CSCanada
Management Science and Engineering
Vol. 13, No. 1, 2019, pp. 17-21
DOI:10.3968/11350

ISSN 1913-0341 [Print]
ISSN 1913-035X [Online]
www.cscanada.net
www.cscanada.org

Location Analysis of Chain Supermarket Distribution Center Based on CFLP

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Supported by the Sichuan's Training Program of Innovation and Entrepreneurship for Undergraduate (No.S201910619020).

Received 8 August 2019; accepted 25 October 2019
Published online 26 December 2019

Abstract

The number of stores operated by chain supermarkets is large, and the distribution of goods has the characteristics of low delivery volume and multiple delivery times. Logistics transportation costs account for a large proportion of operating costs. Establishing distribution centers is an effective measure to reduce operating costs. Through large-scale distribution, the chain supermarket distribution center can centrally manage the inventory of goods and distribute them to each store, thereby improving the distribution efficiency. This paper analyzes the influencing factors of the location of chain convenience supermarket distribution center, and then qualitatively analyzes the actual situation of the location object, determines the initial location plan, and establishes the CFLP model to solve the problem of the location selection of the chain supermarket distribution center.

Key words: Chain convenience supermarket; Distribution center location; CFLP model; Influencing factors

Shang, X. F., Jiang, H., Xiao, X. L., & Liu, T. Y. (2019). Location Analysis of Chain Supermarket Distribution Center Based on CFLP. *Management Science and Engineering*, *13*(1), 17-21. Available from: URL: http://www.cscanada.net/index.php/mse/article/view/11350 DOI: http://dx.doi.org/10.3968/11350

INTRODUCTION

In recent years, the development of China's retail industry has become more and more large, and the development level of chain supermarkets has increased. According to the National Bureau of Statistics, the retail sales of goods in 2018 was 338. 271 billion yuan, an increase of 8. 9%. Among them, the sales growth rate of supermarkets reached 3. 8%. According to statistics from China Chain Store & Franchise Association, the sales volume of China's top 100 retail chains reached 2. 2 trillion in 2017, an increase of 8%. In order to comply with consumers' personalized, quality and diversified consumer demands, physical supermarket chains are striving to create a safe and efficient circulation chain. According to relevant statistics, the average logistics cost of China's chain-operated enterprises accounts for 20%-30% of the total logistics costs. To achieve rapid growth and scale of chain supermarkets, it is necessary to strictly control operating costs.

Distribution is the core link of the chain supermarket supply chain. The distribution efficiency of the distribution center will directly affect the service of the chain supermarket to the end consumers. The location of the distribution center will play an important role in reducing the logistics distribution cost and improving the distribution efficiency.

In recent years, domestic and foreign scholars have matured the research on the location of distribution centers. Common location models include multi-objective location model, bi-level programming model, and CFLP method. The solution methods are commonly used in intelligent optimization algorithms and compromise planning methods. Based on the optimized location method of particle swarm optimization algorithm, Gan Bin et al. established an optimized location economic model and an auxiliary model to obtain the logistics distribution location plan with the lowest transportation cost. Wang Sijing et al. responded to the total system cost and logistics service. The efficiency is the objective function, and the multi-objective planning model for the location of the pharmaceutical cold chain logistics distribution center is established. The case analysis verifies the reliability of the model; Li Ming et al. incorporate the direct supply and demand relationship between the producer and the seller into the research on the location and layout of the multi-logistics distribution center. Established The nonlinear mixed 0-1 planning model is optimized for the transportation scheme. At present, most of the research on the location of the distribution center does not give the application scope and application object of the model, and the developed algorithm also has problems such as slow operation speed.

Foreign scholars have more mature and extensive research on the location of distribution centers, and use supply chain management ideas for site selection. The location model and methods used are: dynamic location model, location model with capacity limitation, P-median problem, and Capacitated Faciliti Location Problem, and so on. Qiang Song et al. (2017) established an immune optimization algorithm that optimizes the location of logistics distribution centers based on logistics cost. Linda K. Nozick et al. proposed warehouse selection for two-level inventory systems for single products and multiple products. Simultaneously optimized mathematical model for site and distribution center location, using this model to determine the optimal location and number of warehouses and distribution centers. Spohrer and Kmak combine quantitative methods with qualitative methods, and apply weight analysis method to study the location problem of distribution centers. Vlachopoulou applied GIS to the logistics distribution center location process and developed a geographic decision support system that enables managers to sort candidate logistics distribution centers with quantitative and qualitative criteria.

Based on the above research background, this paper establishes the CFLP distribution center location model, taking small and medium-sized supermarket chains as the research object, and calculating the location of the distribution center with the minimum transportation cost as the calculation target.

1. ANALYSIS OF FACTORS AFFECTING LOCATION SELECTION OF CHAIN CONVENIENT SUPERMARKET DISTRIBUTION CENTER

There are many internal and external factors that need to be considered in the field selection process of chain convenience supermarket distribution centers. It is necessary to select the supply of the economic regional network composed of several demand points and supply points to minimize the total cost and the satisfaction of the demand center address. The main influencing factors are divided into the following three categories:

1.1 Natural Condition

In the distribution center, bulk storage and transfer of goods will be carried out, so there are certain requirements in terms of natural conditions (terrain, geology, climate, etc.). In terms of terrain, because large-scale machinery and equipment are used to move the cargo horizontally or vertically in the distribution center, flat terrain and pressure bearing capacity are required. In terms of climate, in order to ensure a proper storage environment for the cargo, floods should be avoided. Areas with frequent rainfall; in terms of geology, try to reduce the possibility of economic losses caused by natural disasters and avoid the areas with frequent geological disasters.

1.2 Economic Factors

(1) Construction cost: It consists of land acquisition cost, central design and construction cost, facility equipment purchase cost, product loss cost, etc. The construction cost of the chain supermarket distribution center is high. Therefore, it is necessary to determine the scale of the construction of the distribution center in combination with the existing development scale of the chain supermarket, and reduce the number of establishment of the distribution center while fully satisfying the customer's needs.

(2) Transportation cost: It is mainly composed of the labor cost of the business personnel, the delivery personnel, and the distribution vehicle cost. When distributing goods to multiple stores, the distribution center should analyze the type, quantity, time, and distance of each store's product demand, and design the optimal delivery route and delivery batch. Reduce the number of transportation, increase the loading rate of the whole vehicle, reduce the return rate of the return, and improve the distribution efficiency of the distribution center, thereby reducing transportation costs.

(3) Operating costs: administrative expenses, equipment maintenance costs, energy costs such as water and electricity, and labor costs of employees, etc., when assessing the location, the operating costs should be evaluated. Consider the impact of the location of the alternative distribution center on the post-operating costs.

1.3 Traffic Condition

The distribution of goods in the supermarket chain distribution center has the characteristics of high frequency and low distribution. Therefore, the distribution center should be located in a convenient place, close to the road collection. The daily operation of the distribution center needs to consume a lot of electricity and water. Therefore, the location of the distribution center requires strong power supply and water supply capacity.

2. CFLP LOCATION MODEL

2.1 CFLP Model and Basic Assumptions

The CFLP model uses the principle of linear transportation planning to establish a location model. The basic contents of the CFLP model are as follows:

In a given initial plan alternative point, the linear transportation planning method is used to find the supply range of each distribution center, and then the distribution center is moved to other distribution centers in each supply range, so that the total regional cost is reduced, and the iterative calculation is repeated until the total cost is no longer falling.

The model is applicable to: the distribution capacity of the distribution center is limited; the address and demand of the demand point, and the number of construction sites of the distribution center are known to solve the location model.

The basic assumptions of the CFLP model are as follows:

• Assume that the infrastructure construction costs of the distribution center are fixed;

• Assume that the capacity of the distribution center is limited;

• Assume that the distribution center has a limited amount of traffic to the demand site;

• Assume that there is a limit to the number of best distribution centers;

• Assuming the demand is known, the initial distribution center alternative is determined through qualitative research;

2.2 Model Construction

Parameter definition:

X_{ij}- the amount of traffic from the distribution center alternative i to the demand point j:

Y_{ij} – the transport distance from the distribution center alternative i to the demand point j;

m—the transport rate from the distribution center to the demand point;

C_i- the fixed construction cost of the distribution center alternative I;

D_j- the demand for demand point j; N_i - the number of places required;

A_j- the maximum storage capacity of the distribution center alternative I;

K - the number of distribution center construction; W - comprehensive cost;

Z_i- Assume that it is 1 when the distribution center is established at the distribution center alternative i, otherwise 0.

Objective function:

$$\mathrm{MINW} = m\sum_{i=1}^{N}\sum_{j=1}^{K} X_{ij} Y_{ij} + \sum_{i=1}^{N} C_i Z_i \quad \text{Formula (2.1)}$$

Restrictions:

$$Z_i = \begin{cases} \text{1, In the alternative i build a distribution center} \\ \text{0, Not building a distribution center in the alternative i} \end{cases}$$

Formula (2.2)

$$\sum_{i=1}^{N} X_{ij} \geq D_j \quad , \ i=1,\ 2\cdots N, \quad , \ J = 1,\ 2 \ldots K, \quad \text{Formula (2.3)}$$

$$\sum_{j=1}^{k} X_{ij} \leq A_i Z_i \quad \text{Formula (2.4)}$$

$$\sum_{i=1}^{N} Z_i \leq K \quad \text{Formula (2.5)}$$

Model description:

• The objective function in equation (2.1) represents the minimum of the sum of the transportation cost of the distribution center to the demand point alternately and the fixed construction cost of the distribution center.

• Equation (2.2) indicates whether or not the 0-1 variable of the distribution center is constructed in the distribution center candidate site i.

• Equation (2.3) indicates that the total transportation volume of the distribution center alternatively i to the demand point j cannot be less than the total demand amount of the demand point j.

• Equation (2.4) indicates that the total transportation volume of the distribution center from the alternative i to the demand point j cannot exceed the maximum construction capacity of all the distribution centers.

• Equation(2.5) indicates that the optimal number of establishment of the distribution center cannot exceed K.

3. EXAMPLE ANALYSIS

In a city in southwest China, there is a chain convenience supermarket. In order to achieve the rapid response of the chain store replenishment demand and reduce the operating cost, the chain convenience supermarket will implement self-built distribution center to implement centralized management and unified distribution of goods. There are three distribution centers of J1, J2 and J3, and five chain stores K1, K2, K3, K4 and K5. Due to working capital constraints, the number of distribution centers established cannot exceed two. The transportation rate of the chain supermarket distribution center is known to be 0.06 yuan/kg. •km.

Table 1 is an alternative to each supermarket chain to each supermarket chain store. The data is obtained by Baidu map ranging: the distance from the distribution center J1 to the five demand points is 14. 8, 15. 0, 7. 5, 8. 4, 14. 9; the distribution center J2 to The distances of the five demand points are 10. 5, 10. 0, 17. 6, 20. 6 and 13. 3. The distance from the distribution center J3 to the five demand points is 13. 6, 17. 9, 13. 2, 8. 7, and 9. 4.

Table 2 Distribution Center alternatively fixed construction Ci cost and storage capacity Ai: The fixed construction cost of the distribution center J1 is 320, 000 yuan, the fixed construction cost of the distribution center J2 is 590, 000 yuan, and the fixed construction cost of the distribution center J3 is 48. Ten thousand yuan. The storage capacities of the three alternative distribution centers J1, J2, and J3 are 660, 1220, and 1010 respectively.

Table 3 shows the demand Di of each supermarket chain store. The demand for goods at the five demand points is 500, 400, 330, 180, 330 (unit: kilogram)

Table 1
Distance From the Distribution Center to the Demand Store (unit: km）

Demandpoint/ Distribution center	K1	K2	K3	K4	K5
J1	14. 8	15. 0	7. 5	8. 4	14. 9
J2	10. 5	10. 0	17. 6	20. 6	13. 3
J3	13. 6	17. 9	13. 2	8. 7	9. 4

Table 2
Distribution Center Alternative Construction Cost and Storage Capacity

Distribution center	J1	J2	J3
Distribution center fixed construction cost Ci (ten thousand yuan)	32	59	48
Distribution center storage capacity Ai (kg)	660	1220	1010

Table 3
The Demand for Each Chain Store Di

Demand point	K1	K2	K3	K4	K5
Demand Dj (kg)	500	400	330	180	300

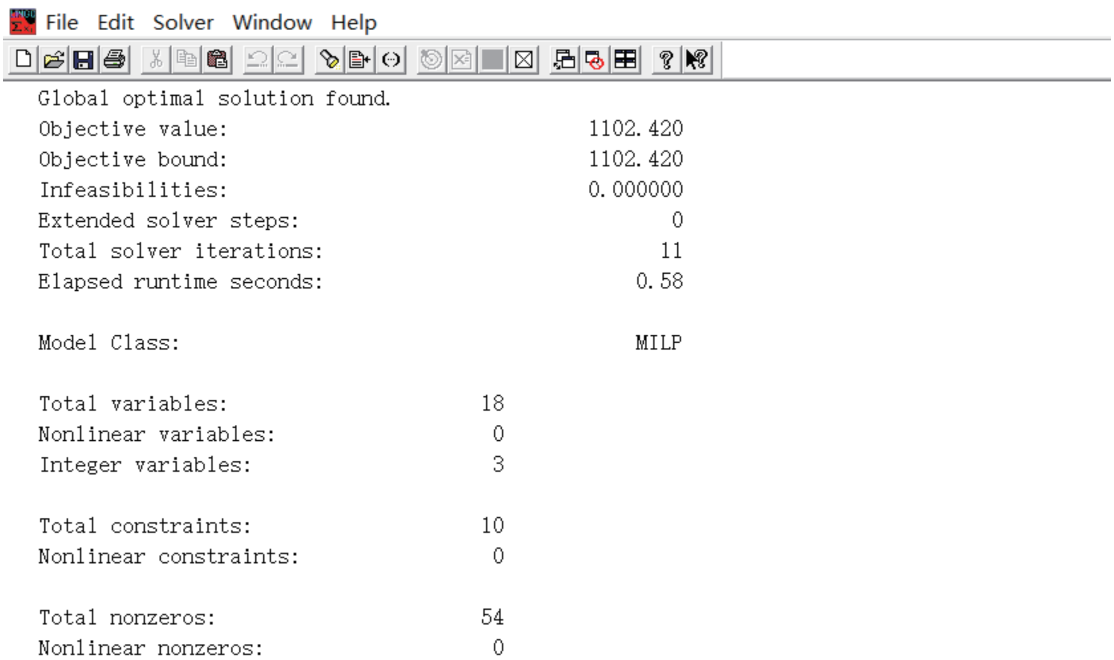

Figure 1
Lingo operation results

This paper establishes the CFLP model and solves the model with software lingo17. 0. After the calculation, the global optimal solution is obtained, and the distribution center of the chain supermarket is selected in JI and J2, and the total transportation cost reaches the minimum value of 11. 2462 million yuan. The distribution center J1 is responsible for the transportation of goods at two demand points of K3 and K4. The transportation volume from the distribution center J1 to the demand point K3 is 330Kg, the transportation volume to the demand point K4 is 180kg;the distribution center J2 to K1, K2 two chain convenience supermarkets The goods are required for distribution. The transportation volume of the distribution center J2 to the demand point K1 is 500Kg, and the transportation volume to the demand point K2 is 400Kg. The transportation volume from the distribution center J2 to the demand point J1, J2 distribution center to each demand point is shown in Table 4.

Table 4
Transportation Volume From the Distribution Center to Each Demand Point (Kg)

Demand point Distribution center	K1	K2	K3	K4	K5
J1	0	0	330	180	0
J2	500	400	0	0	300

4. CONCLUSION AND PROSPECTS

With the continuous expansion of the chain supermarket, the location of the distribution center has become an indispensable part of its development strategy. In this paper, the influencing factors of the location of chain convenience supermarket distribution center are qualitatively analyzed from three aspects: natural conditions, economic factors and traffic conditions.

Secondly, by programming the model, the mathematical programming software LINGO 17. 0 is used to solve the problem. Establishing the CFLP model to determine the location of the distribution center of the chain supermarket has reference value for the establishment of a distribution center with limited distribution capacity. However, in the practical application of the problem of the location of the chain supermarket distribution center is very complicated, this paper did not fully consider the changes of various factors in the study, there are three shortcomings.

(1) In this paper, only the fixed construction cost of the distribution center is considered in the modeling. The operation cost of the distribution center, the operation cost of the supplier to the distribution center, the variable cost of the infrastructure, and the inventory cost of the distribution center are not considered.

(2) Only the CFLP model has been established, and the intelligent optimization algorithm is not used to further optimize the solution results.

(3) The actual analysis of the model was carried out using specific cases, but the rationality of the model was not verified by other models.

In view of the above deficiencies, the author will further study the location of the chain supermarket distribution center in the future.

REFERENCES

Cao, J., & Chen, X. X. (2013). Research status of distribution centers in China's chain store enterprises. *Logistics Technology*, *32*(07), 77-79+144.

Chen, A. P. (2017). Study on the location strategy of supermarket distribution center—Taking agricultural and industrial supermarkets as an example. *Logistics Technology*, 36(03), 114-117.

Chen. S. T, Wang, C. J, & Liu, Y. (2017). Study on site selection and flow distribution simulation of multi-product cold chain logistics distribution center considering aging and cargo damage. *Journal of Donghua University(Natural Science)*, *43*(03), 436-442.

Chen, Y. L. (2011). Research on location problem of express delivery center in the same city based on CFLP model. *Chongqing Jiaotong University.*

Gan, B., Li, H. D, Gong, W., & Ling, J. (2018). Simulation of location optimization of visual logistics distribution under big data. *Computer Simulation*, *35*(08), 293-296+419.

Li, P. (2016). Study on the model of location selection of circulation distribution center—Taking fresh food as research object. *Commercial and Economic Research*. (12), 96-97.

Linda , K. N., & Mark A. T. (2001). A two-echelon inventory allocation and distribution center location analysis. *Transportation Research Part E: Logistics and Transportation Review, 7*(6), *425-441*.

Liu, C. H., Liu, P. W., Gai, L., Shi, X. F., &Zhang, H. Q. (2014). Optimization of Material Warehousing Network Layout Based on CFLP Model. *Economic Research Guide*, (31), 20-21.

Ma, S. (2018). Study on the location and path optimization of urban fresh food cold chain logistics distribution center. *Beijing Jiaotong University*. .

Ma, X. H., & Li, G. M. (2012). Study on the location problem of logistics distribution center based on CFLP model—Taking Shihezi XX pure water company as an example. *Business Vitality*, (03), 16-20.

Maro. V., George. S., & Vassiliki. (2001). Geographic Information Systems in Warehouse Site Selection Decisions. *International Journal of Productoin Economics*, *71*(1-3), 205-212

Niu, D. L., & Hao, Y. (2017). Study on Location Selection of Fresh Food Processing Distribution Center of Chain Supermarket Based on AHP Method. *Logistics Technology and Application*, *22*(09), 139-141.

Ou, Y. H. (2018). Research on collaborative optimization of inventory and distribution in distribution center of large-scale retail chain supermarket. *Beijing Jiaotong University.*

Phuong N., Nathalie B. & Olivier P．(2008). A dynamic model for facility location in the design of complex supply chains ．*International Journal of Production Economics*, 113（2）：678-693

Qiu, S. G., & Zhou, Y. F. (2018). Site-path problem of urban distribution self-reporting based on nested Logit selection model. Computer Applications. 38(02), 582-588.

Shao, M. X., & Zhang, J. (2018). Study on Location Selection of Logistics Distribution Center Based on Fuzzy Comprehensive Evaluation Method. *Management Observation*. (28), 112-113+117.

Wang, P. W., Xiao, Q., & Wang, M. X. (2015). The Location Selection of Chain Supermarket Logistics Distribution Center Based on Gravity Method. *E-commerce*. (01), 43-44.

Wang, P. Z., & Hong, G. (2018). Analysis of Location Selection of Urban Cold Chain Warehouse Distribution Center Based on Gravity Method. *Shopping Modernization*. (13), 41-43.

Wang, Q. Y. (2016). Analysis of the rationalization of the location of Wal-Mart China Distribution Center. *China Storage and Transportation*. (07), 97-100.

