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Grade Evaluation Research of Green Logistics Development Based on Fuzzy Comprehensive Evaluation Method: Taking Beijing as An Example

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Abstract: **It collects environmental pollution, environmental governance index data of green logistics development evaluation index system in Beijing. It gets the qualitative index data by questionnaire. According the principle of comparability， it standardizes data. Establish index evaluation grade using fuzzy comprehensive evaluation method. The objective of this study is to prepare data for the further study of green Logistics comprehensive evaluation.**

Keywords: Green logistics; Logistics statistics; Quantitative indicators; Fuzzy comprehensive evaluation

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1. Introduction

With the rapid development of the logistics industry, its impact on the ecological environment is more and more obvious. The implementation of green logistics is an important driving force for the sustainable development of economy. Evaluation on the development of green logistics, domestic and foreign scholars study focused on two aspects. One is the research on the construction of green logistics evaluation system; the other is the empirical research on the development of green logistics.

Guochuan Yang [1] points out the urgency and necessity of developing green logistics in our country, and points out that the development of green logistics is to meet the needs of the development of the world economy, is an important step to realize the strategy of sustainable development, is advantageous for the enterprise to achieve new competitive advantages, to meet the needs of people's life, and at the same time also pointed out that the existing green logistics development in our country's restrictive factors, has a certain guiding significance which is the development of green logistics in China. Daohua Du [2] from the conservation of resources and environmental protection two aspects, to establish the evaluation index system of green logistics of two oriented society. He points out that the evaluation index system of green logistics construction must follow the principle, and establish evaluation index. Aibin Li researches on the construction of green coal logistics system, and its optimization [3]. His paper first introduces the coal which is a special industry, the characteristics of green logistics; build the green coal logistics system and the green waste logistics by using system dynamics simulation. Fuzzy comprehensive evaluation method is a comprehensive evaluation method based on fuzzy mathematics. This comprehensive evaluation method by using fuzzy mathematics principle turns qualitative evaluation to quantitative evaluation. It makes some problems restricted by many factors and difficult to evaluation be solved. Fuzzy comprehensive evaluation method can solve some fuzzy, and difficult to quantify problem, more and more widely application [4].

The research literature and research status of the green logistics and the fuzzy comprehensive evaluation method exists following problems.

(1) Foreign has high degree of concern about the green logistics research than domestic, research time is earlier, development is also more mature. Foreign research angle and direction are very innovative; by contrast, domestic research seems to stay in one area and is unable to break through.

(2) For the study of green logistics, the current domestic research is mainly qualitative aspects; there is little quantitative research on the development of green logistics.

It have constructed the evaluation index system of green logistics in the previous research achievements [5], used the AHP method and fuzzy comprehensive evaluation method combining scoring investigation and expert questionnaire, and calculated the weight distribution. On this basis, this paper collects environmental pollution, environmental governance index data of green logistics development evaluation index system in Beijing. It gets the qualitative index data by questionnaire. According the principle of comparability，it standardizes data. Establish index evaluation grade using fuzzy comprehensive

evaluation method. The objective of this study is to prepare data for the further study of green Logistics comprehensive evaluation.

Table 1 The normalized results of Beijing green logistics evaluation index

Normalized value	Q11	Q12	Q13	Q14	Q15	Q21	Q22	Q23
2003	0	0.212	0.021	0	0.103	0.541	0.545	0
2004	0.074	0	0.006	0.038	0	0.588	0.367	0.090
2005	0.031	0.116	0	0.096	0.224	0	1	0.213
2006	0.154	0.334	0.313	0.204	0.621	1	0.953	0.571
2007	0.069	0.112	0.602	0.218	0.902	0.870	0.975	0.608
2008	0.030	0.495	0.722	0.407	0.665	0.234	0.742	0.794
2009	0.075	0.532	0.765	0.803	0.657	0.440	0.246	0.786
2010	0.172	1	0.88	0.890	0.946	0.637	0.099	0.973
2011	1	0.878	1	1	1	0.570	0	1

2. Fuzzy Comprehensive Evaluation Method

2.1. Construction of Evaluation Index System Set

When using fuzzy comprehensive evaluation method, determine the evaluation index first. Usually the index is divided into the level one and level two indexes. Assuming a level index is *Qi*, and each first level index consists of a plurality of two level indexes Q_{ij}.

In the evaluation process of qualitative index, because it is difficult to get quantitative data, fuzzy evaluation results so generally need to set up a quantitative to qualitative indexes, established the index weight through questionnaire investigation and expert scoring method. Usually need to set up four kinds of fuzzy evaluation results for each qualitative index. B_1 is better, B_2 is good, B_3 is general, B_4 is poor.

2.2. Construction of Fuzzy Comprehensive Evaluation Matrix

Through a questionnaire, evaluate each of the two level indicators of Q_{ij}. According to the evaluation of personnel and distribution of total number of comments, set up two grade fuzzy judgment matrix U_k follows below.

$$U_k = \begin{bmatrix} a_{11} & \cdots & a_{1m} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nm} \end{bmatrix}, \quad (1)$$

Where, $0 \le a_{ij} \le 1$, and $\sum_{j=1}^{m} a_{ij} = 1, i = 1,2,\ldots,n$.

$$a_{ij} = \frac{\text{The number of select the } j\text{th option people when evaluation of index } S_k}{\text{The total number of participating people}} \quad (2)$$

According to the data of two level fuzzy evaluation matrix U_k, then according to the weight vector X_{ij} of two level indexes calculated by AHP method, by fuzzy transformation formula of $B_i = X_{ij}U_k$ can calculate all two level indicators of the result vector, each result vector representation as follows.

$$B_i = X_{ij}U_k = \{b_{i1}, b_{i2}, \ldots, b_{in}\} \quad (3)$$

All two levels of evaluation results matrix vector consist the fuzzy judgment matrix U.

$$U = \begin{bmatrix} b_{11} & \cdots & b_{1m} \\ \vdots & \ddots & \vdots \\ b_{n1} & \cdots & b_{nm} \end{bmatrix} \quad (4)$$

Similarly，according to the fuzzy transformation formula of $B = X_i U$, can get the results of the first level indexes vector B, denoted as $B = \{b_1, b_2, ..., b_p\}$.

3. The Establishment of Quantitative Evaluation Index Grade

Because of the quantitative index is time series data, in order to get a comprehensive evaluation value, and each index units are not the same, it needs to be normalized. Then calculate the variance of each index data, as well as the mean and standard deviation. Using the mean standard deviation method, green logistics development level of Beijing is divided into four grades, and then can determine the grade of each index, so as to further evaluation. We deal data processing for the environmental pollution and environmental governance of the two quantitative indicators.

We will standardize 2003~2011 years' indexes data

of Beijing. According to the following normalization formula, the original data denotes x_{ij}, the new data denotes d_{ij}, where, the subscript i is years, and j is index.

$$d_{ij} = \frac{x_{ij} - \min}{\max - \min}. \quad (5)$$

Where, Max and Min is the maximum value and the minimum value in 2003~2011 years, as shown below (Table 1). After obtaining the normalized results, mean, variance, standard deviation calculated and shown below (Table 2).

Table 2 Mean, variance, standard deviation of Beijing logistic industry index value

Index	Mean	Variance	Standard deviation
solid waste(Q11)	0.1783	0.0872	0.2953
traffic noise pollution(Q12)	0.4085	0.1084	0.3293
carbon emissions amount(Q13)	0.4789	0.1421	0.3769
wastewater discharge amount(Q14)	0.4063	0.1352	0.3677
exhaust emissions volume(Q15)	0.5687	0.1242	0.3525
solid waste comprehensive utilization rate(Q21)	0.5422	0.0809	0.2844
pollution abatement investment(Q22)	0.5475	0.1349	0.3673
sewage treatment rate(Q23)	0.5595	0.1252	0.3539

Table 3 Four grade classification standard of normalized data

Index	Direction	Mean	Variance	Grade I	Grade II	Grade III	Grade IV
Q11	-	0.1783	0.2953	[0,0.0307)	[0.0307,0.3260)	[0.3260,0.4736)	[0.4736,1]
Q12	-	0.4085	0.3293	[0,0.2439)	[0.2439,0.5732)	[0.5732,0.7378)	[0.7378,1]
Q13	-	0.4789	0.3769	[0,0.2904)	[0.2904,0.6673)	[0.0.6673,0.8558)	[0.8558,1]
Q14	-	0.4063	0.3677	[0,0.2225)	[0.2225,0.5906)	[0.7167,0.7740)	[0.7740,1]
Q15	-	0.5687	0.3525	[0,0.3925)	[0.3925,0.7450)	[0.7450,0.9212)	[0.9212,1]
Q21	+	0.5422	0.2844	[1,0.8266)	[0.8266,0.6844)	[0.6844,0.4)	[0.4,0]
Q22	+	0.5475	0.3673	[1, 0.9148)	[0.9148,0.7312)	[0.7312,0.3639)	[0.3639,0]
Q23	+	0.5595	0.3539	[1, 0.9134)	[0.9134,0.7365）	[0.7365,0.3826)	[0.3826,0]

After processing the data, it classifies the green logistics development level by using the mean standard deviation method, divided into four grades by the mean addition and subtraction 0.5 times standard deviation, then use the 2011 data calculate each quantitative index and qualitative index grade, then together into evaluation. Details are as shown below (Table 3). It combines qualitative index classification grade and quantitative index questionnaire results, then get the comprehensive evaluation matrix U_i of green logistics development level of each two level indicators of Beijing shown as follows.

$$U_1 = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad U_2 = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \end{bmatrix} \quad U_3 = \begin{bmatrix} 0.04 & 0.22 & 0.51 & 0.23 \\ 0.05 & 0.09 & 0.5 & 0.36 \\ 0 & 0 & 0.72 & 0.28 \\ 0 & 0 & 0.78 & 0.22 \end{bmatrix}$$

$$U_4=\begin{bmatrix}0.05 & 0.27 & 0.47 & 0.21\\ 0.02 & 0.08 & 0.65 & 0.25\\ 0 & 0.12 & 0.65 & 0.23\\ 0 & 0.1 & 0.68 & 0.22\\ 0.04 & 0.1 & 0.66 & 0.2\\ 0.05 & 0.1 & 0.52 & 0.33\end{bmatrix} \quad U_5=\begin{bmatrix}0.07 & 0.18 & 0.49 & 0.26\\ 0.08 & 0.13 & 0.56 & 0.23\\ 0.12 & 0.18 & 0.52 & 0.18\\ 0.12 & 0.2 & 0.54 & 0.14\\ 0.04 & 0.1 & 0.66 & 0.2\\ 0.07 & 0.15 & 0.62 & 0.16\end{bmatrix} \quad U_6=\begin{bmatrix}0.05 & 0.21 & 0.24 & 0.5\\ 0.11 & 0.34 & 0.3 & 0.25\\ 0.39 & 0.46 & 0.09 & 0.06\end{bmatrix}$$

Then, according to the fuzzy comprehensive evaluation method can be used to find all two level indicators result vectors B_i.

$B_1 = X_1U_1$ =[0.0890, 0.1629, 0.0552, 0.2614, 0.4315]

$$\begin{bmatrix}0 & 0 & 0 & 1\\ 0 & 0 & 0 & 1\\ 0 & 0 & 0 & 1\\ 0 & 0 & 0 & 1\\ 0 & 0 & 0 & 1\end{bmatrix}$$ =[0, 0, 0, 1],

$B_2 = X_2U_2$ =[0.1095, 0.5815, 0.3090]

$$\begin{bmatrix}0 & 0 & 1 & 0\\ 0 & 0 & 0 & 1\\ 1 & 0 & 0 & 0\end{bmatrix}$$ =[0.3090 ,0 , 0.1095 , 0.5815].

Similarly,

$B_3 = X_3U_3$ = [0.024, 0.1083, 0.6057, 0.262],

$B_4 = X_4U_4$ = [0.0301, 0.1667, 0.5738,0.2286],

$B_5 = X_5U_5$ = [0.1025, 0.1703, 0.4229, 0.1731],

$B_6 = X_6U_6$ = [0.1827, 0.3614, 0.2356, 0.2203].

Then, integrated vector B_i, can get U as below.

$$U=\begin{bmatrix}B_1\\ B_2\\ B_3\\ B_4\\ B_5\\ B_6\end{bmatrix}=\begin{bmatrix}0 & 0 & 0 & 1\\ 0.309 & 0 & 0.1095 & 0.5815\\ 0.024 & 0.1083 & 0.6057 & 0.262\\ 0.0301 & 0.1667 & 0.5738 & 0.2286\\ 0.1025 & 0.1703 & 0.4229 & 0.1731\\ 0.1827 & 0.3614 & 0.2356 & 0.2203\end{bmatrix}$$

First level index vector results of Beijing calculated as below.

$B = XU$ = [0.4385,0.2643,0.0721,0.0583,0.1253,0.04]

$$\begin{bmatrix}0 & 0 & 0 & 1\\ 0.309 & 0 & 0.1095 & 0.5815\\ 0.024 & 0.1083 & 0.6057 & 0.262\\ 0.0301 & 0.1667 & 0.5738 & 0.2286\\ 0.1025 & 0.1703 & 0.4229 & 0.1731\\ 0.1827 & 0.3614 & 0.2356 & 0.2203\end{bmatrix}$$ =[0.1055,0.0537,0.1687,0.6651].

The above data more visually represented as shown in Figure 1.

Through the above Figure 1 we can see that 2001 year the development of Beijing green logistics is in worrying situation. The figure shows four development grade proportion, can be seen the grade IV was the highest, which is the worst grade, reaching 66.5%, this shows that Beijing green logistics development level need to make more efforts.

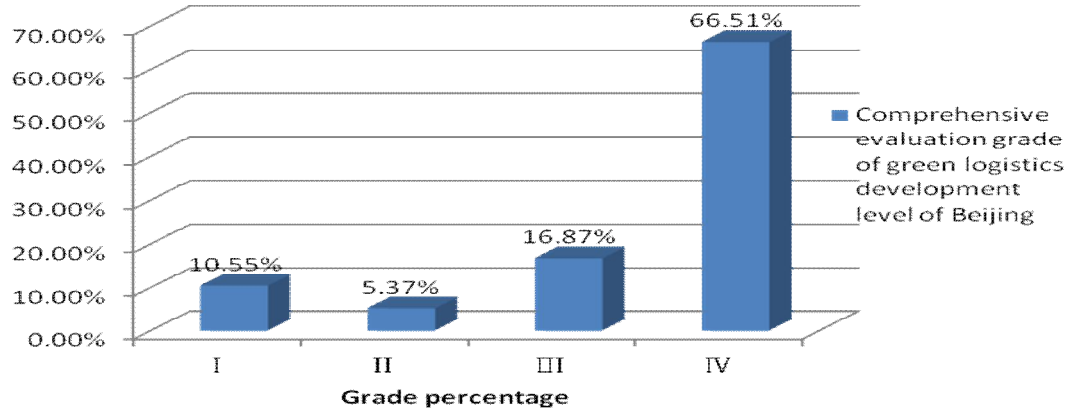

Figure 1. Comprehensive evaluation of green logistics development level of Beijing.

4. Conclusion

In this paper, taking Beijing city as an example, carries on the statistical analysis on the current situation of the development of green logistics, established evaluation index system from environmental pollution levels, environmental governance level and the level of social environment three aspects. The aim of the study is to make quantitative research on the development of green logistics, points out the insufficiency in the green logistics in our country, is of great significance for the development of green logistics, but also the important impetus to realize sustainable development of economy.

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References

[1]G. C. Yang, Journal of Business Ecnomics, 2 (2010)18-23

[2]D. H. Du, G.H. Zheng, L.M. Zhang, Logistics Engineering and Management, 33 (2011)13-17.

[3]A. B. Li, China University of Mining Technology, 2012.

[4]C. W. Liu, S.P. Yi, X.L. Yang, M. Chen, China Mechanical Engineering, 15 (2004)1309-1311.

[5]L. Zhou, J. Guo, J. Zhu, Z. Y. Tian, Proceedings of Liss, 10 (2013)1035-1039.