

Research on Location Selection of Railway Logistics Center

Runxiang Shen^{1, a}, Xiaodong Zhang^{1, b}, Maoxiang Lang^{1, c}, Xinjun Wang^{2, d}

¹School of Traffic and Transportation, Beijing Jiaotong University, Beijing 100044, China;

²Yinchuan Freight Center, Yinchuan 750000, China.

^a16120879@bjtu.edu.cn, ^bzhangxd@bjtu.edu.cn, ^cmxiang@bjtu.edu.cn, ^dwangxinjun30@163.com

Abstract. The railway logistics centers, where handling and carrying out railway logistics business, are important parts of the railway logistics network. In order to improve the capacity of railway logistics service, increase the railway transportation market share, accelerate the transformation of traditional railway freight yards into modern logistics centers, this paper builds a 0-1 mixed integer programming model to optimize the location of railway logistics centers comprehensive cost, and used Lingo to find the global optimal solution. Taking Ningxia as a case, this paper found out the optimal railway logistics center location scheme. and analyzed the coverage of the main supply points in the region to prove the rationality of the scheme.

Keywords: Railway; logistics center; location selection; integer programming.

1. Introduction

With the changes in China's social and economic environment, the demand for bulk materials has declined, and the proportion of railway transportation has decreased year by year. In order to improve the marketization level of railway freight transportation, the Railway Corporation has promoted the reform of freight transportation and upgraded the modern logistics service level of the railway. At the same time, the government pay more attention to environmental protection and energy conservation and emission reduction, promoting the adjustment of transportation structure. The construction of the railway logistics center will help the rational distribution of railway productivity, improve the capacity of railway logistics services, accelerate the adjustment of transportation structure, and help China win the battle against pollution.

In terms of site selection of logistics nodes, Xiaodong Zhang [1] proposed to a macro location for the construction of national, regional and regional three-level railway logistics nodes, and to identify different levels of logistics center's cities. Tao Wan [2] applied the AHP method to determine the index weights and fuzzy comprehensive evaluation to get the scores of the alternative yards, and it is combined with the potential energy theory to design the site selection scheme of the Beijing Railway Logistics Center. Yasanur Kayikci [3] established a model based on fuzzy analytic hierarchy process and artificial neural network to locate the logistics center. Tuncay zcan [4] analyzed the advantages and disadvantages of several methods such as AHP, TOPSIS, selection elimination method, and gray theory, which are commonly used to solve the location problem. These methods are used to solve the problem of retailer warehouse location. Pei Wang [5] concluded the mode of railway commodity vehicle logistics Optimization which named "forward stocking", and proposed a four-level logistics network consisting of commodity vehicle main engine manufacturers, regional logistics bases, city regional logistics bases and customers. Then a dynamic mathematical model for optimizing railway commodity vehicles logistics network is designed, which solved out a multi-period optimization scheme for railway commodity vehicles logistics network. The existing research has more research on external supply demand and alternative point self-conditions, but less research on the convenience of railway internal turnover. In view of this, this paper considers the transportation cost of the source point to the railway logistics node and the construction cost of the railway logistics center. In addition, this paper transfers time of the railway logistics node to the marshalling station to construct the location 0-1 integer programming model and uses the railway logistics center of Ningxia region Site selection for case analysis.

2. Construction of Railway Logistics Center Location Model

2.1 Problem Analysis.

The building of railway logistics center by abandoning existing freight yard will result in a great waste of resources. Therefore, the construction of railway logistics center should be based on existing freight yard to make the construction cost smaller. Railway logistics center should be built according to the distribution of goods, so that its service level is higher. Due to the time delay caused by the internal turnover of railway, so time is also a key factor of customer concern. In order to ensure the consistency of the calculation of indicators, the time delay of turnover is converted into cost.

The assumptions are as following: ①the candidate points of the railway logistics center are selected from the existing freight stations J ; ②the number of known source areas is I , the freight volume generated by the source of goods is g_i , and the railways generated by the main source of goods are shared by the railway. The supply of goods is all served by the railway logistics center and the railway logistics node, and the railway freight volume generated by each source point is allocated to different railway logistics nodes; ③the location of the marshalling station is known.

2.2 Model Building.

The aim of the location model is the minimum sum of the road short-distance charge from the point of supply to each railway logistics node, the cost of the node being converted into a railway logistics center, and the turnover delay cost of each logistics node to the marshalling station.

$$\text{Min}Z = Z_1 + Z_2 + Z_3 \quad (1)$$

$$Z_1 = \sum_{i=1}^I \sum_{j=1}^J c_{ij} d_{ij} x_{ij} \quad (2)$$

$$Z_2 = \sum_{j=1}^J a_j \left(\sum_{i=1}^I x_{ij} - Q_j \right) y_j \quad (3)$$

$$Z_3 = K \cdot \sum_{j=1}^J t_j \sum_{i=1}^I x_{ij} \quad (4)$$

s.t

$$\sum_{i=1}^I x_{ij} - Q_j - (N_{\max} - Q_j) y_j \leq 0 \quad (5)$$

$$\sum_{i=1}^I x_{ij} - y_j \cdot N_{\min} \geq 0 \quad (6)$$

$$\sum_{j=1}^J x_{ij} = X_i \quad (7)$$

$$M \cdot y_i - \sum_{i=1}^I x_{ij} \geq 0 \quad (8)$$

$$y_j \in \{0, 1\}; x_{ij} \geq 0 \quad (9)$$

In the formula, c_{ij} is the transportation rate of the goods from the source aggregation point i to the logistics node j ; d_{ij} is the road distance from the source point i to the logistics node j ; X_i is the total freight volume of the source point i entering the railway logistics center; a_j is the unit capacity construction rate for the logistics node j to be converted into the logistics center; Q_j is the current capability of node j ; t_j is the average transfer time of the freight station to the marshalling station; K is the time delay price per unit of cargo; N_{max} and N_{min} are the maximum and minimum service capacity of the railway logistics center respectively. x_{ij} is the freight volume allocated from the source point i to the logistics node j ; y_j is a variable of 0 and 1. When building a railway logistics center at the alternative point j , y_j takes 1; otherwise, it is 0. M is a value close to infinity.

In the objective function, the formula (2) represents the cost of the road short-distance of the goods to the railway logistics node; the formula (3) represents the reconstruction cost of the freight yard to the railway logistics center; the formula (4) represents the turnover cost of the goods from the railway logistics node to the marshalling station. The constraint (5) indicates that the amount of freight assigned to node j does not exceed the upper limit of the service capacity of the railway logistics center; the constraint (6) indicates that the amount of freight assigned to node j cannot be lower than the lower limit of the service capacity of the railway logistics center; the constraint (7) indicates that the sum of the freight volume assigned to each node is equal to the total freight volume of the source point i entering the railway logistics center; the constraint (8) indicates that as long as a node allocates the freight volume, the alternative must be constructed as a railway logistics center; the constraint (9) indicates that y_j is a 0-1 variable, the shipment amount from the supply point i to the node j is a non-negative value.

2.3 Model Solving.

The equation (3) in the objective function in the model is nonlinear. It is difficult to meet the application requirements by the traditional operation research optimization method. It is generally solved by heuristic algorithm, but the result of the heuristic algorithm is the local optimal solution. To obtain the global optimal solution, the objective function can be equivalently transformed into the following objective function and linear constraint by the following auxiliary variable transformation.

Let $\xi_{ij} = x_{ij} \cdot y_j$, $\bar{\Gamma}^{(o)}$ is the upper limit of ξ_{ij} , $\underline{\Gamma}^{(o)}$ is the lower limit of, then Z_2 is equivalent to the following formula:

$$Z_2 = \sum_{j=1}^J a_j \left(\sum_{i=1}^I \xi_{ij} - Q_j y_j \right) \quad (10)$$

s.t

$$\xi_{ij} \leq \bar{\Gamma}^{(o)} \cdot y_j \quad (11)$$

$$\xi_{ij} \geq \underline{\Gamma}^{(o)} \cdot y_j \quad (12)$$

$$\xi_{ij} \leq x_{ij} - \underline{\Gamma}^{(o)} \cdot (1 - y_j) \quad (13)$$

$$\xi_{ij} \geq x_{ij} - \bar{\Gamma}^{(o)} \cdot (1 - y_j) \quad (14)$$

Lingo is a general-purpose optimization tool for solving linear and nonlinear optimization problems. After the above transformation, the model can be accurately solved by Lingo12.0 programming, input various relevant parameters and variables to solve, and the output is the final value of the objective function value and the node selected as the railway logistics center.

3. Empirical Analysis

3.1 Parameter Value.

Taking Ningxia as the research object, this paper studies the location of railway logistics center in Ningxia. There are 25 freight yards in Ningxia, which are used as an alternative point for railway logistics centers, and their capabilities are known. Investigated the supply of suitable railway transportation such as industry and manufacturing industry in Ningxia, as well as trade and residential materials, and obtained the cargo volume of 46 major railway supply points.

It should be noted that some source points have railway dedicated lines, and their goods are sent directly to the designated freight station. Therefore, the d_{ij} of these sources to the corresponding freight station is taken as 0, and the d_{ij} of other freight stations is taken as M , which is a value close to infinity. C_{ij} is calculated according to the average rate of each source point to the alternate node which calculated by Yinchuan Freight Center. The value of c_{ij} of the source point of transportation using railway dedicated lines is 0. As to a_j , in Yinchuan City, a_j takes 90 yuan/ton, and other areas a_j takes 80 yuan/ton. The freight volume of the railway logistics center accounts for 0.6 of the railway freight volume. K pick-up value is 1% of the price per ton. t_j take the average of the turnaround time of each freight yard to the marshalling station.

3.2 Solution Result Analysis.

Solve with lingo12 and bring relevant data into the model to get $y_1=1$ (Huinong), $y_3=1$ (Dawukou), $y_7=1$ (Yinchuan South), $y_8=1$ (Qingtongxia), $y_{10}=1$ (Zhongning), $y_{18}=1$ (Guyuan), the distribution of sources is shown in Table 1.

Table 1. Result of freight stations' cargo distribution (Unit: tons)

Number	Hai Nong	Dawukou	Yinchuan S	Qingtongxia	Zhongning	Guyuan
source points 1	0	0	0	0	8.4	0
source points 2	138.4	1	86.8	0	54.2	0
source points 3	8.5	0	0	0	0	0
.....
.....
source points 44	5.7	0	0	0	0	0
source points 45	54.5	0	0	0	0	0
source points 46	0	0	244	0	0	0

With 50 km as the core attraction radius of the railway logistics center, in the paper's location plan, the attraction of the railway logistics center covered 84.8% of the supply points, and the covered freight volume reached 91.6%, which proved that the model solved the results well. At the same time, Lanzhou Railway Bureau has planned to build Yinchuan South, Huinong and Guyuan freight station as railway logistics base. The planned construction site of the railway logistics base coincides with the selected points of the model, and the model solution results are also verified. It's effective.

4. Summary

The existing freight station was selected to transform into a railway logistics center, and a model for discrete location of railway logistics center based on 0-1 integer programming was constructed. The model was constructed with minimum cost and achieved good economic feasibility. The case-solving results were carried out in six freight yards including Yinchuan South, Huinong, Dawukou, Qingtongxia, Zhongning and Guyuan in Ningxia. Analyze and evaluate the scope of their services and meet the demand for goods, the program has good adaptability and reasonableness. In view of the location plan, only the scale of the railway logistics center is defined, so in the future research,

the precise scale of the railway logistics center construction can be considered to make it more applicable.

Acknowledgments

This research was supported by National Key R&D Program of China (2018YFB1201402); National Key R&D Program of China (2016YFE0201700); Railway multi-cargo intermodal adaptation system technology (2017YFB1201301-1).

References

- [1]. Xiaodong Zhang. Research on the Theory of the Location Planning for Logistics Park. China Materials Publishing House. 2004.6.
- [2]. Wan Tao. Research on Location Planning and Planning of Railway Logistics Center. Master, Beijing Jiaotong University, China 2009.
- [3]. Yasanur Kayikci. A conceptual model for intermodal freight logistics centre location decisions. *Procedia Social and Behavioral Sciences*.2010.
- [4]. Tufan Demirela. Multi-criteria warehouse location selection using Choquet integral. *Expert Systems with Applications*.2010,37(5): 3943–3952.
- [5]. Wang P., Zhang X.D., He J., Han B.L. & Yang H.Y. (2017). Research on hierarchical and dynamic location optimization for railway automobile logistics bases under business mode of “Forward Stocking”. *Journal of the China Railway Society*, Volume 39, pp1-9.
- [6]. Wang P., Zhang X.D., Han B.L. & Lang M.X. (2018). Research on vehicle location-distribution problem based on uncertain demand and low carbon emission. *International Journal of Heavy Vehicle Systems*, Volume 25, pp455-484.