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On optimization of cold chain logistics systems for Rokin logistics company

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ON OPTIMIZATION OF COLD CHAIN LOGISTICS SYSTEMS FOR ROKIN LOGISTICS COMPANY

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Declaration

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

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

(Signature): …..............................

(Date): …...............................

Abstract

The research paper focuses on the optimization of cold chain logistics system based on the case of one Chinese company, Rokin Logistics.

A brief look is taken into the development of cold chain logistics in the global market, where chances and challenges exist. The sharp growth of Chinese market is attractive to all investors, but Chinese cold chain logistics is still in its infancy with low entry barrier. Literature review also shows that although quite a lot research paper investigated cold chain logistics, not so much of them stands for companies.

Then the case of Rokin Logistics is examined and the problem is found that as the company invested more in vehicle and temperature controlling in transportation, the company lacked in distribution and the best and quickest approach is to build logistics centers between the pre-cooling locations, where the warehouses stores for the fresh products.

The center of gravity method is used as the quantitative method to help the firm to determine the best location of logistics center based on the minimization of the transportation cost. Based on calculations where total cost equals unit cost multiplies the distances between the points, the method runs several times to find a stable answer.Data of twenty southern cities and nine northern cities are collected from the company, and the statistics is applied for the center of gravity method. The result indicates that the logistics center for north and south is influenced by different factors and the two reveal no straight links.

KEYWORDS: cold chain logistics, Rokin Logistics, optimization, logistics center location, center of gravity method

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1 Introduction

1.1 Backgrounds of this dissertation

Cold chain logistics is the management of the flow of products from origin to destination in a temperature-controlled supply chain involving an uninterrupted series of refrigerated production, distribution, and storage activities.[1] Cold chain logistics is used in ensuring extended shelf-life preservation of products such as fruits and vegetables, meat and seafood, beverages, dairy products, and frozen foods, as well as chemicals and pharmaceutical drugs.[2]

2016 IARW Global Top 25 List

	Company Name	Locations	Cubic Feet	Cubic Meters
1	Americold Logistics	Argentina, Australia, Canada, China, New Zealand, and United States	992,032,503	28,091,186
2	Lineage Logistics	United States	609,276,429	17,252,759
3	Swire Group[i]	Australia, China, Sri Lanka, United States, Vietnam	409,818,004	11,604,734
4	Preferred Freezer Services	China, United States, and Vietnam	325,393,595	9,214,105

Figure 1.1 2016 IARW Global Top 25 List
Source: http://www.lenglian.org.cn/news

As of 2016, the overall global capacity of refrigerated warehouses reached around 600 million cubic meters. The gross refrigerated storage capacity in the United States alone is over four million cubic meters. The leading provider in refrigerated warehousing and logistics provider in the world is Atlanta-based company, Americold Logistics, shown by Figure 1.1. In 2017, Americold alone generated over 1.5 billion U.S. dollars in net revenue and accumulated a capacity of up to 25.4

million cubic meters in temperature-controlled space in the U.S. and Canada alone. In North America, the capacity of refrigerated warehouses amounted to over 136 million cubic meters in 2016.[3]

Food and pharmaceutical industries are taking the most important part in the cold chain logistics. In 2017 alone, more than 18 billion U.S. dollar in the global third-party logistics revenue was earned in the food and grocery market, while over 17 billion U.S. dollars was generated from the healthcare market.[4]

People are passionate chasing food safety and healthcare, which is indicated from the statistics, that the market is on growing. At the same time, it is no doubt that the cold chain logistics, especially 3PLs, impacts the upstream and downstream. We take food industry as an example. For growers, because the most important thing after harvesting a crop is to get it refrigerated, there are always cooling warehouses near crop fields, stated by Stenzel, President and CEO of the United Fresh Produce Association.[5] Those tend to be smaller farms that are producing locally grown produce and while their logistics needs are the same as the larger farms, they might not have cooling facilities and currently smaller farms might have to go to a wholesaler for their refrigeration needs. If 3PLs can fill that need on a regional basis, an aggregation service with shared warehouse space could be very attractive to a grower. There is a tremendous amount of imported fruits and vegetables entering the country, especially through the ports in winter, reported by Stenzel, and there is a lot of competition and investment to have enough refrigerated warehouse space to be the port selected to offload that produce.[6] So another need in the produce supply chain that could be met by 3PLs is refrigerated warehouse space at ports and borders, for those importers. Stenzel also has pointed to opportunities to serve today's produce wholesalers. Thousands of produce wholesalers have warehouse sand storage facilities and sooner or later these wholesalers will have to decide whether they're going to invest capital to improve and update existing facilities, build new state-of-the-art storage facilities or turn their storage needs over to a third party, and that is another growth opportunity for 3PLs.[7]

Meanwhile, the cold chain also faces many of the same issues challenging the entire supply chain: serving the global market, driving out costs, becoming more strategic, and addressing capacity and resource constraints, all while managing the exacting needs of the sector's precious cargo—primarily food and pharmaceutical products.[8]

The Big Chill has forecasted the ten trends in the cold chain logistics: cold chains are becoming more global, an increasing focus on quality and product sensitivity, regulation is on the rise, market pressures drive demand for supply chain efficiency, cold chain is experiencing some mode shifting, packaging is evolving to meet new needs and customer habits persist as the cold chain's weakest link.[9]

In a short summary, chances and difficulties are existing in the development of global cold chain logistics.

When it comes to China, Chinese consumers have been demanding higher standards with regard to safety, health and quality of life. However, there is increasing concern regarding food and drug safety, especially with ecommerce. Cold chain logistics form the foundation of supply for perishable products (e.g., fresh fruits and vegetables, meat, dairy, aquaculture products, fresh flowers) and medical products (e.g., drugs, reagents, vaccines, biologics), which have strict temperature, humidity and other environmental requirements.

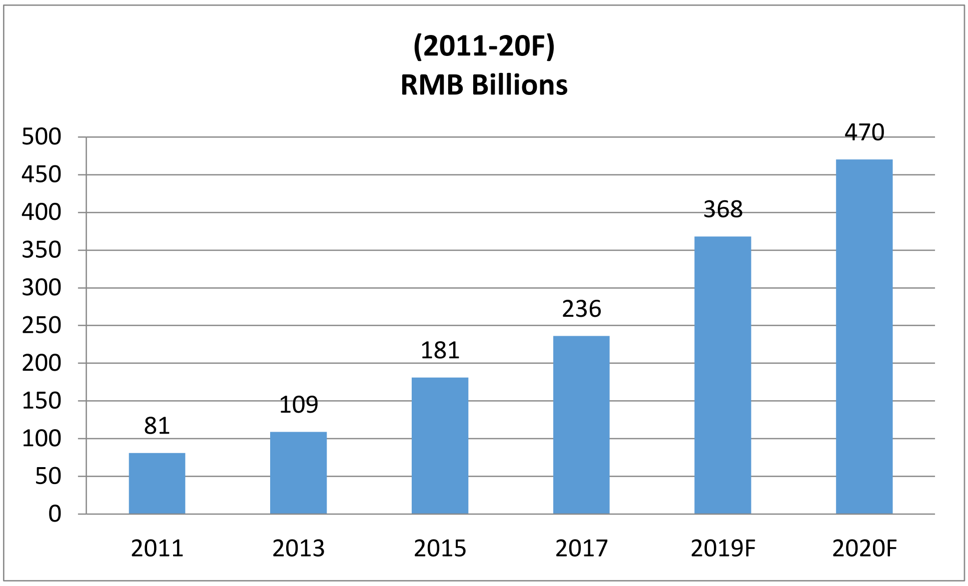

Figure 1.2 China's cold chain logistics market size
source: L.E.K. analysis websites

Benefiting from the rapid growth of such needs, the Chinese cold chain market has grown at over 20% annually. Over the past five years, the market size has increased from RMB 80 billion in 2011 to RMB 181 billion in 2015, as recorded in Figure 1.2. Persistently increasing demand for fresh food and drugs will continue to drive growth in the cold chain industry.[10]

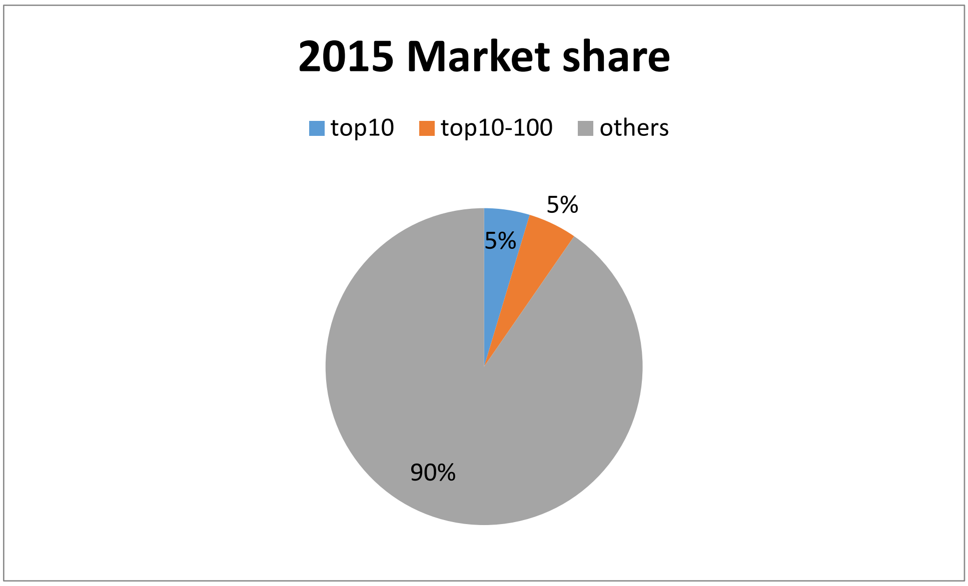

Figure 1.3 China's domestic cold chain market split by players

source: L.E.K analysis website

Despite the remarkable growth, China's cold chain industry is still in its infancy, indicated by Figure 1.3. The market itself is also extremely fragmented, with the China Federation of Logistics and Purchasing's Cold Chain Logistics Committee estimating that revenue from the top 100 cold chain logistics companies accounts for less than 10% of the overall market.11 Although the market is growing rapidly, the unreliability and "breakage" of the cold chain remains a serious problem. As ownership of each stage of the cold chain including warehousing, ground transportation, air freight, airports, distribution and other services is very fragmented, the lack of end-to-end process control resulting widespread mismanagement of such logistics. Additionally, the use of temperature monitoring technology, information systems and other forms of technical damage to fresh products within the cold chain could be as high as 20-30% much higher than the 5-10% in developed countries.

1.2 Literature Review

Although some scientists have paid attention to optimization of cold chain logistics system, there are not so many the research papers and the content is diversified in different countries.

First, Saif, A. et al. (2016) use simulation to model the cold supply chain design problem as a mixed-integer concave minimization problem with dual objectives of minimizing the total cost including capacity, transportation, and inventory costs and the global warming impact.

Second, others like Hariga, M. et al. (2017), Wang, S. Y. et al. (2017) and Fan L. N. et al. (2017) who also think about emission reduction taking other ways. The former one presented an operational cost minimization model, a carbon footprint minimization model, together with a hybrid economic and environmental minimization model where all models seek to determine the optimal lot sizing and shipping quantities. The second one investigated optimization of Vehicle Routing Problem (VRP) with time windows for cold-chain logistics based on carbon tax in China and constructs a green and low-carbon cold chain logistics distribution route optimization model to minimize cost. The last one set the cold chain logistics path optimization model of agricultural products and let simulation results show that the improved genetic algorithm is an effective method to achieve agricultural products cold chain logistics route optimization considering the carbon emissions.

Third, in operational perspective, Chinese scientists dig more into important part of traditional logistics. Zheng, J. G. et al. (2015) developed a novel location inventory routing (LIR) model to optimize costs of location, inventory and transportation. Guo J. M. et al. (2017) built the distribution route optimization model for the costs in the distribution process. Quite some studies try to solve distribution center location problem. Chen S. T. et al. (2016) used a mixed integer linear programming model to describe multi-product cold chain logistics distribution center location and flow allocation problem and CPLEX was applied to solve this model. Wang, X. X. (2014) set a linear-programming model applying for a real case, using genetic algorithm methods to solve the minimum costs of locating cold chain logistics distribution center and losing quality of the goods, which has proved that genetic algorithm is feasible and can gain a more optimal solution than that gained by Lingo. Yang, J. (2016) built the model of fresh agricultural product cold chain logistics distribution center location based on the Entropy Weight-ANP Method with the case study of Xi'an. Zheng, Y. (2015) analyzes empirically the improved CFLP model through taking a new factor (customer satisfaction) into consideration, combing with the case that company H establishes distribution centers in cold chain logistics for fresh agricultural products in Baoding and Langfang. Other studies abroad focus more on the cold chain equipment, Robertson, J. et al. (2017) reviewed the innovations in cold chain equipment for immunization supply chains. Shih, C. W. et al. (2016) solved the problem that manufacturers in the food industry facing the dilemma of having to choose between frozen storage and cool storage in delivering products to retailers by integrating wireless sensor networks with statistical quality control. Zhang, X. N. et al. (2018) investigated the modal choice between reefer bulk and container vessels by a value-based decision model. Lutjen, M.et al. (2012) focused on the development of a new scheduling method for distribution by applying principles of quality-driven customer order decoupling corridors (qCODC) under the concept of “Intelligent Container”.

Fourth, some of them discussed on the niche part of the optimization of cold chain logistics like risk management, Kim, K. et al. (2016), and rerouting transportation solutions, Mejjaoulia, S. et al. (2018).

When it comes to the center of gravity method, which is widely used in the logistics distribution problem, the real cases are often used although the solution procedures are often different. SHEN, M. and DAI, B. (2015) introduced the current status of the application of the gravity center method in the location allocation of logistics distribution centers, then analyzed the strength and weakness of this method in this respect, in connection with the case of Suning. CHEN, H. and MOU, R. (2013) discussed the introduction and the derivation of the center of gravity formula in detail, and made the corresponding improvement for the previous iterative scheme. Gravity method and genetic algorithm was used by WANG, H. et al. (2015) for researching Urumqi Zhongtong express distribution center location with the apply of AHP (analytic hierarchy process) to do scientific evaluation on the selected plan.

Existing problems

However, problem and weakness still exist.

- ✧ Quantities of research actually contains one type of cold chain such as agricultural cold chain, vaccine, food etc. The complicated cold chain logistics system which should include all is seldom discussed.

Ashok, A. et al. (2017) reviewed the challenges and solutions of cold chain systems, but the research only focused on vaccine cold chain and the equipment of monitoring temperature. Feng, H. et al. (2009) introduced the problems existing in China raw and fresh food logistics, and pointed out that the cold chain logistics is an effective way to solve agricultural products losses and to ensure food security, while the paper was linked with food cold chain logistics.

- ✧ Less research stands for a company, which faces the situation of competition and self-improvement. What a company providing cold chain logistics service needs reflects the reality of the industry.

Many research papers are discussing about the models of solving temperature-monitoring problems in cold chain logistics system, which is one of the most important point in the industry. What about in the real cases? As different companies have different strategy, the technology part is not what they really want. There should be more attention paid to strategy level of companies.

In a word, optimization of cold chain logistics systems still has a lot of areas which have not been explored yet. And optimization of cold chain logistics system should have more real cases of companies. Optimization of cold chain logistics system still has a long way to go.

1.3 The framework and content of the dissertation

The main content of this paper is around the optimization of cold chain logistics system. Taking Rokin logistics as an example, we examine the situation and problems, the solution therefore is provided as location distribution. The center of gravity method, as quantitive method, is used to solve the problem of cold chain logistics center.

The content of the first chapter is the introduction part, including research background, method used in the paper, and the research status of logistics distribution center location problem at China and abroad .

The content of the second chapter is the analysis of Rokin logistics to reveal the problems and current situation of Rokin logistics.

The third chapter is to establish a sites selection model by using the center of gravity method.

The fourth chapter is about data inputting, solving the model with Excel and drawing conclusions.

Finally, there is a summary.

In this paper, three research methods are mainly used:

(1) literature research method: Before the writing of the paper, I have reviewed a lot of literature materials on location selection of cold chain logistics center, and made selective references.

(2) qualitative and quantitative method: What has been done is, the same problem should be analyzed from different aspects, and then the conclusions obtained should be compared and analyzed. Qualitative research is mainly about the nature of the research object, and quantitative research is to quantify the object to be studied.

(3) case analysis: the main research object is a logistics company.

2 Rokin Logistics situation and problems

2.1 The company's situation

Rokin Logistics, established in 1997, presently owns more than 780 refrigerated trucks and numerous refrigerators serving an area of 10,000 m^2. It is constituted of three business sections, namely, the cold storage truck line transportation covering the entire cold chain process, the inter-city cold chain distribution, and the storage. It is the cold chain logistics provider for Pepsi, Nestle and several other Fortune 500 companies.

In most industries, identifying the company's situation is to understand the competitors' advantage, where conflicts and confrontation constitute the existing competition between enterprises. Therefore, Rokin logistics company should be familiar with the situation of competing enterprises. We should pay attention to the development direction of our competitors and analyze their advantages and disadvantages so as to help ourselves in the market get rid of the competition. At present Rokin logistics company is in the early stage of development, the center of gravity is located in the east China region centered on Shanghai.

The industry of cold chain logistics mainly includes the following five types:

First one is the companies which focus on production.

Typical case is Shanghai wengpai refrigeration, the company mainly engaged in the import of aquatic products and aquatic products processing business, before the establishment of their own cold storage which used to be rent to a third party. And later as the company's aquaculture business continued to expand, the company then invest in self-built cold storage. In addition to supporting its own business, the company's cold storage space is also used for leasing to other enterprises. Through this way of operation, the company can manage the goods independently, reduce the logistics cost, and pass through service to create benefits for the company. There are many other companies of this type, such as Shanghai Hanqiang Industry and Trade, Shuanghui Logistics, Bright Group's Leading Fresh Logistics is also such a type of enterprises.

Second one is marketing-based.

A typical case is Dongfang International Aquaculture Center, which belongs to Shanghai Aquaculture Group, specially responsible for providing stores with water products storage. Its cold storage annual benefits so that the rate can reach above, in addition, in bad season, the cold storage also provides external leasing business. Jiangqiao Wholesale Refrigeration also belongs to this type, which relies on jiangqiao vegetable wholesale market. Shanghai jinjiang cold huangpu cold storage, which is built in Shanghai next to the market.

Third is customer-based, providing services for core customers.

Xia Hui logistics is a typical example of McDonald's global logistics service provider, which acts as the largest McDonald's Party third party logistics provider for many years. Xia Hui followed McDonald's during its expansion into the Chinese market, building strategy to establish a logistics network for the development and growth of McDonald's in China. In another way, Xia Hui Logistics is also the leader of China's cold chain industry.

The forth is integrating the upstream and downstream of cold supply chain.

OOCL is the leader in this way. OOCL is one of the largest integrated international container shipping, logistics and terminal companies in Hong Kong. OOCL takes the lead in providing full-line logistics and transportation services in China, and is also an expert in information services. With its logistics service network in China and even around the world, OOCL has a strong and thoughtful information system and outstanding ability of resource integration. OOCL itself does not have a lot of cold storage and low temperature, under the condition of vehicles through the whole

cold chain logistics services are carried out in the manner of third-party cold chain logistics services, although their prices are relative to other cold chain logistics companies. The service is much more expensive compared with what others have provided, but out of the strong integration capabilities, OOCL has achieved good performance.

The fourth is similar with Rokin, professional third party cold chain logistics.

A typical case is Shanghai Jiaorong Cold Chain Logistics LTD, which is affiliated to Shanghai Jiaotong Group, a subsidiary of Shanghai Jiaotong Rihong International Logistics co., LTD., engaged in frozen, refrigerated and preserved fresh goods. As a logistics enterprise that stores and transports goods, with a refrigerated, thermostatic warehouse, with temperature cargo handling area and closed temperature control platform, the company handles many goods. The company has three cold stores, each of which has nearly six thousand storage location. Jiaorong owns nearly one hundred cold-chain cars, among which 40 percent mainly distributed by supermarkets, including TESCO, Auchan, lotus, WALMART, etc. At the same time, Jiaorong also provides storage and delivery services for a world - strong brand French SODEXO Catering Management LTD and other customers. In addition to Jiaorong, this type of company also includes Xintian Tianvolkswagen Low Temperature Logistics co., LTD., Yilu, Shanghai Hengfu, etc.

Potential entrants can also mean threats from new entrants, combined with the development of cold chain logistics market.

Shanghai cold chain logistics company faces two main threats.

One is cross business scope with foreign cold chain logistics company.

At present, China has not really formed the third party cold chain logistics service providers market nationally, most of them have their own key service market and radiation service market, so there may be potential competition causing from overlapping. For example, Zhejiang Tongguan Logistics Development Co., LTD. is a joint investment group of Taiwan United Group and Kukang Group, its key market is Hangzhou, center of Zhejiang market, and radiate to the sunan area, and the key market of Shanghai Cold Chain is the long triangle with Shanghai market using the center Zhonghe, mainly in Jiangsu, Zhejiang and Anhui, has caused potential competition in the cross-market between the two companies.

Taking Zhejiang market as an example, it is the main market for Tongguan Logistics and Shanghai Cold Chain Logistics Company and it is the radiation market, which causes many customers who need to ship goods from Shanghai to Zhejiang to consider the Zhejiang market instead of the cold chain logistics supplier Shanghai cold chain logistics supplier in the Shanghai market, Tongguan logistics is choosen for distribution.

If the national third party cold chain logistics company after a large number of development, there will be a broader cross-regional competition problem.

Foreign cold chain logistics company stepped into Chinese market.

American Cold Corporation, established the United States, corporate kangxin logistics to continue to grow strength. In 2010, It built a new company with China Merchants Bureau of the International, separate equity joint venture. The world's largest cold-chain logistics company has several cold storage facilities in the United States, from port storage to regional storage and terminal delivery. With the most complete business structure, basically the largest food companies in the United States are their partners. It is no doubt that the new company will get enough capability to grow stronger in Chinese market. And then there's Australia's biggest cold chain logistics provider Swire, moved into southern China. U.S. cold-storage logistics operator Pfeith's also has set up cold-chain warehouse in Shanghai. Japanese companies like Yamato, Itochu also entered China's cold chain market and so on.

These big foreign companies are now in the business exploration phase, trying to find the right customers and access. Chinese customers now are paying more attention to costs, not to quality, and cannot afford their expensive services fees. But the foreign giants represented by Mei Leng have been looking for opportunities once the environment of the industrial chain is mature. Their control over the industry will come into play and will certainly change the dynamics and pattern of China's cold-chain industry in recent future.

2.2 Existing shortages

2.2.1 Problems inside

Rokin Logistics focus mainly on transportation and the cold storage are far behind the international companies, which is an important evaluation of cold chain logistics companies. As concluded in the first part of the paper, the statistics of IARW showed that, the cold storage of Chinese logistics companies is on the way of development, far less than the American companies.

The bargaining power of Rokin is limited and value-added is low. The bargaining power of big customers is very strong, so their profit out of service price is not high. But because big customers have big influence and stable storage and distribution volume, long-term and stable cooperation is needed. In addition to that, the market is crowded, profit margin is very low. In comparison, the depreciation cost of Shanghai cold chain logistics company is high compared with the quotations of most cold chain logistics companies. The price of Rokin is too high to be competitive. Therefore, most of the company's services stay in low profitable state.

Human resource management is lagging behind. The overall cultural quality of enterprise employees is low, lack of high quality, professional management and operation personnel with pioneering spirit. Staff turnover rate is too high, and employees' remuneration, performance, incentive, training and other aspects of work lag. The company lacks a strong cohesive corporate culture and employees have a weak sense of mission.

The company's marketing team is backward in construction and efforts on marketing are insufficient. The marketing work of enterprises mainly relies on the company's senior management and department managers, the lack of overall marketing planning and implementation work, resulting in the unsuccessful publicity of enterprise brand , not enough to cultivate the market and customers.

2.2.2 Threats behind

As China's cold chain market is generally believed to have a bright future, competitors such as Pfeisi, Swire and Meileng are in a hurry entering into Chinese cold chain market, through establishing sole proprietorship or joint venture company. This type of foreign companies with strong financial strength and first-class cold chain logistics service background will be the biggest threats for Rokin, such as Meileng, Taigu cold chain, etc, although Rokin Logistics is actually belonged to CJ Group, a Korean group.

Rokin's cold chain transport services are mainly road transport, but in China the rapid development of railway refrigerated transportation represented by Railway express transportation and Tielong logistics has caused a great threat to Rokin, in the long-distance cold-chain transport.

Numerous logistics companies are separated from food companies for vast market. Compared with a third party cold chain logistics enterprises to provide services to the society, such enterprises have strength because their stable volume of business, and the ability to carry goods on its own lines of business, in low cost. For example, Shuanghui cold chain logistics.

The entry bar for cold chain industry is not high, no qualification restrictions, so that many normal temperature cars and low-grade retrofits are flooding into the industry, in addition to low needs of the majority customers for cold chain service quality requirements, a lot of enterprises with low-grade service, very competitive price and pressure are produced. Profit margin is reduced.

As a short summary, the shortages of the company are obvious: low bargaining power, unsuccessful human-resource management and marketing management, small profit margin and limited cold strorage.

3 Location distribution and the Center of gravity method

The company is in a hurry to build more cold areas. But the next question is, where are the logistics centers to transfer these goods? We consider the logistics centers as cold areas and other points as pre-cooling areas, so the problem is shown as followings.

3.1 location distribution problem description

A whole cold chain includes the following: pre-cooling, the food processing refrigerated refrigerator, the highway (rail, road, the ocean) refrigerated vechnicles, refrigerated storage, distribution, retail, refrigerated, refrigerated display case.

Pre-cooling is the first step and is very important in the storage and transportation of fresh foods.

If we take fruits and vegetables as an example, pre-cooling of fruits and vegetables is the process of rapidly removing the field heat and cooling the harvested fresh fruits and vegetables to the predetermined temperature before transportation, storage or processing. It is an essential key link to keep fruits and vegetables fresh and prolong storage. Pre-cooling of fruits and vegetables is realized by introducing special facilities for pre-cooling of fruits and vegetables.

There are two main differences between the precooling warehouse and the cold storage:

(1) The special fan is used to force the circulation of cold air into cool fruits and vegetables in the pre-cooling warehouse, and the wind speed of the cold air blower in the cold storage is generally low.

(2) The refrigerating capacity of the refrigerating machine is different. The refrigerating capacity of the precooler should be two to three times that of the refrigerator. Strictly speaking, cold storage is pre-cooled fruits and vegetables,

further reduce and maintain the temperature of the product, and remove the heat load from the walls, roof and floor around the store. And pre cold storage is just postharvest 25 ~ 30℃ temperature of fruits and vegetables with cool about 10 ~ 15 hours to 5℃ or so required refrigeration capacity.

The pre-cooling points are set separately in China, we need to build two logistics centers out of them based on center of gravity method.

3.2 Center of gravity method

The method is of site selection under normal conditions, on candidate position and without any restrictions. In each of the service object of known position, through input, logistics facilities to its service place under the premise of the linear distance, using center of gravity method is a good way to determine the position of the distribution center.

The theory of gravity method is simple and easy to understand, and the data is easy to collect. Gravity method under the transportation cost and the transportation distance was positively proportional changes, that is to say, is linear relationship between them, so the operation is convenient, fast computing speed, through several iterative calculation can quickly calculate the theoretical position.

The objective of the center gravity method is minimizing the total transport cost. It is based on the idea that all possible locations have value which is the sum of all transportation costs to and from that location. The best location, which minimizes costs, is represented by a physical analogy would be the weighted centre-of-gravity of all points to and from which goods are transported.

a) assumptions

This paper does not consider the cost of capital required to build logistics center warehouses in different locations and other costs related to operating in different locations, but only calculates transportation costs.

Assume that all city-based listed are the company's large pre-cooling warehouses across the country. They are mainly laid in the different parts of china, divided into two groups: northern parts and southern parts. Assume that the route between the logistics center warehouse and other network nodes is a straight line.

Assume that the transportation cost increases linearly with distance.

Assume the horizontal and vertical coordinates are based on geographic coordinates.

b) parameters

x: the horizontal coordinates of logistics center

y: the vertical coordinates of logistics center

x': the horizontal coordinates of the best location

y': the vertical coordinates of the best location

k: representing the points

x_n: the horizontal coordinates of the pre-cooling warehouses locations

y_n: the vertical coordinates of the pre − cooling warehouses locations

F_n: the transport cost $\left(\frac{USD}{km * ton}\right)$

D_n: quantity in units to be transported at each points (tons)

d_n: the distance between the logistics center and pre-cooling warehouses

TC: total cost

c) equations

$$d_n = \sqrt{((x - x_n)^2 + (y - y_n)^2)}$$

$$x' = \frac{\sum_{n=1}^{k} \frac{D_n * F_n * x_n}{d_n}}{\sum_{n=1}^{k} \frac{D_n * F_n}{d_n}}$$

$$y' = \frac{\sum_{n=1}^{k} \frac{D_n * F_n * y_n}{d_n}}{\sum_{n=1}^{k} \frac{D_n * F_n}{d_n}}$$

$$TC = \sum_{n=1}^{k} d_n * F_n * D_n$$

3.3 solution procedure

chaging d_n helps us find the best location of logistics center

At the start: $x = 0, y = 0, d_n = \sqrt{}((x - x_n)^2 + (y - y_n)^2)$

The first run:

$$x' = \frac{\sum_{n=1}^{k} \frac{D_n * F_n * x_n}{d_n}}{\sum_{n=1}^{k} \frac{D_n * F_n}{d_n}}$$

$$y' = \frac{\sum_{n=1}^{k} \frac{D_n * F_n * y_n}{d_n}}{\sum_{n=1}^{k} \frac{D_n * F_n}{d_n}}$$

$$d_n = \sqrt{}((x' - x_n)^2 + (y' - y_n)^2)$$

The second run:

$$x'' = \frac{\sum_{n=1}^{k} \frac{D_n * F_n * x_n}{d_n}}{\sum_{n=1}^{k} \frac{D_n * F_n}{d_n}}$$

$$y'' = \frac{\sum_{n=1}^{k} \frac{D_n * F_n * y_n}{d_n}}{\sum_{n=1}^{k} \frac{D_n * F_n}{d_n}}$$

$$d_n = \sqrt{}((x'' - x_n)^2 + (y'' - y_n)^2)$$

The third run:

$$x''' = \frac{\sum_{n=1}^{k} \frac{D_n * F_n * x_n}{d_n}}{\sum_{n=1}^{k} \frac{D_n * F_n}{d_n}}$$

$$y''' = \frac{\sum_{n=1}^{k} \frac{D_n * F_n * y_n}{d_n}}{\sum_{n=1}^{k} \frac{D_n * F_n}{d_n}}$$

$$d_n = \sqrt{}((x''' - x_n)^2 + (y''' - y_n)^2)$$

$$\vdots$$

until x', y' becomes statebal

$$TC = \sum_{n=1}^{k} d_n * F_n * D_n$$

4 The case

4.1 Data collection

Considering the network of Rokin Logistics, 20 southern cities and 9 northern cities are chosen as pre-cooling areas. Represented by capital letters, 20 southern cities are: Hefei, Chongqing, Fuzhou, Ningde, Putian, Quanzhou, Xiamen, Zhangzhou, Dongguan, Guangzhou, Huizhou, Shenzhen, Nanning, Wuhan, Changsha, Changzhou, Huai'an, Nankin, Nantong and Soochow. Some are bigger, like Xiamen, Guangzhou, Shenzhen and Nanjing. But smaller cities also have their own strength including vast land and higher circulation. Nine northern cities are: Peking, Langfang, Shijiazhuang, Tangshan, Daqing, Harbin, Zhengzhou, Baotou and Huhhot.

I contacted the administration department of Rokin Logistics and explained my purpose trying to get some statistics as I can. Luckily they accepted my requirement and we had a nice meeting. The management team of Rokin Logistics is generous while we were talking about the cost the company has spent. One manager led me toward the warehouses and we had a general view about what the company has owned over the years. I wrote down all the data I have got and collected it as Table 4.1. Small differences of unit cost are minimized to reduce the complexity.

Table 4.1 indicates the data which is needed in the calculation. Transport cost is different in the two parts, as the economics of scale is included. The currency here calculated is US dollars. 10 US dollars in southern part per unit per km, and 15 US dollars in northern part per unit per km. The cargo stands for the fresh food here. The statistics are not so accurate as there are not fresh reports about the pre-cooling tons. But we do know that Chinese logistics companies still lack of equipment and management, therefore the number here included in the table is not high.

One unit here means one ton, and quantity in units transported from the pre-cooling parts are set by hundreds.

Table 4.1 Data inputting

Pre-cooling areas in cities	Horizontal coordinates (X_n)	Vertical coordinates (Y_n)	Transport cost (F_n)	Quantity in units (D_n)
HF	117.25	31.83	10	1500
CQ	106.55	29.57	10	800
FZ	119.3	26.08	10	1200
ND	119.52	26.67	10	300
FT	119	25.43	10	200
QZ	118.67	24.88	10	300
XM	118.08	24.48	10	1200
ZZ	117.65	24.52	10	500
DG	113.75	23.05	10	1000
GZ	113.27	23.13	10	1800
HZ	114.42	23.12	10	1800
SHZ	114.05	22.55	10	2000
NN	108.37	22.82	10	600
CZ	119.95	31.78	10	700
HA	119.02	33.62	10	500
NJ	118.78	32.07	10	1600
NT	120.88	31.98	10	700
SZ	120.58	31.3	10	900
WH	114.3	30.6	10	800
CS	112.93	28.23	10	800

BJ	116.4	39.9	15	1500
LF	116.7	39.52	15	400
SJZ	114.52	38.05	15	1200
TS	118.2	39.63	15	700
DQ	125.03	46.58	15	500
HEB	126.53	45.8	15	500
ZHZ	113.62	34.75	15	700
BT	109.83	40.65	15	400
HT	111.73	40.83	15	350

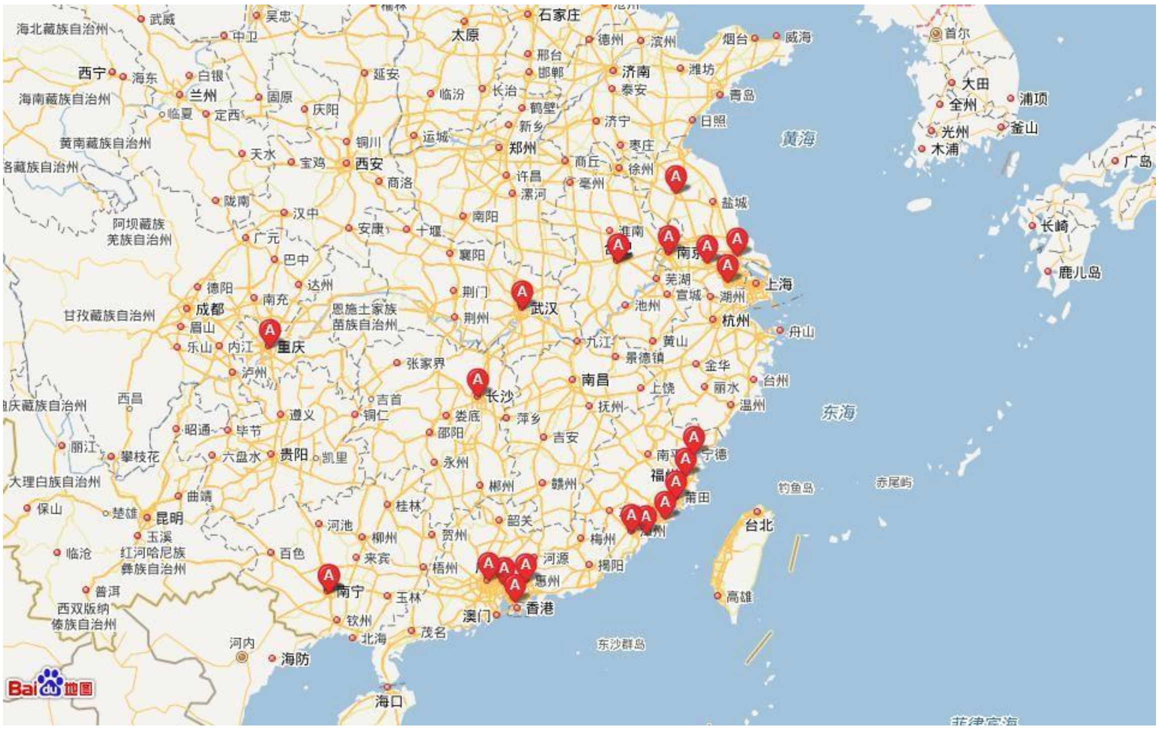

Figure 4.2 Locations of southern pre-cooling areas

Figure 4.2 reveals the geographic locations of the southern pre-cooling areas. It is clear that some of them are close to each other near the sea. Several lie in the middle and eastern China. As the demand market is in the west southern China, these pre-cooling warehouses, in function, are the preparation step before transferring to the demand market. So the locations are set more or less close to the reality.

Figure 4.3 shows the locations of the northern pre-cooling areas, which in function, as the origin, are storing the fresh goods from the production market. These locations, definitely, are as important as the demand side.

Figure 4.3 Locations of northern pre-cooling areas

Table 4.4 Calculation for equations

Coordinates		Transport	Quantity in	**(1) start from (0,0)**			
x_n	y_n	cost (F_n)	Units (D_n)	$\boldsymbol{d_n}$	$D_nF_nx_n/d_n$	$D_nF_ny_n/d_n$	D_nF_n/d_n
117.25	31.83	10	1500	**121**	14476	3930	123.5
106.55	29.57	10	800	**111**	7709	2139	72.3
119.3	26.08	10	1200	**122**	11723	2563	98.3

119.52	26.67	10	300	**122**	2928	653	24.5
119	25.43	10	200	**122**	1956	418	16.4
118.67	24.88	10	300	**121**	2936	616	24.7
118.08	24.48	10	1200	**121**	11750	2436	99.5
117.65	24.52	10	500	**120**	4895	1020	41.6
113.75	23.05	10	1000	**116**	9801	1986	86.2
113.27	23.13	10	1800	**116**	17636	3601	155.7
114.42	23.12	10	1800	**117**	17643	3565	154.2
114.05	22.55	10	2000	**116**	19620	3879	172.0
108.37	22.82	10	600	**111**	5871	1236	54.2
119.95	31.78	10	700	**124**	6767	1793	56.4
119.02	33.62	10	500	**124**	4812	1359	40.4
118.78	32.07	10	1600	**123**	15447	4171	130.0
120.88	31.98	10	700	**125**	6767	1790	56.0
120.58	31.3	10	900	**125**	8711	2261	72.2
114.3	30.6	10	800	**118**	7728	2069	67.6
112.93	28.23	10	800	**116**	7761	1940	68.7

To prepare better for calculations, the parameters needed by the equations are listed in Table 4.4. $\frac{D_n F_n x_n}{d_n}$, $\frac{D_n F_n y_n}{d_n}$ and $\frac{D_n F_n}{d_n}$ are a group for the result of best location. Another table built in the excel, Table 4.5 is used for the calculation of total cost. And the two sides (north and south) get the same pattern and it is clear to release one.

Table 4.5 Calculation of total cost

Coordinates					
x_n	y_n	Price	Cargo	Distance	**Transport cost**

117.25	31.83	10	1500	6	57
106.55	29.57	10	800	10	100
119.3	26.08	10	1200	3	33
119.52	26.67	10	300	4	36
119	25.43	10	200	3	31
118.67	24.88	10	300	3	30
118.08	24.48	10	1200	3	28
117.65	24.52	10	500	2	24
113.75	23.05	10	1000	4	39
113.27	23.13	10	1800	4	41
114.42	23.12	10	1800	3	35
114.05	22.55	10	2000	4	42
108.37	22.82	10	600	8	83
119.95	31.78	10	700	7	68
119.02	33.62	10	500	8	80
118.78	32.07	10	1600	6	65
120.88	31.98	10	700	8	76
120.58	31.3	10	900	7	69
114.3	30.6	10	800	5	47
112.93	28.23	10	800	4	36

4.2 Model Application

1. Northern side

Table 4.6 Finding the center of gravity of northern China

(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)

0	117	116	116	116	116	116	116	116
0	40	40	40	40	40	40	40	40
(9)	**(10)**	**(11)**						
116	116	116						
40	40	40						

As we know from last chapter that changing d_n brings the value of x' and y'. Table 4.6 illustrates that the center of gravity of northern China settles down after practices of testing. The horizontal coordinate of the location is 116, and the vertical coordinate of it is 40. It will not change once found even if d_n still changes. The process is a repeating work and it will be shown later.

Table 4.7 The first change

(2)	d_n	$D_nF_nx_n/d_n$	$D_nF_ny_n/d_n$	D_nF_n/d_n
BJ	0	13499783	4627503	115978
LF	0	1711011	579427	14662
SJZ	3	739144	245585	6454
TS	2	760623	255021	6435
DQ	11	87217	32493	698
HEB	12	82173	29744	649
ZHZ	6	200175	61222	1762
BT	7	96863	35851	882
HT	5	118532	43316	1061

Figure 4.8 Stable state

(8)	d_n	$D_nF_nx_n/d_n$	$D_nF_ny_n/d_n$	D_nF_n/d_n
BJ	0	78580042	26935942	675086
LF	0	1517337	513840	13002

SJZ	3	789356	262268	6893
TS	2	682012	228665	5770
DQ	11	85740	31942	686
HEB	12	80810	29251	639
ZHZ	6	204938	62679	1804
BT	7	99660	36886	907
HT	5	123126	44994	1102

Table 4.7, 4.8 are one of the process when the calculations are applied and repeated. The values of four parameters are seized and changed. And the values are the basement of x', y', with the equations of

$$x' = \frac{\sum_{n=1}^{k} \frac{D_n * F_n * x_n}{d_n}}{\sum_{n=1}^{k} \frac{D_n * F_n}{d_n}}$$

$$y' = \frac{\sum_{n=1}^{k} \frac{D_n * F_n * y_n}{d_n}}{\sum_{n=1}^{k} \frac{D_n * F_n}{d_n}}$$

$$d_n = \sqrt{}((x' - x_n)^2 + (y' - y_n)^2)$$

The calculating is repeating and the second time is the result as it stops changing. The coordinates (116,40) in geographic, lie close to Beijing.

2. Southern side

The southern part has more statistics and the result is a bit confusing before it stops finally, as we see in Table 4.9.

Table 4.9 Finding the center of gravity of southern China

(0)	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
0	116	116	116	116	116	116	116	116
0	27	26	26	26	26	26	25	25
(9)	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**	**(15)**	**(16)**	**(17)**

116	116	116	116	116	116	116	116	116
26	26	25	26	26	26	26	26	26

The equations and process are same with the northern one. So the work is repeated and the best choice came out at the second run. But the result changes at the seventh and eighth run, the calculation were still under progressing, before it came to an end. The coordinates are known as (116,26), lying in Sanming city, Fujian.

4.3 Results Analysis

The center of gravity is revealed: north (116, 40), in Figure 4.8, south (116, 26), in Figure 4.10 and Figure 4.11.

Figure 4.10 Best location for the north market

$$TC = \sum_{n=1}^{k} d_n * F_n * D_n$$

$$d_n = \sqrt{((x' - x_n)^2 + (y' - y_n)^2)}$$

The transport cost here means $\sum_{n=1}^{k} d_n * F_n$.

The objective function is:

$$TC = \sum_{n=1}^{k} \sqrt{((x' - x_n)^2 + (y' - y_n)^2)} * F_n * D_n$$

The result reveals that the company should spend 365,542USD and 958,066USD on transport cost after building the logistics center for northern and southern cities of China for Rokin logistics. Average 40615.8USD and 4354.8USD are spent on each pre-cooling region, which can be production and demand area.

Figure 4.11 Best location for the south market

Millions of dollars for transportation is not easy for a logistics company, but there are facts we could dig into:

1) The objective function has suggested that once the best location of logistics center is found, the most influencing factor is the unit cost of transportation. As the cold chain logistics market of China is not standardized and the equipment fee is never declining.

2) Some pre-cooling warehouses are far away and the center gravity is seldom impacted as it lies between the main points. Those crowded points, although

there are not so many goods, it is cost-saving to build a logistics center among them. The distance between the best location and the far points is an influencing factor which is also stated in Table 4.6. The company cannot achieve the best optimization of transportation cost with a big map. These lies in inland has less chance competing with the east southern cities, indicated by Figure 4.10.

3) The best location in north and south is different: one stands near the capital city, while the other one is unknown city in Fujian. The difference will affect the strategy map of the company, once the logistics centers are built. If other factors and types of cost are considered, the two will be examined in detail and decided to be or not to be. Decision-making is not just looking into one side, but the whole map should be seized.

5 Conclusion

This paper focuses on the development of Rokin company and the use of center of gravity method to solve the problem of location selection. Through the combing of the development of the company, this article obtains from the pre-cooling warehouse, transport costs optimization was used to study the cold chain logistics distribution center location problem. But in this study, limited to the author's academic level and research time, there are existing certain deficiencies, such as the distance between cities is not necessarily a straight line, and the transportation cost and distance may not be linear relations, but due to the limit of my academic level and knowledge skills, this paper adopts the center of gravity method which takes linear relationship. Therefore, more factors influencing transportation cost should be considered in future research on relevant topics. At the same time, in the cold chain logistics distribution center location research, including the management cost and inventory cost for enterprise cost influential factors, in addition to the cost of transportation, optimization of cost is a study on system as a main object. As far as possible the studies on cold-chain logistics distribution center location are better and better, so as to drive the cold chain logistics industry overall healthy development.

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