

# Study on Logistics Center Site Selection of Jilin Province

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**Abstract**—Based on the introduction of the concepts of logistics and logistics center, this paper analyzed the status and problems of Jilin Province's logistics center, and proposed the steps, principles and factors for site selection of logistics center. Then by listing and comparing nine kinds of logistics center site selection method, including Analytic Hierarchy Process, Cluster Algorithm, Genetic Algorithm, Weight Grade Method, P-Median Method, System Simulation Method, Fuzzy quality function method, Dijkstra Method, we chose the best site selection method, namely the center of gravity method. Finally, this paper found out the exact logistics center location of Jilin Province with the center of gravity method.

**Index Terms**—center of gravity method, logistics, logistics center, principles, site selection, steps

## I. INTRODUCTION

Logistics center occupies an important position in the logistics system, which plays a linking role. The upstream of logistics are the supply factories, and downstream are users. Modern logistics center plays an important part in the circulation community, and it is the support of the entire logistics network, which can not only optimize the logistics networks, but also link, coordinate, the logistics infrastructure of the whole society. The transit and distribution function of modern logistics center can enlarge the functions of logistics infrastructure, and effectively reduce logistics costs, improve the logistics situation, so as to improve logistics efficiency. In a sense, the lack of modern logistics center will inevitably lead to the waste of resources of regional infrastructure and other circulation elements. In other words, if the modern logistics center is not perfect, the infrastructure function will be seriously affected.

Site selection of logistics center means that in the economic areas where contain a number of supply points and demand points, choosing a good place to set up a logistics center planning process. Better logistics center

location solution can effectively save money, promote production and consumption of coordination and cooperation to ensure the balanced development of the logistics system. Therefore, a reasonable distribution center location is very important. And once selected, it will be a long operation, which is not only related to operating costs but also directly related to the level of logistics efficiency<sup>[1]</sup>.

The logistics center of Jilin province is a magnificent logistics infrastructure, which has a big impact on social economy. Reasonable site selection of logistics center can save costs effectively and guarantee the balance development of logistics system as well as reduce traffic congestions that appeared in many cities, so as to reduce the pollution to the environment. Thus, it will definitely promote the sustainable development of Jilin province. With the acceleration of the planning for logistics center in Jilin Province, a reasonable plan for the site selection of logistics center is an important topic.

## II. OVERVIEW OF LOGISTICS CENTER IN JILIN PROVINCE

### A. Logistics and Logistics Center

Originally, logistics is a military term, first used in the Napoleonic era, which was defined as "the art of moving armies and keeping them supplied". The term has become popular since the Gulf War of 1991; particularly since the publication in November, 1992 of an interview with William Pagonis, the general who had been in charge of logistics in that war. William Pagonis defines it as:

"the integration of transportation, supply, warehousing, maintenance, procurement, contracting and automation into a single function that ensures no sub optimization in any of those areas, to allow the overall accomplishment of a particular strategy, objective, or mission."

Later, in business field, a commonly used definition for logistics was given by the Council for Logistics Management (SCM):

"Logistics is that part of the supply chain process that plans, implements, and controls the efficient, effective forward and reverses flow and storage of goods, service, and related information between the point of origin and

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the point of consumption in order to meet customers' requirements."

So far, many definitions of logistics have been proposed. But a widely used definition of logistics is that: Logistics is the process of strategically managing the procurement, movement and storage of materials, parts and finished inventory (and the related information flows) through the organization and its marketing channels in such a way that current and future profitability are maximized through the cost-effective fulfillment of orders.

When the products are moved from the suppliers to users, we need a central location for a series of logistics management, or centralized or distributed, or storage, or flow, or the packaging or handling, the place is what we call the logistics center.

The definition of logistics center can be described like this: it is a workplace or an organization that deals with logistics activities, and it should meet the following requirements: a, mainly serve for the whole society; b, the logistics functions are sufficient; c, the information networks are perfect; d, the radiation ranges are wide; e, the variety is small and the batch is big; f, the capacity of storage is high; g, all the logistics activities are operated together. The site selection of logistics center is to choose a location in an economic area that contains several supply points and demand points<sup>[2]</sup>.

#### *B. The Status of the Logistics Center in Jilin Province*

Logistics has become an important international economic system component. Modern logistics is a product of economic globalization. Economic globalization is an important service. In recent years, the modern logistics industry showed steady growth, Europe, the United States, Japan has become the worldwide important logistics base. China's logistics industry started late, with the rapid development of the national economy, the market demand for the logistics industry continues to expand. In the 21st century, the country continues to strengthen and improve macro-control policies, China's logistics industry to maintain rapid growth, continuous improvement of logistics systems, the industry has become more sophisticated and standardized operation.

As the socialist market economic system of continuous improvement, China's logistics industry has made significant infrastructure development, logistics, have been expanding, business concepts, and operating mode of operation means great changes have taken place, while China's logistics industry has just started, is an emerging, with potential for investment and financing's financial industry should be in the technical means, the service concept of continuous improvement, credit policy, due to its support. to explore the great potential of the logistics industry, and gradually to the collection of information, automation and intelligence in one of modern logistics development, the trend of China's logistics industry

With the rapid growth of economic globalization and information network, modern logistics industry has become the sunrise industries, which is the "third profit source" following the production profits and sales profits, The development level of logistics is an important

indicator of measuring the overall competitiveness of a country or a region. Currently, Jilin province is in an important period of entering the building a moderately prosperous society and accelerating socialist modernization, therefore, accelerating the development of modern logistics industry and building the logistics industry of Jilin province that in line with trends of modern logistics development are of great significance to adjust and optimize industrial structure, enhance the overall competitive strength and improve the level of economic development of Jilin province.

#### *C. Problems of Logistics Center in Jilin Province*

Jilin Province has started the construction of logistics centers and showed the trend of rapid and potential development in some areas and regions. Its development conditions are gradually taking shape, with a regional logistics center in northeast good foundation, but still in the early stages of development. Because logistics demand is limited, not yet formed a relatively complete system, compared with the requirements of modern logistics industry, there is still a big gap. Main questions are as follows<sup>[3]</sup>.

(1) A poor sense of modern logistics, decentralized logistics management system, lack of overall planning

Currently, the industrial policy and industrial planning that are required for the development of modern logistics industry of Jilin Province has not been introduced. There are no uniform laws and regulations to follow in the logistics competition market. Besides, the modern logistics concept is so weak that some companies do not get rid of the planned economy and they are accustomed to "large", "small", they did not follow the concept of modern logistics, internal logistics integration and restructuring, or the implementation of outsourcing. The degree of specialization is low, and distribution costs account for the high proportion of production costs. Most companies are still focused on road transport, water transport, and wholesale, retail and other traditional logistics industry. Whereas a few companies operate modern e-commerce, logistics and distribution, large supermarket chains, and the technology level is low, and lack of modern management tools.

(2) Inadequate environment of logistics industry, difficult operating of logistics corporations

Logistics enterprises mostly come from the traditional transport and warehousing company, many of which are the old state-owned enterprises, and have heavy historical burden. Due to lack of modern logistics and unable to scientifically manage logistics process, the logistics costs are so high that it is hard for a logistics company to operate well. In addition, financing channels are so poor and lack of financial services action between logistics enterprises, the transaction for the establishment of the network on the basis of trade, finance, insurance, how to provide financial services, settlement, payment settlement and other logistics center will be the key to successful development. Enterprise funds were tight, which limited the logistics corporations to expand the development space.

(3) Inefficient logistics system, low technical equipment quality

The level of hardware technology of Jilin transport is low, and the high-speed freight and operations management modernization are still in its infancy, and handling, transportation, handling equipment are left behind. Jilin Province is currently operating general cargo vehicles, are trucks are still the main model. The majority of companies are still at the stage of traditional freight forwarding, and the extension services are less. The main operating form is self-cycling, whereas, the low scale, specialization and modernization of the transport enterprises impact the enterprise's market competitiveness.

(4)Lack of professional logistics talent

With the rapid development of logistics industry in Jilin Province, professional talent shortage problem has surfaced. Logistics talent has become one of 12 kinds of shortage talent. At present, the logistics industry mainly lacks three kinds of people: logistics planners, logistics export-oriented international talent, logistics researchers.

### III. OVERVIEW OF LOGISTICS CENTER SITE SELECTION

#### A. *The Early Development of Logistics Center Site Selection*

The early theory of site selection problem was proposed by land economist and regional geographer. The common theme in all these early studies was that transportation costs play an important role in location decisions. The first location problem was proposed from the Weber in 1909, it was to determine a good warehouse location, so as to make the distance between warehouse and the other customers' location shortest. For this problem, Siard restudied this problem in 1956 based on the industrial site selection and land use and related issues. Another earlier site selection problem was proposed in 1929 by Hotellnig, who was an economist. he raised the issue in a straight line on the location of two competing suppliers. Then Smithies and Stevens extended this issue. In the 1850s and early 1960s, many people study the facility layout and design issues. Loshc and Moses think that economic factors are related to site selection of production center. Miheie mainly study of the problem of making the length of connections within the network minimized. In the mid-1860s, theoretical research of site selection was expanded in several unrelated areas, and therefore did not form a unified theory. Until 1964, Hakimi conducted more theoretical studies on site selection issues, and considered the general problem that was to select one or more facilities location in a network so as to make the total distance between points or facilities minimum. Thus location theory has made significant progress, and extended to practical applications<sup>[4]-[6]</sup>.

#### B. *Steps of Logistics Center Site Selection*

The logistics center site selection of Jilin Province is based on demand forecasts, considering the socio-economic development, traffic and environmental factors, so as to determine the location and layout of the logistics center. Specifically, the site selection process can be divided into the following steps:

(1) Site constraints analysis. This part includes cost and non-cost factors, transportation costs, land costs, geographical conditions. When selecting a site, firstly, we should clear the necessity, purpose and significance of the establishment of logistics centers. Then analyzing the status of logistics systems, so as to make a basic plan for logistics systems and determine the basic conditions needed to understand, in order to greatly reduce the scope of the site.

(2)Collecting data and selecting the location method. When selecting a method, we should take the following factors into consideration: transportation costs, distribution costs and logistics facilities costs. Then we establish a mathematical formula according to constraints and objective, so as to seek a minimum cost program. However, when we seek the optimal solution using this site selection model, we must make a correct analysis and judgments for the volume of business and production costs.

(3)Choosing a calculation model and solving. Selecting the different models in different situations, then calculate outcome. Then the calculated result is the final result. But the calculate outcome maybe not necessarily the optimal solution. It may only be a eligible satisfactory solution that in line with the conditions<sup>[7]</sup>.

#### C. *The Principles of Logistics Center Site Selection*

Logistics center site selection process should comply with the adaptability principle, coordination principle, economic principle and strategic principle.

(1) Adaptability principle

Logistics center site selection should be adapted to the national, provincial and municipal economic development policies and be compatible with the distribution of logistics and the distribution resources and requirements and economic and social development.

(2) Coordination principle

Logistics center site selection should consider the country's logistics network system as a whole, so the logistics center facilities can be coordinate with the geographical distribution, operations productivity and technology level.

(3) Economic Principle.

The site selection costs in Logistics center development including construction costs and logistics costs (operating expenses). The logistics facilities construction scale and construction costs and freight are different when choosing different logistics center location such as the urban, peri-urban areas or outer suburbs. The economic principle should make the total cost of the logistics center lowest.

#### (4) Strategic principle

Site selection of logistics center should have a strategic vision. First, we must consider the overall situation. Second is to consider the long term. Part should obey to the whole situation, and the current interests should obey to the long-term interests<sup>[8]</sup>. We should consider both the present needs and the possibility of future development.

#### D. Factors of Logistics Center Site Selection

Logistics center location is a decision-making process affected by a number of factors. In order to facilitate the study, this paper summarized as three major aspects to analyze: the business environment, infrastructure, natural environment. Then we specifically analyze these factors.

##### (1) Business environment

① Services. Service level means that the logistics center should meet the users' logistics needs in the greatest possible. An important indicator of the service level in modern logistics process is the Punctual and qualified delivery. When selecting the logistics center, we should ensure that the customers' logistics demand can be quickly satisfied at any time. At the same time, the logistics center should try to deliver the high quality services at the lowest costs.

② Labor conditions. As the logistics are labor-intensive industries, so the sufficient quantity and high-quality labor conditions are to ensure the basic operation of the logistics center. Therefore, the labor condition is one of the factors taken into account when selecting a logistics center.

③ Logistics costs. Logistics cost is the most important factor of logistics center site selection. Most of the logistics centers are compatible with existing facilities and close to the demanding points in order to reduce logistics costs. This indicator has become a major concern in the logistics center quantitative location model. The lower the logistics costs are, the closer to the optimal program

##### (2) Infrastructure status

① Traffic conditions: Logistics centers must have convenient transportation conditions. The logistics should close to the port, hub, main roads, railway marshalling station or airport, and there are two or more modes of transport connections.

② State of public facilities: Logistics center location requires the city's roads, communications and other public facilities available. There is plenty of power, water, heat, gas capacity, and there are sewage, solid waste disposal capacity around the field area.

##### (3) Natural environment

① Hydrological and geological conditions: Logistics center location need to stay away from the river basin and flood overflow area. To seriously examine the recent hydrological data, and water table should not be too high. In general, setting the logistics center near good hydrological conditions can help to improve the security of the logistics operations. Logistics center is staging a large number of commodities. If there is silt, sand flow, loose soil and other adverse geological conditions below the surface layer of the logistics center, it may cause

serious consequences. Therefore, soil bearing capacity must be high.

② Terrain conditions. Convenient access of vehicle, security, delivery of goods efficiency and energy efficiency and other aspects will be subject to the impact of topography. So the best place is completely flat, easy terrain area; followed a slight slope, or consider ups and downs of the place. We can choose rectangular in shape, but we should not choose a narrow or irregular shape<sup>[9]</sup>.

#### IV STUDY ON METHOD OF LOGISTICS CENTER SITE SELECTION

At present, there are many methods related to the site selection of logistics center, which can be divided into two major categories of qualitative and quantitative. Qualitative method is to make decisions according to the personal or collective experience. Generally, the step is to determine the evaluation indicator based on experience, and then we carry out the pros and cons of testing for the selected centers, so as to make decisions based on test results. Qualitative method has the advantage of focusing on historical experience, which is simple. However, the drawback is that it is easy to make empirical and subjective errors, and when there are more optional place, it is difficult to make good decisions. Quantitative methods can transform the site selection problems into a function according to various constraints and objectives to be achieved, and then using the appropriate algorithm to solve and find the most qualified solution as the location of logistics center. Here are some widely used site selection methods<sup>[10]</sup>.

##### A Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions. Rather than prescribing a "correct" decision, the AHP helps decision makers find one that best suits their goal and their understanding of the problem<sup>[11]</sup>. It is a process of organizing decisions that people are already dealing with, but trying to do in their heads.

##### B Cluster Algorithm

Cluster Algorithm involves the task of dividing data points into homogeneous classes or clusters so that items in the same class are as similar as possible and items in different classes are as dissimilar as possible. Clustering can also be thought of as a form of data compression, where a large number of samples are converted into a small number of representative prototypes or clusters. Depending on the data and the application, different types of similarity measures may be used to identify classes, where the similarity measure controls how the clusters are formed. Some examples of values that can be used as

similarity measures include distance, connectivity, and intensity.

### C Centre of Gravity Method

Centre of gravity method is one of the most common location testing methods of logistics center, static, in which the transport costs(TC) is the only strategic element, there is a coordinate with fixed supply point and demand point and traffic volume between nodes. It means the objective of logistics center location selection is the minimum of total TC<sup>[12]</sup>, which is, total TC= linear distance between facility and customer×Quantity demanded<sup>[13]</sup>.

### D Genetic Algorithm (GA)

Genetic Algorithm (GA) is a search technique used in computing to find exact or approximate solutions to optimization and search problems. GA is categorized as global search heuristics and it is a particular class of evolutionary algorithms (EA) that use techniques inspired by evolutionary biology such as inheritance, mutation, selection, and crossover<sup>[14]</sup>. GA can help select the best location of logistics center.

### E Weight Grade Method

Many important factors of site selection are difficult to quantify precisely, but the lack of these factors and indicators would be difficult to quantify the degree of site options for a variety of comparative analysis, commonly used approach is the Weight Grade Method. Weight Grade Method is to determine several factors and give their weight, so as to get the final scores of the candidate location. The location which gets the highest scores is the optimum location. The concrete steps are as follows<sup>[15]</sup>:

- (1) lists the alternative locations;
- (2) lists the various factors affecting site selection;
- (3) gives the range of scores for each factor;
- (4) experts in various alternative locations for the various factors on the score;
- (5) the location of each factor score for each sum, calculated to compare the total score after the score up to the site as a site location.

The factors to be considered are: construction costs, transportation costs, the energy situation, the labor environment, living conditions, traffic, water, climate, political.

### F P - Median Method

P - Median Method can help determine a known set of requirements and a candidate facility' locations and quantities, so as to determine the location of facilities and assign each facility to a specific facility to make the transportation costs lowest between the facility and demand points. Greedy heuristic algorithm can be used to calculate this problem.

### G System Simulation Method

Logistics management system and the external environment or the link that exists between certain mathematical or logical relationships, so you can use qualitative and quantitative analysis methods, by means

of some mathematical models to describe these mathematical logic or the logic of relations, reflecting the nature of the system. Simulation model is a mathematical logic, through computer experiments, for a system operating according to certain rules of transformation from one state to another state or describe the dynamic behavior analysis.

### H Fuzzy Quality Function Method

In the selection process we should not only consider the needs of the logistics enterprises but also consider the needs of customers. We can build quality house of site selection decision then according to the customer care site needs to establish the weight matrix to calculate the site selection criteria weights, the fuzzy evaluation of the program, in the vague sort of program, find the best location of the final position. The quality house of site selection decision is shown in Figure 1, and the site selection process is shown in Figure 2.

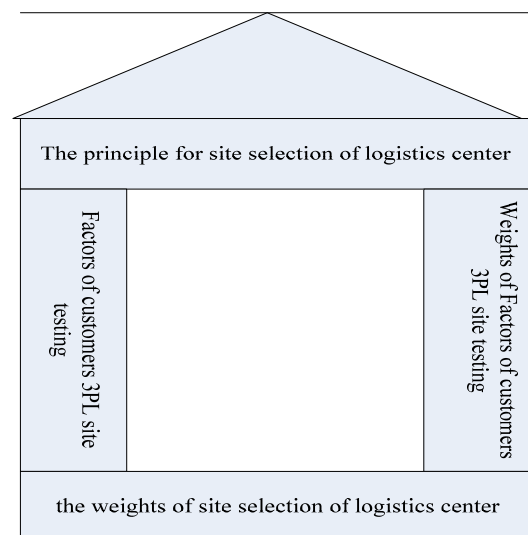


Figure 1. The quality house of site selection decision

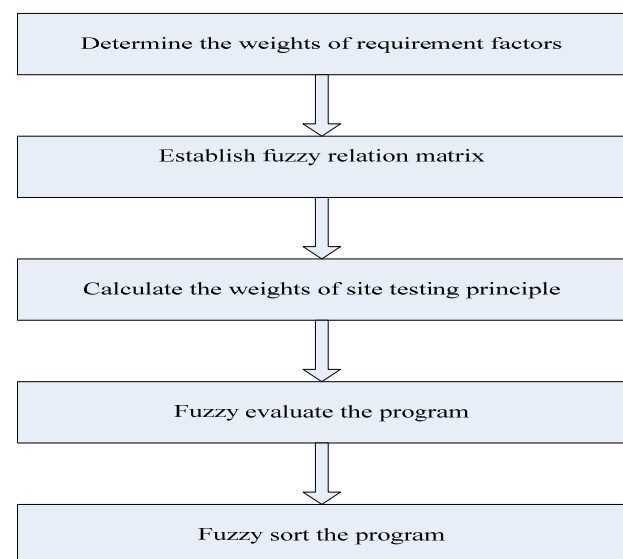


Figure 2. Site selection process

### I. Dijkstra Method

The main idea of Dijkstra Method is the distance between two vertices from the representative of the weight matrix, every time a vertex inserted compare any shortest path between two points is known as the middle vertex and vertex insertion may arise when the path distance, and then take a smaller value the right to get the new distance matrix. When all the vertices are a vertex, the resulting final weight matrix reflects all the vertices on the shortest distance between the information. By the shortest distance as the minimum cost, that is the best site location.

Because Centre of gravity method is quite flexible and does not confine selection to the specific prospective locations<sup>[16]</sup>, so we adopt Centre of gravity method to select the logistics center of Jilin province.

## V MODEL FOR SITE SELECTION OF LOGISTICS CENTER OF JILIN PROVINCE

### A. Model Establishment

Given the coordinate of supply point and demand point and traffic volume between nodes, then the objective of logistics center site selection is the minimum of total transport costs(TC), which is,

$$\text{MinTC} = \sum_i V_i R_i d_i \quad (1)$$

In which,

TC → total transport costs

$V_i$  → total traffic volume of node i

$R_i$  → transport fare rate between logistics center location selected and node i

$d_i$  → the distance between logistics center location selected and node i<sup>[17]-[19]</sup>

Calculating the initial site coordinate of logistics center of Jilin province:

$$\begin{aligned} \bar{x}_0 &= \frac{\sum_i v_i r_i x_i}{\sum_i v_i r_i}, \\ \bar{y}_0 &= \frac{\sum_i v_i r_i y_i}{\sum_i v_i r_i} \end{aligned} \quad (2)$$

The precise site coordinates of logistics center:

$$\begin{aligned} \bar{x} &= \frac{\sum_i v_i r_i x_i / d_i}{\sum_i v_i r_i / d_i}, \\ \bar{y} &= \frac{\sum_i v_i r_i y_i / d_i}{\sum_i v_i r_i / d_i} \end{aligned} \quad (3)$$

In which,  $(\bar{x}, \bar{y})$  are coordinates of selected logistics center,  $(x_i, y_i)$  are coordinates of known supply and demand points.

Recalculate  $d_i$  till  $(\bar{x}, \bar{y})$  change to less than ideal accuracy.

The formula of  $d_i$  is as follows<sup>[20]</sup>:

$$d_i = \sqrt{(x_i - \bar{x})^2 + (y_i - \bar{y})^2} \quad (4)$$

The cities' coordinate of Jilin province is shown in figure 3. The traffic volume and transport fare rate of Jilin province are shown in table 1.

TABLE I.  
LOGISTICS VOLUME AND FARE RATE OF JILIN PROVINCE

| node i       | coordinate |      | Total traddic volum 10<br>thousand tons | Transport fare rate<br>yuan/ton, km |
|--------------|------------|------|-----------------------------------------|-------------------------------------|
|              | X          | Y    |                                         |                                     |
| 1. Changchun | 10         | 10   | 26.8                                    | 0.41                                |
| 2. Jilin     | 13.4       | 11.2 | 11                                      | 0.41                                |
| 3. Yanji     | 23         | 8.8  | 10.4                                    | 0.41                                |
| 4. Tonghua   | 12.8       | 1.2  | 10                                      | 0.41                                |
| 5. Siping    | 7          | 7    | 8.8                                     | 0.41                                |
| 6. Baishan   | 15         | 2.4  | 6                                       | 0.41                                |
| 7. Liaoyuan  | 10         | 6.2  | 5.8                                     | 0.41                                |
| 8. Songyuan  | 7.8        | 17   | 5.8                                     | 0.41                                |
| 9. Baicheng  | 1.2        | 17.2 | 5                                       | 0.41                                |

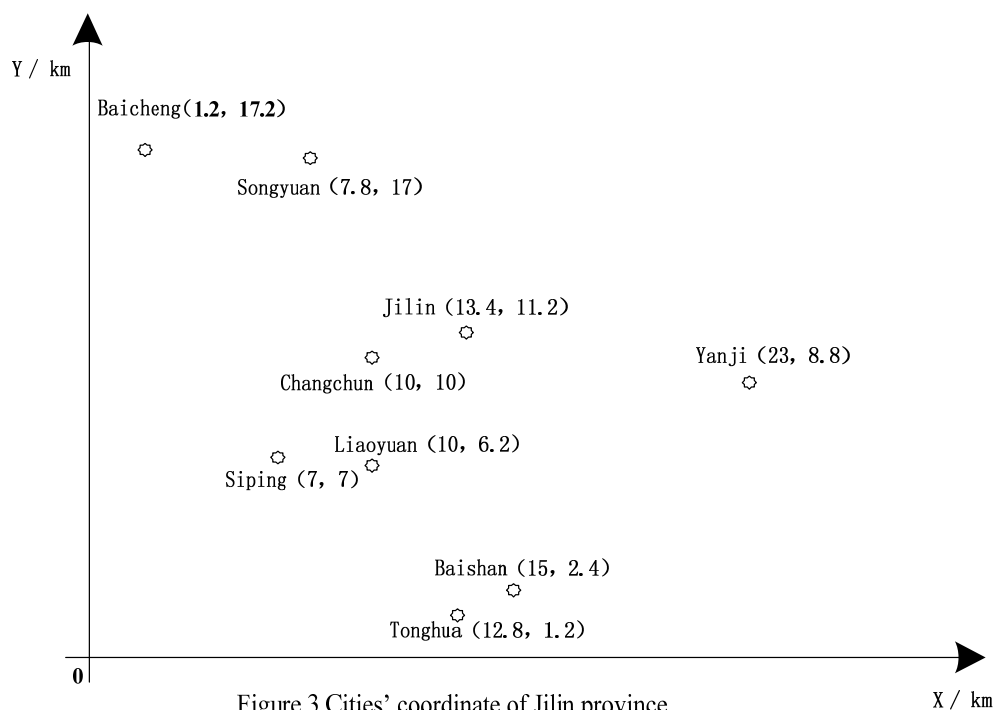


Figure 3 Cities' coordinate of Jilin province

### B. Model Solving

(1) We can calculate the initial point, according to the formula:

$$\bar{x}_0 = \frac{\sum_i v_i r_i x_i}{\sum_i v_i r_i}, \quad \bar{y}_0 = \frac{\sum_i v_i r_i y_i}{\sum_i v_i r_i}$$

$$\begin{aligned} \bar{x}_0 &= \frac{0.41 \times (26.8 \times 10 + 11 \times 13.4 + 10.4 \times 23 + 10 \times 12.8 + 8.8 \times 7 + 6 \times 15 + 5.8 \times 10 + 5.8 \times 7.8 + 5 \times 1.2)}{0.41 \times (26.8 + 11 + 10.4 + 10 + 8.8 + 6 + 5.8 + 5.8 + 5)} \\ &= 11.65 \text{ km} \\ \bar{y}_0 &= \frac{0.41 \times (26.8 \times 10 + 11 \times 17.2 + 10.4 \times 17 + 10 \times 11.2 + 8.8 \times 7 + 6 \times 24 + 5.8 \times 6.2 + 5.8 \times 17 + 5 \times 17.2)}{0.41 \times (26.8 + 11 + 10.4 + 10 + 8.8 + 6 + 5.8 + 5.8 + 5)} \\ &= 8.8 \text{ km} \end{aligned}$$

(2) Put the initial point into formula (4), we can calculate  $d_i$ :

$$d_1 = 1.65, d_2 = 2.97, d_3 = 11.35, d_4 = 7.69, d_5 = 4.99, d_6 = 7.22, d_7 = 3.08, d_8 = 9.06, d_9 = 13.41.$$

(3) Put  $d_i$  into formula (3), we can calculate the revised coordinate  $(\bar{x}, \bar{y})$ :  $\bar{x}_1 = 10.81 \text{ km}$ ,  $\bar{y}_1 = 9.29 \text{ km}$

(4) After repeating the above steps, we got the best site coordinate, that is,  $\bar{x} = 10$ ,  $\bar{y} = 10$ . Therefore, the best location for logistics center of Jilin province is Changchun city (10, 10), and the best site is located in the junction of Southeast Lake Road and East Ring Road. The minimum transport costs  $\text{MinTC} = 51.29$  million Yuan.

### CONCLUSION

By using the Centre of gravity method, this paper determined the precise location for logistics center of Jilin province, namely, the junction of Southeast Lake Road and East Ring Road. This establishment of logistics center's location can help reduce transport costs considerably. What's more, it can tackle some problems that exist in Jilin province's logistics industry and promote economic development of Jilin province significantly.

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