Research on Location Based on Gravity Method of Changsha City Greenery Fruit Supermarket Chain Distribution Center

Lu-Tao WANG ¹,a, Ye-Yun LIU ¹,b,*

¹Hunan Normal University, Yuelu district, Changsha City, Hunan Prov. China
a2292038462@qq.com,bliu_yeyun@126.com
*Corresponding author

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Abstract. Fruit supermarket chain is a combination of standardization, specialization and chain wholesale and retail business. Its distribution center meets the needs of various stores to provide distribution services of fruit and fruit products and timely service for customers. Fruit supermarket distribution center location, should be from the perspective of the whole enterprise, considering the needs of all stores, to minimize the total costs and to the maximum benefits of economic. This paper is a study based on gravity method of location selection of distribution center in Changsha City Greenery fruit supermarket chain to compare the existing distribution center of Changsha city green fruit supermarket chain, to put forward the improvement suggestions.

Introduction

With the rapid development of China's economy, people's quality of life is getting higher and higher. Fresh fruit as an important part of people diet, the demand become larger with the increase of people's income level. At the same time, compared with the traditional single fruit shop, people love visiting professional fruit supermarket chain with a good brand. But the fruit is seasonal, timeliness, perishable consumer products, therefore, the problem that the fruit of chain supermarket how to choose the location of distribution center with the distribution of the various stores become great.

This paper reviews the relevant literature on the basis of analysis of fruit supermarket chain distribution center location theory, including comparative study of fruit supermarket chain location method and main factors influencing the location of distribution center. Based on gravity method, this paper will design of fruit supermarket chain distribution center location model. Finally, this paper specific will calculate the location of distribution center of Changsha greenery fruit supermarket chains, in contrast to the existing location of distribution center, will analyze Changsha green fruit supermarket chain distribution center problem to put forward suggestions for improvement.

Literature Review

Foreign research distribution center location problem has more than 60 years of history, Webb in 1909 first put forward the location problem. [1] The domestic research of distribution centers location problem including: Hang Huitian, Yan Wei will combined gravity method with discrete optimization model;[2] Ruan Guoxiang, Yin Yuqi, Fu Kejun are located in center of gravity method combined with cluster analysis method [3]; Kang Malin Ding was considering the distance and miscellaneous freight transportation facilities between the design of precise centroid method [4]; Tan Yangbo, Yang Huai zheng, Lu Guangling were based on the iterative centroid method to select distribution center; [5] Cheng Heng, Mou Ruifang used the mathematical induction method to complete and improve the corresponding to the center of gravity method in the previous iterative
scheme; [6] Yang Maosheng, Li Xia for the transformation of the center of gravity method, added the variable cost and fixed cost to the model the location cost, considering more comprehensive.[7]

There are few researches on the distribution center of fruit supermarket chain. Some scholars have studied the fresh food distribution center. Jianhua, Xiong Huan put forward the timeliness and response of fresh agricultural products distribution center location model based on timeliness and response characteristics of fresh agricultural products; [8] Li Mengxun, Li Zhi establish the freshness of fresh food distribution center under the condition of location model with the characteristics of fresh food, fresh food distribution center on the traditional location model to improve. [9]

Theory Analysis

Functions of Fruit Chain Supermarket Distribution Center

Fruit chain supermarket distribution center functions are divided into basic functions and value-added functions. The basic functions of fruit chain supermarket distribution center include: purchasing function, collection function, storing function, distribution function, sorting function, processing function, packaging function, distribution function and information processing function. The value-added functions of distribution center include settlement function, demand forecasting function and logistics education and training.

Main Factors Affecting Distribution Center of Fruit Supermarket Chain

Space factors include: city traffic infrastructure and city traffic control ability; urban layout structure; natural environment factors such as temperature and humidity; Economic factors include: economic development level; local government of logistics policy, local tax policy; land resources, including land prices, appreciation of space, and energy resources, including industrial electricity prices; Factors about distribution center include: investment cost of the fruit of chain supermarket distribution center; the timely request of satisfactory service of the best retail demand.

Comparative Study on Main Methods of Distribution Center Selection in Fruit Supermarket Chains

The common methods of selecting the distribution center of fruit supermarket are mathematical programming method, multi criteria decision making simulation methods and center of gravity method. The mathematical programming method is a linear constraint to obtain fruit logistics center location of the feasible region. This method is difficult to model and large-scale problems are difficult to solve; multi criteria decision making method is based on two or more than two goals, a number of factors affecting the comprehensive fruit supermarket distribution center, through weighted multi factors, multi project evaluation. The method has strong subjectivity; the simulation method is to use a variety of models and techniques for modeling fruit supermarket chain distribution center, through the model using artificial test (Trial-and-error) method. It is difficult to test the credibility and validity of the method; gravity method is a logistics system based on the center of gravity, in order to pursue the lowest cost of logistics and distribution of fruit supermarket chain distribution center location decision method. The main advantages of the distribution center of fruit supermarket chain based on the center of method are suitable for the location problem of the transportation cost in the operation cost, which can reduce the distribution cost. Fruit supermarket enterprise is a new enterprise with fruit wholesale retail chain, whose unified and professional distribution center location must be from the perspective of the enterprise as a whole, in general, all of the store’s transportation costs to a minimum under the premise, to achieve maximum economic benefits. The center of gravity method meets the needs of the fruit supermarket chains whose transportation costs are high and have many scattered stores and independent single distribution center features. Therefore, by using the center of gravity method to analyze the
distribution center location of fruit supermarket chain can fruit supermarket chain enterprises better choose the most satisfactory distribution center.

**Location Model Design of Fruit Chain Supermarket Distribution Center Based on Gravity Method**

**Hypothesis**

(1) Only one distribution center; (2) Transportation costs are straight-line distances, regardless of route; (3) Distribution center capacity can meet the total demand of each store; (4) The daily delivery quantity of the distribution center is equal to the daily demand of each store, and is known; (5) The demand for goods at each demand point can be accomplished by one transport, and the transport speed between all points and points is the same; (6) The transportation cost of distribution products is proportional to the number of products and has nothing to do with the types of products; (7) The demand of various stores for various products.

**Variable Design and Description**

S $(a^\circ, b^\circ)$ for each retail point (demand point), the minimum latitude and longitude minimum combination, but also the origin of the Cartesian coordinate system; $P_i (A_i, B_i)$ for each retail point (demand point) and $S (a^\circ, b^\circ)$ latitude and longitude difference; $P_i (X_i, Y_i)$ for retail locations specific geographical location; $P_0(X_0, Y_0)$ for the specific location of the distribution center; $N$ as the number of retail outlets; $W_i$ as retail demand for fruit; $R_i$ as transport rates between retail and distribution centers; $T$ as daily transportation costs.

**The Basic Design of the Center of Gravity Method**

Center of gravity method is mainly through the plane rectangular coordinate system analysis, to obtain the lowest cost distribution center method. The steps of gravity method:

1. Set a rectangular coordinate system. The enterprise retail point (demand point) system according to its actual location into the plane rectangular coordinate system. The specific geographic location of each retail point (demand point) of the enterprise is transformed into the coordinate process in the plane rectangular coordinate system: \( \odot \) The various retail outlets (demand) latitude and longitude are compared numerically, the minimum value were selected the latitude and longitude, latitude and longitude of the minimum value of the minimum value of the portfolio, and the integer value obtained, expressed as $(a^\circ, b^\circ)$ called $S$; \( \odot \) Set the $S$ point as the origin of the plane Cartesian axis $(0,0)$, each retail point (demand point) latitude and longitude minus the latitude and longitude value of $S$ points, get latitude and longitude difference $P_i (A_i, B_i)$; \( \odot \) According to the Earth meridian (Antarctic to Arctic connection) of length, about 39940.67 km, 110.9463 km latitude at the same distance for different latitudes, retaining only the integer part of the retail point (demand) specific coordinates $(X_i, Y_i)$ $P_i$.

2. The location of the distribution center

In order to obtain the specific location of the distribution center, assuming that there are $n$ retail points (demand points) $P$ in a plane rectangular coordinate system, each retail point (demand point) $P$ coordinates set to $(X_i, Y_i)$ $(i=1, 2, 3,..., n)$, the location of the distribution center $P_0$ coordinates $(X_0, Y_0)$. It also assumes that the demand for each retail point is $W_i$ $(i=1, 2, 3,..., n)$, the transportation rates between each demand point and the distribution center (the transportation cost per unit flow per unit distance) is set to $R_i$ $(i=1, 2, 3,..., N)$. The center of gravity method coordinate $P_0(X_0, Y_0)$, as shown in formula (3.1), is calculated according to the center of gravity method:

\[
Y_0=\frac{\sum_{i=1}^{n} (Y_i * W_i * R_i)}{\sum_{i=1}^{n} (W_i * R_i)}
\]

\[
X_0=\frac{\sum_{i=1}^{n} (X_i * W_i * R_i)}{\sum_{i=1}^{n} (W_i * R_i)}.
\]  \(\text{(4.1)}\)

However the location $(X_0, Y_0)$ is a construction area in nature, or occupied area or forbidden establishing a regional distribution center because of legal restrictions and regulations, so according
to the needs of the reality, to \((X_0, Y_0)\) as the center, with a unit length of radius to draw a circle, screening of 2-3 alternative locations in the region.

(3) Total cost of transportation
Assuming transport costs of \(T\), transportation costs for the distribution center \(P_0 (X_0, Y_0)\) with \(n\) retail outlets \(P_i (X_i, Y_i)\) \((i=1, 2, 3, \ldots, N)\), the straight-line distance fee, then

\[
T = \sum_{i=1}^{n} R_i \times W_i \times \sqrt{(X - X_i)^2 + (Y - Y_i)^2}. \tag{4.2}
\]

**Location Analysis of Distribution Center of Greenery Leaf Fruit Supermarket in Changsha Based on the Center of Gravity Method**

**The Basic Situation of the Distribution Center Changsha Greenery Fruit Supermarket Chain**

(1) Changsha green fruit supermarket chain has an independent single distribution center. The distribution center is located in Changsha Yuhua District Hongxing fruit wholesale market, \(N\) at 28.1144°N, longitude 113.0255°E, its distribution center covers an area of more than 3 thousand square meters, a modern logistics center for the Hunan fruit and vegetable industry's largest, for more than sixty of local production direct supply base, with dozens of refrigerated trucks throughout the cold chain transportation, origin direct store.

(2) Changsha greenery fruit supermarket chain existing distribution center has obvious advantages. The existing distribution center is in road traffic in the Changsha City Beltway and Beijing Zhuhai Expressway Interchange and waterway transportation in the lower reaches of Xiangjiang, the traffic is convenient; the distribution center is in the existing red fruit wholesale market, suppliers, wholesalers, in cargo distribution, by economies of scale.

(3) The transportation cost of the existing distribution center of greenery fruit supermarket chain in Changsha is high. On the one hand, its existing distribution center will be distributed to the fruits of Changsha stores for a long time, on the other hand, its existing distribution center fruit distribution high transportation costs.

**Main Problems of Existing Distribution Center of Changsha Greenery Fruit Supermarket under Gravity Method**

**Distribution for a Long Time.** Different consumers have different demand for fruits, the existing distribution center which requires Changsha greenery fruit supermarket chain distribution services for multi species, small batch and multi batch, but based on some means of transportation, distribution center Changsha green fruit supermarket chain, the existing part of the fruit or have to delay some stores distribution services, resulting in long delivery time.

**Distribution Costs are high.** Through analysis of the main Changsha city green fruit supermarket chain of 11 stores location, sales and other specific data, combined with the third chapter gravity model, assumed the latitude and longitude \((28°N, 112°E)\) origin as the Cartesian coordinate system \((0,0)\). And calculated the various stores to the distribution center of transportation costs, it sees in table 5.1.
By table 5.1, we use equation (4.1) to calculate

$$X_o = \frac{\sum_{i=1}^{n} (X_i \ast Wi \ast Ri)}{\sum_{i=1}^{n} (Wi \ast Ri)} = \frac{10559.06}{81.3} = 129.88$$

$$Y_o = \frac{\sum_{i=1}^{n} (Y_i \ast Wi \ast Ri)}{\sum_{i=1}^{n} (Wi \ast Ri)} = \frac{1586.43}{81.3} = 19.51$$

To calculate the ideal address of distribution center Changsha green fruit supermarket chain, its specific coordinate values (129.88, 19.51). The specific location is near the village of Hexin in the town of Huanghua Changsha, Latitude and longitude (28.1985°N, 113.1706°E). Changsha green fruit supermarket chain distribution center in the existing Changsha Yuhua District Hongxing wholesale market, longitude (28.1144°N, 113.0255°E), the specific coordinates (114,11).

According to table 5.1 and equation 4.2, we can compute the original line distance and ideal straight line distance, to compare the transportation cost of original address with its of ideal address. We find that daily distribution costs to send the original center for 1896.19 yuan, the daily delivery costs 1787.56 yuan for the ideal distribution center, Changsha city greenery fruit supermarket chain distribution center distribution costs than the existing high ideal distribution center.

**Suggestions for Changsha City Green Fruit Supermarket Chain Distribution Center Location Based on the Center of Gravity Method**

According to the gravity model, the distribution center obtained ideal greenery fruit supermarket chain located near the village of Hexin in the town of Huanghua Changsha. Aiming at the main problems of distribution center of greenery fruit supermarket chain, I put forward constructive suggestions on distribution center of Changsha green fruit supermarket chains:

Aiming at the problem of long transit time, Changsha city green fruit supermarket chain distribution center, on the one hand, should increase the professional transport, on the whole, improve fruit distribution service efficiency, reduce transportation time; on the other hand can be the fruit demand data stores, through the management information system, fast calculation quantity and reasonable transportation route and provide quick fruit distribution for all stores.

For high transport costs, Changsha Huanghua town has convenient transportation, fruit distribution convenience, while in the outskirts of Changsha, convenient fruit procurement. Therefore, with the expansion of green fruit supermarket chain stores, the group should consider various stores, from the cost of the Changsha Huanghua town near the city, as a new distribution center location important reference position.
Conclusion and Prospect

In this paper, we analyze the function and influence factors of fruit supermarket distribution center and the location of the main method; select based on gravity method, analyze of the location of fruit supermarket distribution center, and establish the corresponding model; finally analyze of the Changsha green fruit supermarket chain distribution center the basic situation and existing problems, provide a theoretical reference for the location of distribution center. Due to the author's limited theoretical basis and practical experience, the paper has many deficiencies. To be further studied, there are specific: Many assumptions of the site selection model do not exist in reality, we should reduce unreasonable assumptions in the future; In the model, only considering the demand and transportation rate factors, more factors should be considered to establish the more accurate and realistic model.

Reference


