Logistics Center Location Based on AHP-Fuzzy Comprehensive Evaluation Method

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Abstract. The logistics center's practical placement can significantly save logistics expenses and costs while enhancing logistics effectiveness. In order to address the fuzziness and uncertainty in the logistics center location problem, the influencing factors of logistics distribution center location are examined, the index system of logistics distribution center location is established in accordance with the influencing factors, and the weights of indexes at all levels are determined by using an analytical hierarchy process. Based on this, the fuzzy comprehensive evaluation model is constructed using fuzzy comprehensive evaluation. Finally, the actual scenario of the Beijing Shunfeng Logistics Center is used as an example for the examination of the site selection process.

Keywords: Analytic Hierarchy Process · Logistics Center Location · Fuzzy Comprehensive Evaluation

1 Introduction

With the vigorous development of China's logistics industry, the planning and construction of a logistics center has become an important symbol of the development of a country's logistics level and is closely related to the convenience and happiness of national life. The main benefit of logistics centers is the efficient supply of goods. For the suppliers of commercial establishments, this means facilitating the way of supply [1]. Logistics centers mainly secure the flow of a big amount of goods between suppliers and manufacturers, and between manufacturers and end-consumers. The role of the logistic centers in the retail chain is to provide an uninterrupted operation of large retail networks via last mile deliveries [2]. Determining the location of the logistics center is an important decision regarding cost and benefit analysis [3]. Inadequate supply of logistics centers has led to inefficient management of logistics flows [4]. At present, China's logistics industry is in a period of rapid development, and the construction of logistics centers is crucial for a city, a region, and even the whole country. However, in practice, a series of problems have emerged in the location of some logistics centers. These problems are ultimately due to the lack of theoretical research basis for logistics center location planning and construction. Therefore, it is of great theoretical and practical significance to conduct further research on the location planning of logistics centers.

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There are many factors affecting the location of logistics centers, including the principles of adaptability, coordination, cost, and strategy [5], and the factors affecting the location of logistics centers into natural environment factors, business environment factors, infrastructure conditions, and other factors; and the cases are evaluated based on the weighted entropy of information entropy.

How should one determine which influencing factors are more important for logistics center location decisions? This question is particularly critical. The use of analytic hierarchy process to solve this problem has become very common, Sabina Kauf [6] proposed that the use of AHP to locate logistics centers in a regular hierarchical logistics network is effective when determining the optimal location of a logistics center given the selection criteria. Tomic V et al. [7] to more accurately analyze the environmental impact and find the appropriate location for logistics centers, the existing method of finding the most appropriate location for logistics centers was improved using a greedy heuristic algorithm implemented in AHP. Some other scholars used fuzzy comprehensive evaluation to study the logistics location problem. Logistics center location is one of the decision problems involving uncertainty, and to reflect the uncertainty in the selection process, fuzzy logic is usually applied. Sürmeli, Gözde [8] et al. used a fuzzy decision method to select the location of logistics centers in the Eastern Anatolia region of Turkey when they studied the location selection problem. Thi Yen Pham [9] et al. developed a benchmarking framework by applying fuzzy comprehensive evaluation method to select the location of logistics centers based on the findings of logisticians. Zhang Yan [10] applied the entropy weighting method to determine the weights of each evaluation index based on the evaluation indicator system, then ranked the results using the fuzzy comprehensive evaluation method approach, and finally demonstrated the effectiveness and feasibility of the proposed method by an example.

Locating a logistics center involves weighing a variety of intricate issues, including the tension between quantitative and qualitative considerations. Contrarily, the AHP-fuzzy comprehensive evaluation technique-based logistics site selection process makes extensive use of the fuzzy evaluation method due to its thorough analysis of elements, simple model, high practicality, and high dependability of selection outcomes. In conclusion, it is reasonable and valuable to analyze the location of logistics parks using the fuzzy comprehensive evaluation approach and AHP.

2 Location Evaluation Indicator System Establishment

There are many indicators describing the status of site selection, so the selected indicators should be both broad enough to cover all aspects and representative enough to capture the main contradictions.

This article divides the four evaluation components of logistics center placement decision-making into economic variables, social benefits, government policies, and infrastructure by synthesizing pertinent literature and innovation. According to the evaluation criteria and indicator selection principles, combined with relevant literature, this paper divides the evaluation indicator system of logistics center location into two levels, including the above-mentioned four primary indicators (B1 economic factors, B2 social benefits, B3 government policies, B4 infrastructure) and 11 secondary indicators (C1 low price of construction address, C2 labor availability, C3 proximity to traffic arteries, C4 impact on natural environment, C5 impact on urban residents, C6 impact on neighboring enterprises, C7 logistics industry funding policy, C8 long-term construction planning, C9 layout of neighboring enterprises, C10 neighboring freight hubs, C11 complete infrastructure).

3 Establishment of Logistics Center Location Model

Establishing a hierarchical model, creating a judgment matrix, figuring out the weight vector for hierarchical single sorting, performing a consistency test, performing hierarchical total sorting, etc. are the major components of AHP.

According to the AHP, we determine the weight of each indicator by dividing the indicators in the indicator system; we determine the rubric, and then determine the judgment set P. Using the weight vector composed of each indicator in the AHP, combined with the judgment matrix R, obtained from the expert survey, the fuzzy operation $\hat{B}$.

4 Empirical Analysis

4.1 Build Judgment Matrix

Through the AHP method, the judgment matrix Z of the first-level indicators and the judgment matrix B_1, B_2, B_3, B_4 of the second-level indicators are established respectively.

$$Z = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \end{bmatrix}$$

$$B_1 = \begin{bmatrix} 1 & 1 & \frac{1}{5} \\ 1 & 1 & \frac{1}{4} \\ 5 & 4 & 1 \end{bmatrix}$$

$$B_2 = \begin{bmatrix} 1 & 3 & 7 \\ \frac{1}{3} & 1 & 5 \\ \frac{1}{7} & \frac{1}{5} & 1 \end{bmatrix}$$

$$B_3 = \begin{bmatrix} 1 & \frac{1}{2} \\ 2 & 1 \end{bmatrix}$$

$$B_4 = \begin{bmatrix} 1 & \frac{1}{3} & \frac{1}{7} \\ 3 & 1 & \frac{1}{3} \\ 7 & 3 & 1 \end{bmatrix}$$

Table 1. Judgment matrix and weights

A	B1	B2	B3	B4	W
-	0.25	0.25	0.25	0.25	-
C1	0.15	-	-	-	0.0375
C2	0.16	-	-	-	0.04
C3	0.69	-	-	-	0.1725
C4	-	0.65	-	-	0.1625
C5	-	0.28	-	-	0.07
C6	-	0.07	-	-	0.0175
C7	-	-	0.33	-	0.0825
C8	-	-	0.67	-	0.1675
C9	-	-	-	0.09	0.0225
C10	-	-	-	0.24	0.06
C11	-	-	-	0.67	0.1675

4.2 Calculate the Weight Vector of Hierarchical Single Ranking and Perform a Consistency Check

According to the algorithm for the maximum matrix λ_{max} eigenvalue, the consistency test and results are obtained as follows: in matrix Z,$\lambda_{max} = 4$, CI = 0, RI = 0.89, CR = 0 < 0.1; in matrix B_1,$\lambda_{max} = 3$, CI = 0, RI = 0.52, CR = 0 < 0.1; in matrix B_2,λ_{max} = 3.06, CI = 0.03, RI = 0.52, CR = 0.06 < 0.1; in matrix B_3, $\lambda_{max} = 2.01$, CI = 0.01, RI = 0, CR < 0.1; in matrix B_4, $\lambda_{max} = 3.02$, CI = 0.01 < 0.1, RI = 0.52, CR = 0.07 < 0.1.

From the calculation results, it can be seen that Z, B_1, B_2, B_3, and B_4 all pass the consistency test. The judgment matrix and weights can be obtained as shown in "Table 1".

4.3 Fuzzy Comprehensive Evaluation

The AHP method has been derived for the evaluation items and weights of the logistics center location. The logistic center location has been judged according to the relevant experts as well as the relevant literature on the options.

(1) Fuzzy comprehensive evaluation judgment matrix establishment.

Determine the set of factors F and evaluation set V. The AHP can determine the set of factors F, that is, F = {low price of construction address, labor availability, proximity to traffic arteries, impact on natural environment, impact on urban residents, impact on neighboring enterprises, logistics industry funding policy, long-term construction planning, layout of neighboring enterprises, neighboring freight hubs, complete infrastructure}. The evaluation set V = {Excellent (A), Good (B), Medium (C), Poor (D)} = {V1, V2, V3, V4}. And the single-factor evaluation was determined to form the affiliation matrix, as follows in "Table 2".

Table 2. Single-factor affiliation matrix

Evaluation items and weights	Evaluation Level			
	Excellent	Good	Medium	Poor
C1 low price of construction address (0.0375)	0.5	0.3	0.1	0.1
C2 labor availability (0.04)	0.6	0.3	0.1	0
C3 proximity to traffic arteries (0.1725)	0.5	0.4	0	0.1
C4 impact on natural environment (0.1625)	0.4	0.4	0.1	0.1
C5 impact on urban residents (0.07)	0.5	0.3	0.2	0
C6 impact on neighboring enterprises (0.0175)	0.7	0.1	0.1	0.1
C7 logistics industry funding policy (0.0825)	0.5	0.4	0.1	0
C8 long-term construction planning (0.1675)	0.6	0.2	0.2	0
C9 layout of neighboring enterprises (0.0225)	0.6	0.2	0.1	0.1
C10 neighboring freight hubs (0.06)	0.4	0.4	0.2	0
C11 complete infrastructure (0.1675)	0.5	0.4	0.1	0

(2) Evaluation analysis.

Using the weight vectors obtained by the AHP method and the expert survey method, the evaluation matrix R can be found as follows:

$$R_1 = \begin{bmatrix} 0.5 & 0.3 & 0.1 & 0.1 \\ 0.6 & 0.3 & 0.1 & 0 \\ 0.5 & 0.4 & 0 & 0.1 \end{bmatrix}$$

$$R_2 = \begin{bmatrix} 0.4 & 0.4 & 0.1 & 0.1 \\ 0.5 & 0.3 & 0.2 & 0 \\ 0.7 & 0.1 & 0.1 & 0.1 \end{bmatrix}$$

$$R_3 = \begin{bmatrix} 0.5 & 0.4 & 0.1 & 0 \\ 0.6 & 0.2 & 0.2 & 0 \end{bmatrix}$$

$$R_4 = \begin{bmatrix} 0.6 & 0.2 & 0.1 & 0.1 \\ 0.4 & 0.4 & 0.2 & 0 \\ 0.5 & 0.4 & 0.1 & 0 \end{bmatrix}$$

Therefore, the evaluation matrix of secondary indicators can be obtained as follows:

$$B_1 = W_1 \circ R_1 = [0.516\ 0.369\ 0.031\ 0.084] \tag{1}$$

$$B_2 = W_2 \circ R_2 = [0.449\ 0.351\ 0.128\ 0.072] \tag{2}$$

$$B_3 = W_3 \circ R_3 = [0.567\ 0.266\ 0.167\quad 0] \tag{3}$$

$$B_4 = W_4 \circ R_4 = [0.485\ 0.382\ 0.124\ 0.009] \tag{4}$$

Similarly, the evaluation matrix of the first-level indicators can be obtained as $B = W \circ \left[B_1^T\ B_2^T\ B_3^T\ B_4^T\right] = [0.5043\ 0.3420\ 0.1125\ 0.0413]$. In the above first-level evaluation indicator, the comprehensive affiliation of the four evaluation levels is excellent (0.5043), good (0.3420), medium (0.1125), and poor (0.0413), among which the affiliation of the level excellent is the largest, so the site selection evaluation result of this logistics center is considered excellent.

5 Conclusion

By developing a model of AHP-fuzzy comprehensive assessment approach to analyze the siting of this example, this research comes to the conclusion that the siting plan of Beijing Shunfeng Logistics Center is outstanding and fits the criteria of an excellent plan. The effectiveness of the AHP-fuzzy comprehensive evaluation method for the study of the logistics center location is confirmed, the evaluation system for the logistics center location is established, and the conclusion of the study has some practical significance and value thanks to the study of the Beijing Shunfeng logistics center case.

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