Factor Analysis Model on Impact Index for Logistics Center Location

Kuang Wang

Basic Teaching and Research Institute, Bohai University, Jinzhou, 121013, China

411502202@qq.com

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Abstract. Reasonable logistics center location has important role in optimizing the transport route, reducing the logistics cost, improving the operational efficiency and promoting the regional development. According to the current situation, the impact index of the logistics center location is more, this paper based on factor analysis method to study. First, build the impact indicators system of logistics center location, it consists of 12 indicators; then, according to the solving steps of factor analysis method to build mathematical model, to carry out the data calculation, and analyses the result. The 12 impact index are abstracted into 6 factors by dimensional reduction method, with less dimension integrate the data, obtained on logistics center location accurate and convenient research, the further study of the logistics center location provides a simple method.

Introduction

Principal component analysis is a multivariate statistical method to research the correlation between multiple variables, to reveal the internal structure of multiple variables through a few principal components, Export few principal components from the original variable, as far as possible to preserve the original variable information, and unrelated to each other, the principal component than the original data with a superior performance. Factor analysis is the promotion and expansion of the principal component analysis, with few factors to describe the connection between many of the indicators or factors that will more closely related to several variables classified in the same class, each class variable becomes a factor, a few factors to reflect most of the information of the original data.

Logistics center is based on a region as the main service object, from the whole region to the logistics service needs to consider, is set up in accordance with its own characteristics of region, services for regional economic and social development. Location of logistics center is a complicated systematic project, because of the large investment in the construction of logistics center, involving many factors, long service period, high risk, whether location is reasonable directly affects the smoothness, and economic benefit and operational efficiency of social logistics systems, while also have an important influence on regional planning, traffic conditions and regional environment. The preferred solution of logistics center location is to make the collection, transfer and distribution of goods through the logistics center, until benefit that the whole process of delivery to the demand node is the best. In the location planning of logistics center, have a comprehensive analysis for the impact index of the logistics center. In this paper, using factor analysis method, impact indicators will be closely grouped in a class with few factors to describe the relationship between the plurality of impact indicators, simplified analysis, for logistics center location research to provide a theoretical method.

Impact Index System

System refers to a range or similar things in a certain order and internal relations as a whole combination. Index system is an organism composed of several interrelated statistical indicators. Making a scientific, systematic and comprehensive index system is the basic work of factor analysis. Using single index or several indexes to study the logistics center location problem has certain one-sidedness and subjective. Only scientific and rational index system, it is possible to draw a scientific and impartial research conclusion. In the process of index system construction, the first to

follow the general principles of index system construction, but also pay attention to the necessity of elements in the index system, under the circumstances without losing the overall situation, to minimize the number of system indicators, and attach much importance to the function of index system.

Logistics center is the infrastructure to achieve logistics business office, goods distribution and transport service activities, it is hardware and material carrier of logistics nodes, in order to make the logistics center embodies the organic division in function, coordination ability, spatial rational distribution, specific location should follow the following basic principles: (1) traffic guiding principles. Traffic is a key factor restricting the development of logistics, selecting the traffic conditions are good, located in the cargo occurred mainly direction and closer to the highway entrance to construct, both to avoid duplicate construction, but also to reduce the capital investment, to prevent a large number of goods back and circuitous transport; (2) urban-oriented principles. Logistics center itself is an important part of the urban infrastructure, is bound to be included in the overall urban planning. Since the logistics center involves office, storage and transportation links, covers a larger area, large quantities of goods from transport have a certain impact on the surrounding, so in general should be chosen city boundaries; (3) the terrain oriented principles. Open flat terrain, the region has scalability, reserve space for future expansion. With the development of the city, product logistics volume will increase, may put forward higher request to the scale and function of logistics park, must have enough extension space to meet the needs for further development; (4) economic adaptation principles. Logistics center should be closely related to the local economic development and industrial planning, to meet the needs of local freight volume; (5) facilities matching principle. Logistics center development is inseparable from perfect supporting facilities. Whether logistics center have sufficient energy, water and good living conditions has become an important factor in logistics center location. Structural logistics center location principle, referring to results of previous studies [1, 2], this paper constructs the index system of logistics center location as shown in Fig. 1.

Fig. 1. Impact index system on logistics center location

Factor Analysis Model

Mathematical model is a real problem as the corresponding mathematical problem, and using mathematical concepts, methods and theories in-depth analysis, and it portrayed the practical problems from qualitative and quantitative point of view, and provide accurate data and reliable guidance to solve the problem. Factor analysis is a strict mathematical model, combined with results of previous studies [3-6], constructing the mathematical model and data calculation steps are as follows:

(1) Construct the initial matrix

Suppose there are m samples, n indexes, the j -th index value of the i -th sample is y_{ij} ($i = 1, 2, \dots, m$ $j = 1, 2, \dots, n$), all the sample values with the matrix is represented as:

$$Y = \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ y_{m1} & y_{m2} & \cdots & y_{mn} \end{bmatrix} \quad (1)$$

The initial matrix using expert scoring method, employing nine experts in the field of logistics research for 12 impact indicators were respectively scored. In order to score is more normative, the provisions of each expert for all factors of the scoring and for 120 points. Expert scoring is the original data for the calculation of the data, as shown in Table 1.

Table 1. Initial matrix

Expert	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	Total
1	14	12	13	10	11	10	7	8	9	10	9	7	120
2	10	7	11	9	14	6	9	9	10	16	8	11	120
3	9	15	14	7	9	10	8	7	12	10	9	10	120
4	13	10	15	11	12	7	6	4	10	9	12	11	120
5	12	16	13	8	9	8	6	7	7	11	10	13	120
6	11	12	13	8	15	6	9	8	6	11	12	9	120
7	14	14	12	12	10	5	7	9	10	9	6	12	120
8	15	9	14	10	8	11	10	4	8	12	11	8	120
9	16	15	13	9	9	8	5	5	9	12	9	10	120

(2) Calculate the factor loading matrix

Factor loading matrix is the coefficient of the factor expression of each original variable, and the influence degree of the extracted common factor to the original variable. Eigenvector matrix U with p -dimensional can be decomposed into:

$$U = [U_1 U_2 \cdots U_k U_{k+1} U_{k+2}] = \begin{bmatrix} U(1) & U(2) \\ n \times k & n \times (n-k) \end{bmatrix} \quad (2)$$

U will be substituted into the factor analysis, the basic equation are:

$$x = U f = \begin{bmatrix} U_1 & U_2 \end{bmatrix} \begin{bmatrix} f(1) \\ f(2) \end{bmatrix} = \begin{bmatrix} U(1) & U(2) \end{bmatrix} \begin{bmatrix} f(1) \\ f(2) \end{bmatrix} = U(1)f(1) + U(2)f(2) = U(1)f(1) + e \quad (3)$$

The calculation results of initial factor loading matrix are shown in Table 2.

Table 2. Initial factor load matrix

Code	Name	Component					
		1	2	3	4	5	6
X ₁	Land price	0.537	-0.242	0.680	0.002	-0.418	0.031
X ₂	Construction cost	0.303	-0.663	-0.549	-0.114	-0.303	-0.218
X ₃	Transportation cost	0.870	0.195	-0.155	-0.187	0.380	-0.023
X ₄	Human resources	0.088	-0.330	0.887	-0.031	0.238	-0.097
X ₅	Competitors	-0.658	0.392	0.110	-0.482	0.232	-0.185
X ₆	Market demand	0.669	0.350	-0.224	0.557	-0.156	-0.049
X ₇	Road traffic	-0.323	0.735	0.046	0.304	0.053	-0.164
X ₈	Peripheral situation	-0.837	-0.224	-0.139	0.098	-0.100	-0.441
X ₉	Public facilities	-0.022	-0.340	-0.082	0.606	0.671	0.112
X ₁₀	Meteorological conditions	-0.570	0.425	0.048	0.255	-0.310	0.555
X ₁₁	Geological conditions	0.466	0.670	-0.135	-0.550	0.077	0.077
X ₁₂	Topographical conditions	-0.303	-0.616	-0.222	-0.341	0.141	0.492

To make the square of coefficients u_{ij} of k factors in each equation close to 1, the need for further normalization process, taking load factors $u_{ij}\sqrt{\lambda_j}$ as the coefficients a_{ij} , and even if the i -th variable load on the j -th principal factors are:

$$a_{ij}=u_{ij}\sqrt{\lambda_j} \quad (4)$$

So get a factor loading matrix A is:

$$A = (a_{ij}) = \begin{bmatrix} u_{11}\sqrt{\lambda_1} & u_{12}\sqrt{\lambda_2} & \cdots & u_{1k}\sqrt{\lambda_k} \\ u_{21}\sqrt{\lambda_1} & u_{22}\sqrt{\lambda_2} & \cdots & u_{2k}\sqrt{\lambda_k} \\ \vdots & \vdots & \cdots & \vdots \\ u_{n1}\sqrt{\lambda_1} & u_{n2}\sqrt{\lambda_2} & \cdots & u_{nk}\sqrt{\lambda_k} \end{bmatrix} \quad (5)$$

The calculation results of factor loading matrix are shown in Table 3:

Table 3. Final factor load matrix

Code	Name	Component					
		1	2	3	4	5	6
X ₁	Land price	0.108	-0.462	0.805	0.011	-0.067	-0.328
X ₂	Construction cost	-0.185	-0.468	-0.277	-0.399	-0.684	-0.167
X ₃	Transportation cost	0.879	-0.170	-0.011	0.124	-0.408	0.118
X ₄	Human resources	-0.048	0.164	0.948	-0.032	-0.088	0.184
X ₅	Competitors	-0.110	0.910	-0.113	0.081	0.170	-0.172
X ₆	Market demand	0.357	-0.692	-0.185	0.555	-0.023	0.090
X ₇	Road traffic	-0.057	0.276	-0.221	0.678	0.423	0.045
X ₈	Peripheral situation	-0.879	0.385	-0.234	0.032	-0.082	0.020
X ₉	Public facilities	-0.089	-0.130	0.003	-0.059	-0.041	0.961
X ₁₀	Meteorological conditions	-0.235	0.023	-0.208	0.021	0.931	-0.109
X ₁₁	Geological conditions	0.847	0.217	-0.198	0.183	-0.004	-0.400
X ₁₂	Topographical conditions	-0.133	0.117	-0.106	-0.915	0.023	0.133

Factor analysis model adjusted is expressed as:

(6)

The factor analysis model constructed according to the data of Table 3 is:

$$[X_1 = 0.108f_1 - 0.462f_2 + 0.805f_3 + 0.011f_4 - 0.067f_5 - 0.$$

$$\left\{ \begin{array}{l} X_1 = 0.108f_1 - 0.462f_2 + 0.805f_3 + 0.011f_4 - 0.067f_5 - 0.328f_6 \\ X_2 = -0.185f_1 - 0.468f_2 - 0.277f_3 - 0.399f_4 - 0.684f_5 - 0.167f_6 \\ X_3 = -0.486f_1 + 0.553f_2 - 0.396f_3 + 0.011f_4 - 0.067f_5 - 0.328f_6 \\ X_4 = -0.633f_1 + 0.624f_2 + 0.257f_3 + 0.011f_4 - 0.067f_5 - 0.328f_6 \\ X_5 = 0.760f_1 - 0.070f_2 - 0.613f_3 + 0.011f_4 - 0.067f_5 - 0.328f_6 \\ X_6 = 0.785f_1 - 0.402f_2 + 0.144f_3 + 0.011f_4 - 0.067f_5 - 0.328f_6 \\ X_7 = 0.768f_1 - 0.039f_2 + 0.6418f_3 + 0.011f_4 - 0.067f_5 - 0.328f_6 \\ X_8 = 0.853f_1 - 0.151f_2 + 0.027f_3 + 0.011f_4 - 0.067f_5 - 0.328f_6 \\ X_9 = -0.089f_1 - 0.130f_2 + 0.003f_3 - 0.059f_4 - 0.041f_5 + 0.961f_6 \\ X_{10} = -0.235f_1 + 0.023f_2 - 0.208f_3 + 0.021f_4 + 0.931f_5 - 0.109f_6 \\ X_{11} = 0.847f_1 + 0.217f_2 - 0.198f_3 + 0.183f_4 - 0.004f_5 - 0.400f_6 \\ X_{12} = -0.133f_1 + 0.117f_2 - 0.106f_3 - 0.915f_4 + 0.023f_5 + 0.133f_6 \end{array} \right.$$

On the above research

f_1 is the most important impact factor, factor contribution rate reached 28.868%, mainly reflecting the "Transportation cost, Geological conditions, Market demand" and three impact indicators.

f_3 is the third important influence factor, factor contribution rate reached 14.4548%, mainly reflecting the "Human resources, Land price" and two impact indicators.

f_5 is the fifth important influence factor, factor contribution rate reached 9.428%, mainly reflecting the "Meteorological conditions, Road traffic, Competitors" and three impact indicators.

Conclusion

Logistics center is a comprehensive, regional, and large quantities of goods are concentrated, it plays a pivotal role in the logistics system, the upstream of center is suppliers, downstream is the supply point or demand point, plays a connecting role between the preceding and the following. Reasonable logistics center location can effectively save costs, facilitate the coordination of production and consumption, to ensure a balanced development of the logistics system. In this paper, based on factor analysis method, the 12 impact index are abstracted into 6 factors by dimensional reduction method, with less dimension integrate the data, obtained on logistics center location accurate and convenient research, the further study of the logistics center location provides a simple method.

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