

Analysis of urban logistics capability based on fuzzy matter-element quantitative model

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Abstract. An index system of logistics capability analysis in Shenzhen was established, and the fuzzy matter-element quantitative model for urban logistics capability analysis was established based on entropy evaluation method and fuzzy matter-element method. The change process of urban logistics capacity in Shenzhen in 2007~2016 was obtained through the model solution. In result, the overall logistics capacity of Shenzhen had been increasing gradually in 2007~2016, and the logistics capability of all the first level indexes had been increasing and the capacity of the existing logistics scale had increased most rapidly. The results are consistent with the present situation, which provides a scientific basis for the relevant departments to formulate the logistics and economic development strategies.

1. Introduction

In recent years, China's logistics industry has been developing rapidly. Many policies to support the development of logistics have come out in succession. However, there are still many problems in the improvement of urban logistics capability. Therefore, scientific analysis of urban logistics capability is of great significance for improving urban logistics capability and comprehensive competitiveness. Scholars at home and abroad have done some researches on the analysis of urban logistics capability.

Luo Xiantie^[1] finds that the capacity of urban logistics is closely related to the construction of logistics infrastructure, the development level of logistics and the handling capacity of logistics. Liu Lin^[2] considers logistics resources and urban efficiency to build an index system for evaluating logistics capability, and proved that these two dimensions have great impact on urban logistics capability. Zhao Xiuli^[3] adopts the fuzzy comprehensive evaluation method based on entropy weight to analyse the logistics capability of the supply chain. Banomyong R^[4] uses semi-structured analysis of Vietnam's logistics capability to draw the gap between Vietnam's logistics capability and other countries. Sule Önsel Ekici^[5] uses artificial neural network to analyse Turkey's logistics capability. So far, the research on urban logistics capability is not comprehensive. Most of the domestic enterprises only stay in the research of logistics capability of enterprises or supply chain, and build the index system of logistics capability evaluation. There is little scientific way to study how to improve the city's logistics capability. Foreign scholars try to use different methods to study the logistics capability of the country, but the direct research on the logistics capability of the city is relatively rare.

From the research method of logistics capability, the existing research mainly uses cluster analysis, fuzzy comprehensive evaluation, data envelopment analysis, grey relational method, neural network method and so on to evaluate the logistics capability of industry or region. These research methods inevitably have the defects of subjectivity, randomness, and easy to lose information. Fuzzy matter-element is the comprehensive application of fuzzy mathematics and matter element analysis,



combining the quality and quantity of things together, so as to reflect the essence of things more deeply, and to describe the process of the change of objective things more accurately. The fuzzy matter element quantification model is introduced into the field of urban logistics capability analysis. This paper analyses the logistics capacity of Shenzhen, explores the internal rules of logistics development, provides reference for improving the logistics capacity of the city, and verifies the adaptability of the model in the field of logistics capability analysis.

2. Establish fuzzy matter-element quantitative model

2.1. Construct the original matter-element model

Assume that compound matter element is R_{mn} , write down object $i (i=1,2,\dots,m)$ as M_i , write down features $j (j=1,2,\dots,n)$ as C_j , x_{ij} represents object i and feature j , construct the original matter-element model as follows:

$$R_{mn} = \begin{bmatrix} M_1 & M_2 & \dots & M_m \\ C_1 & x_{11} & x_{21} & \dots & x_{m1} \\ C_2 & x_{12} & x_{22} & \dots & x_{m2} \\ \dots & \dots & \dots & \dots & \dots \\ C_n & x_{1n} & x_{2n} & \dots & x_{mn} \end{bmatrix} \quad (1)$$

2.2. The optimal subordinate degree

$$x_{ij}^* = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}}, \quad x_{ij}^* = \frac{\min x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (2)$$

Among them: $\max x_{ij}$ and $\min x_{ij}$ represents the maximum and minimum of all x_{ij} corresponding to feature j respectively, x_{ij}^* is the optimal subordinate degree of object i and feature j .

2.3. Construct the optimal fuzzy matter element

R_{mn}^* represents fuzzy matter-element of the optimal subordinate degree. The optimal fuzzy matter-element refers to the optimal subordinate degree of each index in R_{mn}^* . Assume that $u_{0i} (i=1,2,\dots,n)$ is corresponding fuzzy value, then optimal fuzzy matter element are as follows:

$$R_{0n}^* = \begin{bmatrix} M_0 \\ C_1 & u_{01} \\ C_2 & u_{02} \\ \dots & \dots \\ C_n & u_{0n} \end{bmatrix} \quad (3)$$

2.4. Difference square compound fuzzy matter element

$\Delta_{ij} (i=1,2,\dots,m; j=1,2,\dots,n)$ is used as the square of the difference $\Delta_{ij} = (x_{0j}^* - x_{ij}^*)^2$ between the optimal fuzzy matter element R_{0n}^* and optimal subordinate degree fuzzy compound matter element R_{mn}^* , form a difference square fuzzy matter element R_{Δ}^* :

$$R_{\Delta}^* = \begin{bmatrix} & M_1 & M_2 & \dots & M_m \\ C_1 & \Delta_{11} & \Delta_{21} & \dots & \Delta_{m1} \\ C_2 & \Delta_{12} & \Delta_{22} & \dots & \Delta_{m2} \\ \dots & \dots & \dots & \dots & \dots \\ C_n & \Delta_{1n} & \Delta_{2n} & \dots & \Delta_{mn} \end{bmatrix} \quad (4)$$

2.5. Entropy method to determine the weight

2.6. Euclidean close degree compound fuzzy matter element

The degree of closeness between each plan and the optimal plan is called close degree. The greater the value is, the closer it is to the optimal plan. By calculating the close degree, we can get the close degree between each plan and the optimal plan and the relative order of the plans.

$$dH_i = 1 - \sqrt{\sum_{j=1}^n w_j \Delta_{ij}}, i = 1, 2, \dots, m \quad (5)$$

According to dH_i , construct the compound fuzzy matter element of the Euclidean close degree R_{dH}^* :

$$R_{dH}^* = \begin{bmatrix} & M_1 & M_2 & \dots & M_m \\ dH_i & dH_1 & dH_2 & \dots & dH_m \end{bmatrix} \quad (6)$$

3. Construct index system

3.1. Research objects and data

Shenzhen is a traffic hub city. The transportation network of sea, land and air has developed rapidly. Shenzhen has a market and policy suitable for logistics development. As of 2017, the added value of Shenzhen's logistics industry reached 227 billion 639 million yuan, an increase of 9.8%. The logistics industry plays an important role in supporting and promoting the economy of Shenzhen. During the "13th Five-Year" period, the logistics industry in Shenzhen is facing a major transformation. The traditional extensive mode of development is difficult to survive, and must be developed to modern logistics. The growth rate of the logistics industry will continue to slow. This paper analyses the logistics capability of Shenzhen city with certain representativeness.

The quantitative data are mainly derived from the statistical yearbooks of Guangdong, and the statistical yearbooks of Shenzhen and the prospective database of 2007~2016. Because qualitative data is difficult to quantify, this paper uses questionnaires and interviews with industry related experts. Finally, we use fuzzy comprehensive evaluation to get the conclusion. This paper divides the qualitative index into nine grades, and uses {1, 2, 3, 4, 5, 6, 7, 8, and 9} to express {extreme bad, very bad, bad, a little bad, general, good, a little good, very good, excellent}, specific data are detailed in the appendix.

3.2. Initial index system

This paper uses the literature analysis^[1-5] method to build a first level index system from six aspects to analyse the urban logistics capability. They are logistics infrastructure, the current situation of logistics development, existing logistics scale, relevant economic indicators, logistics information support and logistics development potential. The study preliminarily determines the second level index. Logistics infrastructure is the basic condition for the development of logistics industry. In this paper, the second level indicators are divided into urban real road area, total number of civil vehicles, total number of civil transport vessels and number of port berths. The current situation of logistics development refers to the general development of logistics industry every year. In this paper, the second level index is considered as the number of employees in the logistics industry, the value added of the logistics industry, the proportion of the added value of the logistics industry, and the proportion of the fixed assets investment of the logistics industry to all the fixed assets investment. The existing logistics scale

refers to the existing scale of the city's logistics industry. This paper considers that the second level indicators are the total amount of post and telecommunications, freight volume, freight turnover, airport cargo handling capacity and port cargo throughput. Relevant economic indicators usually measure the overall economic situation of a city and people's living standards. This paper considers that the second level indicators are the total retail sales of consumer goods, the gross domestic product and the per capita GDP. Logistics information support refers to the communication technology and information means to ensure the normal development of logistics activities in this city. This paper considers that the second level indicators are mobile phone users, fixed telephone subscribers, telephone numbers per hundred people, and internet broadband users. Logistics development potential refers to resources and conditions that can promote the development of logistics industry in the future. This paper considers that the second level indicators are the number of college students, the urban basic environmental conditions and the urban logistics development policy.

3.3. Correlation analysis

According to the literature analysis, there is a certain degree of correlation and overlap between the two indicators. At the same time, considering the adaptability of Shenzhen's logistics capability, we use principal component analysis to analyse the correlation of indicators and screen out appropriate indicators to build an index system. The data of the collected quantitative indicators and the score of the qualitative indicators obtained from the questionnaires were input into SPSS for principal component analysis.

3.3.1. Get the initial eigenvalue and the total variance and extract the number of main components

According to the selection principle of principal components, we select the number of principal components whose eigenvalues are greater than 1. A total of four principal components accorded with this condition, and the variance accumulation reached 94.195%. Basically, the four principal components can reflect the information represented by all indicators.

3.3.2. Get the matrix of components after rotation

In order to make the coefficient in the factor load matrix more significant, the rotation factor load matrix is analysed in this study. The result is easy to understand and more explanatory. This paper selects the index of load factor greater than 0.8 to express the meaning of principal component. According to the results of the principal component analysis, the index system used to analyse the logistics capacity of Shenzhen is obtained. Nineteen second level indexes C_1, C_2, \dots, C_{19} are expressed as follows:

Table 1. The index system of logistics capability analysis in Shenzhen.

First level indexes	Second level indexes
Logistics infrastructure	Urban real road area C_1 , Total number of civil vehicles C_2 , Total number of civil transport vessels C_3 .
The current situation of logistics development	The number of employees in the logistics industry C_4 , The value added of the logistics industry C_5 , The proportion of the fixed assets investment of the logistics industry to all the fixed assets investment C_6 .
Existing logistics scale	Total amount of post and telecommunications C_7 , Freight volume C_8 , Freight turnover C_9 , Airport cargo handling capacity C_{10} , Port cargo throughput C_{11} .
Relevant economic indicators	Total retail sales of consumer goods C_{12} , Gross domestic product C_{13} , Per capita GDP C_{14} .
Logistics information support	The number of phones per hundred people C_{15} , Internet broadband users C_{16} .
Logistics development potential	Number of college students C_{17} , Urban basic environment conditions C_{18} , Urban logistics development policy C_{19} .

4. Quantitative process and result analysis

4.1. Quantitative process

The research takes years as objects, indicators as characteristics, and determines all data used to construct complex elements. Among them, M_1, M_2, \dots, M_{10} represent 2007~2016 respectively. According to the entropy method, the weights of the nineteen indicators are calculated.

Table 2. Weight of each index.

Index	Weight	Index	Weight	Index	Weight	Index	Weight
C1	0.015	C6	0.041	C11	0.004	C16	0.125
C2	0.083	C7	0.168	C12	0.072	C17	0.016
C3	0.032	C8	0.034	C13	0.075	C18	0.030
C4	0.084	C9	0.068	C14	0.049	C19	0.020
C5	0.042	C10	0.030	C15	0.013		

According to formula (1) ~ (7), the European closeness in 2007-2016 is calculated:

$$R_{dH}^* = \begin{bmatrix} M_1 & M_2 & M_3 & M_4 & M_5 & M_6 & M_7 & M_8 & M_9 & M_{10} \\ dH_i & 0.045 & 0.138 & 0.190 & 0.241 & 0.345 & 0.413 & 0.535 & 0.607 & 0.709 & 0.773 \end{bmatrix}$$

4.2. Result analysis

Shenzhen's logistics capability in 2007~2016 has been increasing gradually. This shows that Shenzhen's logistics capabilities have improved significantly. Among them, the logistics capability of 2007~2010 has been increasing steadily in the trend of slower growth. The annual growth rate of logistics capacity in 2011~2016 fluctuated significantly, but the upward trend was still obvious. The logistics capability of the first level index is basically on the rise. Among them, the existing logistics scale capacity growth is the fastest. Logistics development potential and logistics information support make the greatest contribution to the upgrading of logistics capability in Shenzhen. Among the second level indicators, total amount of post and telecommunications, internet broadband users, total number of civil vehicles, and the number of employees in the logistics industry are relatively large. As can be seen from Figure 1, the indicators with relatively high weight are basically increasing every year. These indicators have great contribution to the improvement of logistics capability.

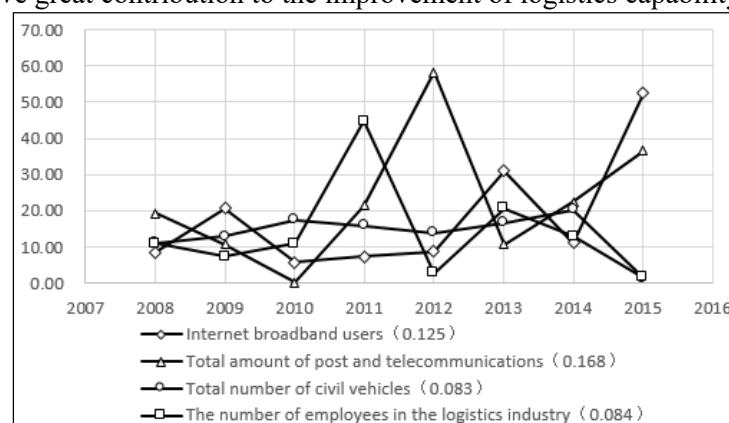


Figure 1. The annual percentage increase of the larger weight index (%).

Based on the analysis of the current situation of logistics in Shenzhen and the quantitative results, this paper puts forward some improvement strategies for the logistics and economic development of Shenzhen: Relevant departments should coordinate the construction of water, land and air, pay attention to the compatibility of various transport facilities and the compatibility of various modes of transportation, and improve land use rate and utilization rate of facilities. They should give full play to

the overall role of the government, plan and coordinate the logistics industry, and optimize the resources and structure of the logistics industry. They also should seek the breakthrough of the port development, improve the level of logistics information, and promote the development of traditional logistics to modern logistics.

5. Conclusions

Taking the urban logistics capability as the research object, this paper combines entropy method and fuzzy matter element analysis to establish a fuzzy matter-element quantitative model. Based on the analysis of the logistics capability of Shenzhen, six indexes of the first level and nineteen indexes of second level are set up to analyse the logistics capability analysis index system of Shenzhen. Based on the fuzzy matter-element quantitative model, the quantitative analysis of Shenzhen's urban logistics capability is carried out. The result of the example shows that the overall logistics capability of Shenzhen 2007~2016 has been increasing gradually. At the same time, it validates the adaptability of fuzzy matter-element quantitative model in urban logistics capability analysis.

6. Appendices

Table 3. Quantitative index and value of urban logistics capacity

C	2007 (M1)	2008 (M2)	2009 (M3)	2010 (M4)	2011 (M5)	2012 (M6)	2013 (M7)	2014 (M8)	2015 (M9)	2016 (M10)
1	8322	8630	8864	8941	9080	10629	11496	11633	11838	11920
2	116.008	128.757	145.264	170.546	197.616	224.922	262.287	315.390	319.350	322.588
3	142	160	173	220	227	245	252	265	269	277
4	15.472	17.143	18.379	20.354	29.443	30.250	36.481	41.122	41.710	41.050
5	290.942	298.497	309.179	379.847	437.480	470.955	463.291	500.405	540.80	626.32
6	18.421	19.212	23.033	18.773	16.315	10.937	16.995	12.728	12.053	10.965
7	513.540	611.750	676.520	293.700	356.260	563.580	622.990	761.990	1040.320	1715.020
8	1.368	1.957	2.237	2.618	2.890	3.034	2.751	2.938	3.097	3.116
9	794.100	1094.160	1136.640	1654.160	1955.690	1878.740	1998.920	2386.370	2267.250	2246.860
10	62	60	61	81	83	85	91	96	101	113
11	1.999	2.113	1.937	2.210	2.233	2.281	2.340	2.232	2.171	2.141
12	1930.805	2276.586	2567.844	3000.763	3520.874	4008.779	4500.456	4918.998	5017.838	5512.756
13	6801.571	7786.792	8290.284	9773.306	11515.86	12971.46	14572.66	16001.82	17502.86	19492.60
14	7.627	8.343	8.506	9.618	11.052	12.345	13.763	14.950	15.799	16.741
15	244	246	234	243	274	296	286	362	296	264
16	189	205	247	261	280	304	398	442	674	632
17	5.891	6.563	6.695	6.732	7.000	7.557	8.240	8.767	9.011	9.188
18	3	4	4	4	5	5	5	6	6	6
19	4	5	5	6	6	6	6	7	7	7

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