity.

Whereas, the construction of cold chain center is a project of high investment and with a long recycle time. Most of equipment in cold chain logistics is too expensive to buy. There are difficulties for many logistics companies to outfit those facilities. That's why there is few 3rd party logistics company in cold chain in China.

There are also successful examples: HAVI, the global logistics service provider of MacDonald's, had already cooperate with Macdonald's for more than 30 years. More than 60 suppliers of Macdonald's are distributed by logistics system of HAVI to each branch. At 10 o'clock every morning, East Balt Inc., bread supplier of Macdonald's, transfers bread to shelf on time and transports to the warehouse of HAVI through a sealed channel, then distributes to each branch store by refrigerated truck. The amount and times of freight are calculated carefully by HAVI.

Steve Bryant, freezing technology director in Ingersoll-Rand that has the biggest refrigerated warehouse and distribution center in the world, said if the cold chain can

be used properly, the quality of products would be obviously different. Only if those products taste different by supply chain, companies will be willing to invest. Most of the fresh products are precooled. For instance, in the agricultural center in California, the temperature of 20 boxes lettuce is lowered down to 32 degree from 75 degree in 90 minutes. (Translated by Zhang Gong, 2005, pp. 80-81) And then, they are put into a refrigerated warehouse and distributed by temperature-controlled trucks. Before they get to the retailer, they are stored in distribution centers.

5.2.2 Set up alliances

Cold chain logistics market is still waiting to be exploited while enterprises are poor in facilities and equipment. Under this condition, it's difficult for a logistics company to do the 3rd party logistics business alone. Cooperation and conformity becomes the best choice for development. Cooperate with different parts is a necessary and useful tool.

5.2.2.1 Set alliance with producers

Cold chain logistics department should set alliance with different kinds of producers. At first, they'd better provide refrigerated transportation service according to small pieces of business and implement pertinent logistics management and operation system. Most of the enterprises that do the business of refrigerated transportation, such as quick frozen food transportation, cold drinks transportation as well as dairy products transportation are doing like this.

To the producers, logistics company, which has abundant experience, can help them to set up a more safety transportation environment and can enhance the management

level for producers. They can assure the consistency of cold chain in a certain extent.

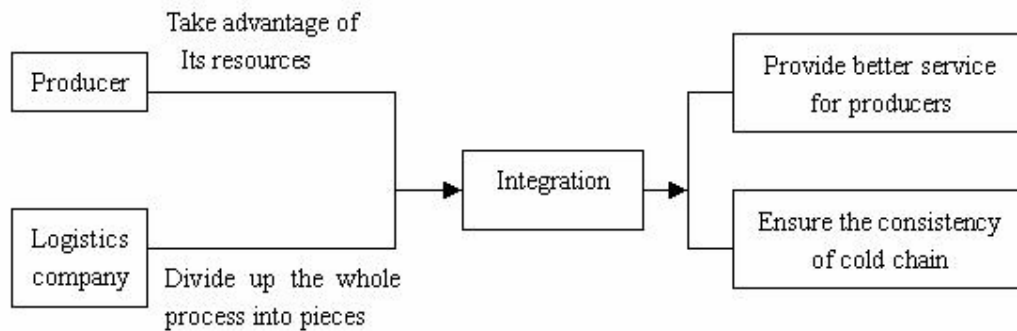


Figure 17: Set Alliance with Producers

To the logistics company, they can use the resources of producers. With the continuous cooperation, the relationship with producers will be stable. They can take advantage of the refrigerated resources of producers, societies. This kind of alliance is easy to set up, can make the best of trucks and facilities resources. Although the result may not be seen in a short time, in the long run, it will increase the managing and operating level.

5.2.2.2 Set alliance with other logistics companies

Many of the cold chain logistics service providers are still middle sized or small ones. Their capital, experience and operational level are waiting for enhancing. However, during the process they have accumulated a certain amount of cold chain logistics basic facilities or resources or specific customer colony. Some are outstanding in brand, some are outstanding in capital while some others are prominent in management and network. If these logistics companies can work together,

especially on different aspects of business, they will make the best use of whole resources and improve themselves.

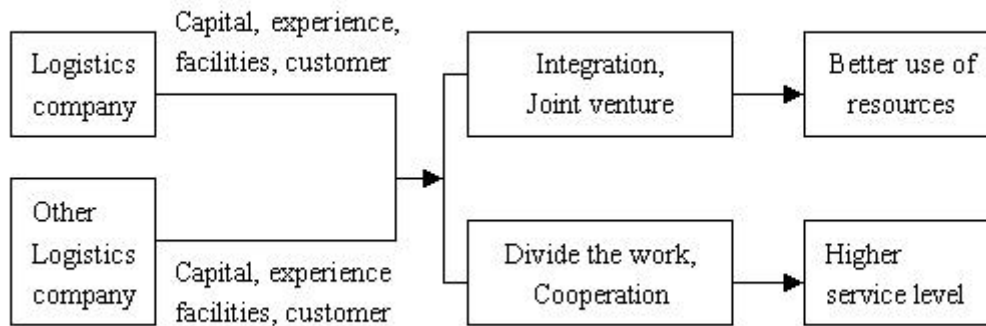


Figure 18: Set Alliance with Other Logistics Companies

This kind of alliance is good for the operation of business, it can help the logistics companies to share the resources and operate flexibly. However, there's a disadvantage. Set up logistics joint venture need a large sum of capital. Besides that, when they are doing business together, both of the companies are growing quickly, which cultivate a strong potential rival for themselves. After the cooperation of one program, the company may become their competitor.

5.2.2.3 Set alliance with business companies such as chain stores

Because the time-effect characteristics of cold chain logistics is obviously, logistics companies can consider to implement professional cold chain logistics district distribution service based on some common logistics distribution program which has already operated and matured enough. Thus, set alliance with some business companies such as chain stores is a good idea for the logistics companies.

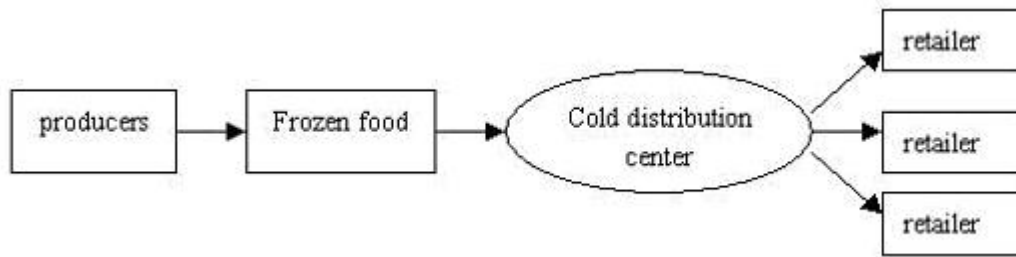


Figure 19: Set Alliance with Chain Stores

Source: Yan Yongli. Analysis on Cold Chain Logistics in Logistics Company

Shanghai Xintiantian Dazhong Cold Logistics Co., Ltd, which used to be a distribution center, began its business in 3rd party cold logistics as early as the beginning of 21st century. During several years' marketing operation, the company has accumulated many customer resources and has cultivated a lot of professionals. It takes up 34,000 square meters, has more than 11,600 refrigerators at different temperature zone, 2,800 square meters of normal temperature warehouses and 40 low temperature refrigerator trucks. It has now formed a cold chain system that can satisfy the requirement of food storage, picking and processing, transportation and so on. As an integrated logistics center of producers, supermarkets and chain stores, it mainly does the food logistics business (storage, load and unload, logistics processing, matching and distribution, transportation), especially frozen foodstuffs.

5.3 Technology part

5.3.1 Bring in information system to reduce logistics cost

Wherever the fresh foods come from, new technology should better run through the whole process of storage, transportation and temperature controlling. If the new information technology could be used properly, much cost will be saved. Moreover,

the information can be send much quicker and the veracity will be much higher.

Bryant, frozen technology global director in Ingersoll-Rand, said, ‘the wireless receiving facility at present can only record the transportation temperature of only one product. In 5 years, after the use of radio-frequency technology, the temperature report can be offered from the factory or farms continuously to the retail stores’. (Zhang Gong translated, 2005, pp. 81-82) Even consumers and some retailers can visit this kind of chip and grasp the temperature record of the product during the whole producing and transportation process.

Because the transportation distance is long, so that we should better take control of refrigerator’s door or key. If some cargo get lost or changed during the transportation, or some dangerous things added in, the safety of the cargo will be hard to estimate or even it may become a disaster. There’s one example for this: after it left factory, during the transportation, some company’s dairy products were changed by others with some fake products. Thus, it will be better for the safety of food stuffs’ transportation if electronic technology can be used in the refrigerator’s door or key controlling in transportation facilities, especially combined with geography information system application.

In cold chain transportation, some transportation are simply point-to-point. Under this condition, trucks’ route, exact location, and even the oil consumption of one-way transportation or round transportation can be easily got. However, it’s more commonly that the transportation process isn’t such an easy route. It’s always important to grasp the route and exact location of cargo when the products are vegetables, fruits, dairy products or cold drinks. If the cargo barges up against traffic jam, or postponed in airport or port, the transportation company needs to take

actions. Thus, the information system that can control and report the route and time is virtually important.

Figure 20 is on-board info platform and web info shared platform. As can be seen from the graph, the on-board info platform can collect information not only about the vehicle itself, like oil consumption, driving speed, but can also get information related with cargo, like temperature, humidity. Then the wireless communication facilities can send this information to the internet information platform center through GPRS/CDMA. After that, center can realize the sharing data according to user's jurisdiction.

What remarkable is, through the electronic tool, it's easier to manage the trailer and container. Through the onboard information platform in yard and dock, it can trace and manage the cargoes in yard. According to the wireless tag installed in container, it can judge automatically whether the truck or vessel transport the right cargo to avoid the phenomenon of transporting wrong cargo.

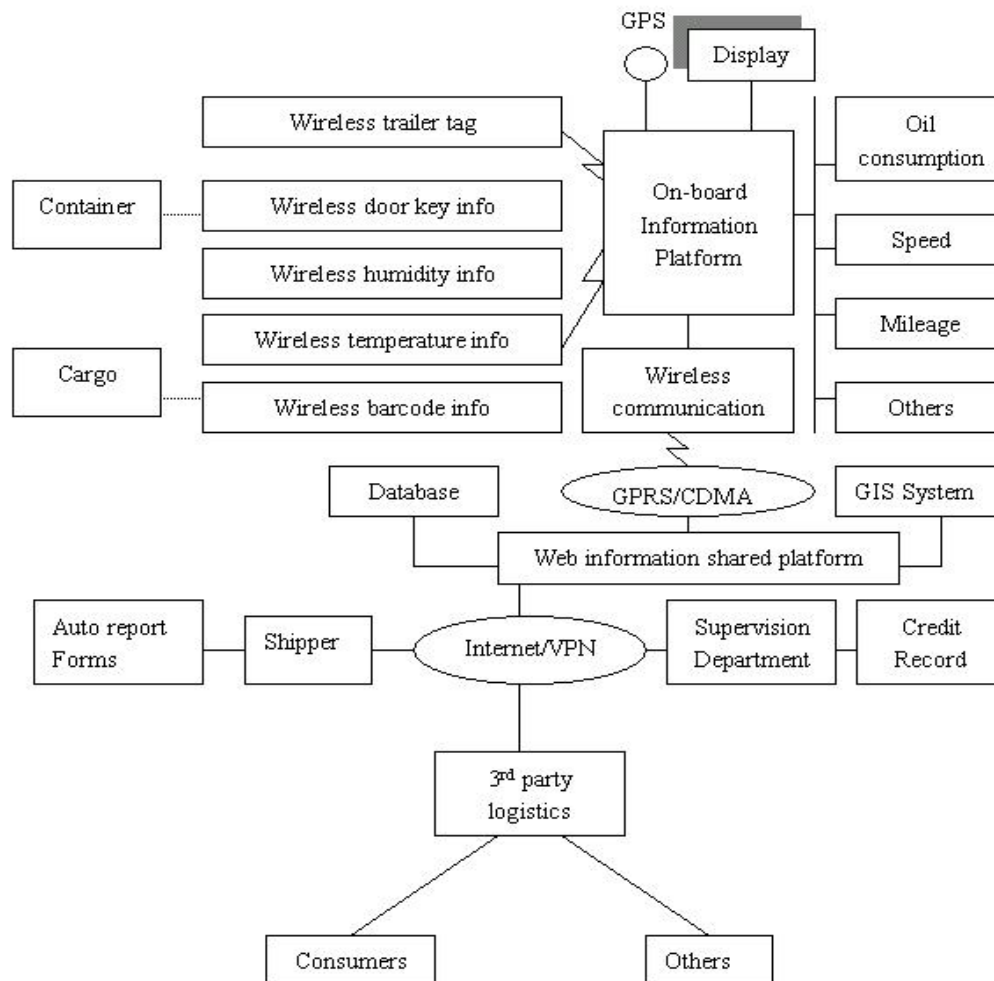


Figure 20: On-board Info Platform & Web Info Shared Platform

Source: NI Shikun, Gao Baocheng & Li Changhua. Cold Chain Transportation Process Control which is Based on IT Technology

Keeping fresh of the food is a principal requirement for the food market. However, there are so many products in a supermarket, how can they ensure which one is fresh and change those which are not fresh enough? If they need to go to the shelf and check one by one, it will be a complex and difficult job. If we bring in information system, that's will be easy. They need at first investigate each shelf and goods, and then input them into computer system in logistics center, thus set up an association

with shelf, cargo and store. Then it can easily tell which store needs which kind of cargo and how much they need. It surely enhances efficiency. And if you input the leave factory time and shelf life into the information system, they will tell you whether the products can get into the warehouse or not, which product is going out of date and you need to change, which saves a lot of time and energy to check. Thus reduce the logistics cost.

5.3.2 Increase investment in developing science and technology

We need to solve the problem of technological bottleneck that restrict the development of cold chain logistics and improve the refrigerated technology and facilities. In this way, we could use the temperature control facilities effectively and decrease the risk of delay in the process of transportation of those temperature sensitive foods.

Food cold chain contains disposing material, precooling, quick frozen, refrigeration, transportation and distribution, the corresponding facilities are disposing material facilities, precooling facilities, quick frozen facilities, refrigerated show box, refrigerator and so on. Precooling is a very important step. It's usually done in a separated equipment to quickly lower the temperature of foods in several hours or even few minutes. Especially those vegetables and fruits, after the picking, respiration and evaporation will consume the nutrition and water of the products themselves and then bring on the crimple, wither, fade, and lower of the quality and value of the products. Precooling can restrict this kind of respiration and evaporation through four kinds of precooling techniques: air-cooling, hydrocooling, forced- air evaporative cooling and vacuum cooling. Quick frozen facilities are the key facilities in the cold-working production line and worthy the highest investment.

The quality of facilities directly influences the quality of frozen foods. Blast quick freezers, contact quick freezers, cryogenic quick freezers, liquid immersion quick freezers are the facilities used commonly at present. Besides, controlled atmosphere (CA) is always used to keep the fresh of foods.

Now, some new kinds of technologies are used in refrigerated area. First is the use of INA (ice nucleation active bacteria). (Huang Jian, Du En-jie & Shi, Wen-xing, 2004, pp. 404-410) In the process of freezing and torrefaction, water in foods can only be freezed under a certain low temperature. But if we add ice nucleation active bacteria in, we can freeze in a comparatively high temperature, thus lower the consuming cost. Besides, to keep the quality of food materials, if we add ice nucleation active bacteria in lemon juice, orange juice, coffee or dairy products, the speed of freezing and condensing can be highly increased and the cost will be lower. Another is CAS (Cell Alive System). This kind of technology can make sure that even if the food is freezing, the cell is still alive, and the products can keep fresh even if the products are ice-out. The color, fragrance and taste is as fresh as if it's just processed. We can use this way to produce high quality foodstuffs.

Besides the refrigerated technology, facilities in refrigerated trucks and technology used in these trucks are also important. There are more than 80 refrigerated truck and heat preservation trucks producing companies in China. And more than 30,000 refrigerated trucks and heat preservation trucks are put into use. Take Henan Ice Bear Refrigerated Truck Company for example, most of their techniques are from Europe. Its characteristics are corrosion-proof, light, high density, high temperature preservation ability, good sealability and decent appearance.

Now in some advanced countries, they focus more on the refrigerated ability. They

develop different kinds of refrigerated trucks according to various requirements of customers. For instance, they add air handling installation, lift control lever, product fixture facilities in the trucks.

6. Some quantitative analysis method in reducing logistics cost

There are several quantitative methods in the practicing of improving logistics service level, which related with reducing cost, analyzing cost, choosing the best route, how to set distribution center and so on. Here, I'd like to introduce some of the methods in solving logistics problems.

6.1 Use NPV method in purchasing facilities

NPV is short for Net Present Value, which means the present value of an investment's future net cash flows minus the initial investment. Thus, the bigger the NPV is, the better the program is.

Here is an example:

Assume a cold chain logistics company is about to purchase an advanced refrigerated truck to expand the working ability. Now there are two projects A and B we can choose, assume tax rate is 40%, capital cost rate is 10%:

Project A: need to invest ¥ 300,000, life-span is 5 years, take straight-line amortization method, there's no residual value after 5 years, during these 5 years, the equipment can bring an income of ¥150,000 every year. Out-of-pockets cost every year is ¥50,000.

Project B: need to invest ¥360,000, life-span is 5 years, take sum-of-the-digits amortization method, residual value is ¥60,000. The equipment can bring an income of ¥170,000 every year, out-of-pockets cost in the first year is ¥60,000, during the following years the cost will increase ¥3,000 as maintenance fee. Moreover, it need to prepay ¥30,000 as current capital.

We can solve the problem like this:

Operating cash flow= (income-out-of-pockets cost–depreciation)* (1-tax rate)+ depreciation

Project A: Depreciation=300,000/5=¥60,000

Year 1-5: Operating cash flow = (150,000-50,000-60,000)*(1-40%)+60,000
=84,000

NPV(A) = 84,000*3.7908¹-300,000 =¥18,427.2

Project B:

Depreciation = (investment-residual value)*years can be used/ total years

¹ Get from PVIFA table, PVIFA_{10%, 5}

Table 5: Calculation of Operating Cash Flow in Each Year

| | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---------------------|---------|---------|---------|---------|---------|
| Income | 170,000 | 170,000 | 170,000 | 170,000 | 170,000 |
| Out-of-pockets cost | 60,000 | 63,000 | 66,000 | 69,000 | 72,000 |
| Depreciation | 100,000 | 80,000 | 60,000 | 40,000 | 20,000 |
| Before tax profit | 10,000 | 27,000 | 44,000 | 61,000 | 78,000 |
| Tax | 40% | 40% | 40% | 40% | 40% |
| After tax profit | 6,000 | 16,200 | 26,400 | 36,600 | 46,800 |
| Depreciation | 100,000 | 80,000 | 60,000 | 40,000 | 20,000 |
| Residual value | - | - | - | - | 60,000 |
| Operating cash flow | 106,000 | 96,200 | 86,400 | 76,600 | 156,800 |

$$\begin{aligned}
 NPV(B) &= 106,000 \times 0.9091^{#1} + 96,200 \times 0.8264^{#2} + 86,400 \times 0.7513^{#3} \\
 &\quad + 76,600 \times 0.6830^{#4} + 156,800 \times 0.6209^{#5} - 360,000 - 30,000 \\
 &= \text{¥}415.52
 \end{aligned}$$

NPV (A) > NPV (B), thus, we should choose the project A.

6.2 Use spreadsheet to solve the covering problem

When tackling with the logistics business, we can always come across the problem of setting up new warehouses or distribution centers. How many distribution centers we shall build so that we can serve all the retailers with the least capital and places? Spreadsheet is a useful tool in solving this kind of problem. I will take an example

^{#1} See PVIF table, PVIF_{10%, 1}

^{#2} See PVIF table, PVIF_{10%, 2}

^{#3} See PVIF table, PVIF_{10%, 3}

^{#4} See PVIF table, PVIF_{10%, 4}

^{#5} See PVIF table, PVIF_{10%, 5}

to show how to use the tool and set the model.

Assume: I am a logistics director who takes charge of Shanghai business of a dairy products company. I divide Shanghai city into 10 districts. And there are now 4 distribution centers (A, B, C and D). Figure 21 shows the location of 10 districts and 4 distribution centers.



Figure 21: Map of Shanghai

According to experience, each distribution center can distribute the dairy products to the districts they are responsible of on time. In the picture, dotted line means the district can be transported to on time from the corresponding distribution center. Now we want to know, under the prerequisite of making sure the goods can be transferred to those districts on time, which distribution centers we need indeed? Can we reduce the number of distribution centers?

In the problem above, there are following steps we should do.¹ (See table 6)

First, to input the figures we know already in the table of EXCEL. We can use number 0 or 1 to show whether the distribution center can be connected with the district or not. If they are connected, use 1 and if not, we input 0. In the area of B5:E14, we input the connection of distribution centers and districts.

Next step is to set a model.

The decision variables in the problem are whether to use or not use the distribution center. We use B16:E16 in the table to show, and these numbers need to be 0-1

¹ We can also use implicit enumeration to solve the problem although it's little bit complex. First we can present the problem as following: to optimize the following 0-1 integer programming: $\text{Min } Z = X_1 + X_2 + X_3 + X_4$ And should satisfy the following constraints:

$$\left\{ \begin{array}{ll} X_1 + X_2 & \geq 1 \quad \textcircled{1} \\ X_2 + X_3 & \geq 1 \quad \textcircled{2} \\ X_3 & \geq 1 \quad \textcircled{3} \\ X_3 + X_4 & \geq 1 \quad \textcircled{4} \\ X_4 & \geq 1 \quad \textcircled{5} \\ X_1 + X_4 & \geq 1 \quad \textcircled{6} \\ X_1 + X_2 + X_3 & \geq 1 \quad \textcircled{7} \\ X_1 + X_3 + X_4 & \geq 1 \quad \textcircled{8} \\ X_1, X_2, X_3, X_4 & = 0 \text{ or } 1 \quad \textcircled{9} \end{array} \right.$$

From the above constraints ③ and ⑤, we know that variables X_3 and X_4 must be 1. Then we only need to test the coefficient of X_1 and X_2 . There are 4 kinds of conditions left.

| Result (X_1, X_2, X_3, X_4) | Constraints | | | | | | | | |
|------------------------------------|-------------|---|---|---|---|---|---|---|---|
| | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ | ⑧ | Z |
| (0, 0, 1, 1) | × | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| (0, 1, 1, 1) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 3 |
| (1, 0, 1, 1) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 3 |
| (1, 1, 1, 1) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 4 |

We can see from the table above that we can get two answers: (0, 1, 1, 1) and (1, 0, 1, 1), both of them can optimize the final answer.

However, when we use spreadsheet to solve the problem, the spreadsheet can usually give us the first suitable answer it calculates. In this case, the spreadsheet gives us the first answer it gets, which is (0, 1, 1, 1). That is to use distribution center B, C and D. Actually if we use distribution center A, C and D and close B, it's ok. We should consider some other factors such as cost, distance to determine which one to choose.

variables, while 0 means we don't use the DC, and 1 means we use the DC.

In the problem, what we want to know is the minimum number of distribution center. So the objective function is the minimum number of distribution centers that needed. It's G16 in the table, which is the sum of decision variables.

The last step is to fix on the constraints. There are 2 constraints in the problem. The first one is that the decision variables must be a 0-1 variable. And another one is we need to calculate how many distribution centers can be covered in total of each districts, these number must satisfy the condition that they are covered by at least one distribution center, which means that there is at least one DC can distribute the dairy products to the district on time. Then how can we get this number? We can use SUMPRODUCT (B5:E5, \$B\$16: \$E\$16) to get the number. So, if the DC is open, we can get the connection, and if the DC is close, we can close the connection also.

Table 6: The Spreadsheet Model of the Covering Problem of DC

| | A | B | C | D | E | F | G | H | I |
|----|--|----------------------------|----------|----------|----------|---|--|--|---|
| 1 | The Covering Problem of Distribution Center | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | Distribution Center | | | | | | | |
| 4 | Districts be covered | A | B | C | D | | Can be covered by how many DCs in total | Must be covered by how many DCs | |
| 5 | Jiading | 1 | 1 | 0 | 0 | | 1 | >= | 1 |
| 6 | Baoshan | 0 | 1 | 1 | 0 | | 2 | >= | 1 |
| 7 | Pudong | 0 | 0 | 1 | 0 | | 1 | >= | 1 |
| 8 | Nanhui | 0 | 0 | 1 | 1 | | 2 | >= | 1 |
| 9 | Fengxian | 0 | 0 | 0 | 1 | | 1 | >= | 1 |
| 10 | Jinshan | 1 | 0 | 0 | 1 | | 1 | >= | 1 |
| 11 | Songjiang | 1 | 0 | 0 | 1 | | 1 | >= | 1 |
| 12 | Qingpu | 1 | 1 | 0 | 0 | | 1 | >= | 1 |
| 13 | Shanghai city | 1 | 1 | 1 | 0 | | 2 | >= | 1 |
| 14 | Minhang | 1 | 0 | 1 | 1 | | 2 | >= | 1 |
| 15 | | | | | | | Number of DC | | |
| 16 | whether to use the DC or not | 0 | 1 | 1 | 1 | | 3 | | |
| 17 | | | | | | | | | |

Table 7: The Formula of Spreadsheet Model of the Covering Problem of DC

| | A | B | C | D | E | F | G | H | I |
|----|---|---------------------|---|---|---|---|---|----|---------------------------------|
| 1 | The Covering Problem of Distribution Center | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | Distribution Center | | | | | | | |
| 4 | Districts be covered | A | B | C | D | | Can be covered by how many DCs in total | | Must be covered by how many DCs |
| 5 | Jiading | 1 | 1 | 0 | 0 | | =SUMPRODUCT(B5:E5,\$B\$16:\$E\$16) | >= | 1 |
| 6 | Baoshan | 0 | 1 | 1 | 0 | | =SUMPRODUCT(B6:E6,\$B\$16:\$E\$16) | >= | 1 |
| 7 | Pudong | 0 | 0 | 1 | 0 | | =SUMPRODUCT(B7:E7,\$B\$16:\$E\$16) | >= | 1 |
| 8 | Nanhui | 0 | 0 | 1 | 1 | | =SUMPRODUCT(B8:E8,\$B\$16:\$E\$16) | >= | 1 |
| 9 | Fengxian | 0 | 0 | 0 | 1 | | =SUMPRODUCT(B9:E9,\$B\$16:\$E\$16) | >= | 1 |
| 10 | Jinshan | 1 | 0 | 0 | 1 | | =SUMPRODUCT(B10:E10,\$B\$16:\$E\$16) | >= | 1 |
| 11 | Songjiang | 1 | 0 | 0 | 1 | | =SUMPRODUCT(B11:E11,\$B\$16:\$E\$16) | >= | 1 |
| 12 | Qingpu | 1 | 1 | 0 | 0 | | =SUMPRODUCT(B12:E12,\$B\$16:\$E\$16) | >= | 1 |
| 13 | Shanghai city | 1 | 1 | 1 | 0 | | =SUMPRODUCT(B13:E13,\$B\$16:\$E\$16) | >= | 1 |
| 14 | Minhang | 1 | 0 | 1 | 1 | | =SUMPRODUCT(B14:E14,\$B\$16:\$E\$16) | >= | 1 |
| 15 | | | | | | | Number of DC | | |
| 16 | whether to use the DC or not | 0 | 1 | 1 | 1 | | =SUM(B16:E16) | | |
| 17 | | | | | | | | | |

Table 8: Use Solver to Get the Answer

规划求解参数

设置目标单元格 (E): 求解 (S)

等于: ☐ 最大值 (M) ☒ 最小值 (N) ☐ 值为 (V) 关闭

可变单元格 (B): 推测 (G) 选项 (O)

约束 (U):

- 添加 (A)
- 更改 (C)
- 删除 (D)

全部重设 (R) 帮助 (H)

规划求解选项

最长运算时间 (T): 秒 确定

迭代次数 (I): 取消

精度 (E): 装入模型 (L)...

允许误差 (E): % 保存模型 (S)...

收敛度 (V): 帮助 (H)

☒ 采用线性模型 (M) ☐ 自动按比例缩放 (U)

☒ 假定非负 (G) ☐ 显示迭代结果 (R)

估计 导数 搜索

- ☒ 正切函数 (A) ☒ 向前差分 (F) ☒ 牛顿法 (N)
- ☐ 二次方程 (Q) ☐ 中心差分 (C) ☐ 共轭法 (O)

Having set up the model, we can use the solver to get the answer. And choose non-negative and linear programming in the option. So we can finally get the answer that only 3 distribution centers B, C and D are needed.

7. Some suggestions

7.1 Balance the relationship between cost and service level

It's impossible to increase both the logistics cost and service level at the same time usually. There is a negative correlation between logistics cost and service level. Better service asks for abundant freight, enough warehouses for storage, advanced equipments and facilities to keep the foodstuffs fresh. However, all of these need capital, you need investment in building new warehouses, and need enough capital to buy advanced equipment, then the logistics cost becomes high. And if you want to constrain the logistics cost in a certain range, the warehouse may be smaller, and you may not be able to afford the advanced facilities, service level will low down. Logistics companies should realize that in the business, they can't just concentrate on service level and omit cost, neither just focus on logistics cost and neglect service. But between these two, service levels should come first anyway.

As for the logistics cost, we can't just consider it as a cost and expenditure. We should realize that logistics cost is also a production factor that can bring us profit if we can use the resources properly to promote sells and get more customers.

Suning Appliance Chain Store (Group) Co.,Ltd is a good example in taking advantage of logistics cost as resources. In the year 2004, Suning promise to the customers if they buy air-conditioners in Suning, they will fix them for the customers

in 24 hours, and this promise covered both dead season and peak season. For many companies, there are only 10 to 15 days which can be seen as selling rush hours even in peak seasons, they don't want to invest too much money in keeping fixing and maintaining workers in dead seasons which result in the lack of fixing workers in peak seasons. But in Suning, they have one countrywide logistics center, seven regional logistics distribution center that assures that they can deliver the goods for customers in 3 hours as soon as they buy. Moreover, Suning pay much attention on the construction of distribution center. They recruit more than 700 workers in Nanjing in June 2002 and hire more than 500 retail distribution trucks. Their distribution service including general storage, distribution, transportation service, except that, they first introduced debug door-to-service in the industry that shorten the waiting time of customers in stores. Besides that, they also provide service such as arrearage selling, telephone shopping and drop in gathering and so on. With the increasing of service investment and enlargement of service scope, the service system in Suning changed totally, the service scope enlarged from air-conditioner to synthesize appliance, from simply selling to the special command to different customers. They invest much money in building the distribution center and hiring workers, but they also provide better service for customers. And more and more customers will go and buy their products because they provide better service even if the price and quality of products are little bit higher than other companies and some are just the same with other companies. Better service brings them higher profit. The theory can also be used in cold chain logistics.

7.2 Green logistics and recovery logistics

Environmental problem is becoming serious and serious. Many countries and industries have realized the importance of environmental protection. As for the

logistics, primarily cold chain logistics, which always produces many wastes especially when the cold chain isn't perfect that lead to the putrescence of foodstuffs, need to be paid more attention to on the green logistics construction.

Green logistics, just as its name implies, is a kind of logistics activity that melt in the environmental sustainable development concept. Green logistics can help with reducing the environmental pollution and cutting down resource consumption.

Green logistics in cold chain can be divided into the following parts. First is the intensivism of existing resources. Enterprises can higher the utilization of resources and lower the consumption and wastage of resources through integration of existing resources and optimization of resource collocation. In our country, when some places decide to build a new logistics center, they never take into account the compatible of logistics hardware establishment. A common problem is that always when the new facilities are just built up, the old ones are discarded which reflect on the huge wastage of recourses. It's said that the vacancy rate of logistics facilities is as high as 60% in China. It's far away from the requirement of green logistics. As actors in societies, on account of the speciality of the suppliers and producers of farm products, we'd better assemble those separate individuals and let them work together, which can help with the building of enlarging scale and realizing the economy of scale, reducing cost and increasing the utilization of resources.

Another part can be considered as green transportation. Without any question, fuel consumption and tail gas in the transportation is a main reason for the environmental pollution that is caused by logistics. The trucks used in cold chain logistics transportation are special, with many refrigeration facilities in them, they cost much more fuel and the pollution will be worse. Thus it's important to position and

program the distribution center reasonably. In this way, we can shorten the route and reduce vacancy rate, thus reach the goal of saving energy and decreasing the discharging amount. Besides that, another requirement is that we improve the gas engine technology and use some clean fuel to improve the utility of energy. Finally, another important thing is to avoid the leakage accident that may happen during the transportation especially when transporting by sea. The government can blaze a highway, railway or airway in food's transportation. Thus can take advantage of the each kind of transportation tool, reduce unnecessary tool-gate and charge, and set up a green transportation net and thorough transportation net with high efficiency and low pollution, low cost in the countrywide.

The third part is green storage. Green storage asks for the reasonable overall arrangement of warehouses to save transportation cost. If the distribution of the warehouses is too dense, it will increase the times of transportation, thus increase the resource consumption; if the distribution is too loose, it will decrease the efficiency of transportation and increase the vacancy rate.

Next part is green package. Package is an important tool of marketing. However, many of the packages are discarded by consumers after used once only and causes pollution problem. For example, a serious environmental problem in China is white pollution, which is caused by the discarding of plastics package that can't be degraded. As for the logistics companies or factories, they can use environmental protection materials to improve the utilization of materials, design some kind of folded package to save room or set up package recovery system.

The final part is the converse logistics, which means those logistics activities which related with resources cycle, resources substitution, resources return and resources

disposition. Converse logistics is a very important part in logistics development. It can help with the reutilization of existing resources, save cost to make new ones especially for some expensive materials. Also, with the converse logistics, we can gather those important materials that may be useless for customers and decrease the pollution. Moreover, with the converse logistics, we can know which part of our product is weak, how is the customers' reaction to our products, and then take some actions to improve the product, either in service or quality or transportation part.

What we need to realize is that green logistics is a cost, but it can also create value. Some people think that green logistics is only an expense, and it's the business of government but not enterprises. That's totally wrong. According to the research of westerners, an enterprise with good environment always performs favorable in making profit.

7.3 Risks and energy development

There are many risks in front of the cold chain logistics: high investment of facilities, high operation cost, and high wastage during transportation. Besides that, the most serious thing the logistics company now facing is the shortage of energy, especially the electric power. The speciality of cold chain logistics needs the refrigerated facilities. If there's no electric power for refrigerated facilities, the foodstuffs will turn bad easily which causes the broken of cold chain and wastage of resources. Actually China has already become the second biggest electricity consumer in the world. Until the end of last year, the total amount of electricity power installation exceeded 500 million kilowatt, the total amount of electricity generated exceeded 200 million kilowatt-hours. Although since 2000, the rising of electricity is the fastest in the increasing of resources production, it's still far from the requirement of

social and economic development in China. In the summer of 2004, there appeared such a complexion: a cold chain danger caused by the shortage of electric power. Many provinces have to direct switch-off the electricity. Meanwhile, the utilization rate of resources in China is only 33%, 10% lower than in advanced countries. Many enterprises have to change or shorten their working time. It's a vital hit to the refrigerated food producing enterprises. Thus, it's important for us to explore new kind of energy for producing of electric power, such as rain power, terrestrial heat power, ocean power, hydrogen power and so on.

7.4 Can't copy the western model

Although many developed countries are advance in cold chain logistics. They have sound regulations and managing model, they have abundant investment and capital, they have better facilities and equipment and they have enough money in training the professionals. They are several years advanced than us. We need to learn from their advanced skills and experience, however, what we should notice is that we should not just copy their model. China is just an infant in cold chain logistics industry, the capital put in the industry is limit and it needs some time for the government to set up regulations to standardize the marketing operation. Advanced countries have several years experience in cold chain logistics, their technology and managing model are higher. However, they may not suitable for the condition of China now. For example, the equipment and facilities they used now is much more advanced, but also much more expensive. It's difficult to require the cold chain logistics companies to buy this kind of advanced facilities. Though there is a trend to develop through the trace of developed countries, we need to go step by step.

Besides, the needs in China are not as high as in those advanced countries. There

are some cold chain logistics companies in China, but still not many. And those existed ones are not that professional because of the limitation of capital and lack of the promotion of customers' needs and market. But with the development of China's economy, more and more consumers in China will certainly realize the importance of fresh food and require for the fresh of food. In order to satisfy the customers and catch the business opportunity to gain profit, government will pay more attention to the cold chain logistics and enterprises will be willing to invest for the expensive facilities. And with the mature of the technology, those expensive facilities may also become companies' necessities. Then the huge requirement of customers will promote the development of cold chain logistics.

7.5 Avoid reduplicated construction

The condition in China is that there are many small logistics companies, some also do cold chain logistics business. These companies build logistic centers, buy expensive facilities, and set up bases. A common problem is that sometimes, the old ones just finish construction; they begin to build new ones. And years later, when the new ones completed, the old ones are discarded. And each company has their own facilities and centers. But because of the limitation of capital, none of them can do well in the logistics business, some are weak in temperature controlling part, some are weak in basic facilities. They are keeping doing reduplicated construction and waste a lot of money and energy. If those companies can cooperate, set a large logistics center, and realize combinative distribution, each small company can focus on its strength, the level of cold chain logistics service will be improved without any doubt.

8. Conclusions

Cold chain logistics construction in China is still on its primary step. There are still many problems and weakness of cold chain logistics in China. There are no standardized regulations to restrict cold chain logistics operation. Besides, lack of professionals, short of operational experience and poor facilities are the serious problems. Comparing with those advanced countries, China is poor in facilities, lack of capital and professionals, short of 3PL and has few regulations and laws in the area.

However, there are also opportunities and huge potential for the development of cold chain logistics. We could improve the cold chain logistics level by gaining governmental support, setting up cold chain logistics standardization, developing information system and so on. Also, as for the logistics companies, they should improve their managing and organizing structure. They should better set up professional cold logistics management system such as continuous replenishment and midway tracing strategy, value-added service strategy and so on. Besides that, set up alliances with producers, other logistics companies and business companies are useful ways in improving the cold chain logistics condition in food industry in China.

When dealing with the cold chain logistics problem in real practice, we may always come across the problem of purchasing new facilities which are expensive and complicated. Under this condition, NPV will be a very useful tool in making a

decision. Another problem we may meet is the distribution center covering problem. How to improve the conditions of distribution centers that have already been set up, are they necessary to build? Shall we reduce the number while taking full use of other distribution center to save cost and energy? If we use spreadsheet to set a model, it will be a problem that can be solved very easily. Apart from that, we should try every means to lower logistics cost. When we lower the logistics cost, we should also guarantee the logistics service. We should notice that logistics service is not an expense but more of a kind of income, in the long run, we will gain much more from it. And we need to do the green logistics that is also a trend of cold chain logistics development. When we are constructing the cold chain logistics, we need to know exactly which steps we are in, how the customers' requirement for our service is, what we can do at present and how our ability is. We can't just blindly copy the model of westerners and only to find that it's just a waste of time and capital, as the needs is not as high as in advanced countries. So there is another problem that how to set up a set of developing model of our own in China according to the special system and development step? But with the continuous development of economics in China, customers' requirement for cold chain logistics will certainly be higher and will promote the government, logistics companies and producers of cold products to construct better cold chain logistics. Every member in cold chain logistics field should get ready for the innovation and revolution.

References

1. Carmi A. Lyon and Catherine A. Durham. *Refrigeration and Food Demand in China---Can Refrigerator Ownership Help Predict Consumption of Food Products in China?* Retrieved February 20, 2006 from the World Wide Web:
<http://scholar.google.com/url?sa=U&q=http://www.china.wsu.edu/pubs/pdf-99/3-Carmi%2520Lyon.pdf>
2. Chen Xia and Wang Haitao. (2005, January). Some Ideas on Logistics Cost Management. *International Logistics*, 85-86.
3. Conditions About Fresh Food's Cold Chain Logistics. *Logistics*, Dec 2003. Retrieved February 21, 2006 from the Disk.
4. David Boselie, Spencer Henson and Dave Weatherspoon. *Supermarket Procurement Practices in Developing Countries: Redefining the Roles of the Public and Private Sectors*. Retrieved February 20, 2006 from the World Wide Web:
<http://scholar.google.com/url?sa=U&q=http://www.kennisonline.wur.nl/NR/rdonl yres/271DABD5-46DC-44B3-96EC-9C507751B807/5782/Supermarketprocurementpracticesindevelopingcountri.pdf>

5. Debra J. Perosio, Edward W. McLaughlin, Sandra Cuellar and Kristen Park. *Supply Chain Management in the Produce Industry, September 2001*. Retrieved February 2, 2006 from the World Wide Web:
<http://scholar.google.com/url?sa=U&q=http://aem.cornell.edu/research/researchpdf/rb0105.pdf>
6. Denise Y. Mainville and Thomas Reardon. *Scale, Scope and Specialization Effects on Retailer' Procurement Strategies: Evidence from the Fresh Produce Market of Sao Paulo Brazil, International Food and Agribusiness Management Association Annual Meetings, Chicago, 2005*. Retrieved February 20, 2006 from the World Wide Web:
http://scholar.google.com/url?sa=U&q=http://www.ifama.org/conferences/2005Conference/Papers%26Discussions/1066_Paper_Final.pdf
7. Donato Romano. *"Food Risk Communication and Consumers' Trust in the Food Supply Chain" TRUST, June 2003*. Retrieved February 3, 2006 on Disk.
8. Edward F. Durner, E. Barclay Poling, and John L. Maas. *Recent Advances in Strawberry Plug Transplant Technology, October-December 2002, 12(4)*. Retrieved February 15, 2006 from the Disk.
9. Fergal Tansey BSc, Ronan Gormley BSc PhD, Serge Carbonell BSc PhD, Jorge Oliveira BE PhD, Paula Bourke BSc PhD and David O'Beirne MAgSc PhD, *Developing Sous Vide/Freezing Systems For Ready-meal Components*. Retrieved February 2, 2006 from the World Wide Web:
<http://scholar.google.com/url?sa=U&q=http://www.teagasc.ie/research/reports/foodprocessing/4875/eopr-4875.pdf>

10. Floor Brouwer and Jos Bijman. *Dynamics in crop protection, agriculture and the food chain in Europe*. Retrieved February 2, 2006 from the World Wide Web:
http://scholar.google.com/url?sa=U&q=http://www.lei.dlo.nl/publicaties/PDF/2001/3_xxx/3_01_08.pdf
11. Francisco Artés. *Refrigeration for Preserving the Quality and Enhancing the Safety of Plant Foods, Bulletin of the IIR – No. 2004-1*. Retrieved February 20, 2006 from the World Wide Web:
http://scholar.google.com/url?sa=U&q=http://www.iifiir.org/2enarticles_bull041.pdf
12. He Yeli. *Research on Logistics Rationalization in Asia-Pacific Area*. Retrieved February 20, 2006 from the Disk.
13. Huang Jian, Du En-jie and Shi Wen-xing. (2004). Developmental Status and Trends of Food Cold Chain in the World. *Food Science*, 25 (11), 404-410.
14. Huang Zhu. (2003, June). Consideration on the Construction of Cold Chain System in China. *Storage, Transportation & Preservation of Commodities*, 12-14.
15. Lai Ting. *Quantitative Analysis of Logistics Rationalization*. Retrieved February 20, 2006 from the Disk.
16. Li Weihua. (2004). To be the Leader of Food Cold Chain in China. *China Logistics & Purchasing*, 3, 62-63.

17. Li Xu. (2004, November). Conditions and management Countermeasures of Food Supply Chain in China, *China Logistics & Purchasing*, 8-10.

18. Li Xuejun and Wangjian. (2002). Build Food Cold Chain Logistics in China. *Market and Computer*, 12, 25-28.

19. Li Yue. *Study on City Logistics Rationalization*, March 2003. Retrieved February 20, 2006 from the Disk.

20. Linda Calvin and Roberta Cook (coordinators), Mark Denbaly, Carolyn Dimitri, Lewrene Glaser, Charles Handy, Mark Jekanowski, Phil Kaufman, Barry Krissoff, Gary Thompson, and Suzanne Thornsbury. *U.S. Fresh Fruit and Vegetable Marketing: Emerging Trade Practices, Trends, and Issues. Market and Trade Economics Division, Economic Research Service, U.S. Department of Agriculture, Agricultural Economic Report No. 795. January 2001*. Retrieved February 20, 2006 from the World Wide Web:
<http://scholar.google.com/url?sa=U&q=http://www.ers.usda.gov/publications/aer795/aer795a.pdf>

21. Livija Tušar, Salon Orhideja, Miklošičeva 3 and Ljubljana. *Trans-national Training Session in Food Quality and Safety, 8-9 July 2004*. Retrieved February 20, 2006 from the World Wide Web:
<http://scholar.google.com/url?sa=U&q=http://www.rtd.si/slo/6op/podr/prehrana/gradio/inc/BookOfAbstract-new-SI.pdf>

22. Lu Gang. (2005, March). Technical Innovation on Refrigerator Car, *Logistics Magazine*, 50-52.

23. Nerlita M. Manalili. *Linking Farmers to Markets Through Cooperatives Vegetables Supply Chain Redesign Options for Kapatagan, Mindanao, Philippines, 11-14 February 2003*. Retrieved February 20, 2006 from the World Wide Web:

http://scholar.google.com/url?sa=U&q=http://www.regoverningmarkets.org/docs/Linking_Farmers_to_Markets_AARES.pdf

24. NI Shikun, Gao Baocheng and Li Changhua. (2006, April). Cold Chain Transportation Process Control which is Based on IT Tecnology. *Shanghai Logistics*, 49-54.

25. Peter Gibbon. *Global Commodity Chains and Economic Upgrading in Less Developed Countries*. Retrieved February 20, 2006 from the World Wide Web:

<http://scholar.google.com/url?sa=U&q=http://www.ids.ac.uk/ids/global/pdfs/worldev.pdf>

26. R.H. Schmidt, R.M. Goodrich, C.A. Sims, and M.E. Parish. *Fresh Juice Processing GMPs, April 1999*. Retrieved February 4, 2006 from the World Wide Web:

<http://scholar.google.com/url?sa=U&q=http://edis.ifas.ufl.edu/pdffiles/FS/FS07800.pdf>

27. Ronan Gormley B.Sc.Ph.D, Martine Brennan B.Sc.Ph.D and Francis Butler B.E. Ph.D. M.B.A. *Upgrading The Cold Chain For Customer Food Products*. Retrieved February 2, 2006 from the World Wide Web:

<http://scholar.google.com/url?sa=U&q=http://www.teagasc.ie/research/reports/foodprocessing/4682/eopr-4682.pdf>

28. S.A. Sargent, M.A. Ritenour and J.K. Brecht. *Handling, Cooling and Sanitation Techniques for Maintaining Postharvest Quality*. Retrieved February 20, 2006 from the World Wide Web:
http://scholar.google.com/url?sa=U&q=http://www.gladescropcare.com/postharvest_quality.pdf
29. Shi Guichun. (2001). Conditions, Trend and Countermeasures of Storage of Vegetables. *Journal of Jilin Agricultural Science*, 26 (4), 49-53.
30. Silvia Estrada-Flores Ph. D. *Novel Cryogenic Technologies for the Freezing of Food Products, The Official Journal of Airah, July 2002*. Retrieved February 20, 2006 from the World Wide Web:
<http://scholar.google.com/url?sa=U&q=http://www.airah.org.au/downloads/2002-07-01.pdf>
31. S.N. Sethi, K.N. Mohanta, B.K. Das, S.C. Mukherjee and S. Soni. *Responsible Fisheries and Sustainable Aquaculture--- A Pledge for 21st Century*. Retrieved February 20, 2006 on the Disk.
32. Song Liang. (2005, May). International refrigeration producers proposed to China's foodstuff industry that the value of foodstuff depends on cold storage chain. *Global Food Industry*, 18-20.
33. Su Xiujin. (2005, May). Logistics Programming of Cold Chain in Food Industry. *Logistics World*, 31-36.
34. Trend of Chilled Logistics Industry. *International Logistics*, Oct 2005. Retrieved

February 20, 2006 on the Disk.

35. Walter J. Armbruster and William T. Coyle. *Transportation Infrastructure and the Asia-Pacific Food System*. Retrieved February 20, 2006 from the World Wide Web:
<http://scholar.google.com/url?sa=U&q=http://207.57.10.231/Conf2005/PapersPDF/ArmbrusterAARES2005.pdf>
36. Wang Xinyu and Tian Yuan. (2005, May). Pilot Study on Some Specific Technical Problem in Fruit & Vegetable Cold Chain. *Logistics World*, 37-40.
37. Wang Zilin. (2005). Cold Chain Logistics Face Four Problems. *China Logistics & Purchasing*, 7, 18-20.
38. Wu Runtao and Wang Li. (1994). Research on Rational Logistics in China. *Logistics Technology*, 2, 65.
39. Wu Shaolian. (1995). On Rationalization of Physical Distribution. *Journal of Tianjin University of Commerce*, 15 (4), 40-43.
40. Xie Jing, Liu Xiaodan and Xu Shiqiong. (2005, January). Method and Technology of Preserving Fresh Vegetables, *Refrigerator Technology*, 6-9.
41. Xu Bonian. (2004). Special Supply Chain---Recent Development of Refrigeration Chain, *Port Handling*, 5 (157), 33-35.
42. Yan Yongli. (2005, January). Analysis About Freezing and Chill Logistics'

Business in Logistics Company, *Logistics Magazine*, 61-66.

43. Yang Bo and Zhao Gang. (2005). Freezing: Lagged Behind Chain and Its Rebuilding. *China Logistics & Purchasing* 14, 38-40.
44. Zhang Gong translated. (2005). Don't let beefsteaks go bad on the road. *Global Supply Chain*, 27, 80-81.
45. Zhang Jihua. (2005). Problems and Countermeasures in Food Cold Chain in China. *Special Zone Economics*, 6, 269-270.
46. Zhang Rentang, Niu Zhumei, Liu Wei and Gu Duanyin. (2005, March). Study on Cold Storage Chain Mode of China Modern Fruits Logistics, *Logistics Technology*, 51-58.
47. Zhao Rongguang and George Kent. (2004). Human Right and the Governance of Food Quality and Safety in China. *Asia Pacific J Clin Nutr*, 13 (2), 178-183.
48. Zhao Zhijun. (2005, September). Continue on the Development of Cold Chain and Moral Industry in China, *Logistics Technology*, 5-6.
49. Zhen Hailang. (2004, April). Optimization of Cold Chain Logistics. *China Storage & Transport*, 8-10.
50. Zhou Junfei. (2003, April). Japan Accelerate Rational Logistics by Means of IT, *Logistics Technology*, 46-47.

51. Zhou Yefu. (2005, April). Synthetical Analysis of Logistics Cost. *Logistics Magazine*, 46-47.