Erasmus University Rotterdam

MSc in Maritime Economics and Logistics

2018/2019

A Study on Optimization of Sites Selection of Overseas Warehouses Located in China for Cross-Border E-Commerce Companies

by

Siyuan Wang

Acknowledgements

As I was preparing for this thesis, the MEL Programme was to draw on a full stop. This is a precious journey in my life that cultivated my interests in logistics filed and trained some key skills. Hereby, I would like to show my thankfulness to those who accompanied me during this trip.

First, I sincerely appreciate my supervisor, Dr. Kim. I cannot complete this work without his care and guidance. With rich knowledge in both academia and industry, Dr. Kim gave me many wise suggestions to strengthen the logic and rigor. When I was confused, Dr. Kim would always be patient to set examples and put forward detailed explanations to aid in comprehension.

In addition, I would like to thank my friend, Ze Fan, who inspired me the idea of e-commerce logistics. Many friends had been helpful to me, while I am especially thankful to Zhen Shen. There were some spots in the past year, but Zhen always stood behind me, comforting me with encouragement and trust. He also assisted me much on the courses and I really enjoy the time when we discussed tricky questions.

Last but not the least, I would like to express my gratitude to my parents, who financially supported me for the study and were always willing to listen to me. I love you and am proud to be your child.

Abstract

With the e-commerce rising, Chinese customers have more selections to purchase foreign products. For the overseas companies, a rational project to operate its business in China is to participate in local logistics activities, including warehousing and delivery. This thesis aims to establish a supply chain network for an Australian milk powder company – A2 that optimizes its profit by determining the number of oversea warehouses and their locations as well as the designation plan.

The methodology is to compare the profit of two modes: central distribution center (CDC) and regional distribution center (RDC). While the profit of each mode is the revenue (fixed) minus the costs which are variable, depending on the warehouse renting cost, labor cost and transportation and delivery costs. Due to the nonexistence of retail data, the revenue is based on the forecast of demand. The warehouse costs are derived from estimation of the local economy and transportation costs are related to simulation to describe the demand points.

The results show that the RDC mode is more profitable and after t-test, these results are proven to be highly convincing. The supply cities and their designated assignments are also generated. Combined with some tendencies, additional strategies are also given as reference.

Content

List of Tables

List of Figures

List of Appendixes

List of Abbreviations

B2C	Business-to-Consumer
CDC	Central Distribution Center
FBA	Fulfillment by Amazon
FMCG	Fast Moving Consumer Goods
GDP	Gross Domestic Product
GIS	Geographic Information System
KPI	Key Performance Index
Lingo	Linear Interactive and General Optimizer
MRP	Material Requirements Planning
RDC	Regional Distribution Center

Chapter 1 Introduction
In this chapter, we will point out the research significance and objectives, combining with the background of China's import cross-border e-commerce market and an empirical company case. Besides, the research questions and research structure are designed to improve cohesion and logics.

1.1 Research Background
Over the past few years, with the popularization of the Internet and the rise of middle -class families, China's e-commerce industry has been witnessing its prosperity. Along with purchasing home commodities online, a substantial proportion of Chinese customers show consumption preference to foreign brands. According to China Internet Network Information Center (2019), China's online retail volume in 2018 was top 1 in the world for 6 consecutive years (90 trillion China Yuan) with year-on-year rate of nearly 24%, from the scale side. From the niche field side, the transactions concentrate in cities (over 84%). From the auxiliary industry side, the mobile payment and express industry supports the e-commerce powerfully. The growth rates of transactions of mobile payment handled by financing institutes and parcels handles by mail system are 33% and 26%, respectively. Figure 1 reflects the rapid expansion of import cross-border e-commerce demand, despite a slipping tendency of growth rates recently.

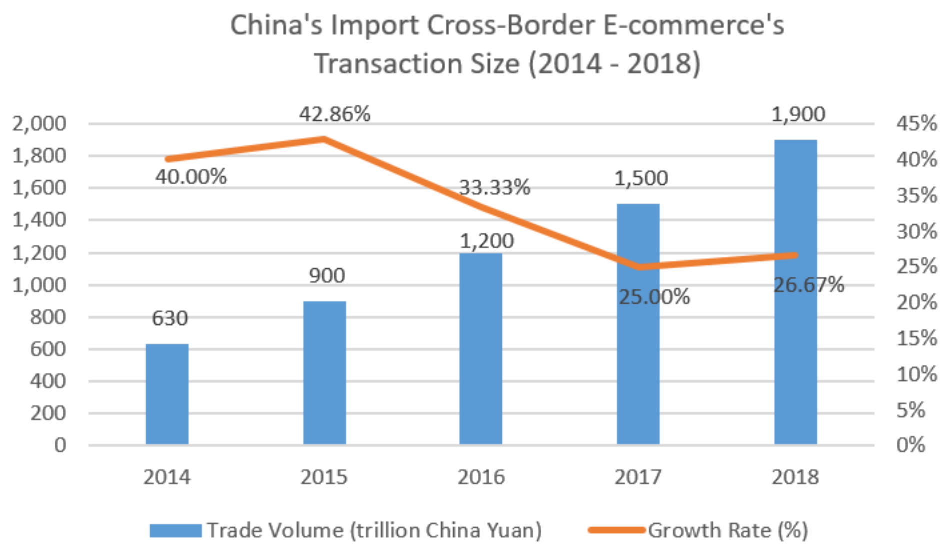


Figure 1 China's Import Cross-Border E-commerce's Transaction Size (2014 - 2018)

Source: iiMedia Research, 20019. "2018-2019 China Cross-border E-commerce Market Research Report."

1.2 Research Significance
Many Chinese clients have been accustomed to using cross-border e-commerce platforms to buy commodities abroad, bringing opportunities to other countries' companies for the large scale of China's market. However, competition is highly fierce, causing difficulties to enjoy a significant market share. In order to improve a company's competition power, it is significant to cut down its total cost and improve service qualities by various strategies.

Peter Drucker identified logistics industry as "the economy's dark continent" (1962), because the importance of logistics is usually neglected, in company with its economic potential. Hence, it is worthwhile cutting down logistics cost which contains mainly inventory cost and transport cost (Ballou R, 2004) and enhance logistics service qualities (e.g. shortening lead time) by some measures, among which the establishment of an overseas warehouse system attracts a significant number of firms' notice. Much closer to market overseas warehouses than countries of origin, delivery time can be remarkably reduced for customs processes have already been completed and transport distance has been shortened and native staff are more qualified to handle customers' complaint, and thus be more efficient in handling disputes and reverse logistics issues.

1.3 Research Objectives

The aim of this thesis is to design an optimal logistics solution plan for a foreign company that is ambitious to enter China's e-commerce market. Details of this company are listed as below:

A2 is an Australian milk powder manufacturer focusing on baby powder products. Having noticed China's fast-moving consumer goods (FMCG) market whose value is roughly $200 billion (Ang T, 2018), A2 is now seeking business opportunity in China and considering setting overseas warehouses in China to flexibly meet end customers' demand. However, there are uncertainties in decision, including demand, lead time and customer experience, etc. To maximize its profits, A2 suggest it necessary to forecast demands of major cities and accordingly explore warehouse and distribution solutions.

Thus, this thesis will be concerned about the optimal numbers, sites and allocation design of overseas warehouses, to set a balance between low costs and high service level. Some quantitative methods will be introduced based on former scholars' academic results and original ideas to solve this problem. Hopefully, this thesis will be beneficial to guide foreign companies like A2 to decide on selecting sites of overseas warehouses in China, although it is not accurate on every factor due to inaccessibility of some commercial data.

1.4 Research Questions and Sub-Research Questions

The core of this research is to the following question:

What is the most economic warehouse and distribution project for A2 company?

Some sub-research questions can be added to decompose it into several stages:

1. How to forecast demand and relate it to other economic factors?

2. What is the optimal number, location and distribution plan for supply cities?

3. How to examine the reliability of results?

1.5 Research Structure

Chapter 2 lists literature review, which introduces former researchers' claims, methodology and results, regarding cross-border e-commerce, demand forecast, and warehouse location selection.

Chapter 3 gives the methodology of this thesis by setting and comparing key performance indexes (KPI) of two warehouse modes, following by mathematical model and verification criteria.

Chapter 4 collects data for modelling and simulation, calculates results, as well as designs the optimal network for A2 company.

Chapter 5 verifies the reliability of hypotheses in Chapter 3 and gives a short description of selected supply cities.

Chapter 6 puts forward some advice to the company based on the results and the outlook on the prospect in a dynamic environment.

Chapter 7 points out the limitations of this thesis and suggests some orientations for later researchers to discover.

Chapter 8 concludes the reasoning, the main findings and advice of this thesis.

Chapter 2 Literature Review

In this chapter, we will discuss some scholars' research on e-commerce and overseas warehouses. It will begin with the characteristics of cross-border e-commerce logistics and especially its practice in China, then introduce methods to forecast demand, and ultimately discuss the approaches to locate overseas warehouses. By combining with these results, this chapter will propose some improvements to fit in the company's case.

2.1 Cross-Border E-commerce Logistics

The theory of logistics has attracted worldwide scholars' attention since the 1940s as it became an independent industrial department. Murphy P and Wood D pointed the two types of economic utilities of logistics: place and time (2009), which emphasizes the crucial function of logistics that transferring goods from point of production to point of consumption in a proper time period. Sudalaimuthu S and Raj S put forward 7 R's of logistics (right product, right place, right quantity, right condition, right time, right customer and right cost) and 5 P's of logistics (production, price, product, promotion, and place or physical distribution) (2009). These arguments reflected the value of logistics to facilitate the circulation of commodity, capital and information.

The emergence of e-commerce was a strong stimulus of logistics, since the Internet strengthens the transparency of transaction by tracking orders and solves the trust issue on payment by third party payment platform (Kayikci Y, 2019). While merchants massively use the e-commerce to manage orders and stock more efficiently, the significance of offline activities is usually neglected. In fact, Lee H and Whang S (2001) set an example in 1999 when many sellers failed to deliver goods on time and cause breach of contract, low level customer service level and even falling stock prices. They accordingly highlighted the fulfillment of orders ("the most expensive and crucial operation") when confronting substantial and dense orders, which should rely on innovative fulfillment strategies, including logistics postponement, dematerialization, resource exchange, leveraged shipments and the Clicks-and-Mortar Model. They considered mainly "the last mile distribution" issue, where the delivery costs zoom up and jam in distribution centers due to small batches and high frequency mode in local delivery, opposite to the inter-city distribution mode.

The above-mentioned research was on the traders' perspective while customer satisfaction was not brought to a focus. Many researchers defined customer satisfaction as service quality, or in an economics term, utility (Grönroos C, 1982; Heim G and Field J, 2007). While they found the logistics service quality was the gap between customers' expectation of service quality and perception of service quality, Mentzer J and Roger G (1989) set 3 major indices to evaluate the logistics service quality: quality of goods, timeliness and accessibility, pressuring companies to be customer centric. Giovanis A et al (2013) further gave a complete definition of logistics service quality by adding another 6 indices: accuracy of orders, number of orders, quality of information, status of orders, and differentiation on orders. With the development of a binding relationship between e-commerce and logistics, scholars like Bienstock C et al (2007) valued the information technology and customers' feedbacks.

Some Chinese researchers analyzed the situation of China's (cross-border) e-commerce logistics on these two perspectives. Cheng S (2016) took Fuzhou city as an example and argued that the delivery cost for "the last mile" occupies over 30% of the total logistics cost and the imbalance of distribution of delivery network. The delivery vehicles need a common standard to avoid traffic hazards and parking problems. Liu Z (2015) selected a maternal and infants' goods company to learn the problems of cross-border e-commerce and concluded that reverse logistics derived from return of goods will be more likely to cause disputes, especially when the origin country is involved. Another crisis is the pricing war among various cross-border e-commerce platforms to attract the Internet traffic and cultivate customers' dependence, which makes profitability doubtful. Jin S (2017) did a survey on G company, a mega mall that recently adopted e-commerce solution to summarize the typical drawbacks of domestic B2C (business-to-consumer) companies for customer satisfaction: legged update of logistics information, broken package and neglection on individual service, like "next-day delivery" service. Tian X et al (2016) organized a questionnaire on customer satisfaction in terms of imported cross-border e-commerce. According to their model which contains delivery capacity, delivery modes, receiving choices, quality of goods, guarantee of complaint, logistics service capacity, customers perceptual value, design of websites (whether offers Chinese translation or not) and payment choices, they found that delivery capacity, guarantee of complaint, logistics service capacity and design of websites were the most significant factors, among which the former two factors performed least pleasingly while the latter two were better by contrast.

Based on these descriptions and analyses, the balance between cost control and customer service level will be critical to engage in cross-border e-commerce logistics. It determines the selling mode (to put warehouses homely or abroad), selection of demand regions, modes of warehouses and transport. Detailed process will be discussed in Chapter 3.

2.2 Demand Forecast

As mentioned in Chapter 1, the selling amounts of A2 products in China's market is unknown. Then the methods of forecast of demand should be employed to examine the feasibility of entering markets.

Based on causation, the (multiple) linear regression model can roughly describe the trend of logistics demand (dependent variable Y), given some economic variables (independent variable X). The equation is expressed as follows:

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_i x_i + \varepsilon \tag{1}$$

Where β_0, β_1, i and ε stands for y-intercept, slope of the line, the number of independent variables and error variable, respectively. Fang W et al (2009) selected total value of social logistics goods and services (Y), China's GDP (X_1), as well as total fee of social logistics goods and services (X_2) from 1993 to 2007, and estimated the total value of social logistics goods and services in 2008 would be 840.72 trillion China Yuan after substituting the growth rate of GDP in 2008 estimated by the World Bank, which turned out to be 890.90 trillion China Yuan, with around only 6% of error. Li J and Sun L (2011) also inspected national logistics demand but aimed at a niche market – aquatic products cold chain industry. They defined cold chain logistics amount instead of its value as the dependent variable and GDP, ratio of industrial structure, population, annual output of aquatic products, circulation rate of aquatic products, aquatic product price index as well as loss rate as independent variables. The result showed 99.9% of the variation of the logistics demand could be explained by the 7 variables and thus the prediction performance of the multiple regression model is pleasing.

Much as the linear regression model works in some case, the objectives can usually be complicated and non-linear. Besides, this model focuses only on demand and ignores the change of supply. Then some researchers in Operations Research and System Dynamics fields have discovered alternative approaches. Huang X et al (2011) established a regional logistics network and applied Dijkstra's shortest path algorithm to calculate the demand of each supply point and its delivery plan. They used an empirical case in Changsha-Zhuzhou-Xiangtan Area and improved the delivery efficiency by avoiding repeat and detour when the demands of warehouses are significantly different. Liu B and Yang M (2009) did not collect accurate data, instead they considered the dynamic influence social economy system (GDP, Industrial Structure, Trade and Consumption Level) and logistics park supply capacity (scale, efficiency and transport accessibility). The conclusion seems to be ambiguous, but worth referring to for planning.

Nowadays the popular research methodology is a combination of several tools. Yan J (2011) innovatively combined Gray Model with Neural Network Model, where the first model is to predict the tendency by differential equation based on accumulated series of primary data and the second model is to simulate logistics system by its multi-layer perceptron. This combination overcomes Gray Model's shortcoming (cannot handle non-linear functions) and offers inputs to Neural Network. They compared the simulation results of each of the single model and the combination in a case, and found the combination is most close to the reality. Chu L et al further added linear regression (2004). By this combination, the accuracy can be enhanced, and the model will ultimately be converted into a simple linear programming problem. Again, the comparison with an empirical case illustrates that the combination model is more accurate than each of the single model. Some industrial managers even use computer management tool to automatically adjust the inventory. Hong F et al (2018) combined time series with MRP (Material Requirements Planning) to build a forecast mechanism. Thanks to the usage of ABC Classification (where goods are divided into 3 categories based on their importance, and therefore the priority of replenishment is decided), the adjustment can be more intellectual.

This thesis will thereby consider the dynamic factors and current economic variables instead of historical logistics data. However, the models mentioned above are all not applicable for this thesis's case due to the lack of primary data. Yet, the idea of simulation is an inspirable option to generate data rationally. Plus, the relationship between population and logistics is a suitable reference.

2.3 Location Selection of Warehouses

When designing the locations of warehouses, it is important to set principles and steps, followed by considering both macro factors and micro factors. Zang H (2009) identified 4 principles of location selection, including adaptability (of national and regional planning), coordination (matched in logistics productivity and technique level), economy (lowest total cost, consists of construction cost and operation cost) and strategic engagement (considering the whole situation and long term). Zhu J (2017) put forward 7 steps to determine the location of the warehouse: determining the goal of the warehouse, identifying the restraints (i.e. capital, infrastructure, demand, etc.), collect and categorize data (establishing objective function and formulas to form a model), quantitative or qualitative analysis, assess the plan (combined with dynamic factors), verification (recheck the results) and gain the eventual results. The macro factors can be divided into 5 types, according to Li Y (2017) who introduced the

PESTEL model for site selection issue. These factors comprise politics (policies), economy (regional income level and wage costs), society (relationship with local inhabitants and labor amounts), technology (technology of storage and package), environment (climate, geology, hydrology and sustainability) and law (customs and tax).

The exploration of micro factors (at the company level) is a hot spot that most researchers focus on. Generally, there are qualitative and quantitative ways to evaluate the influence of these factors and finalize a plan. One typical qualitative method is Delphi method where experts anonymously make judgements in several rounds (Dalkey C, 1969). The experts will be informed the mean and variance of last round before next judgement. This method can concentrate the major mind of professionals but will be exposed to subjective and one-sided views.

Hence, qualitative methods or mixed methods are more commonly seen. Modelling can be classified into two types: continuous and discrete. The most classic example of continuous model is gravity method, which supposes any point in a designated area can be the optimal location of the warehouse (Mickus K, 1980). It sets the coordinates for each demand point (xn, yn) and compute the optimal supply point (x*, y*) by minimizing the total cost derived from transport volume, transport rate and transport distance. The following equations are the final expression of gravity method after substitutions:

$$x' = \frac{\sum_{n=1}^{k} \frac{DnF_n x_n}{dn}}{\sum_{n=1}^{k} \frac{DnF_n}{dn}} \tag{2}$$

$$y' = \frac{\sum_{n=1}^{k} \frac{DnF_n y_n}{dn}}{\sum_{n=1}^{k} \frac{DnF_n}{dn}} \tag{3}$$

Where k, D_n, F_n and d_n represents for times for iterative proceedings, transport volume, unit transport rate and distance between supply point and demand point. The proceeding will not stop until the new location (x', y') almost equals to (x*, y*). This scheme is theoretically feasible but not realistic. Because this method follows a straight route which is impossible in practice. Worse still was the restriction of geology, for example, the computed optimal point may lie on a lake or mountain. Thus, this method should not be employed directly.

The Baumol-Wolfe method is an alternative that can also be easily calculated by linear programming (Shakya S & McCall J, 2007). This method is more practical for it considers the factor of diminishing marginal costs and the storage rate will reduce as the size of the warehouse enlarges. As a special integer programming problem, it can be solved like simple transportation programming problem, and decides the lowest total logistics cost and the flow of the warehouse at the same time. However, as the successive approximation is applied, the outcome may not be optimal and thus the change of the number of the warehouses may cause decrease on total costs.

Li Y and Xie H (2006) designed a mixed method where they firstly used GIS (Geographic Information System) to filter proper candidate locations (considering hydrology, geology, infrastructure, retailers' structure, population and effect on the environment), then established integer programming model, and finally introduced Greedy Dropping Heuristic Algorithm to solve the problem. This method considers factors comprehensively and the algorithm is an effective way. However, it is quite complicated when the size of the demand cities is large. Besides, the essence of this problem stays the same as Baumol-Wolfe method, which means the solution may again not be optimal.

In this thesis, a new way should be introduced to compute the number of warehouses needed and their delivery plan, and the validity of the optimal value should be examined. More details will be discussed in Chapter 3 and Chapter 4.

Chapter 3 Methodology

In this chapter, we will discuss the methods concerning three stages to select the optimal project. Before data collection, the operating option for warehouse should be clear. Then some criteria will be set to collect primary economic data. After that, some quantitative methods will be applied for decision.

Firstly, we will we will design the optimal project for supply cities by 0 – 1 integer programming. Secondly, we will prove in this case, the maximal profit issue can be converted into a minimal total logistics issue and then establish two sets of equations for the RDC mode and CDC mode for comparation, especially the introduction of simulation to solve the delivery distance issue. Lastly, we will use t - test to verify the results of stage two, in case of accidental errors.

3.1. Selection of Overseas Warehouse Options

3.1.1 Modes of Oversea Warehouses

In daily life, there are some sellers who store goods in overseas students' accommodations and seek to sell them online. However, as the transaction size is relatively nominal and may be involved in legal risk, this option should be deserted. Generally, overseas warehouses can be divided into three modes based on the identities of operators.

3.1.1.1 FBA

Fulfillment by Amazon (FBA) is a logistics solution offered by Amazon. In this mode, sellers firstly send their goods to Amazon's overseas warehouses where the goods are temporarily stored. Once customer orders are placed, Amazon will handle all the confirmations, transportation, distribution and after-sell services. For foreign sellers, this mode can shorten their lead time and get rid of complex procedures, especially when language barriers involved. Besides, there is less risk of inventory backlog. However, recently, Amazon claimed that China's e-commerce services will be abandoned since May 2019 due to fierce competition (Weise K, 2019). Hence, this mode cannot be selected.

3.1.1.2 Third Party Warehouse

This option means that overseas companies can cooperate with local inventory companies to gain special distribution services. For instance, some of China's cross border e-commerce platform, like Kaola and Tmall Global, have their warehouses to store and deliver products. This mode is focusing on overseas businesses and therefore, more professional than Amazon. However, as their official websites show, this mode is based on a push process supply chain, which means the commodities will not be imported from foreign countries by e-commerce platform until final customer orders are placed. Hence, the lead time is rather long, with a high standard deviation (varying from 7- 15 days according to their official websites). To make it worse, since the shippers cannot participate in the warehouse operation, the quality control is doubtable. Actually, Kaola was exposed to fake goods scandal (Wernau J & Kubota Y, 2019).

3.1.1.3 Own Warehouse

In this mode, the sellers rent and operate their overseas warehouses in importing countries. This method can solve problems as mentioned above and is beneficial to form the company's brand image. This will cause considerable rental costs and operating costs and risks. In addition, the abundant supply of personnel who have local knowledge forms another challenge.

Based on these assessments, it is worthwhile choosing the third solution if a company can assure the quality of goods and delivery them responsively, as well as take the initiative by selecting the locations of warehouses on its own. This solution confronts a low risk when the prospect of demand is positive.

To compensate the expensive warehouse costs, the service range should be major cities of China where enough demands exist. While the supply cities should be logistics hubs and be balanced between low rent costs, labor expenses and transportation costs.

3.2. Selection of Demand Cities

3.2.1 Selection Criteria

Selection criteria for demand cities is flexible because in China's administrative system, one "city" contains urban area, neighboring suburbs and villages, as well as subsidiary counties. This classification method causes abundant samples for demand cities in view of the ultra large size of China's cities in terms of population, economy and traffic volumes. For example, according to the World Population Review, there are 65 cities that have a population over 1 million by 2019. Hence, a method to cover major cities should be introduced.

Geographically and administratively, China can be divided into six parts, including North East China, North China, East China, Middle and South China, North West China and South West China. Nevertheless, according to a geographer Hu Huanyong's finding in 1935, China's population density can be roughly regarded as two parts, left and right of Heihe-Tengchong Line with thin population and dense population, respectively (Annex 1). This phenomenon still dominates China's industries and infrastructure layout today (Annex 2 & 3), making it necessary to reconsider the division, in case that the demand of habitants living in the vast area of the north-west is neglected.

Hence, this thesis decides not to select cities on the top list in terms of population or economy. Instead, it is based on politics and administration. China has 34 first level administrative areas, including 23 provinces, five autonomous regions, four municipalities and two special administrative regions (Hongkong and Macau). To make the samples more typical and comparable, the capital cities are selected. Due to the differentiation of economic policies, this thesis considers mainland China and thus excludes Hongkong, Macau and Taiwan. Besides, Lasa is also excluded because of lacking the newest data availability. Besides, five municipalities with independent planning status (Dalian, Qingdao, Ningbo, Xiamen and Shenzhen) are also included since they are politically unique than other ordinary cities. To sum up, this thesis observes 35 cities and part of their economic data can be found in Chapter 4.

3.2.2 Indices of main economic data

Jiang C and Chen D took three aspects into consideration when investigated assessment system of urban logistics capability, including supply and demand capacity, economic development capability and transportation development level (2009). They selected ten factors to reflect the assessment system as accurately as possible. While this thesis's main concern is to design a distribution plan based on demand, we can apply three factors.

3.2.2.1 Population Size – Demand

Population, along with income and lead time, influence consumption demands. To simplify the scenario, this thesis assumes demand is only related to population. This is realistic because for one thing, many Chinese parents believe in a traditional belief that the older generation should invest as much as possible on their offspring, even at the expense of their own life quality; for another, trusting in A2 company's product quality control level, moderately low delivery efficiency is tolerable and will not tremendously affect demand. As a result of "One Child Policy" (although this restriction has been lessening these years), parents are especially willing to bias resources to children.

As end consumers are babies, the related data (population, number of families, children ratio per family and baby percentage of the whole society) should be collected and then generate the number of babies. In China, there are two different terms in statistics regarding to population: usual residence population and household registration population. For example, if a couple from Jinan city work in Shanghai, they are categorized as "household registration population" of Jinan (also known as they hold "hukou" of Jinan) and "usual residence population" of Shanghai. While Shanghai Statistics Bureau only counts family members of "household registration population", ignoring this couple are consuming in Shanghai, this thesis assumes the family members of each family of "household registration population" equal to "usual residence population" and then estimates each city's usual residence families. After that, by assuming that each family breeds one child (due to "One Child" Policy) and checking national 0 to 4 years old baby's proportion of all children under 18 years old (lacking of each city's population structure, we assume this proportion is a constant for every city), the number of target customers can be estimated.

3.2.2.2 Cost Index – Warehouse Costs

Rent rates for warehouse are easily available, but workers' wage level are trade secrets. Thus, wage rates can be assumed based on another economic variable. GDP (Gross Domestic Product) per capita is a universally adopted index to measure a region's market value of final goods and services produced during a certain period (normally a year). Despite the dispute, it approximately reflects the region's income and wage level (Nolan B et al, 2016). Thus, if the relation between labor wage rate and GDP per capita can be found, the labor costs will also be computed.

3.2.2.3 City Distance – Delivery Cost

Except for warehouse costs, another vital expenditure is transportation and delivery cost. Given demand from one supply city to a certain demand city which can be converted into weight of cargo, distances between two cities should be found in order to calculate the freight turnover (which is defined as the product of the gross weight of cargo carried and average distance of cargo transported), the product of freight weight transported in tons and distance transported in kilometers. Combining with the haulage rate (usually in China Yuan per ton per kilometer), transportation and delivery costs will be generated.

It should be noted that haulage rates for motorways and local roads are in fact different. Moreover, they may vary from region to region. To avoid this complicated issue, we assume a unitary haulage rate around the country.

Another annoying question is the reliability of distance between two cities. In general, they are defined as the distance between city centers. However, only few of customers exactly live in the city center; instead, the orders come from scattered points. The solution of distances will be mentioned in the next section.

To conveniently compare these main economic data, Table 1 is built up as below.

Factor	Indicator	Source
Demand	Population size	Collect
Warehouse Costs	Rent size & wage & wage rate	Collect & estimation
Delivery Cost	City distance & haulage rate	Collect & simulation

Table 1 Summary of Economic Data

3.3. Selection of Supply Cities

Criteria for supply cities is more complex since they should be reasonably selected from demand cities (as logistics hubs, supply cities themselves usually gain substantial orders and there is no reason to be fulfilled by other cities' warehouses).

For the optimal solution for the company is to operate its warehouses, it is necessary to decide how many warehouses it needs and which warehouse supplies to which cities. Depending on the size and service area of warehouses, there are two options: regional distribution center (RDC) and central distribution center (CDC). As the names imply, the RDC option usually consists of several warehouses while the CDC contains only one warehouse, serving the entire market. Hence, a comparison of their advantages and disadvantages are listed below.

	RDC	CDC
Short lead time	+	-
Quick response	+	-
Low total fixed cost	-	+
Reduce risk of inventory backlog	+	-

Table 2 CDC versus RDC: Advantages and Disadvantages

Source: Farahani R et al, 2011. Logistics Operations and Management

The following graph illustrates the difference of distribution plan between these two options:

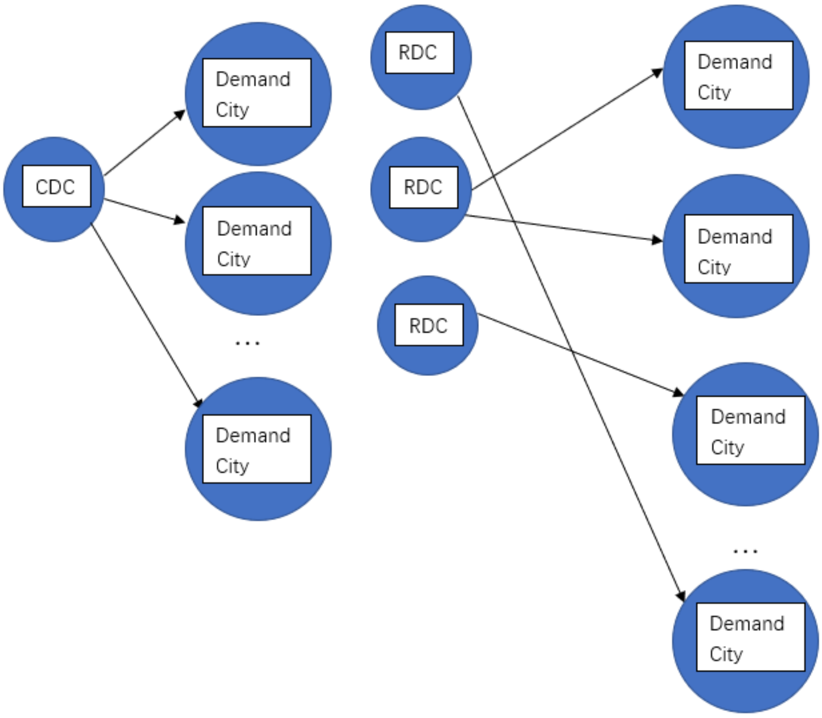


Figure 2 Distribution Plans of CDC and RDC

3.3.1 Principles of sort

(1) Candidate supply cities should be coastal cities because of convenient transportation (seaports) and exuberant demand (dense population).

(2) Candidate supply cities' ports should be connected to the port of origin.

(3) Candidate supply cities should be competitive with total operation costs, including rent, labor and delivery costs. In practice, other accounting items exist while this thesis considers merely three factors to simplify the problem.

3.3.2 Model

A2 projects to rent warehouses to rent warehouses in order to avoid construction costs. Hence, total logistics cost hereby contains three parts: warehouse fixed cost (rent cost), warehouse variable cost (labor cost) and transportation and delivery costs. Some assumptions are applied to simplify the model:

3.3.2.1 Assumptions

(1) Consumption demands of demand cities are known (decided by population of 0 – 4 years old baby numbers) and independent among each other.

(2) Freight tariff and sailing days of each shipping company are the same, and therefore need not to be considered in decision, given the known demands.

(3) Sizes of warehouses and numbers of labor hours are known (decided by demand).

(4) Rent rates of each city are known; labor wage can be computed based on GDP per capita of each city.

(5) Haulage rate is a constant and therefore delivery costs merely related to the distance between each supply city and demand city and cargo weight.

(6) A demand city can only be supplied by a certain RDC / CDC, and each demand city should be supplied.

(7) The selling price of milk powder product is a constant for each demand city.

(8) Cities are circles rather than irregular shapes they are.

3.3.2.2 Mathematical Expression of Model

0 – 1 integer programming is applicable when decisions regarding to whether or not undertake some activities are involved (Anderson D et al, 2012). When the value of the variable equals to 1, the corresponding activity is decided; when the value of the variable equals to 0, the corresponding activity is abandoned. Given the decision variables (whether to select a candidate supply city as an RDC or CDC) and constraints (demand of demand cities must be guaranteed), the objective function (minimal total logistics cost) can be calculated by running Excel or other linear programming solving tools. Table 1 shows some crucial factors and their definitions to establish a model.

Characteristics	Symbol	Definition
Constant	Q_j	Demand quantity of demand city j
	w_j	Weight of cargo of demand city j
	d_{ij}	Distance between supply city i and demand city j (city centers' distance)
	R_h	Haulage rate
	R_{ri}	Rent rate of supply city i (monthly)
	S_j	Warehouse size to fulfill demand of city j
	R_{li}	Labor rate of supply city i
	L_j	Labor hours to fulfill demand of city j
	Z_1	Total logistics cost of RDC mode
	Z_2	Total logistics cost of CDC mode
	m	Number of candidate supply cities
	m_0	Number of selected supply cities
	n	Number of demand cities
Decision Variable (0 – 1 variable)	y_i	Rent a warehouse in city i (y_i = 1) or not (y_i = 0)
	x_{ij}	City i supplies to city j (x_{ij} = 1) or not (x_{ij} = 0)
Subscript	i (i = 1, 2…, m)	One certain candidate supply city
	j (j = 1, 2…, n)	One certain demand city

Table 3 Symbols and the Definition for Selecting Supply Cities

Hence, the objective functions for RDC and CDC can be expressed as follows:

$$\mathrm{Min Z_1} = \mathrm{R_h} \Sigma_{\mathrm{i=1}}^{\mathrm{m}} y_i \Sigma_{j=1}^{n} x_{ij} w_j d_{ij} + 12 * \Sigma_{\mathrm{i=1}}^{\mathrm{m}} y_i \Sigma_{j=1}^{n} x_{ij} R_{r_i} S_j + \Sigma_{\mathrm{i=1}}^{\mathrm{m}} y_i \Sigma_{j=1}^{n} x_{ij} \mathrm{R_{li}} L_i \quad (4)$$

$$\mathrm{Min Z_2} = \min \{\mathrm{R_h} y_1 \Sigma_{j=1}^{n} x_{1j} w_j d_{1j} + 12 * y_1 \Sigma_{j=1}^{n} x_{1j} R_{r_1} S_j + y_1 \Sigma_{j=1}^{n} x_{1j} \mathrm{R_{l1}} L_1, \ldots, \mathrm{R_h} y_m \Sigma_{j=1}^{n} x_{mj} w_j d_{mj} + 12 * y_m \Sigma_{j=1}^{n} x_{mj} R_{r_m} S_j + y_m \Sigma_{j=1}^{n} x_{mj} \mathrm{R_{lm}} L_m \}$$
(5)

The constraints can be expressed as follows:

$$\Sigma_{i=1}^{m} x_{ij} = 1, \forall j \in n \quad (6)$$

$$y_i, x_{ij} \in \{0,1\}, \forall i \in m, \forall j \in n \quad (7)$$

Objective functions (4) and (5) indicates the minimal total annual logistics costs for RDC mode and CDC mode, respectively, including transportation and delivery cost, warehouse rent cost and warehouse labor cost. Equation (6) indicates each demand city must be supplied and only be supplied by one supply city. Equation (7) indicates if one certain candidate supply city is selected and supply to a certain demand city.

3.3.3 Compare of Profits

Except for costs, revenues must be gained to calculate profits. As selling price is assumed to be a constant as mentioned above, the profit equations can be expressed as follows:

$$\Pi_1 = P * \Sigma_{j=1}^{n} Q_j - MinZ_1 \quad (8)$$

$$\Pi_2 = P * \Sigma_{j=1}^{n} Q_j - MinZ_2 \quad (9)$$

Where Π_1, Π_2 and P represents for the profit of RDC mode, profit of CDC mode and price of the milk powder, respectively. By comparison of two values, the better mode can be determined. As the revenues are constants for both modes, the core issue is to choose a lower minimal cost project.

However, there is a problem to measure the minimal total annual logistics costs: delivery distances for each supply city to deliver cargo to itself. Literally, these values should be 0 which is not practical. Hence, an alternative should be introduced to get the likely delivery distances for supply cities.

According to Bartley P et al (2011), simulation can be applied to simulate the outcomes of a system with a known mathematical model. After running considerable times of a model, the average value tends to be close to a constant. Then in this thesis, the equation for the distance one supply city delivers to itself can be expressed as follows:

$$d_{ii} = Average\ (Rand\ (\ \ ) * r_i) \quad (10)$$

Where d_{ii}, Rand (), and r_i represents for average delivery distance from one supply city to deliver to itself, random numbers between zero and one, radius of a certain supply city. This equation will be highly convincing if we take the average number of the simulation results when we simulate many times (such as 1,000 times). While the simulation times can be an assigned large number, radii of all the supply cities are certain constants.

Once the optimal transportation and delivery plan is generated, the rental cost and wage cost will be easily calculated. The transportation and delivery cost will yet not be accessible, because in the reality, a delivery is not necessarily originated from a supply city center to a demand city center. Instead, demand points (end users' home addresses) can be scattered across the city. Hence, when comparing the profits of two modes, the simulation of distances (from one certain warehouse to its designated demand points) shall be applied again and thus cause n profit results (if the simulation takes n samples). Then the criteria of comparison of two sets of profits (each has n profit results) can be defined as the comparison of each mode's average profit.

3.3.4 Verification

By the last two stages, the profitability of two modes can be visible. However, it is rather slipshod to conclude the optimal project due to accidental errors. In other words, the present optimal project can be an accidental event which may change if the transportation and delivery distances change. This argument is logical because in the daily operation, the demand points, or the delivery addresses of the orders can be infinite, which means the samples selected from two populations can be random (e.g. the sample from mode A contains mainly small figures while its counterpart is on the contrary) and the result maybe change when comparing another samples.

Statistics is usually applied to clarify this confusion, for it is impossible to assess every figure of the population. Given this premise, the estimation of population is based on some methods (e.g. last section). To learn what the probability is when the result is reliable, Keller G (2014) suggests that t - test can be used to examine if there is a significant difference between two sets of data. The process is handled as follows:

To begin with, hypotheses should be established. The critical issue is if the profitability of two modes is highly likely different. While in above-mentioned text, it is proved that the mean of a population tends to be fixed when the number of the sample is sufficiently large. Hence, the hypotheses can be expressed as:

H0: There are no significant differences between the profitability of RDC and CDC mode ($\mu_1 - \mu_2 = 0$).

H1: There are significant differences between the profitability of RDC and CDC mode ($\mu_1 - \mu_2 \neq 0$).

Where μ_1 and μ_2 refer to the mean of RDC mode and CDC mode, respectively.

Besides, significance level α and its corresponding confidence interval $(1 - \alpha)$ should be defined. Typically, $\alpha = 5\%$, which means there is a 95% probability that the mean of a population is contained in the range only if the event occurs many times. In this case, it means the difference of means between two sets of data are highly likely to be existing or not existing if the number of sample n is quite large.

Lastly, compare the computed t - value and its theoretical value with a corresponding degree of freedom. In Excel, it can also be solved by "t – test: Two-Sample Assuming Equal Variances". If t - stat value is higher than that of t critical two-tail, then we conclude that we reject H0 in favor of H1.

Another issue is the source of profit data. While other factors are fixed, transportation and delivery distances between supply city and demand city can vary because demand points in the reality are scattered points. Being similar to the method of above-mentioned text, simulation is applied again to simulate the potential transportation and delivery distances:

$$\mathrm{d}'_{\mathrm{ij}} = \text{Average}\,(Rand(\quad) * 2r_j + \mathrm{d}_{\mathrm{ij}} - r_j) \tag{11}$$

Where d'_{ij} represents for n different results of simulated transportation and delivery distances when the number of the sample is n (generally, n >= 100), leading to n different results of profits, because Equation (8) restrains the distances to be random numbers between city center distance minus / plus demand city radius.

Chapter 4 Data issues and Results

In this chapter, we will first collect primary data and then process them to sites selection decision, profit comparation and optimal supply chain network results using methods in the last chapter. Due to inaccessibility of data, some reasonable assumptions and estimations are made as alternatives.

4.1 Primary Data of Demand Cities

As mentioned in chapter 3, 35 major Chinese cities are selected as demand cities. Basic data related to population size, cost index and city distance are listed in Table 3 and 4.

Cities	Usual Residence Population	Household Registration Population	Household Registration Families	Population per Household Registration Family	Estimated Usual Residence Families	GDP in U.S. Dollars	GDP per capita	Warehouse Rent Rate	Labor Rate
Beijing	2170.70	1359.20	543.10	2.50	867.35	4149.25	19114.82	4.85	5.18
Tianjin	1556.87	1049.99	385.62	2.72	571.78	2747.30	17646.27	3.69	4.78
Shijiazhuang	1087.99	943.73	309.45	3.05	356.75	956.91	8795.23	2.19	2.38
Taiyuan	437.97	369.17	118.45	3.12	140.52	500.93	11437.54	2.37	3.10
Hohhot	311.48	242.85	94.33	2.57	120.99	406.37	13046.38	2.36	3.53
Shenyang	829.40	736.95	271.80	2.71	305.90	868.65	10473.27	2.75	2.84
Dalian	705.00	594.89	214.30	2.78	253.97	1090.66	15470.36	2.97	4.19
Changchun	802.00	748.92	279.01	2.68	298.78	967.15	12059.27	3.09	3.27
Harbin	1092.90	955.00	389.27	2.45	445.48	941.24	8612.30	3.19	2.33
Shanghai	2418.33	1455.13	546.13	2.66	907.63	4537.01	18760.92	5.34	5.08
Nanjing	833.50	680.67	238.88	2.85	292.52	1735.11	20817.13	3.80	5.64
Hangzhou	946.80	753.88	235.26	3.20	295.46	1866.67	19715.53	3.71	5.34
Ningbo	800.50	596.93	227.49	2.62	305.07	1457.70	18209.87	3.44	4.93
Hefei	796.53	742.76	250.51	2.96	268.64	1068.37	13412.86	2.67	3.63
Fuzhou	766.00	693.35	213.08	3.25	235.41	1052.07	13734.66	3.25	3.72
Xiamen	401.00	231.03	74.07	3.12	128.56	644.52	16072.93	3.20	4.35
Nanchang	546.35	524.66	157.36	3.33	163.87	741.02	13563.02	2.74	3.67
Jinan	732.12	643.62	208.08	3.09	236.69	1066.67	14569.64	2.96	3.95
Qingdao	929.05	803.28	262.38	3.06	303.46	1634.72	17595.57	3.01	4.77
Zhengzhou	988.10	782.08	224.06	3.49	283.08	1352.26	13685.47	2.43	3.71
Wuhan	1089.29	853.65	310.88	2.75	396.69	1986.19	18233.78	3.42	4.94
Changsha	791.81	708.79	256.22	2.77	286.23	1560.40	19706.75	3.33	5.34
Guangzhou	1449.84	897.87	295.02	3.04	476.38	3184.80	21966.58	3.74	5.95
Shenzhen	1252.83	434.72	107.64	4.04	310.21	3330.97	26587.58	4.58	7.20
Nanning	715.33	756.86	225.78	3.35	213.39	610.03	8528.01	2.85	2.31
Haikou	227.21	171.05	54.92	3.11	72.95	205.96	9064.61	3.27	2.46
Chongqing	3075.16	3389.82	1260.93	2.69	1143.88	2876.97	9355.51	3.65	2.53
Chengdu	1604.47	1435.33	550.65	2.61	615.54	2057.14	12821.30	3.06	3.47
Guiyang	480.20	408.31	128.09	3.19	150.64	524.00	10912.17	5.12	2.96
Kunming	678.30	562.99	205.25	2.74	247.29	719.46	10606.79	2.99	2.87
Xian	961.67	905.68	267.68	3.38	284.23	1106.35	11504.46	2.66	3.12
Lanzhou	372.96	325.55	110.49	2.95	126.58	373.76	10021.40	2.79	2.71
Xining	235.50	205.58	74.87	2.75	85.77	190.31	8080.95	2.89	2.19
Yinchuan	222.54	188.59	77.30	2.44	91.22	267.08	12001.37	2.20	3.25
Urumuqi	351.96	222.62	83.35	2.67	131.78	406.38	11546.30	2.71	3.13

Table 4 Population Size, Rent and Wage rates of Demand Cities

Source: Statistics Bureau of each city, 2017; China Entrepreneur Investment Club; OYM Warehouse Alliance.

It should be noted that units for all forms of population and families are 10 thousand while units of GDP are 0.1 billion. The unit for rent rate is U.S. $ / m2 · month and U.S. $ per hour for wage rate. Another issue is that household registration families of Shijiazhuang and Hohhot, as well as usual residence population of Changchun, are estimated upon their nearest 5-year average growth rate (Chaisang News, 2018). As the newest economic available is in 2017, the raw figure of China's GDP (in China Yuan) is also collected on 2017 level, and according to World Bank's report of China's GDP (in U.S. dollars), the exchange rate can be computed and employed as the foundation for computing warehouse rent rates and labor wage rates.

As the Statistics Bureau of each city provides only household registration population and household registration families, an assumption that population per household register family equals to that of usual residence is regarded as an alternative method to estimate usual residence population that forms the basis of actual number of children live in each city and GDP.

As for warehouse rates, there are some consultancies publishing some core cities' figures, not covering all the sample cities. Hereby, the average rent rates on each city's warehouse rental transactions derived from a third-party online warehouse rental information platform, the OYM Warehouse Alliance. As a large intermediary channel who refers to 366 cities and over 1,000 warehouse enterprises around China, the rent rates offer a reference.

According to Li H et al (2012), national average annual wage level of low-educational workers (such as warehouse employees) accounts for approximately 78.01% of the corresponding period national GDP per capita. Assuming this proportion works for every city, the labor wage rate of each city is generated.

	Beijing	Tianjin	Shijiazhua	Taiyuan	Hohhot	Shenyang	Dalian	Changchun	Harbin	Shanghai	Nanjing
Beijing	0	130	292	490	483	685	840	966	1223	1207	1014
Tianjin	130	0	311	508	604	669	824	964	1221	1083	891
Shijiazhuang	292	311	0	221	5833	956	1111	1253	1511	1113	906
Taiyuan	490	508	221	0	455	1156	1310	1453	1710	1328	1074
Hohhot	483	604	581	455	0	1169	1323	1405	1587	1693	1500
Shenyang	685	669	956	1156	1169	0	383	289	546	1693	1500
Dalian	840	824	1111	1310	1323	383	0	679	937	1848	1655
Changchun	966	964	1253	1453	1405	289	679	0	262	1990	1797
Harbin	1223	1221	1511	1710	1587	546	937	262	0	2247	2054
Shanghai	1207	1083	1113	1328	1693	1693	1848	1990	2247	0	298
Nanjing	1014	891	906	1074	1500	1500	1655	1797	2054	298	0
Hangzhou	1272	1148	1172	1342	1757	1758	1912	2054	2311	177	273
Ningbo	1356	1232	1256	1471	1842	1842	1996	2139	2396	216	420
Hefei	1029	931	851	984	1434	1585	1740	1882	2139	461	171
Fuzhou	1888	1764	1780	1838	2289	2374	2528	2670	2927	772	889
Xiamen	2097	1999	1900	1959	2409	2620	2774	2916	3174	1015	1135
Nanchang	1430	1353	1223	1282	1732	2008	2162	2305	2562	695	589
Jinan	422	324	305	520	910	931	1085	1227	1484	829	626
Qingdao	662	538	637	851	1148	1133	1288	1430	1687	705	550
Zhengzhou	703	680	420	433	884	1334	1489	1631	1888	945	671
Wuhan	1152	1114	901	936	1386	1769	1923	2065	2322	827	533

Table 5 Distances between Any Two Cities

Source: Toponavi.com

Table 5 shows the distances from any origin to each destination. Since we take 35 cities as the sample, this is a 35 * 35 matrix. Hence, the graph shows only part of this matrix and the whole one can be found in the attached Excel file “Primary Data” under sheet “Distance”.

These data are defined to be from one city center to another, causing 35 values of “0” for the same city. The measurement for improving will be discussed in the next section.

4.2 Results of Supply Cities

In the 35 candidate cities, there are ten coastal cities: Dalian, Tianjin, Qingdao, Shanghai, Ningbo, Fuzhou, Xiamen, Shenzhen, Guangzhou and Haikou. By checking sailing schedules of the main shipping lines, Fuzhou and Haikou are excluded. Hence, supply cities will be selected from the rest 8 candidate cities.

4.2.1 Process to Choose the CDC

Given the model in Chapter 4, Excel’s tool – “Solver” can be applied to handle this 0 – 1 programming issue. However, Excel’s threshold for processing variables is 200, beneath the variables we have (8 candidate supply cities and 35 demand cities, therefore $8 * 35 = 280$ variables). Consequently, other data analysis software should be introduced.

Linear Interactive and General Optimizer (Lingo) is a specially designed modelling language to solve optimization problems, including both linear and non-linear problems. Based on programming language, it can solve 0 – 1 integer programming models with massive variables. However, it needs some programming knowledge which may make it difficult to understand, we can search for an alternative plan.

OpenOffice is an open-source office suite which allows users to input over 300 variables. Being similar to the "Solver" function of Excel, it is convenient to implement and easy to understand. Before applying the model mentioned in Chapter 3, the relative data and sources are listed in the following tables:

Demand Cities	population Per family	children Per family	numbers of Families (10k)	number of Children (10k)	potential customers Number	total yearly demand (kg)	company's Demand
Beijing	2.50	0.83	867.35	723.57	184.87	67478018.42	3373900.92
Tianjin	2.72	0.91	571.78	518.96	132.59	48396601.34	2419830.07
Shijiazhuang	3.05	1.02	356.75	362.66	92.66	33821075.81	1691053.79
Taiyuan	3.12	1.04	140.52	145.99	37.30	13614662.43	680733.12
Hohhot	2.57	0.86	120.99	103.83	26.53	9682615.37	484130.77
Lanzhou	2.95	0.98	126.58	124.32	31.76	11593772.40	579688.62
Xining	2.75	0.92	85.77	78.50	20.06	7320713.75	366035.69
Yinchuan	2.44	0.81	91.22	74.18	18.95	6917841.35	345892.07
Urumuqi	2.67	0.89	131.78	117.32	29.98	10940969.90	547048.50
Shenyang	2.71	0.90	305.90	276.47	70.64	25782590.17	1289129.51
Dalian	2.78	0.93	253.97	235.00	60.04	21915512.50	1095775.63
Changchun	2.68	0.89	298.78	267.33	68.30	24930838.33	1246541.92
Harbin	2.45	0.82	445.48	364.30	93.08	33973707.25	1698685.36
Shanghai	2.66	0.89	907.63	806.11	205.96	75175803.33	3758790.17
Nanjing	2.85	0.95	292.52	277.83	70.99	25910042.08	1295502.10
Hangzhou	3.20	1.07	295.46	315.60	80.64	29432067.00	1471603.35
Ningbo	2.62	0.87	305.07	266.83	68.18	24884209.58	1244210.48
Hefei	2.96	0.99	268.64	265.51	67.84	24760798.83	1238039.94
Fuzhou	3.25	1.08	235.41	255.33	65.24	23811748.33	1190587.42
Xiamen	3.12	1.04	128.56	133.67	34.15	12465419.17	623270.96
Nanchang	3.33	1.11	163.87	182.12	46.53	16983745.04	849187.25
Wuhan	2.75	0.92	396.69	363.10	92.77	33861487.39	1693074.37
Changsha	2.77	0.92	286.23	263.94	67.44	24614073.69	1230703.68
Shenzhen	4.04	1.35	310.21	417.61	106.70	38945264.58	1947263.23
Chongqing	2.69	0.90	1143.88	1025.05	261.90	95593911.23	4779695.56
Guiyang	3.19	1.06	150.64	160.07	40.90	14927417.17	746370.86
Jinan	3.09	1.03	236.69	244.04	62.35	22758560.30	1137928.02
Qingdao	3.06	1.02	303.46	309.68	79.12	28880293.46	1444014.67
Zhengzhou	3.49	1.16	283.08	329.37	84.15	30715911.92	1535795.60
Chengdu	2.61	0.87	615.54	534.82	136.65	49876287.01	2493814.35
Xian	3.38	1.13	284.23	320.56	81.90	29894313.34	1494715.67
Guangzhou	3.04	1.01	476.38	483.28	123.48	45069484.60	2253474.23
Nanning	3.35	1.12	213.39	238.44	60.92	22236629.16	1111831.46
Haikou	3.11	1.04	72.95	75.74	19.35	7063012.19	353150.61
Kunming	2.74	0.91	247.29	226.10	57.77	21085520.75	1054276.04

Table 6 Milk Powder Demand of each City

Source: PopulationPyramid.net

Table 6 forecasts consumption demand of milk powder of every selected city, among which "population per family" and "numbers of families" are cited from Table 4. Due to the everlasting influence of "One Child" Policy, each family is assumed to have around one child. Yet more accurate figures are necessary to reduce errors for computing demands. By dividing by 3, children number of each family is available. Next, to get the total number of children of each family, these figures need to be multiplied by the number of families of each city. For a baby milk powder manufacturer as A2, "children" is an ambiguous concept and the scope need to be narrowed. Thus, the column "potential customer number" means that the percentage of babies (0 – 4 years old) of children (the percentage is about) multiplies number of children to get the total babies' number. According to daily life experience, a baby usually eats 1 tin of milk powder (800 g) per ten days, or $365/10 = 36.5$ tins per year. Combined with its parcel weight, each milk powder product weighs 1 kilogram. Multiplied by the number of children per city, each city's total demand of baby milk powder (both in kilogram and number) can be calculated. As fierce competition exists, the A2 company is assumed to occupy 5% share of the market, and then the company's demand for each city can be forecasted.

Known of demands, the freight costs and warehouse costs can also be generated. Relative results and reasoning are shown as follows:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	AI	AJ	AK
1	Transportation Cost																			
2	haulage rate	0.08																		
3																				
4	Weight	Beijing	Tianjin	Shijiazhuang	Taiyuan	Hohhot	Shenyang	Dalian	Changchun	Harbin	Shanghai	Nanjing	Hangzhou	Ningbo	Hefei	Fuzhou	Xiamen	Yinchuan	Urumuqi	
5	Tianjin	3,373.90	2,419.83	1,691.05	680.73	484.13	1,289.13	1,095.78	1,246.54	1,698.69	3,758.79	1,295.50	1,471.60	1,244.21	1,238.04	1,190.59	623.27	345.89	547.05	
6	Dalian	3,373.90	2,419.83	1,691.05	680.73	484.13	1,289.13	1,095.78	1,246.54	1,698.69	3,758.79	1,295.50	1,471.60	1,244.21	1,238.04	1,190.59	623.27	345.89	547.05	
7	Shanghai	3,373.90	2,419.83	1,691.05	680.73	484.13	1,289.13	1,095.78	1,246.54	1,698.69	3,758.79	1,295.50	1,471.60	1,244.21	1,238.04	1,190.59	623.27	345.89	547.05	
8	Ningbo	3,373.90	2,419.83	1,691.05	680.73	484.13	1,289.13	1,095.78	1,246.54	1,698.69	3,758.79	1,295.50	1,471.60	1,244.21	1,238.04	1,190.59	623.27	345.89	547.05	
9	Xiamen	3,373.90	2,419.83	1,691.05	680.73	484.13	1,289.13	1,095.78	1,246.54	1,698.69	3,758.79	1,295.50	1,471.60	1,244.21	1,238.04	1,190.59	623.27	345.89	547.05	
10	Qingdao	3,373.90	2,419.83	1,691.05	680.73	484.13	1,289.13	1,095.78	1,246.54	1,698.69	3,758.79	1,295.50	1,471.60	1,244.21	1,238.04	1,190.59	623.27	345.89	547.05	
11	Guangzhou	3,373.90	2,419.83	1,691.05	680.73	484.13	1,289.13	1,095.78	1,246.54	1,698.69	3,758.79	1,295.50	1,471.60	1,244.21	1,238.04	1,190.59	623.27	345.89	547.05	
12	Shenzhen	3,373.90	2,419.83	1,691.05	680.73	484.13	1,289.13	1,095.78	1,246.54	1,698.69	3,758.79	1,295.50	1,471.60	1,244.21	1,238.04	1,190.59	623.27	345.89	547.05	
13																				
14	Distance	Beijing	Tianjin	Shijiazhuang	Taiyuan	Hohhot	Shenyang	Dalian	Changchun	Harbin	Shanghai	Nanjing	Hangzhou	Ningbo	Hefei	Fuzhou	Xiamen	Yinchuan	Urumuqi	
15	Tianjin	130	31	311	508	604	669	824	964	1,221	1,083	891	1,148	1,232	931	1,764	1,999	1,152	2,895	
16	Dalian	840	824	1,111	1,310	1,323	383	33	679	937	1,848	1,655	1,912	1,996	1,740	2,528	2,774	1,924	3,605	
17	Shanghai	1,207	1,083	1,113	1,328	1,693	1,693	1,848	1,990	2,247	22	298	177	216	461	772	1,015	1,929	3,978	
18	Ningbo	1,356	1,232	1,256	1,471	1,842	1,842	1,996	2,139	2,396	216	420	149	28	555	577	823	2,062	4,124	
19	Xiamen	2,097	1,999	1,900	1,959	2,409	2,620	2,774	2,916	3,174	1,015	1,135	865	823	1,073	254	11	2,431	4,624	
20	Qingdao	662	538	637	851	1,148	1,133	1,288	1,430	1,687	705	550	795	879	689	1,410	1,657	1,452	3,430	
21	Guangzhou	2,117	2,079	1,852	1,866	2,317	2,733	1,887	3,030	3,287	1,426	1,362	1,254	1,344	1,209	873	666	2,283	4,476	
22	Shenzhen	2,153	2,115	1,946	1,995	2,446	2,769	2,924	3,066	3,323	1,426	1,361	1,253	1,344	1,226	816	576	2,406	4,600	
23																				
24	Freight Cost	Beijing	Tianjin	Shijiazhuang	Taiyuan	Hohhot	Shenyang	Dalian	Changchun	Harbin	Shanghai	Nanjing	Hangzhou	Ningbo	Hefei	Fuzhou	Xiamen	Yinchuan	Urumuqi	sum
25	Tianjin	36,793.68	6,292.80	44,117.96	29,009.36	24,529.98	72,346.95	75,743.68	100,804.86	173,990.75	341,486.94	96,830.77	141,719.70	128,588.50	96,690.08	176,180.34	104,517.08	33,426.48	132,853.18	5,141,604.07
26	Dalian	237,743.79	167,266.76	157,604.66	74,807.60	53,730.40	41,418.36	3,033.42	71,002.60	133,521.16	582,703.48	179,859.63	236,034.90	208,330.07	180,709.70	252,485.20	145,037.70	55,826.86	165,435.48	7,765,915.50
27	Shanghai	341,615.18	219,842.11	157,888.37	75,835.49	68,757.05	183,084.29	169,871.75	208,093.03	320,194.29	6,936.95	32,385.60	21,850.51	22,544.74	47,877.69	77,103.87	53,068.95	55,971.94	182,552.66	5,286,223.34
28	Ningbo	383,786.40	250,088.17	178,174.12	84,001.51	74,808.32	199,197.43	183,476.20	223,673.86	341,426.58	68,108.20	45,644.13	18,393.93	2,922.47	57,640.16	57,628.15	43,030.29	59,831.08	189,252.68	5,545,451.88
29	Xiamen	593,510.38	405,784.29	269,530.92	111,868.77	97,835.63	283,331.86	254,991.47	304,924.25	452,290.46	320,045.47	123,347.84	106,783.57	85,899.62	111,437.65	25,368.37	575.13	70,538.00	212,197.97	6,849,773.71
30	Qingdao	187,364.75	109,210.58	90,363.79	48,596.39	46,623.21	122,524.81	118,395.46	149,534.19	240,395.09	222,297.59	59,772.08	98,142.13	91,744.55	71,556.89	140,824.42	86,635.71	42,131.29	157,404.63	5,303,873.09
31	Guangzhou	599,170.95	422,023.78	262,721.71	106,558.01	94,099.28	295,551.89	173,456.71	316,845.16	468,392.80	449,640.24	148,017.41	154,805.32	140,278.36	125,562.09	87,191.29	34,821.60	66,243.62	205,406.16	6,530,046.36
32	Shenzhen	609,359.97	429,331.55	276,056.40	113,924.56	99,338.29	299,445.00	268,779.76	320,609.66	473,522.75	449,640.24	147,908.73	154,681.87	140,278.36	127,327.64	81,498.39	30,115.98	69,812.60	211,096.59	6,857,677.13

Table 7 Freight Costs from each Origin to Each Destination

Source: Ministry of Transport of the People's Republic of China

Table 7 records the haulage rate ($ / t · km), demands (kg) and distances (km) from one supply city to each demand city, and thus the delivery costs as the products of these figures. Again, as the matrixes' size is 8 * 35, some columns are hidden. It should be noted that much as most of distance data are cited from Table 5, each distance one supply city delivers to itself is elaborated not to be 0, aiming to be practical. The results are based on simulation, which will also be mentioned in the next section. The process of simulation of these results can be found in Table 8.

	A	B	C	D	E	F	G	H	I
1		Tianjin	Dalian	Shanghai	Ningbo	Xiamen	Shenzhen	Qingdao	Guangzhou
2	city land area (km^2)	11,903	13,238	6,340	9,241	1,516	2,020	11,064	7,436
3	city radius (km)	61.55	64.91	44.92	54.24	21.97	25.36	59.34	48.65
4									
5	random delivery distar	49.72	12.59	29.98	47.71	12.94	0.66	12.65	0.34
6		56.47	54.16	38.36	42.91	8.89	24.04	7.03	4.65
7		48.87	17.21	5.30	16.68	8.75	18.34	4.96	21.62
8		13.52	49.12	35.00	13.48	0.57	14.24	6.35	43.21
1001		15.50	43.89	17.91	36.83	12.56	7.41	53.81	36.93
1002		18.35	58.13	34.29	11.50	13.10	4.17	31.46	18.40
1003		48.13	23.93	24.78	16.85	5.82	5.67	44.38	45.49
1004		61.13	62.21	25.48	39.72	10.13	2.44	44.62	6.73
1005	avg delivery distance	32.28	32.05	22.96	25.92	10.94	12.84	30.38	24.65
1006									
1007									
1008	value only								
1009	avg delivery distance	31	33	22	28	11	13	30	24

Table 8 The Simulated Distances each City Delivers to Itself

Source: Ministry of Civil Affairs of the People's Republic of China

From the official website of the Ministry of Civil Affairs, each supply city's land area can be found. By dividing by π, the cities' radii are also generated. After that, by using the equation mentioned in Chapter 3 to simulate 1,000 results, the supposed 1,000 demand points' distances to the warehouse can be computed. As these results vary from 0 to the radius of the city itself, the means can be selected as a typical sample. It should be noted that the area "values only" means the paste numbers of the results. This step is done because every time we edit the file, the simulation results will alter. While no matter how the simulation results change, the means tend to a constant, supporting the theory in Chapter 3 again.

Demand Cities	number of parcels (yearly)	yearly parcels volume (m^3)	weekly parcels volume	volume including safety stock	warehouse size (m^2)
Beijing	3,373,900.92	91,095.32	1,751.83	5,255.50	4,379.58
Tianjin	2,419,830.07	65,335.41	1,256.45	3,769.35	3,141.13
Shijiazhuang	1,691,053.79	45,658.45	878.05	2,634.14	2,195.12
Taiyuan	680,733.12	18,379.79	353.46	1,060.37	883.64
Hohhot	484,130.77	13,071.53	251.38	754.13	628.44
Lanzhou	579,688.62	15,651.59	300.99	902.98	752.48
Xining	366,035.69	9,882.96	190.06	570.17	475.14
Yinchuan	345,892.07	9,339.09	179.60	538.79	448.99
Urumuqi	547,048.50	14,770.31	284.04	852.13	710.11
Shenyang	1,289,129.51	34,806.50	669.36	2,008.07	1,673.39
Dalian	1,095,775.63	29,585.94	568.96	1,706.88	1,422.40
Changchun	1,246,541.92	33,656.63	647.24	1,941.73	1,618.11
Harbin	1,698,685.36	45,864.50	882.01	2,646.03	2,205.02
Shanghai	3,758,790.17	101,487.33	1,951.68	5,855.04	4,879.20
Nanjing	1,295,502.10	34,978.56	672.66	2,017.99	1,681.66
Hangzhou	1,471,603.35	39,733.29	764.10	2,292.31	1,910.25
Ningbo	1,244,210.48	33,593.68	646.03	1,938.10	1,615.08
Hefei	1,238,039.94	33,427.08	642.83	1,928.49	1,607.07
Fuzhou	1,190,587.42	32,145.86	618.19	1,854.57	1,545.47
Xiamen	623,270.96	16,828.32	323.62	970.86	809.05
Nanchang	849,187.25	22,928.06	440.92	1,322.77	1,102.31
Wuhan	1,693,074.37	45,713.01	879.10	2,637.29	2,197.74
Changsha	1,230,703.68	33,229.00	639.02	1,917.06	1,597.55
Shenzhen	1,947,263.23	52,576.11	1,011.08	3,033.24	2,527.70
Chongqing	4,779,695.56	129,051.78	2,481.77	7,445.30	6,204.41
Guiyang	746,370.86	20,152.01	387.54	1,162.62	968.85
Jinan	1,137,928.02	30,724.06	590.85	1,772.54	1,477.12
Qingdao	1,444,014.67	38,988.40	749.78	2,249.33	1,874.44
Zhengzhou	1,535,795.60	41,466.48	797.43	2,392.30	1,993.58
Chengdu	2,493,814.35	67,332.99	1,294.87	3,884.60	3,237.16
Xian	1,494,715.67	40,357.32	776.10	2,328.31	1,940.26
Guangzhou	2,253,474.23	60,843.80	1,170.07	3,510.22	2,925.18
Nanning	1,111,831.46	30,019.45	577.30	1,731.89	1,443.24
Haikou	353,150.61	9,535.07	183.37	550.10	458.42
Kunming	1,054,276.04	28,465.45	547.41	1,642.24	1,368.53

Table 9 Minimal Warehouse Size for each Demand City

Source: Own Calculation and Industry Standards

Table 9 shows the warehouse size needed to fulfill each demand city's orders. Assuming each parcel's size is 30 * 30 * 30 cm^3 or 0.03 m^3, we can convert the annual number of parcels (also the weights of parcels as explained in the last part) into annual parcels' volume. By dividing by 52 weeks per year and then plus 2 weeks flows of safety stock, the volume of the space can be computed (to simplify the question, we assume the consumption rate is fixed and thus excludes the scenarios of slack seasons and peak seasons). As parcels are stacked for 4 tiers (1.2 m) according to industry standards, the minimal warehouse sizes are also available.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	AI	AJ	AK
34																				
35	Warehouse Cost																			
36	Whs Size	Beijing	Tianjin	Shijiazhuang	Taiyuan	Hohhot	Shenyang	Dalian	Changchun	Harbin	Shanghai	Nanjing	Hangzhou	Ningbo	Hefei	Fuzhou	Xiamen	Yinchuan	Urumuqi	
37	Tianjin	4,379.58	3,141.13	2,195.12	883.64	628.44	1,673.39	1,422.40	1,618.11	2,205.02	4,879.20	1,681.66	1,910.25	1,615.08	1,607.07	1,545.47	809.05	448.99	710.11	
38	Dalian	4,379.58	3,141.13	2,195.12	883.64	628.44	1,673.39	1,422.40	1,618.11	2,205.02	4,879.20	1,681.66	1,910.25	1,615.08	1,607.07	1,545.47	809.05	448.99	710.11	
39	Shanghai	4,379.58	3,141.13	2,195.12	883.64	628.44	1,673.39	1,422.40	1,618.11	2,205.02	4,879.20	1,681.66	1,910.25	1,615.08	1,607.07	1,545.47	809.05	448.99	710.11	
40	Ningbo	4,379.58	3,141.13	2,195.12	883.64	628.44	1,673.39	1,422.40	1,618.11	2,205.02	4,879.20	1,681.66	1,910.25	1,615.08	1,607.07	1,545.47	809.05	448.99	710.11	
41	Xiamen	4,379.58	3,141.13	2,195.12	883.64	628.44	1,673.39	1,422.40	1,618.11	2,205.02	4,879.20	1,681.66	1,910.25	1,615.08	1,607.07	1,545.47	809.05	448.99	710.11	
42	Qingdao	4,379.58	3,141.13	2,195.12	883.64	628.44	1,673.39	1,422.40	1,618.11	2,205.02	4,879.20	1,681.66	1,910.25	1,615.08	1,607.07	1,545.47	809.05	448.99	710.11	
43	Guangzhou	4,379.58	3,141.13	2,195.12	883.64	628.44	1,673.39	1,422.40	1,618.11	2,205.02	4,879.20	1,681.66	1,910.25	1,615.08	1,607.07	1,545.47	809.05	448.99	710.11	
44	Shenzhen	4,379.58	3,141.13	2,195.12	883.64	628.44	1,673.39	1,422.40	1,618.11	2,205.02	4,879.20	1,681.66	1,910.25	1,615.08	1,607.07	1,545.47	809.05	448.99	710.11	
45																				
46	Rent Rate	Beijing	Tianjin	Shijiazhuang	Taiyuan	Hohhot	Shenyang	Dalian	Changchun	Harbin	Shanghai	Nanjing	Hangzhou	Ningbo	Hefei	Fuzhou	Xiamen	Yinchuan	Urumuqi	
47	Tianjin	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.69	
48	Dalian	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97	
49	Shanghai	5.34	5.34	5.34	5.34	5.34	5.34	5.34	5.34	5.34	5.34	5.34	5.34	5.34	5.34	5.34	5.34	5.34	5.34	
50	Ningbo	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	3.44	
51	Xiamen	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	
52	Qingdao	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	
53	Guangzhou	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74	3.74	
54	Shenzhen	4.58	4.58	4.58	4.58	4.58	4.58	4.58	4.58	4.58	4.58	4.58	4.58	4.58	4.58	4.58	4.58	4.58	4.58	
55																				
56	Rent Cost	Beijing	Tianjin	Shijiazhuang	Taiyuan	Hohhot	Shenyang	Dalian	Changchun	Harbin	Shanghai	Nanjing	Hangzhou	Ningbo	Hefei	Fuzhou	Xiamen	Yinchuan	Urumuqi	sum
57	Tianjin	193,927.93	139,089.04	97,199.82	39,127.75	27,827.28	74,097.68	62,983.92	71,649.79	97,638.47	216,050.92	74,463.97	84,586.06	71,515.78	71,161.11	68,433.59	35,824.90	19,881.48	31,443.72	2,917,956.50
58	Dalian	156,088.34	111,949.72	78,234.00	31,493.07	22,397.57	59,639.59	50,694.37	57,669.34	78,587.06	173,894.64	59,934.41	68,081.46	57,561.48	57,276.01	55,080.70	28,834.67	16,002.16	25,308.36	2,348,599.14
59	Shanghai	280,643.67	201,283.33	140,663.16	56,623.90	40,270.37	107,230.78	91,147.46	103,688.32	141,297.96	312,659.06	107,760.86	122,409.10	103,494.38	102,981.11	99,033.98	51,844.16	28,771.57	45,503.91	4,222,733.80
60	Ningbo	180,789.18	129,665.66	90,614.47	36,476.82	25,941.96	69,077.51	58,716.72	66,795.47	91,023.40	201,413.33	69,418.98	78,855.30	66,670.54	66,339.89	63,797.17	33,397.73	18,534.49	29,313.38	2,720,262.97
61	Xiamen	168,175.98	120,619.22	84,292.53	33,931.93	24,132.06	64,258.15	54,620.20	62,135.32	84,672.93	187,361.23	64,575.80	73,353.77	62,019.11	61,711.53	59,346.20	31,067.66	17,241.39	27,268.26	2,530,477.18
62	Qingdao	158,190.54	113,457.46	79,287.66	31,917.22	22,699.22	60,442.82	51,377.13	58,446.04	79,645.48	176,236.66	60,741.61	68,998.39	58,336.72	58,047.41	55,822.52	29,223.02	16,217.68	25,649.21	2,380,230.10
63	Guangzhou	196,555.68	140,973.72	98,516.89	39,657.94	28,204.34	75,101.71	63,837.36	72,620.66	98,961.49	218,978.44	75,472.96	85,732.22	72,484.83	72,125.35	69,360.88	36,310.33	20,150.87	31,869.78	2,957,495.21
64	Shenzhen	240,701.88	172,636.26	120,643.68	48,565.07	34,539.01	91,969.47	78,175.16	88,931.18	121,188.13	268,160.76	92,424.11	104,987.58	88,764.85	88,324.63	84,939.25	44,465.59	24,676.74	39,027.70	3,621,745.47

Table 10 Rent Costs of each Candidate Supply City

Source: Own Calculation

Given the warehouse sizes and rent rates cited from Table 4, the warehouse costs for each candidate supply city can be generated by products of sizes and rates as shown in Table 10. The processes are simple multiplications.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	AI	AJ	AK
66	Wage Rate																			
67	Tianjin	4.78	4.78	4.78	4.78	4.78	4.78	4.78	4.78	4.78	4.78	4.78	4.78	4.78	4.78	4.78	4.78	4.78	4.78	
68	Dalian	4.19	4.19	4.19	4.19	4.19	4.19	4.19	4.19	4.19	4.19	4.19	4.19	4.19	4.19	4.19	4.19	4.19	4.19	
69	Shanghai	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	5.08	
70	Ningbo	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	
71	Xiamen	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	
72	Qingdao	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	4.77	
73	Guangzhou	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	
74	Shenzhen	7.20	7.20	7.20	7.20	7.20	7.20	7.20	7.20	7.20	7.20	7.20	7.20	7.20	7.20	7.20	7.20	7.20	7.20	
75																				
76	Labor Hours	Beijing	Tianjin	Shijiazhuang	Taiyuan	Hohhot	Shenyang	Dalian	Changchun	Harbin	Shanghai	Nanjing	Hangzhou	Ningbo	Hefei	Fuzhou	Xiamen	Yinchuan	Urumuqi	
77	Tianjin	84,347.52	60,495.75	42,276.34	17,018.33	12,103.27	32,228.24	27,394.39	31,163.55	42,467.13	93,969.75	32,387.55	36,790.08	31,105.26	30,951.00	29,764.69	15,581.77	8,647.30	13,676.21	
78	Dalian	84,347.52	60,495.75	42,276.34	17,018.33	12,103.27	32,228.24	27,394.39	31,163.55	42,467.13	93,969.75	32,387.55	36,790.08	31,105.26	30,951.00	29,764.69	15,581.77	8,647.30	13,676.21	
79	Shanghai	84,347.52	60,495.75	42,276.34	17,018.33	12,103.27	32,228.24	27,394.39	31,163.55	42,467.13	93,969.75	32,387.55	36,790.08	31,105.26	30,951.00	29,764.69	15,581.77	8,647.30	13,676.21	
80	Ningbo	84,347.52	60,495.75	42,276.34	17,018.33	12,103.27	32,228.24	27,394.39	31,163.55	42,467.13	93,969.75	32,387.55	36,790.08	31,105.26	30,951.00	29,764.69	15,581.77	8,647.30	13,676.21	
81	Xiamen	84,347.52	60,495.75	42,276.34	17,018.33	12,103.27	32,228.24	27,394.39	31,163.55	42,467.13	93,969.75	32,387.55	36,790.08	31,105.26	30,951.00	29,764.69	15,581.77	8,647.30	13,676.21	
82	Qingdao	84,347.52	60,495.75	42,276.34	17,018.33	12,103.27	32,228.24	27,394.39	31,163.55	42,467.13	93,969.75	32,387.55	36,790.08	31,105.26	30,951.00	29,764.69	15,581.77	8,647.30	13,676.21	
83	Guangzhou	84,347.52	60,495.75	42,276.34	17,018.33	12,103.27	32,228.24	27,394.39	31,163.55	42,467.13	93,969.75	32,387.55	36,790.08	31,105.26	30,951.00	29,764.69	15,581.77	8,647.30	13,676.21	
84	Shenzhen	84,347.52	60,495.75	42,276.34	17,018.33	12,103.27	32,228.24	27,394.39	31,163.55	42,467.13	93,969.75	32,387.55	36,790.08	31,105.26	30,951.00	29,764.69	15,581.77	8,647.30	13,676.21	
85																				
86	Labor Cost	Beijing	Tianjin	Shijiazhuang	Taiyuan	Hohhot	Shenyang	Dalian	Changchun	Harbin	Shanghai	Nanjing	Hangzhou	Ningbo	Hefei	Fuzhou	Xiamen	Yinchuan	Urumuqi	sum
87	Tianjin	403,181.16	289,169.69	202,080.93	81,347.61	57,853.63	154,050.98	130,945.19	148,961.76	202,992.90	449,175.42	154,812.50	175,856.60	148,683.15	147,945.77	142,275.20	74,480.88	41,334.10	65,372.30	6,066,506.64
88	Dalian	353,416.12	253,477.20	177,137.88	71,306.79	50,712.70	135,036.32	114,782.50	130,575.27	177,937.29	393,733.27	135,703.85	154,150.45	130,331.05	129,684.68	124,714.03	65,287.63	36,232.19	57,303.33	5,317,711.89
89	Shanghai	428,485.42	307,318.42	214,763.83	86,453.11	61,484.61	163,719.45	139,163.50	158,310.82	215,733.04	477,366.35	164,528.77	186,893.63	158,014.73	157,231.07	151,204.60	79,155.41	43,928.29	69,475.16	6,447,249.74
90	Ningbo	415,833.29	298,244.06	208,422.38	83,900.36	59,669.12	158,885.21	135,054.35	153,636.29	209,362.97	463,270.89	159,670.63	181,375.11	153,348.94	152,588.42	146,739.90	76,818.15	42,631.20	67,423.73	6,256,878.19
91	Xiamen	366,911.73	263,156.52	183,902.10	74,029.73	52,649.22	140,192.83	119,165.60	135,561.43	184,732.03	408,768.43	140,885.85	160,036.86	135,307.89	134,636.84	129,476.38	67,780.72	37,615.76	59,491.52	5,520,774.87
92	Qingdao	402,337.68	288,564.74	201,658.16	81,177.42	57,732.59	153,728.69	130,671.24	148,650.12	202,568.23	448,235.73	154,488.63	175,488.70	148,372.10	147,636.26	141,977.55	74,325.06	41,247.63	65,235.53	6,053,815.21
93	Guangzhou	501,867.76	359,949.72	251,544.25	101,259.05	72,014.45	191,758.01	162,996.62	185,423.11	252,679.45	559,120.04	192,705.94	218,901.00	185,076.31	184,158.44	177,099.88	92,711.56	51,451.45	81,373.46	7,551,404.71
94	Shenzhen	607,302.17	435,569.41	304,389.68	122,531.96	87,143.54	232,043.31	197,239.61	224,377.55	305,763.37	676,582.23	233,190.38	264,888.60	223,957.89	222,847.19	214,305.74	112,188.77	62,260.57	98,468.73	9,137,834.27

Table 11 Labor Costs of each Candidate Supply City

Source: Own Calculation

Tables 11 gives the wage rate, minimal labor hours needed and labor costs that based on multiplications. As mentioned in section 4.1, the wage rates can be expressed as GDP per capita multiplies 78.01%. While the minimal input of labor hours to handle each demand city's parcels can be defined as the parcel numbers divided by labor efficiency where we assume that a skillful worker can fulfill 40 parcels per hour. Plus, for each warehouse, a worker is assumed to work 8 hours a day, 360 days a year.

	A	B	C	D	AM	AN
85						
86	Labor Cost	Beijing	Tianjin	Shijiazhuang	total logsitics cost	
87	Tianjin	403,181.16	289,169.69	202,080.93	14,126,067.22	
88	Dalian	353,416.12	253,477.20	177,137.88	15,432,226.53	
89	Shanghai	428,485.42	307,318.42	214,763.83	15,956,206.88	
90	Ningbo	415,833.29	298,244.06	208,422.38	14,522,593.05	
91	Xiamen	366,911.73	263,156.52	183,902.10	14,901,025.76	
92	Qingdao	402,337.68	288,564.74	201,658.16	13,737,918.39	Qingdao CDC
93	Guangzhou	501,867.76	359,949.72	251,544.25	17,038,946.28	
94	Shenzhen	607,302.17	435,569.41	304,389.68	19,617,256.87	

Table 12 Total Logistics Cost of each Candidate Supply City

Source: Own Calculation

As a summary, Table 12 gives the results of total logistics cost for each candidate supply city, that is the sum of transportation and delivery cost, rent cost and labor cost. This equation is feasible because the characteristic of the CDC requires it to supply every demand city. From the table, it is apparent that Qingdao accepts the lowest logistics cost, and therefore it should be selected as the CDC. In this mode, the lowest logistics cost is $ 13,737,918.39.

4.2.2 Process to Choose the RDCs

The data results for transportation and delivery cost, rent cost and labor cost are still valid in this part. However, to find the optimal allocation plan, that some candidate supply cities are excluded is likely to exist, and each candidate supply city delivers to several demand cities. Hence, the simple method of finding the relative data is not feasible in this case. Considering the complex calculation process, the OpenOffice hereby is introduced to find the optimum.

	A	B	C	D	AH	AI	AJ	AK	AL	AM	AN	AO
95												
96		Beijing	Tianjin	Shijiazhuang	Xining	Yinchuan	Urumuqi	actual allocation				
97	Tianjin	1.00	1.00	1.00	1.00	1.00	1.00	9				
98	Dalian	0.00	0.00	0.00	0.00	0.00	0.00	4				
99	Shanghai	0.00	0.00	0.00	0.00	0.00	0.00	0				
100	Ningbo	0.00	0.00	0.00	0.00	0.00	0.00	5				
101	Xiamen	0.00	0.00	0.00	0.00	0.00	0.00	8				
102	Qingdao	0.00	0.00	0.00	0.00	0.00	0.00	5				
103	Guangzhou	0.00	0.00	0.00	0.00	0.00	0.00	4				
104	Shenzhen	0.00	0.00	0.00	0.00	0.00	0.00	0				
105		1	1	1	1	1	1					
106		=	=	=	=	=	=					
107		1	1	1	1	1	1					
108										total logistics cost		11,586,633.38

Table 13 Results of Allocation and Optimal Logistics Cost of RDC Mode

Table 13 shows the optimal results of RDC mode. The area B97: AJ 104 fills in the decision variables (0 – 1 variables). AK 97: 104 is the sum of each row that reflects the demand cities each candidate supply city serves. B105: AJ 105 is the sum of each column that reflects the time each demand city is supplied. Total logistics cost is defined as the sum product of weight area, distance area and variable area, plus the sum product of warehouse size area, rent rate area and variable area, plus the sum product of the wage rate area, labor hours area and variable area. By calculation, the optimal plan is:

1. Tianjin, Dalian, Ningbo, Xiamen, Qingdao, and Guangzhou are selected as supply cities while candidates Shanghai and Shenzhen are excluded. This is reasonable because Ningbo and Shanghai, Guangzhou and Shenzhen are neighboring cities while Ningbo and Guangzhou hold lower rent rates and wage rates than their neighbors. Hence, Shanghai and Shenzhen are necessarily eliminated.

2. Tianjin supplies to Beijing, Tianjin, Shijiazhuang, Taiyuan, Hohhot, Lanzhou, Xining, Yinchuan and Urumqi (9 cities); Dalian supplies to Shenyang, Dalian, Changchun and Harbin (4 cities); Ningbo supplies to Shanghai, Nanjing, Hangzhou, Ningbo and Hefei (5 cities); Xiamen supplies to Fuzhou, Xiamen, Nanchang, Wuhan, Changsha, Shenzhen, Chongqing and Guiyang (8 cities); Qingdao supplies Jinan, Qingdao, Zhengzhou, Chengdu and Xian (5 cities); Guangzhou supplies Guangzhou, Nanning, Haikou and Kunming (4 cities).

3. The total logistics cost is $ 11,586,633.38.

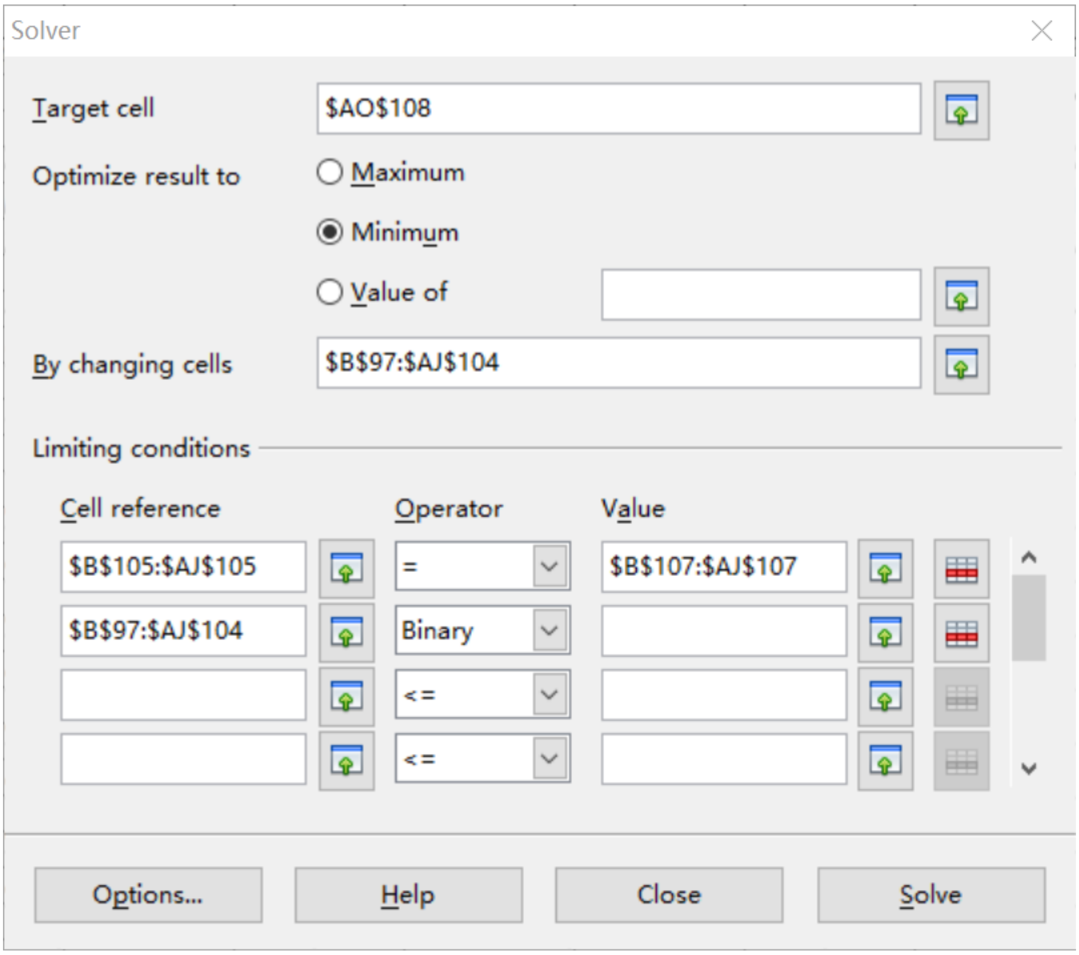


Table 14 The Process to Generate the Optimum

Table 14 records the process in OpenOffice to generate the optimal value. The meanings of the heads are as follows: "Target Cell" represents for the cell where the result will be generated. "Minimum" represents for the optimal objective (in this case, to gain a minimal value) of cell AO 108. "Changing cells" represents for the area where the values will be generated with either 1 (the candidate supply city in this row supplies the corresponding demand city) or 0 (the candidate supply city in this row does not supply the corresponding demand city), because the variables in this case are defined as 0 – 1 variables. "Limiting conditions" represents for the restraints that limits the variables in a certain range to look for an optimum. Specifically, "$B$105: AJ 105 = $B$107: AJ 107" means each demand city should be supplied and only supplied once. "$B$97: AJ 104 Binary" means each supply city can either or not supply every demand city.

4.3 Results of Profits Comparation

As mentioned in Chapter 3, the revenues for both CDC mode and RDC mode are the same. Hence, the only variable here is the logistics cost. But the delivery distance may not be exactly from one city center to another, causing the "distance table" not practical and convincing. Thus, we will use the simulation method to generate 1,000 distances (in reality, the actual number of demand points may vary from city to city, but we suppose they are all 1,000 for simplification), and thus 1,000 delivery costs and 1,000 profit outcomes.

4.3.1 Profit of the CDC Mode

	A	B	C	D	E	F	G	H	I	J	K	L	M	BP	BQ	BR	BS
1	haulage rate ($/t·km)	0.08															
2		Qingdao as CDC															
3		Beijing		Tianjin		Shijiazhuang		Taiyuan		Hohhot		Jinan		Haikou		Kunming	
4	city land area (km^2)	16,412		11,903		14,530		6,909		17,344		10,244		2,315		21,473	
5	city radius (km)	72.28		61.55		68.01		46.90		74.30		57.10		27.15		82.67	
6	weight of parcels (t)	3,373.90		2,419.83		1,691.05		680.73		484.13		1,137.93		353.15		1,054.28	
7	City center distance (km)	662.00		538.00		637.00		851.00		1,148.00		352.00		2,468.00		2,572.00	
8			Delivery cost		Delivery cost		Delivery cost		Delivery cost		Delivery cost		Delivery cost				
9	Distance between	663.12	187,681.81	585.66	118,886.14	592.23	84,012.79	845.49	48,281.66	1,076.20	43,707.15	376.35	35,925.90	2,442.82	72,368.30	2,585.79	228,688.70
10	warehouse and	659.80	186,742.18	494.18	100,315.76	599.95	85,108.04	837.27	47,812.23	1,108.71	45,027.47	326.08	31,127.30	2,453.77	72,692.85	2,572.98	227,555.81
11	demand points (km)	642.80	181,931.61	496.12	100,708.97	624.09	88,532.81	876.77	50,067.93	1,192.98	48,449.82	371.49	35,462.03	2,466.59	73,072.60	2,542.67	224,875.31
1004		607.83	172,033.69	484.28	98,305.42	704.21	99,898.68	855.49	48,853.06	1,175.93	47,757.36	351.87	33,589.09	2,449.52	72,566.79	2,646.30	234,040.36
1005		707.01	200,104.43	558.06	113,282.31	655.67	93,012.37	895.16	51,118.27	1,206.06	48,981.00	363.44	34,693.68	2,458.87	72,843.96	2,627.13	232,344.65
1006		695.17	196,752.88	578.29	117,389.79	628.58	89,169.35	863.70	49,321.65	1,162.67	47,218.84	399.87	38,170.87	2,474.52	73,307.58	2,607.73	230,628.89
1007		714.94	202,347.33	530.71	107,730.56	619.66	87,904.49	836.98	47,795.94	1,083.76	44,014.40	324.58	30,984.13	2,470.65	73,193.01	2,654.35	234,752.40
1008		609.17	172,413.65	534.51	108,501.50	685.80	97,286.55	834.20	47,636.95	1,137.23	46,185.71	394.88	37,694.89	2,475.32	73,331.11	2,494.13	220,582.59
1009		Beijing	Tianjin	Shijiazhuang	Taiyuan	Hohhot	Jinan	Zhengzhou	Wuhan	Chongqing	Chengdu	Xian	Lanzhou				
1010	Mean transit distance	661.32	540.11	639.40	851.40	1,147.90	352.30	715.91	1,029.38	1,813.39	1,885.75	1,165.55	1,758.68				
1011	Mean delivery cost	187,172.25	109,638.87	90,703.90	48,619.18	46,619.15	33,630.04	92,233.81	146,201.22	727,091.54	394,499.25	146,146.20	85,522.32				

Table 15 Delivery Costs by Simulation in the CDC Mode

Table 15 gives the 1,000 simulated distances and the corresponding 1,000 transportation and delivery costs from Qingdao (the CDC) to each demand city. The equation to gain the distances are expressed in the model in Chapter 3, with a range between city center distance minus demand city radius and city center distance plus demand city radius. The delivery costs are calculated with the same equation as mentioned above.

	A	B	C	D	E	F	G	AF	AG	AH	AI	AJ
1047												
1048												
1049	Profit	17,465,281.09	12,566,999.70	8,752,330.16	3,516,680.15	2,487,594.17	2,946,684.55	7,674,106.22	11,431,413.22	5,600,399.36	1,775,975.80	5,291,290.74
1050		17,462,537.17	12,556,625.26	8,766,475.87	3,512,590.24	2,487,375.55	2,950,576.52	7,677,240.34	11,445,211.75	5,606,993.94	1,774,590.97	5,286,779.81
1051		17,453,311.30	12,567,413.00	8,759,566.24	3,514,230.73	2,485,215.08	2,949,416.47	7,681,084.53	11,435,162.78	5,611,396.63	1,775,437.23	5,292,013.05
1052		17,451,551.41	12,561,227.24	8,757,828.79	3,512,919.90	2,488,994.60	2,950,873.16	7,671,948.40	11,443,060.03	5,615,767.83	1,775,033.57	5,287,981.84
2045		17,463,382.80	12,557,136.95	8,754,262.97	3,511,863.33	2,486,958.59	2,950,530.61	7,675,108.86	11,438,348.78	5,604,076.91	1,774,499.73	5,295,314.54
2046		17,465,544.26	12,567,530.49	8,765,244.28	3,515,027.13	2,484,985.98	2,948,227.14	7,680,589.38	11,442,197.60	5,605,743.86	1,775,512.30	5,294,289.47
2047		17,474,754.62	12,549,635.88	8,763,718.92	3,514,916.23	2,487,740.69	2,948,157.60	7,672,927.46	11,446,194.67	5,600,448.76	1,775,739.62	5,292,422.20
2048		17,466,172.83	12,563,643.90	8,766,049.85	3,515,401.41	2,488,838.29	2,949,430.04	7,682,787.66	11,432,376.19	5,614,074.69	1,775,792.07	5,292,141.60
2049	average profit	17,471,357.65	12,556,094.19	8,760,358.63	3,514,335.47	2,487,290.79	2,948,610.63	7,676,839.42	11,438,253.04	5,607,897.24	1,775,254.67	5,290,471.96
2050	total average profit	282,608,737.28										

Table 16 The Profit of the CDC Mode

Table 16 shows the ultimate profit of the CDC mode. These 1,000 profits are given by revenue minus 1,000 delivery costs minus warehouse costs. The revenue is expressed as selling price multiplies demands, where the selling price ($ 23.4) is assumed as FOB (free on board) price ($ 18) multiplies a 30% margin. To be comparable with the RDC mode, we simply take the means of profits created by each demand city, and plus them to gain the total profit, which is $ 282,608,737.28.

4.3.2 Profit of the RDC Mode

	A	B	C	D	E	F	G	H	I	J	K	L	M	BR	BS
1	haulage rate ($/t·km)	0.08													
2		Tianjin as RDC													
3		Beijing		Tianjin		Shijiazhuang		Taiyuan		Hohhot		Lanzhou		Kunming	
4	city land area (km^2)	16,412		11,903		14,530		6,909		17,344		13,083		21,473	
5	city radius (km)	72.28		61.55		68.01		46.90		74.30		64.53		82.67	
6	weight of parcels (t)	3,373.90		2,419.83		1,691.05		680.73		484.13		579.69		1,054.28	
7	City center distance (km)	130		0		311		508		604		1,507		1,344	
8			Delivery cost		Delivery cost		Delivery cost		Delivery cost		Delivery cost				
9	Distance between	152.27	43,096.10	46.83	9,505.27	296.84	42,109.30	549.22	31,363.48	620.43	25,197.30	1,540.56	74,915.30	1,324.40	117,131.20
10	warehouse and	123.63	34,991.63	47.51	9,643.97	257.52	36,530.84	524.03	29,924.52	536.56	21,791.02	1,545.43	75,152.16	1,363.77	120,612.53
11	demand points (km)	169.11	47,862.32	45.78	9,292.68	322.91	45,807.87	507.52	28,982.00	627.61	25,488.82	1,507.89	73,326.77	1,391.22	123,040.41
1004		114.44	32,391.09	7.06	1,432.55	356.63	50,590.49	486.23	27,765.92	605.34	24,584.28	1,532.43	74,520.17	1,419.34	125,527.66
1005		142.00	40,189.51	3.73	758.11	348.88	49,491.54	497.43	28,406.01	659.37	26,778.72	1,569.51	76,323.11	1,425.95	126,112.24
1006		201.02	56,894.26	38.43	7,800.91	363.69	51,592.08	491.84	28,086.30	564.59	22,929.28	1,569.22	76,308.91	1,297.50	114,751.49
1007		86.29	24,421.85	10.70	2,172.89	251.73	35,710.25	503.99	28,780.16	630.36	25,600.45	1,494.72	72,686.40	1,302.08	115,157.23
1008		82.09	23,234.64	16.51	3,350.59	303.99	43,123.08	482.46	27,551.13	570.02	23,150.10	1,502.07	73,043.63	1,391.87	123,098.29
1009		Beijing	Tianjin	Shijiazhua	Taiyuan	Hohhot	Jinan	Zhengzhou	Wuhan	Chongqing	Chengdu	Xian	Lanzhou		
1010	Mean transit distance	132.82	30.85	310.23	507.01	603.96	323.68	679.50	1,116.54	1,765.84	1,819.46	1,091.61	1,507.94		
1011	Mean delivery cost	37,590.74	6,261.96	44,009.17	28,952.93	24,528.52	30,898.15	87,543.16	158,579.32	708,024.31	380,632.03	136,875.08	73,328.92		

Table 17 Delivery Costs by Simulation in the RDC Mode

Like Table 15, Table 17 gives the 1,000 simulated distances and the corresponding 1,000 transportation and delivery costs from each RDC to its allocated demand cities as decided in Section 4.2. The equations to generate these results are again similar and can be found in Chapter 3.

	A	B	C	D	E	F	G	H	AG	AH	AI	AJ
1049	Profit	17,571,733.98	12,635,479.40	8,792,394.75	3,524,294.75	2,501,164.51	2,952,467.64	1,859,656.63	11,695,018.96	5,728,529.28	1,816,471.11	5,357,283.24
1050		17,578,537.52	12,638,427.83	8,789,664.59	3,524,262.38	2,503,825.49	2,952,133.96	1,859,365.59	11,696,154.82	5,722,050.66	1,815,878.88	5,362,833.08
1051		17,576,387.36	12,636,705.86	8,786,844.80	3,528,052.20	2,504,566.17	2,954,354.04	1,860,449.11	11,700,171.56	5,726,324.86	1,817,025.53	5,358,804.02
1052		17,577,230.66	12,637,238.25	8,784,879.39	3,524,487.82	2,501,606.97	2,955,821.25	1,860,017.24	11,697,652.22	5,717,882.00	1,816,085.74	5,351,592.95
2045		17,578,371.64	12,636,894.63	8,779,632.52	3,527,827.78	2,502,278.96	2,951,867.98	1,858,671.66	11,700,992.28	5,716,568.04	1,817,265.81	5,358,311.20
2046		17,602,654.85	12,629,229.55	8,788,976.78	3,524,808.14	2,504,407.25	2,951,626.02	1,858,168.44	11,702,046.54	5,727,280.68	1,816,892.96	5,353,625.56
2047		17,576,067.47	12,633,308.80	8,791,626.13	3,523,891.20	2,503,538.60	2,952,225.10	1,860,856.29	11,698,655.56	5,724,606.57	1,817,079.59	5,359,871.95
2048		17,578,406.34	12,626,953.32	8,783,973.78	3,525,115.32	2,506,860.50	2,955,255.11	1,858,744.01	11,698,559.15	5,719,328.91	1,816,900.88	5,349,981.22
2049	average profit	17,584,329.68	12,632,511.88	8,788,467.59	3,526,426.25	2,503,974.86	2,954,441.20	1,859,500.43	11,697,835.00	5,721,835.75	1,816,477.88	5,356,219.40
2050	total average profit	284,821,773.11										

Table 18 The Profit of the CDC Mode

Table 18 shows the ultimate profit of the RDC mode. In this case, the total profit is $ 284,821,773.11, $ 2.21 million (or 1%) higher than the CDC mode. Hence, the RDC mode should be employed as the optimal solution.

Chapter 5 Verification and Short Introduction of Supply Cities

In this chapter, we will use a statistical analysis tool (t-test) to verify the results and conclusion obtaining in Chapter 4, in case of any occurrence. Then some basic information about the selected supply cities will be listed to support the conclusion.

5.1 Verification

From Chapter 3, it is clear that if the generated t value is higher than the critical value listed in the "Critical Values of the Student t Distribution" table (see Annex 4) with a given significance level α, there is (1- α) possibility that the significant differences between two samples exist. In Excel, these two values are replaced by "t Stat" and "t Critical two-tail", respectively.

	A	B	C	D	E	F	G	H
1	Total Profit of RDC	284,870,375.24		Total Profit of CDC	282,561,136.06			
2		284,863,242.45			282,666,095.96			
3		284,810,871.93			282,533,538.64			
4		284,844,821.09			282,643,945.77			
998		284,816,763.70			282,547,141.22			
999		284,845,560.76	average profit		282,641,261.03	average profit	deifference of average profits	
1000		284,742,762.65	284,821,773.11		282,615,745.67	282,608,737.28	2,213,035.83	
1001	μ_1: RDC and CDC have similar profits. μ_2: RDC and CDC have different profits.							
1002	H0: $\mu_1 - \mu_2 = 0$	H1: $\mu_1 - \mu_2 \neq 0$						
1003		t-Test: Two-Sample Assuming Equal Variances			$\alpha = 0.05$			
1004								
1005			*Variable 1*	*Variable 2*				
1006		Mean	284821773.1	282608737.3				
1007		Variance	2226581359	2175649994				
1008		Observations	1000	1000				
1009		Pooled Variance	2201115676					
1010		Hypothesized Mean Difference	0					
1011		df	1998					
1012		t Stat	1054.756025					
1013		P(T<=t) one-tail	0					
1014		t Critical one-tail	1.64561663					
1015		P(T<=t) two-tail	0					
1016		t Critical two-tail	1.961152015					

Table 19 Result of T-Test

The results of t-test are illustrated in Table 19. By examining the 1,000 profits (based on 1,000 simulated delivery costs), the t Stat value is much higher than t Critical two-tail value, confirming the conclusion in Chapter 4. We reject H0 in favor of H1, that is, there is a 95% chance that the profit of CDC differs from its counterpart.

5.2 Introduction of Supply Cities

According to World Shipping Council (2019), Ningbo – Zhoushan Port, Guangzhou Port, Qingdao, Tianjin, Xiamen and Dalian rank as 4th, 5th, 8th, 9th, 15th and 16th in the world respectively, regarding to the container volumes. Ningbo Port and Zhoushan Port are investigated for these two ports are integrated ever since 2015, following the example of New York – Newark Port (Notteboom T & Yang Z, 2016). Top rankings reflect that these supply cities hold both enough handling capacity and advanced cargo distribution and transportation network, whose details are listed as below:

As a major gateway of North East China and an ice-free port, Dalian carries more than 90% of container cargo and more than 70% of bulk cargo of this area, containing crude oil, log, coal, steel, project and agriculture products (Cai L, 2012). With 199 berths in production (56 out of which can contain vessels larger than 10,000 deadweight), port of Dalian connects with over 300 ports in around 160 countries. By Harbin – Dalian Highway, Hegang – Dalian Highway and Shenyang – Dalian Highway, port of Dalian is permitted to extend its service range (Yu S, 2012).

Tianjin is a traditional economic center of North China. Dredged to 22 meters in depth, the main channel can accommodate vessels up to 300,000 deadweight at high tide. Port of Tianjin owns 160 berths, operating containers, LNG, cruise and ro-ro cargo, etc. Besides, Tianjin has launched its dry port model with inland cities, such as Hohhot, Yinchuan, Taiyuan and Shijiazhuang. Port of Tianjin has established a complete highway network, which includes ten highways to link major cities all around China. Now Tianjin lies on 6 railways, but rail transportation only accounts for 3% of inbound and outbound flows, compared to 80% of road (Wu Z, 2017).

Port of Qingdao owns 90 berths and serves 8.8 million TEU at most annually. Separated to 4 port areas by functions (e.g. Dagang Port Area handles mainly agriculture products and fertilizer, while Huangdao Oil Port Area focuses on chemicals), port of Qingdao guarantees specialization. The port areas are easily accessible to 3 highways and 5 railways, which forms a complete transportation network. It should be highlighted that Qingdao has been constructing a smart logistics program, a platform based on sharing transportation information and intensive coordination, in order to improve truck load efficiency and management of empty containers (Mei Y, 2017).

Combined b two ports, Ningbo – Zhoushan Port contains 19 port areas and 723 berths. It has formed an advantage on some domestic trade routes (like Xiamen) and short – middle distance trade routes (like Australia). On inland transportation, Ningbo has operated a sea – rail intermodal transportation project to Europe via Yiwu, a well-known small commodity trade market center since 2009 (Zhao X, 2018). While Zhoushan is approved by the State Council to be the sea – river transport service center, an unprecedented boom of the bulk commodity trade appeared, especially the scale of futures ranks as the 7th in the nation (Xue S & Gong X, 2017).

Xiamen is in the middle of two so-called “first-tier cities”: Shanghai and Guangzhou. With 165 berths in production, port of Xiamen seems to be a “small” size in China. However, as a popular tourism destination, the port of Xiamen can cater for large size cruises and received 19 million of passengers in 2016 alone (Lin Y, 2017). Restricted by mountainous neighboring economic hinterland and lacking connection between port areas and Xiamen city, port of Xiamen relies a quarter of cargo transportation on water, a relatively high ratio compared to other Chinese ports. In this case, other ports in this region, like the port of Fuzhou and the port of Shantou, gradually become the feeder ports of Xiamen (Yang A, 2016). It is convincible that local governments will invest more on water transportation soon.

As a traditional foreign trade hub, port of Guangzhou has an incredible number of berths (870 to be exactly). Now its old port has transferred to waterfront leisure industry, leaving new ports to handle containers and bulk cargo. Benefit from the region’s dense water network, port of Guangzhou has operated 150 barge routes, connecting itself and ports nearby. It also constructs roads away from Guangzhou city to alleviate the ports’ negative externalities. Port of Guangzhou values cooperation and extends its influence on western provinces, like Hunan and Yunnan railway express service, enhances the logistics path (Gan C, 2017).

Chapter 6 Strategies to A2 Company

In this chapter, we will put forward some suggestions for A2 company to set its warehouses based on results in Chapter 4 in the short term and macro-environment analysis as well as realistic factors in the long term.

6.1 Short Term Strategies

In the short run, the RDC mode project is more favorable and is selected. That is 6 cities are chosen as supply cities to feed 35 demand cities. The details are listed in the following table:

Supply Cities	Demand Cities
Dalian	Shenyang, Dalian, Changchun and Harbin
Tianjin	Beijing, Tianjin, Shijiazhuang, Taiyuan, Hohhot, Lanzhou, Xining, Yinchuan and Urumqi
Qingdao	Jinan, Qingdao, Zhengzhou, Chengdu and Xian
Ningbo	Shanghai, Nanjing, Hangzhou, Ningbo and Hefei
Xiamen	Fuzhou, Xiamen, Nanchang, Wuhan, Changsha, Shenzhen, Chongqing and Guiyang
Guangzhou	Guangzhou, Nanning, Haikou and Kunming

Table 20 Supply Chain Network

6.2 Long Term Strategies

In the long run, some macro factors and trends should be considered. Because these factors may cause changes to demand, supply capacity and competition situations. Some key factors are identified in the following text:

6.2.1 Customs Duty

China used to impose 20% import customs duty on baby milk powder, however, in 2017, the Ministry of Finance announced that the rate would be cancelled for three categories of milk powders, including fully hydrolyzed milk formulas, amino acid milk formulas and lactose-free milk formulas (Scattergood G). Other infant food will also enjoy some cut off on import tariff rates.

Another issue related to customs duty is the Bonded Area (also known as Tariff-Free Zone) in some logistics nodes and Integrated Free Trade Zone where some favorable duty policies and simplified proceedings are employed (Pfaar M & Wang X, 2011). There are plenty of these areas in China, including Meishan Port Area of Ningbo, Binhai Port Area of Tianjin and Huangdao Port Area of Qingdao.

In the foreseeable future, the gap of prices between foreign milk powder and home milk powder will be narrowed and thus A2 is expected to confront less fierce competition. It should consider constructing its factories in Ningbo, Tianjin and Qingdao bonded areas, or expand the warehouse sizes in the long run.

6.2.2 Reproduction Policy

Considering the national total fertility rate was 1.6 babies per women of childbearing age in 2017, 0.5 baby less than the normal rate to maintain a steady population size, relaxations of the One Child Policy were enacted these years in different forms to encourage couples bearing (Westcott B, 2018). However, it seems that this stimulus fails to save the descending fertility rate as it was expected: the newborn population in 2018 was 2.63 million and 2 million less than that of 2016 and 2017, respectively. The birth rate in 2018 was 1.09%, the lowest rate since 1978 (Statistics Bureau of

The People's Republic of China, 2019).

The dynamically growing living expenses should be blamed for the result that deviated from the policy-makers' outlook. In urban areas, young couples are struggling to pay monthly loan of apartment and expensive education fees for their children, and thus reluctant to have more than one baby. Another explanation is like what happens in the developed countries, people tend not to bear children as their education level and life quality get improved.

However, this does not necessarily mean the demand for baby milk powder will shrink dramatically or the prospect of this industry will be pessimistic. For one thing, due to its large population base, the decreasing birth rate will bring numerous babies every year. For another, as parents prefer only one child, they are willing to invest more resources, like milk powder and other maternal and child products. Overshadowed the 2008 milk scandal where illegal traders adulterated melamine, a chemical that can cause kidney stones and even cancer, the middle-class distrust national brand and prefer foreign brand milk powder on a whole. Given these considerations, the market share of A2 is less likely to fluctuate sharply.

Hence, it is not wise to cut in the expectation of demand significantly. Plus, as the warehouses are rented, allowing the company more flexibility to adjust the production scale in a dynamic environment. Besides, A2 can implement a diverse product strategy by introducing complements of milk powder, like nursing bottles. To offer binding commodities, customer utility will be enhanced.

6.2.3 Economic Transport Distance

In this thesis, road transportation is assumed to be the transportation and delivery solution between each origin and destination. However, in the reality, road transport is not selected in each case because the operation cost will climb tremendously as the distance grows. Although the accurate value is a dispute, the economic range of road transport is generally below 500 or 600 km (Pienaar W, 2013). Carrying products from Tianjin to Xining (1703 km) or from Xiamen to Guiyang (1485 km), etc. by haulage industry is not an ideal plan.

Instead, there are two possible alternatives. One is rail transport, the most commonly seen mode of transportation for both passengers and cargo in China. According to National Railway Ministry of People's Republic of China (2018), in 2017, the total amount of cargo conveyed by railway was 3.69 billion tons while the total turnover was 2.70 trillion ton-km. Thereby, the average transport distance was $2700/3.69 = 731.70\ \text{km}$. Under China's present railway administration system, railways can be divided into three major categories: national railways, regional railways and private railways. As the term suggests, regional railways usually serve habitants and local enterprises of a certain area. Restricted by capital and risk-taking capability, private investors generally manage rather short railways. In other words, the connections of major cities in this thesis should be implemented by national railways. Again, by the National Railway Ministry, the total amount of cargo conveyed by national railway was 2.92 billion tons and the total turnover of national railway was 2.41 trillion ton-km. Hence, the average transport distance of national railway was $2410/2.92 = 825.34\ \text{km}$. The results illustrate that middle transport distances around 600 to 1000 km (e.g. Dalian to Harbin 937 km) can be carried out by railway.

As for values much higher than 1000 km, another means shall be applied: introduction of inland hubs. Although some cities do not own seaports, they are directly connected by convenient water, road, air and railway transport. These cities are traditional commerce and transport nodes in an area, and they have interests in dry ports as well as other policies to simplify customs proceedings. For instance, Wuhan is the center of Middle China by its economy and location. It stands near to Yangtze River, which flows through Chongqing, Nanjing and Shanghai. Plus, Wuhan lies on the Shanghai-Chengdu Railway / Highway and Beijing-Guangzhou Railway / Highway, making it a “thoroughfare to nine provinces”. Another example is Xian, which is the node of Beijing-Baotou (an industrial city in Inner Mongolia, the destination of the route from Beijing to Hohhot direction)-Chengdu-Kunming Railway / Highway and Urumqi-Lanzhou-Lianyungang (a port city between Shanghai and Qingdao) Railway / Highway. These inland hubs will shorten transportation and delivery distances as well as lead time.

Yet, some extreme values remain. Take Urumqi as an example, the nearest selected city to it is over 2000 km. Considering these cities are mainly in the vast under-developed west area, A2 may pick up some of these cities who have relatively high demand and rent warehouses there, and pay more attention to advanced east area. China is planning to forge 19 city clusters, only five of which are in the west area. Hence, A2 company can invest mainly in the clusters in the east and middle area as a long-term plan. Three of these city clusters are especially remarkable and worthwhile considering on the top of the agenda, whose names are “Beijing-Tianjin-Hebei City Cluster” (also known as “Circum-Bohai-Sea City Cluster”), “The Yangtze River Delta City Cluster” and “The Pearl River Delta City Cluster” (Preen M, 2018). In these clusters, the organization form is one mega city, several large cities and multiple middle and small sized cities. These cities are economically tightly connected, highly integrated, developing division of industries, and having interplay among transportation, urban planning and infrastructure. Combined with the fact that each city has abundant people with the median and high level of consumption power, A2 should transfer its business to these areas gradually.

Chapter 7 Limitations and Suggestions

In this chapter, we will discuss the limitations of this thesis and therefore some suggestions for future research. While the results that may differ from facts are described as limitations, the suggestions are mainly designed for the scholars for future research.

7.1 Limitations

Although this paper has taken some reasonable assumptions based on the links among economic variables and industrial standards, and various alternative methods drawing core ideas previous researchers to guarantee rigor, the distortions of results are bound to exist because most of the data derived in this paper are generated by manual methods rather than collected in field.

The main challenge of this thesis is the lack of decision data, containing demand and rates, which explains the inapplicability of previous researchers' methods. The situations for these researchers are either to improve or design a supply chain network given clear amount of demand, supply cities, demand cities and cost rates; whereas the aim of this thesis is to design a supply chain network for a company that has not entered China's market and thus have no retail data or cost data. Although these data are generated by reasonable methods (forecasting milk powder demand by 0 – 4 years old children, estimating wage rates by GDP per capita and predicating transport and delivery distances by simulation), the results are not necessarily accurate and may cause deviations on the conclusion. This is because the lack of evidence that shows the linear relation between demand and population. Plus, the criterion to price the transport costs can be revised. Actually, the unitary national haulage rate does not exist; instead, the rates depend on the level of highways and regional tax policies. The assumption that the transport and delivery costs change proportionately with distances is to some extent doubtful, for the rule of so-called "diminishing freight rate by increasing distance" where freight companies tend to charge less unit freight rate as the distance climbs to encourage moderate long-distance shipments as the fixed operation fees at terminals can be shared in longer distance.

Another issue is that the model works mainly on a profit perspective and ignores the relation among lead time, retail price and demand. In practice, customers may purchase commodity from physical stores rather than place orders online, because the longer lead time will cause more uncertainty and affects customer experience. The retail price usually becomes higher if the distance is longer because of higher transport and delivery costs, which is also against the unified price in this paper.

Last but not the least, the model assumes the demand and replenishment are steady but in reality, there are always peak seasons and slack seasons. Hence, the size of warehouse and labor hours shall change accordingly. Besides, time and frequency needed for the logistics processes (including sailing days and dispatch interval, handling, inland transport, etc.) may vary from city to city, which leads to the risks of out of stock or overstock and hence causes variations on warehouse costs.

7.2 Future Research

Suggestions for future research are given to overcome the limitations in the last section and hopefully find results more meaningful as reference to the reality.

Firstly, the relation between demand and other factors should be tested. Data from another segment of FMCG can be used to examine the relationship among demand, population (or families) and lead time and then be taken for milk powder industry. Multiple regression model is the most commonly applied method to calculate and verify the relationship. As for the authentic haulage rates, a survey on basic rates and additional rates (e.g. road toll, fuel surcharge, etc.) should be launched.

Considering the large number of samples, this work will be complicated and nearly impossible to carry out in short time. Hence, the scope can be narrowed down. As what is explained in the above-mentioned text, the designated research region can be Beijing-Tianjin-Hebei City Cluster, The Yangtze River Delta City Cluster or The Pearl River Delta City Cluster. Because in these areas, cities are concentrated and highly connected, with exuberant demand. Plus, investors and scholars pay close attention to these areas, causing it easier to collect data.

Another suggestion is to perfect the model by taking stock alternation factor into account. This will rely on some techniques of lean manufacturing and inventory management, after gathering the data of demand variation and logistics processes. Again, these data can be from a similar company or industry and the time series model can be referred to for predication.

Chapter 8 Conclusion

In this chapter, we will summarize the logic of this thesis and the main results as well as the strategies for the research subject (A2 milk powder company). Except for some limitations, this paper as a whole answers the research questions and is beneficial for the company's investment decision.

The research objective of this thesis is to design a supply chain network for A2 company to undertake its milk powder business in China. As it is the first time for the company to enter China's market, there are no data for sales volume or distinct location for warehouses or demand cities. Hence, the methods provided by former researchers that require actual data cannot be directly employed. Instead, the linear programming model is built considering the variables involved in this paper and data are converted from macro indices. By learning the current overseas warehouse solutions for cross-border e-commerce, the plan is to be carried out by renting warehouses rather than a third-party plan, which leaves a question on the number, location and distribution plan of the warehouse. In other words, the core is to select from either central distribution center (CDC) mode or regional distribution center (RDC) mode, after comparing the profit of each one. To choose the location of markets and warehouses, there are 35 cities selected as demand cities and 8 cities as candidate supply cities based on the political and geographical factors; to finalize the optimal number and distribution plan, the 0 – 1 integer programming is applied as the profit model.

The profit model is built as the difference of revenue and costs where the former is defined as the product of a unitary selling price and selling volume (which is regarded to be the amount of consumption demand) whereas the latter contains transportation and delivery cost (product of a unitary haulage rate, weight of cargo and distance), and warehouse costs (including rental cost and labor cost), which are all linked to consumption demand. The demand is assumed to be proportionally decided by the number of 0 – 4 years old children of each city, and thus the values of revenue and costs can be calculated. By substituting these data which are from market, industrial standard, converted from relative macro-economic data or simulation, the profits of each mode can be found and compared, and then the verification of simulation results is introduced in case of accidental errors.

The main results of this paper are supply cities and their distribution plan, the profit of each warehouse mode and verification outcome. By applying the 0 – 1 integer programming, 6 cities are finalized as the supply cities because of the lowest total cost, together with their corresponding delivery cities in the RDC mode (goods carried from Dalian, Shenyang, Changchun and Harbin; Tianjin to Tianjin, Beijing, Shijiazhuang, Hohhot, Taiyuan, Lanzhou, Xining, Yinchuan and Urumqi; Qingdao to Qingdao, Zhengzhou, Jinan, Xian and Chengdu; Ningbo to Ningbo, Shanghai, Nanjing, Hangzhou and Hefei; Xiamen to Xiamen, Fuzhou, Nanchang, Wuhan, Changsha, Shenzhen, Chongqing and Guiyang; Guangzhou to Guangzhou, Nanning, Haikou and Kunming) and Qingdao is selected to supply all the demand points in the CDC mode. Since each demand city has plenty of end users randomly distributed, the simulation is introduced to estimate the corresponding delivery distances and thus transportation and delivery costs. In this way, the according profits can be generated. After comparison, the RDC mode is around 1% more profitable than the CDC mode, which means the optimal plan for the company is to rent 6 warehouses and distribute goods as above-mentioned.

By comparing the means of two data sets, t-test is used in this paper to verify the existence of significant differences of two modes, or the reliability of results. The outcome of t value is 1054.76, much higher than its threshold value (1.96), which ultimately confirms the conclusion.

In the last part, some additional strategies are given for reference of long-term plan, combined with realistic situation and tendency of the macro environment. These strategies mainly suggest constructing plants in bonded areas to avoid some taxes and make better use of the ports and facilities, employing diverse products to confront a fiercer competitive environment and renting extra warehouses in major inland logistics hubs for both quick response and follow the economic transport distance rule.

Reference

Anderson D, Sweeney D, Williams T, Camm J & Martin K, 2012. “An Introduction to Management Science: Quantitative Approaches to Decision Making”. Chapter 7, “Integer Linear Programming”. South-Western Cengage Learning Press, Mason, USA

Ang T, 2018. “China’s FMCG Market: Latest Trends and the Role of Technology”. China Economic Review, May 2018

Ballou R, 2004. “Business Logistics Management”. Chapter 1, “Business Logistics Management – a Crucial Subject”. Pearson Higher Education, New York, USA

Bienstock C, Royne M, Sherrell D, & Stafford T, 2007. “An Expanded Model of Logistics Service Quality: Incorporating Logistics Information Technology”. International Journal of Production Economics, Volume 113, Issue 1: 205-222

Bratley P, Fox B & Schrage L, 2011. “A Guide to Simulation”. Chapter 1, “Introduction”. Springer Science & Business Media. Composition House Ltd., Salisbury, England

Cai L, 2012. “Current Situation and Strategy Research of Dalian Port”. Commodity and Quality, Issue 7

Chaizang News, 2018. “Comparation of Economic Data for Four Provinces’ Capital Cities: Jinan, Hefei, Fuzhou and Changchun”. Retrieved from http://www.twoeggz.com/news/12525318.html

Cheng S, 2016. “Fuzhou Electric Business Logistics "the Last Kilometer" Problem Research – Based on the Perspective of Government Function”. Master Thesis, Fujian Agriculture and Forestry University, Fuzhou, China

China Internet Network Information Center, 2019. “The 43rd Statistical Report on the Development of China's Internet Network”. Retrieved from http://www.cac.gov.cn/2019-02/28/c_1124175677.htm

Chu L, Tian Z, Xie X, 2004. “Application of a Combination Forecasting Model in Logistics Demand”. Journal of Dalian Maritime University, Volume 39, Issue 4: 43 – 46

Dalkey C, 1969. “THE DELPHI METHOD: AN EXPERIMENTAL STUDY OF GROUP OPINION”. Rand Corporation, Retrieved from https://apps.dtic.mil/docs/citations/AD0690498

Drucker P, 1962. “The Economy's Dark Continent.” Fortune, April 1962, pp 103

Fang W, Xiao H & Ren X, 2009. “Logistics Demand Forecast Based on Linear Regression Model”. Research of Productivity, No. 12: 94 – 96, 110

Gan C, 2017. “Belt and Road Initiative" background of Guangzhou port development orientation research”. Master thesis, South China University of Technology, Guangzhou, China

Giovanis A, Tomaras P, & Zondiros D. “Suppliers Logistics Service Quality Performance and its Effect on Retailers’ Behavioral Intentions”. Procedia - Social and Behavioral Sciences, Volume 73: 302 – 309

Grönroos C, 1982. “An Applied Service Marketing Theory”. European Journal of Marketing, Volume 16, No. 7: 30-41

Heim G and Field J, 2007. “Process Drivers of E-Service Quality: Analysis of Data from an Online Rating Site”. Journal of Operations Management, Volume 25, Issue 5: 962-984

Hong F, Shi M, Xiao F, Dong F & Zhang Y, 2018. “Research on Seasonal Adjustment

Hu H, 1935. “Distribution of China's Population”. Journal of Geography, Issue 2

Huang X, Xiong H, Qiu A & Li H, 2011. “Prediction Model of Inventory Demand for Regional Logistics Network with Multi-distribution Centers”. Industrial Engineering Journal, Volume 14, No. 1: 83 – 86, 109

Intelligent Optimization of Inventory of Electric Power Materials”. Management Science and Engineering, Volume 7, Issue 4: 262 – 266

Jiang C & Chen D, 2009. “Research on Urban Logistics Infrastructure: An Empirical Study of China”. Journal of Science and Management, Volume 2: 80 – 91

Jin S, 2017. “E-commerce Logistics Service Customer Satisfaction Evaluation of G Company”. Master Thesis, Beijing Jiaotong University, Beijing, China

Kayikci Y, 2019. “Advanced Methodologies and Technologies in Business Operations and Management”. Chapter 7, “E-Commerce in Logistics and Supply Chain Management”. IGI Global, Hershey,USA

Keller G, 2014. “Statistics for Management and Economics”. Chapter 12, “Inference about a Population”. Cengage Learning Press, Stamford, USA

Lee H & Whang S, 2001. “Winning the Last Mile of E-Commerce”. MIT Sloan Management Review, Volume 42, Issue 4

Li H, Li L, Wu B & Xiong Y, 2012. “The End of Cheap Chinese Labor”. Journal of Economic Perspectives, Volume 26: 57–74

Li J & Sun L, 2011. “Demand Forecast of the Cold Chain Logistics Based on the Multiple Linear Regression Analysis”. Journal of Anhui Agri, Volume 39, Issue 11: 6519 – 6520, 6523

Li Y & Xie H, (2006). “Study on the Method of Distribution Center Location Based on GIS”. Logistics Technique, Volume 29: 53 – 56

Li Y, 2017. “A New Model of Cross-border Logistics – Research on Site Selection of Warehouses”. Master Thesis, Zhejiang University, Hangzhou, China

Lin Y, 2017. “Study on the Interaction Development of Xiamen Port and City Based on System Dynamics”. Master thesis, Jimei University, Xiamen, China

Liu B & Yang M, 2009. “Development of Urban Logistics Park Demand Forecasting Model Based on System Dynamics”. Urban Transport of China, Volume 7, No. 5: 21 – 26

Liu Z, 2015. “Research on the Development Status and Promotion Strategies of Cross-Border Mother-to-Child E-commerce”. Master Thesis, Beijing Institute of Fashion Technology, Beijing, China

Mei Y, 2017. “Research on the Construction of Intelligent Dispatching Platform for Qingdao Port Based on the Belt and Road Strategy”. Journal of Zhejiang Institute of Communications, Volume 18: 40 – 45

Mentzer J & Roger G, 1989. “Physical Distribution Service: A Fundamental Marketing Concept?”. Journal of the Academy of Marketing Science, Volume 17, Issue 1: 53 – 62

Mickus K, 1980. “Gravity Method”. Geophysics, Volume 45, Issue 11

Murphy P and Wood D, 2009. “Contemporary Logistics”. Chapter 1, “An Overview of Logistics”. Prentice Hall Press, Upper Saddle River, New Jersey, USA

National Railway Ministry of People’s Republic of China, 2018. “2017 Railway Statistics Bulletin”. Retrieved from http://www.nra.gov.cn/xwzx/zlzx/hytj/201804/t20180412_55248.shtml

Nolan B, Roser M & Thewissen S, 2016. “GDP per Capita versus Median Household Income: what Gives Rise to Divergence over Time”. INET Oxford Working Paper no.2016-03, University of Oxford

Notteboom T & Yang Z, 2016. “Port Governance in China since 2004: Institutional Layering and the Growing Impact of Broader Policies”

Pfaar M & Wang X, 2011. “Chinese Bonded Areas: Choosing the Right Location”. Ernst & Young

Pienaar W, 2013. “Comparative Econmic Efficiency, Operating Costs and Fuel Consumption Rates of Freight Transport Modes Between the Largest Industrial Cities and Seaports in South Africa”. Risk Governance & Control: Financial Markets & Institutions, Volume 3, Issue 3

Preen M, 2018. “China’s City Clusters: The Plan to Develop 19 Super-regions”. China Briefing, August 14th, 2018

Scattergood G, 2017. “China Slashes Import Tax on Special Infant Formulas and a Raft of Food Products”. NutraIngredients-Asia, November 27th, 2017

Shakya S & McCall J, 2007. “Optimization by Estimation of Distribution with DEUM Framework Based on Markov Random Fields”. International Journal of Automation and Computing, Volume 4: 262-272

Statistics Bureau of People’s Republic of China, 2019. “Statistical Yearbook 2018”. Retrieved from http://www.stats.gov.cn/tjsj/ndsj/2018/indexeh.htm

Sudalaimuthu S and Raj S, 2009. “Logistics Management for International Business: Text and Cases”. Chapter 1, “Introduction”. PHI Learning Private Limited, New Delhi, India

Tian X, Niu P & Wang C, 2016. “A Survey on Customer Satisfaction on Imported Cross-Border E-Commerce”. China’s Market, Volume 49: 12 – 14

Weise K, 2019. “Amazon Gives Up on Chinese Domestic Shopping Business”. The New York Times, April 18th, 2019

Wernau J & Kubota Y, 2019. “Amazon’s E-Commerce Adventure in China Proved Too Much of a Jungle”. The Wall Street Journal, April 18th, 2019

Westcott B, 2018. “China Moves to End Two-Child Limit, Finishing Decades of Family Planning”. CNN News, August 29th, 2018

World Population Review, 2019. “Population of Cities in China (2019)”. Retrieved from http://worldpopulationreview.com/countries/china-population/cities/

World Shipping Council, 2019. “Top 50 World Container Ports”. Retrieved from http://www.worldshipping.org/about-the-industry/global-trade/top-50-world-container-ports

Wu Z, 2017. “Analysis and Evaluation of the Collecting and Distributing System Container Port in Tianjin Port”. Master thesis, Dalian Maritime University, Dalian, China

Xue S & Gong X, 2017. “How to Overcome the Development Bottleneck of Shipping Soft Power of Ningbo – Zhoushan Port”. China Ports, Issue 2

Yan J, 2011. “Application of Logistics Demand Forecasting Based on Grey Neural Network”. Computer Simulation, Volume 28, Issue 7: 200 – 203

Yang A, 2016. “Research on the Container Collection and Distribution System of Xiamen Port”. Logistics Sci-Tech, Issue 2

Yu S, 2012. “Dalian Port Container Inland Transportation Network Optimization Research”. Master thesis, Dalian Maritime University, Dalian, China

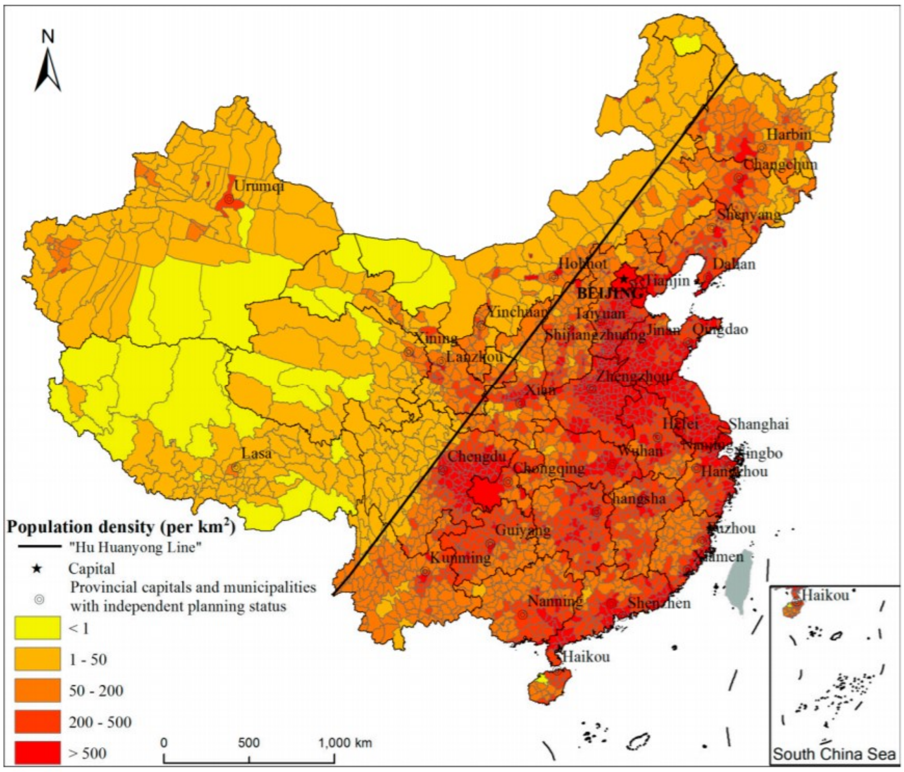
Zang H, 2009. “Research on Location Problems of Enterprise Regional Distribution Centre Based on Qualitative and Quantitative Method”. Master Thesis, Tianjin University, Tianjin, China

Zhao X, 2018. “Research on Evaluation of Ningbo – Zhoushan Port Container Sea-Rail Intermodal Transportation Network”. Master thesis, Zhejiang Ocean University, Zhoushan, China

Zhu J, 2017. “Research on the Location Strategy of Overseas Warehouse of Cross - border Electronic Commerce”. Master Thesis, Guangdong University of Technology, Guangdong, China

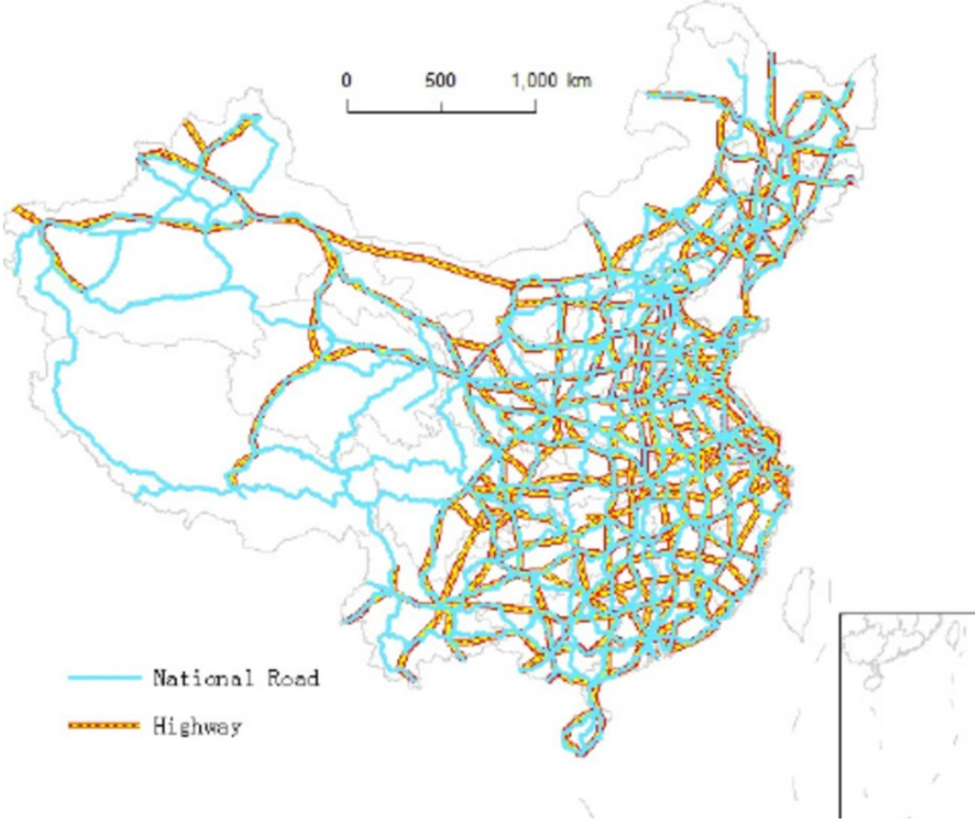
Appendix

Annex 1 China's Population Density and Major Cities Graph



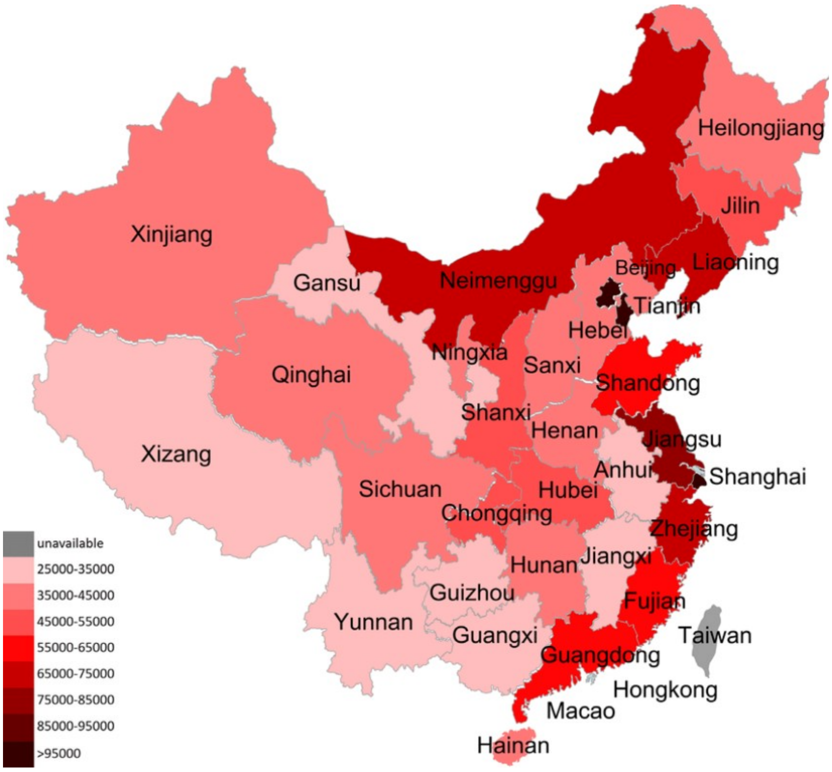
Source: Li M et al, 2018. Study on Population Distribution Pattern at the County Level of China

Annex 2 China's National *Road and Highway*



Source: Wang Z, 2014. Analysis of the Tourism Locations of Chinese Provinces and Autonomous Regions: An Analysis Based on Cities

Annex 3 China's GDP per Capita (Provincial Level) in 2014



Source: Wang Y et al, 2018. Hospitalisation Cost Analysis on Hip Fracture in China: A Multicentre Study among 73 Tertiary Hospitals

Annex 4 Critical Values of the Student t Distribution

Degrees of Freedom	$t_{.100}$	$t_{.050}$	$t_{.025}$	$t_{.010}$	$t_{.005}$
1	3.078	6.314	12.706	31.821	63.657
2	1.886	2.920	4.303	6.965	9.925
3	1.638	2.353	3.182	4.541	5.841
4	1.533	2.132	2.776	3.747	4.604
5	1.476	2.015	2.571	3.365	4.032
6	1.440	1.943	2.447	3.143	3.707
7	1.415	1.895	2.365	2.998	3.499
8	1.397	1.860	2.306	2.896	3.355
9	1.383	1.833	2.262	2.821	3.250
10	1.372	1.812	2.228	2.764	3.169
11	1.363	1.796	2.201	2.718	3.106
12	1.356	1.782	2.179	2.681	3.055
13	1.350	1.771	2.160	2.650	3.012
14	1.345	1.761	2.145	2.624	2.977
15	1.341	1.753	2.131	2.602	2.947
16	1.337	1.746	2.120	2.583	2.921
17	1.333	1.740	2.110	2.567	2.898
18	1.330	1.734	2.101	2.552	2.878
19	1.328	1.729	2.093	2.539	2.861
20	1.325	1.725	2.086	2.528	2.845
21	1.323	1.721	2.080	2.518	2.831
22	1.321	1.717	2.074	2.508	2.819
23	1.319	1.714	2.069	2.500	2.807
24	1.318	1.711	2.064	2.492	2.797
25	1.316	1.708	2.060	2.485	2.787
26	1.315	1.706	2.056	2.479	2.779
27	1.314	1.703	2.052	2.473	2.771
28	1.313	1.701	2.048	2.467	2.763
29	1.311	1.699	2.045	2.462	2.756
30	1.310	1.697	2.042	2.457	2.750
35	1.306	1.690	2.030	2.438	2.724
40	1.303	1.684	2.021	2.423	2.704
45	1.301	1.679	2.014	2.412	2.690
50	1.299	1.676	2.009	2.403	2.678
55	1.297	1.673	2.004	2.396	2.668
60	1.296	1.671	2.000	2.390	2.660
65	1.295	1.669	1.997	2.385	2.654
70	1.294	1.667	1.994	2.381	2.648
75	1.293	1.665	1.992	2.377	2.643
80	1.292	1.664	1.990	2.374	2.639
85	1.292	1.663	1.988	2.371	2.635
90	1.291	1.662	1.987	2.368	2.632
95	1.291	1.661	1.985	2.366	2.629
100	1.290	1.660	1.984	2.364	2.626
110	1.289	1.659	1.982	2.361	2.621
120	1.289	1.658	1.980	2.358	2.617
130	1.288	1.657	1.978	2.355	2.614
140	1.288	1.656	1.977	2.353	2.611
150	1.287	1.655	1.976	2.351	2.609
160	1.287	1.654	1.975	2.350	2.607
170	1.287	1.654	1.974	2.348	2.605
180	1.286	1.653	1.973	2.347	2.603
190	1.286	1.653	1.973	2.346	2.602
200	1.286	1.653	1.972	2.345	2.601
∞	1.282	1.645	1.960	2.326	2.576

Source: Keller G, 2014. Statistics for Management and Economics