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Research on Location Selection of Dairy Products Logistics Distribution Center Based on Mixed Integer Programming Model

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ABSTRACT. *This paper tries to address the issue of site selection of dairy products logistics distribution center based on Lingo language. By optimizing the mixed integer programming model and ranking the alternative sites, this paper determines the best location for the dairy products logistics center in Shanghai.*

KEYWORDS: *mixed integer programming, dairy products, logistics distribution center, Lingo*

1. Introduction

With the rapid development of China's economy, and the increase of urban and rural residents' income as well as the popularization of consumers' nutrition awareness, China's dairy industry has developed rapidly [1].This has played a positive role in improving the dietary structure of urban and rural residents and strengthening the physical quality of the people and finally realizing the goal of a well-off society in an all-round way. Dairy products are known to be perishable and difficult to preserve, requiring the shortest transport routes and the shortest transport time.Therefore, how to determine the reasonable location of the cold chain logistics distribution center for dairy products and establish an appropriate cold chain logistics distribution network is of great significance for dairy enterprises.

The main function of the distribution center is to provide distribution services, with the aim of saving transportation costs and guaranteeing customer satisfaction, which calls on the following characteristics: fast delivery response; the relatively specific distribution objects; sound distribution function; perfect information network; rich varieties and small batch. In addition, it mainly focuses on distribution and storage serves as supplement. [2]. Many scholars have studied the site selection of distribution center. In terms of the transportation organization mode of cold chain

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logistics, Wu et al. [3] first proposed SISP model and AC-SSN model for evaluating the performance of cold chain logistics of aquatic products. Lee and Lee et al. [4] established a mixed integer programming model to determine the generalized layered coverage positioning problem of distribution center location and customer allocation, and achieved good results through tabu search algorithm.Zhang Yanxia et al. [5] studied the location of logistics distribution center by applying fuzzy theory, that is, AHP was adopted to determine the influencing factors of the scheme and the comprehensive evaluation method of sub-factor weight location scheme.Yang Wei et al. [6] studied the route optimization problem of dairy distribution vehicle based on shelf life, and designed an improved genetic algorithm of adaptive cross variation to solve the problem.

At present, with the development of logistics industry in China, many location selection models of distribution centers are applicable, such as the center-of-gravity method model to solve the continuous location problem, the mixed integer programming model to solve the discrete location problem, and the Baumer-Wolff method model to solve the nonlinear programming problem.This paper will use the mixed integer programming model to select the location of dairy logistics distribution center combined with the multi-factors distribution from the logistics distribution center to the factory and the demand points. Finally, this paper finds the best solution by using Lingo software.

2. Location selection model of logistics distribution center

2.1 Model problem description

As shown in Figure 1, the system structure of logistics network layout includes M alternative logistics distribution centers, which purchase goods from L factories and provide distribution to N customers.

This paper assumes the transportation cost from the delivery point to the distribution center, transportation costs from distribution center to customers and the administrative costs of products flowing through the distribution center as well as the fixed investment costs of the distribution center are known [7] . Hence the location of dairy logistics distribution center is determined with the principle of minimizing the total cost.

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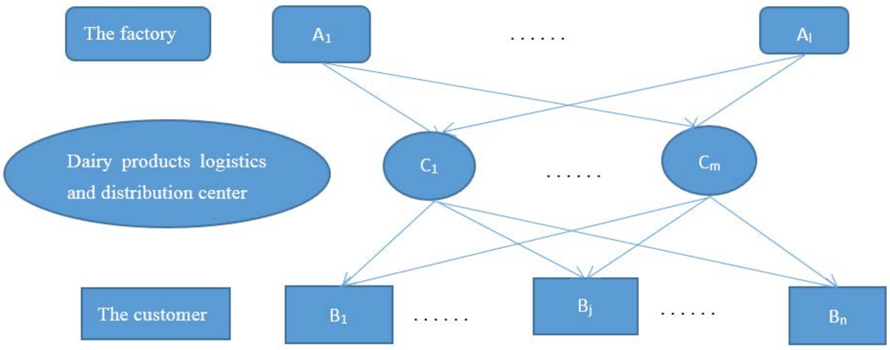

Figure. 1 Schematic diagram of logistics network layout

2.2 Assumptions

The problem studied in this paper is the location of dairy cold-chain logistics distribution center. In order to facilitate the research and reduce the calculation difficulty, the following assumptions are made for the model:

Assume 1 The freight charges from the delivery point to the distribution center and from the distribution center to the customer are known.

Hypothesis 2 The production capacity of each plant is known and meets the demand.
Assume 3 The parameters of each type of transport vehicle are the same.

Assume 4 The capacity and number of distribution centers are limited.

Hypothesis 5 The quantity demanded at each place of demand is certain and known.

Assumption 6 Fixed cost of distribution center, unit management cost is known.

Hypothesis 7 During transportation, factors such as vehicle failure, road congestion and weather influence are not taken into account.

Based on the above assumptions, we mainly consider the following costs: transportation costs from the delivery point to the distribution center;Transportation costs from distribution center to customers;The management cost of products flowing through the distribution center and the fixed investment cost of the distribution center [8].

2.3 Model establishment

Based on the above assumptions and conditions, the objective function of total cost minimization of the mixed integer programming model is obtained:

ISSN 2616-5767 Vol.3, Issue 5: 51-58, DOI: 10.25236/AJETS.2020.030507

$$\min = \sum_{k=1}^{1}\sum_{i=1}^{m} c_{ki} \mathrm{w}_{ki} + \sum_{i=1}^{m}\sum_{j}^{\mathrm{n}} h_{ij} x_{ij} + \sum_{k=1}^{x}\sum_{i=1}^{m} g_i w_{ki} + \sum_{i=1}^{m} f_i z_i \tag{1}$$

$$\sum_{\mathrm{i}=1}^{m} w_{ki} \le p_k, k = 1,2,...,l \tag{2}$$

$$\sum_{\mathrm{i}=1}^{m} x_{ij} = \sum_{k=1}^{x} w_{ki}, i = 1,2,...m \tag{3}$$

$$\sum_{\mathrm{i}=1}^{m} x_{ij} \ge \mathrm{d}_{\mathrm{j}}, j = 1,2,...n \tag{4}$$

$$\sum_{\mathrm{k}=1}^{x} w_{ki} \le a_i z_i, i = 1,2,...,m \tag{5}$$

$$\sum_{\mathrm{i}=1}^{m} z_i \le \mathrm{q} \tag{6}$$

$$\mathrm{z}_i \in \{0,1\} \tag{7}$$

$$\mathrm{x}_{ij} \ge 0, i = 1,2,...,m; j = 1,2,...,n \tag{8}$$

$$\mathrm{w}_{ik} \ge 0, k = 1,2,...,l; i = 1,2,...,m \tag{9}$$

2.4 Symbol description

l: Represents the number of factories;

N: Represents the number of users;

M: Represents the number of alternative distribution centers;

C_{ki}: Represents the transportation cost of unit product from factory K to distribution center I;

w_{ki} : Represents the single transport volume from factory K to distribution center I;

h_{ij}: Represents the logistics cost of unit product from distribution center I to customer J, including loading and unloading, freight, etc.;

x_{ij}: Represents the single transport volume from distribution center I to customer J;

g_i: Represents the management cost per unit product cycle of distribution center;

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f_i: Represents the fixed cost of the logistics distribution center;

z_i: Represents 0-1 variable. When distribution center I is selected, take 1; I =0 means no selection.

p_k: Represents the production supply of factory K;

d_j: Represents the demand for customer J;

a_i: Represents the capacity of distribution center I;

q: Represents the maximum number of logistics centers that can be built.

2.5 Model Interpretation

Although the index is qualitatively defined, there are still many factors affecting the location selection, and the process of fitting is also relatively complicated. In order to guarantee the accuracy of result of location selection of distribution center, a secondary screening model needs to be built, so as to achieve the optimization of the distribution cost of dairy distribution center.Based on the previous model, the new hybrid site selection model is constructed as follows:

$$Min = (c_{ij} + k)(\sum_{k=1}^{l}\sum_{i=1}^{m} c_{ki}w_{ki} + \sum_{i=1}^{m}\sum_{j=1}^{n} h_{ij}x_{ij}) + \sum_{i=1}^{m} Y_i(F_i + E_i) + \sum_{k=1}^{x}\sum_{i=1}^{m} g_i w_{ki} + e(\sum_{i=1}^{m} f_i z_i) \tag{10}$$

Add constraints: Y_i indicates whether there are any goods to be recovered at the distribution point, $\sum_{i=1}^{m} Y_i = p$ is the number of distribution points that meet the need to recover the goods.Among them,

$$Y_i = \begin{cases} 1, \text{there are goods to be recalled at address i} \\ 0, \text{ no goods to be recalled at address i} \end{cases}$$

e represents the transportation cost of the distance of the cargo transport unit, k represents the coefficient of damage, E_i represents the storage cost of goods at distribution point i , F_i represents the cost of recovery of the goods.

3. Dairy products logistics distribution center address calculation example

This paper takes the logistics of a dairy enterprise in Shanghai as the research object, and takes the most typical recycling logistics, namely the fresh food logistics of dairy products, as the research focus.Through the field investigation of specific dairy production enterprises, the optimization of the location of logistics distribution center is studied by combining theory with practice.Lingo software is used to solve

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the model due to the complex data.Lingo software is characterized by simple programming, simple application, wide application range, simple solution process and simple results, etc., and Lingo introduces the concept of set in modeling language.In the actual calculation, in order to simplify the calculation amount of the model, the following constraint assumptions are made:

(1) $c_i = c_{ij} = 1(i = 1,2,...,m; j = 1,2,...,n)$ means the same freight rate of each road in Shanghai;

(2) 345 target demander are randomly sampled, and only 20 demander are selected to enter the model for calculation.

(3) In Shanghai, the demand for commodities is equal in each district. According to the latest data, xuhui District is 187, Putuo District is 257, Changning District is 290 and Jing 'an District is 142.

(4) As for the damage cost coefficient K, k as a constant only affects the size of the optimal value and does not affect the solution of the model.The actual geographic location information of the demander is as follows:

Table 1 The actual location of a dairy supplier

Area	Longitude	Latitude	Area	Longitude	Latitude
Xuhui district	120.791 53	30.054 32	Putuo district	120.527 18	30.048 36
	120.798 08	30.051 49		120.572 81	29.966 01
	120.813 74	30.072 47		120.599 57	29.955 02
	120.807 76	30.070 21		120.593 76	29.976 35
	120.834 28	30.057 26		120.531 67	29.883 49
Changning district	120.599 33	29.913 74	Jing'an District	120.610 27	29.935 62
	120.718 15	30.102.18		120.620 92	29.924 94
	120.786 93	30.054 08		120.614 78	29.914 67
	120.805 64	30.057 18		120.610 58	29.922 55
	120.807 44	30.046 65		120.617 13	29.914 26

Taking demand data of a dairy company as the main analysis object, the results of Lingo solution are shown in Table 2 to 5:

Table 2 Operation results of Xuhui District

The time series	1	2	3	4	5
Freight amount	45.452	46.333	55.428	60.38	50.38
Percentage of shipment	0.06	0.06	0.064	0.062	0.059

Table 3 Operation results of Putuo region

The time series	1	2	3	4	5
Freight amount	683.78	692.233	770.682	869.052	769.952

ISSN 2616-5767 Vol.3, Issue 5: 51-58, DOI: 10.25236/AJETS.2020.030507

Percentage of shipment	0.907	0.899	0.893	0.902	0.903

Table 4 Operation results of Changning District

The time series	1	2	3	4	5
Freight amount	25.1	22.9	27.1	29.1	28.8
Percentage of shipment	0.032	0.029	0.03	0.035	0.032

Table 5 Operation results of Jing 'an Area

The time series	1	2	3	4	5
Freight amount	0	0	0	0	0
Percentage of shipment	0	0	0	0	0

The results of Lingo calculation are shown in Table 6:

Table 6 Results of Lingo solution

	Xuhui district	Putuo district	Changning district	Jing'an District
Freight amount	50.39	795.598	28.8	0
Percentage of shipment	5.76%	90.67%	3.57%	0%

It can be seen that choosing Putuo district as logistics center has more advantages than Xuhui District and Changning District, while Jing 'an District is the least suitable for establishing logistics center.

4. Conclusion

This paper combines the ranking of the location of a dairy product logistics center in Shanghai obtained by the mixed integer programming method, which is Putuo District>Xuhui District>Changning District>Jing'an District.In view of the current situation of an enterprise and above analysis, the best location of logistics distribution center is Putuo District.

The scale of Logistics Park in Putuo District can meet the requirements of commodity characteristics of a dairy enterprise, build warehouses and introduce automated logistics facilities, reduce labor costs and improve the speed of logistics work.

Its traffic conditions and information construction are much better than the existing logistics distribution center, which can improve the level of service and timeliness of logistics distribution center of a dairy enterprise.

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