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
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.
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:
\[
\min = \sum_{k=1}^{l} \sum_{i=1}^{m} c_{ki} w_{ki} + \sum_{i=1}^{m} \sum_{j=1}^{n} h_{ij} x_{ij} + \sum_{k=1}^{r} \sum_{i=1}^{m} g_{ij} w_{ki} + \sum_{i=1}^{m} f_{i} z_{i} \tag{1}
\]

\[
\sum_{i=1}^{m} w_{ki} \leq p_{k}, k = 1,2,...,l \tag{2}
\]

\[
\sum_{i=1}^{m} x_{ij} = \sum_{k=1}^{r} w_{ki}, i = 1,2,...m \tag{3}
\]

\[
\sum_{i=1}^{m} x_{ij} \geq d_{j}, j = 1,2,...n \tag{4}
\]

\[
\sum_{k=1}^{r} w_{ki} \leq a_{i} z_{i}, i = 1,2,...,m \tag{5}
\]

\[
\sum_{i=1}^{m} z_{i} \leq q \tag{6}
\]

\[
z_{i} \in \{0,1\} \tag{7}
\]

\[
x_{ij} \geq 0, i = 1,2,...,m; j = 1,2,...,n \tag{8}
\]

\[
w_{ik} \geq 0, k = 1,2,...,l; i = 1,2,...,m \tag{9}
\]

### 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_{ij}**: Represents the management cost per unit product cycle of distribution center.
\( f_i \): 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:

\[
\text{Min} = (c_l + k) \left( \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij}w_{ij} + \sum_{j=1}^{n} \sum_{i=1}^{m} h_{ij}y_{ij} \right) + \sum_{i=1}^{m} \left( Y_i F_i + E_i \right) + \sum_{i=1}^{m} \sum_{j=1}^{n} g_{ij}w_{ij} \\
+ e(\sum_{i=1}^{m} f_{zi})
\]

(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
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. \( c_i = c_j = 1 (i = 1, 2, \ldots, m; j = 1, 2, \ldots, n) \) 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

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

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

<table>
<thead>
<tr>
<th>The time series</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freight amount</td>
<td>45.452</td>
<td>46.333</td>
<td>55.428</td>
<td>60.38</td>
<td>50.38</td>
</tr>
<tr>
<td>Percentage of shipment</td>
<td>0.06</td>
<td>0.06</td>
<td>0.064</td>
<td>0.062</td>
<td>0.059</td>
</tr>
</tbody>
</table>

### Table 3 Operation results of Putuo region

<table>
<thead>
<tr>
<th>The time series</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freight amount</td>
<td>683.78</td>
<td>692.233</td>
<td>770.682</td>
<td>869.052</td>
<td>769.952</td>
</tr>
</tbody>
</table>
The results of Lingo calculation are shown in Table 6:

**Table 6 Results of Lingo solution**

<table>
<thead>
<tr>
<th>Location</th>
<th>Freight amount</th>
<th>Percentage of shipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xuhui district</td>
<td>50.39</td>
<td>5.76%</td>
</tr>
<tr>
<td>Putuo district</td>
<td>795.598</td>
<td>90.67%</td>
</tr>
<tr>
<td>Changning district</td>
<td>28.8</td>
<td>3.57%</td>
</tr>
<tr>
<td>Jing'an District</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

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.
References