

Research on construction of the green logistics evaluation index system and determination of index weight

Li Zhou, Jie Zhu, Jian Guo

School of Information, Beijing Wuzi University, Beijing, China

Email address:

zhoulibit@126.com (Li Zhou)

To cite this article:

Li Zhou, Jie Zhu, Jian Guo. Research on Construction of the Green Logistics Evaluation Index System and Determination of Index Weight. *American Journal of Theoretical and Applied Statistics*. Vol. 3, No. 4, 2014, pp. 96-99. doi: 10.11648/j.ajtas.20140304.13

Abstract: The evaluation index system of green logistics development is the focus of this paper. Through the questionnaire investigation and expert scoring method obtains the judgment matrix. By using the analytic hierarchy process and fuzzy comprehensive evaluation method establishes the weight of each index. The conclusion of this paper would lay the foundation for the theory and method of green logistics statistical evaluation.

Keywords: Green Logistics, Logistics Statistics, AHP, Fuzzy Comprehensive Evaluation, Weight

1. Introduction

Green logistics is a modern logistics theme, also should be the direction of future development of the logistics. At present, there is little accounting method of logistics in our country. Kwok Hung Lau (2011)^[1] uses composite index to evaluate the implementation of performance of green logistics. He makes an overall evaluation of implementation for enterprise green logistics, which plays an important role in implementation of enterprise green logistics. Ilsuk Kim (2011)^[2] through the establishment of the green logistics performance index (GLPI) and environmental performance system (EPI) to evaluate whether some countries to realize the distribution function at the expense of the environment, in order to prove the importance of green logistics. Benjamin T. Hazen (2011)^[3] puts forward the quality evaluation system of green recycling logistics, and deeply studies the relationship between green supply chain management and competitive advantages. Maria Bjorklund (2012)^[4] puts forward the significance of performance evaluation of green supply chain, and points out that the lack of practice and theory in this field. His article puts forward a new evaluation framework, and proves that these indicators are effective on environmental performance measurement by examples. Karin Isaksson (2013)^[5] deeply studies green service performance of the logistics service provider. His article points out that in order to turn the environment problem into economic opportunities, many companies have begun to

consider the green environmental protection into their service.

Nowadays, our research on green logistics are qualitative research. Green road of logistics industry also requires attention. Although there are some statistical data collected by the authorities every year, quantitative research is not enough, also need to consider the social environment of green logistics. This paper joins the qualitative index into the index system, and combines the quantitative indicators and qualitative indicators on the current situation of the development of green logistics evaluation.

2. Construction the Evaluation Index System of Green Logistics

2.1. Construction Principle

The evaluation index is the basis of comprehensive study on green logistics, which must be in accordance with the requirements green logistics management. It should strictly follow the scientific, comprehensive, representative, simplicity, feasibility, dynamic and static combination principle in order to establish a fair and objective evaluation index system, and assess the development of green logistics accurately.

2.2. The Index System Composition

The development of green logistics involves various aspects of the logistics industry. It should consider the whole logistics process data at the time of evaluation, and it is a complex work. The index system includes target layer, criterion layer and the index layer, are divided into multiple index in the criterion layer on each inspection.

The target layer indicator is green logistics development level, which indicates the green degree of logistics industry

and the sustainable development of resources and environment.

The criterion layer reflects the macro level of evaluation index based on the criteria layer, which includes environmental pollution, environmental governance, government decision making, logistics industry, enterprise management and social masses.

The index layer is arranged under the criteria layer, a total of 27 indexes. Figure 1 is the index system frame diagram.

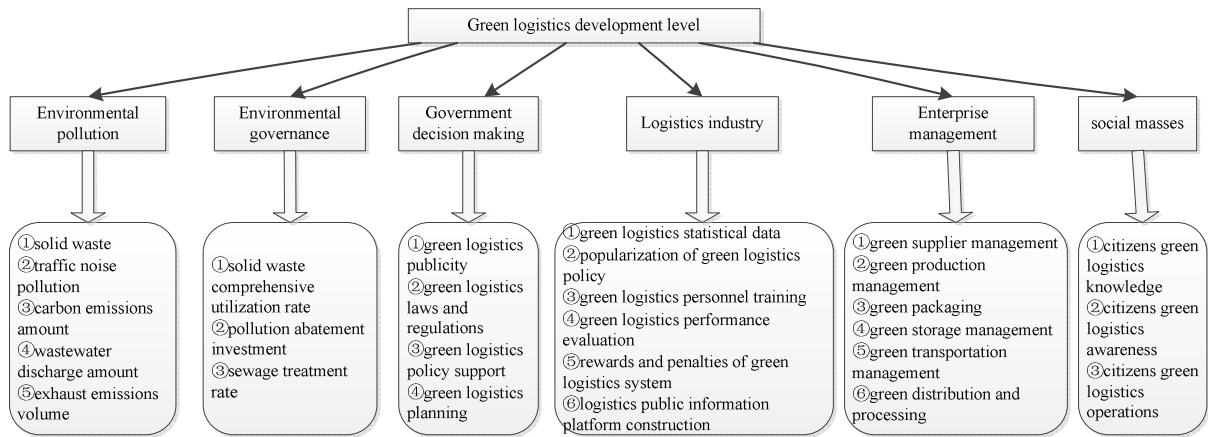


Figure 1. Green logistics development evaluation index system

Analysis of the six indicators we can know, only the environmental pollution level is negative index, the index value on the development of green logistics is more and more unfavorable, the rest of the indicators are positive indicators, namely the index value is getting better and better.

3. Determination of the Index Weight by AHP Method

It establishes the index weight by using 1~9 scaling the relative importance of the index score, based on the collection of nearly 50 expert questionnaires for each index relative importance degree, listed a part below in table 1.

Table 1. Judgment matrix of criterion level

Relative importance of the index	Environmental pollution	Environmental governance	Government decision making	Logistics industry	Enterprise management	Social masses
Environmental pollution	1	2	7	5	6	7
Environmental governance	1/2	1	6	4	3	4
Government decision making	1/7	1/6	1	2	1/3	3
Logistics industry	1/5	1/4	1/2	1	1/3	2
Enterprise management	1/6	1/3	3	3	1	3
Social masses	1/7	1/4	1/3	1/2	1/3	1

When the judgment matrix is completely consistent, there is the only one non-zero eigenvalue, which is remembered as $\lambda = \lambda_{max}$. The eigenvector corresponding to the maximum eigenvalue is the relative importance of each index sorted, also is the target weight value. The premise of this conclusion is that the judgment matrix is consistency, at the same time as the one sidedness of people may develop in the subjective evaluation, it also need to check the

consistency of judgment matrix. Consistency of judgment matrix is $CI = (\lambda_{max} - n) / (n - 1)$, where n is the rank number of judgment matrix. At the same time random consistency ratio is $CR = CI / RI$, where RI is the average consensus standards value corresponding for each rank number of Judgment matrix. RI value is listed in table 2 below.

Table 2. Random consistency index RI value

Rank number	1	2	3	4	5	6	7	8	9
RI	0	0	0.52	0.89	1.12	1.25	1.35	1.42	1.46

When $CR < 0.1$, the weight distribution is reasonable, otherwise it should redistribute weight value^[6]. The eigenvectors C and eigenvalues D of table 1 are solved by matlab. The results are as follows.

$$C = \begin{bmatrix} 0.8168 & 0.8163 & 0.8163 & -0.8892 & 0.8827 & 0.8827 \\ 0.4924 & 0.3520+0.3134i & 0.3520-0.3134i & 0.3921 & -0.3468-0.2322i & -0.3468+0.2322i \\ 0.1344 & -0.1691+0.0317i & -0.1691-0.0317i & 0.0870 & 0.1070+0.0203i & 0.1070-0.0203i \\ 0.1085 & -0.0543-0.0917i & -0.0543+0.0917i & -0.1693 & -0.0665-0.0869i & -0.0665+0.0869i \\ 0.2335 & -0.0445+0.2470i & -0.0445-0.2470i & -0.0796 & -0.1173+0.0746i & -0.1173-0.0746i \\ 0.0772 & 0.0246-0.0835i & 0.0246+0.0835i & 0.1140 & -0.0081+0.0587i & -0.0081-0.0587i \end{bmatrix}$$

$$D = \begin{bmatrix} 6.3980 & 0 & 0 & 0 & 0 & 0 \\ 0 & -0.0371+1.5767i & 0 & 0 & 0 & 0 \\ 0 & 0 & -0.0371-1.5767i & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.0246 & 0 & 0 \\ 0 & 0 & 0 & 0 & -0.1742+0.1151i & 0 \\ 0 & 0 & 0 & 0 & 0 & -0.1742-0.1151i \end{bmatrix}$$

We can know from the above results that $\lambda_{max}=6.3980$, and $CI = (\lambda_{max} - n)/(n-1) = 0.0796$, $CR = CI/RI = 0.0796/1.25=0.0637 < 0.1$, it meets the consistency test that the eigenvector corresponding to the largest eigenvalue is $(0.8168, 0.4924, 0.1344, 0.1085, 0.2335, 0.0772)$. The

weight of criterion layer after normalized is $[0.4385, 0.2643, 0.0721, 0.0583, 0.1253, 0.0415]$.

We can get the weight distribution of all levels by this method, listed in table 3.

Table 3. The weight distribution of all levels

The criterion layer		The index layer	
Index name	Weight value	Index name	Weight value
Environmental pollution	0.4385	①solid waste	0.0890
		②traffic noise pollution	0.1629
		③carbon emissions amount	0.0552
		④wastewater discharge amount	0.2614
		⑤exhaust emissions volume	0.4315
Environmental governance	0.2643	①solid waste comprehensive utilization rate	0.1095
		②pollution abatement investment	0.5815
		③sewage treatment rate	0.3090
Government decision making	0.0721	①green logistics publicity	0.4399
		②green logistics laws and regulations	0.1278
		③green logistics policy support	0.3287
		④green logistics planning	0.1036
Logistics industry	0.0583	①green logistics statistical data	0.4095
		②popularization of green logistics policy	0.2428
		③green logistics personnel training	0.0947
		④green logistics performance evaluation	0.1254
		⑤rewards and penalties of green logistics system	0.0736
		⑥logistics public information platform construction	0.0540
Enterprise management	0.1253	①green supplier management	0.0378
		②green production management	0.1130
		③green packaging	0.2422
		④green storage management	0.3906
		⑤green transportation management	0.1082
		⑥green distribution and processing	0.1082
Social masses	0.0415	①citizens green logistics knowledge	0.0936
		②citizens green logistics awareness	0.6267
		③citizens green logistics operations	0.2797

Namely, the index weight of criterion layer is X .
 $X = [0.4385, 0.2643, 0.0721, 0.0583, 0.1253, 0.0415]$.

Weight of six index layers respectively is
 $X = [X_1, X_2, X_3, X_4, X_5, X_6]$,

$$X_1 = [0.0890, 0.1629, 0.0552, 0.2614, 0.4315],$$

$$X_2 = [0.1095, 0.5815, 0.3090],$$

$$X_3 = [0.4399, 0.1278, 0.3287, 0.1036],$$

$$X_4 = [0.4095, 0.2428, 0.0947, 0.1254, 0.0736, 0.0540],$$

$$X_5 = [0.0378, 0.1130, 0.2422, 0.3906, 0.1082, 0.1082],$$

$$X_6 = [0.0936, 0.6267, 0.2797].$$

4. Conclusion

It constructs the green logistics evaluation index system, and uses the analytic hierarchy process method (AHP) and fuzzy comprehensive evaluation method to establish the weight of each index. It mainly through the questionnaire investigation and expert scoring method obtains the judgment matrix, and calculates matrix to get the weight of indicators at all levels. It establishes the theoretical basis and methods for green logistics statistical evaluation.

At present, it contains a large number of environmental pollution and energy of the data in China Statistical Yearbook, but qualitative index data listed in this paper also very scarce. However, evaluation of the development of green logistics, it should study not only the quantitative part, but also the qualitative part. So, how to combine the quantitative and qualitative indexes is a question worth exploring. And It need to appeal social statistics workers in the future work to take into account the impact of qualitative indicators and quantitative statistical work, so that evaluation can be more specific and comprehensive.

Acknowledgments

The study is supported by Beijing philosophy and social sciences planning project "Statistical measure and quantitative studies on the development of green logistics in Beijing "(13JGC078), Beijing Key Laboratory of Intelligent Logistics System, Beijing Wuzi University(BZ0211), and modern logistics information and control technology of Beijing Wuzi University research base-technology innovation platform (PXM2012_014214_000067).

References

- [1] Kwok Hung Lau, "Benchmarking green logistics performance with a composite index", *Benchmarking*, 2011, 18(6), pp.873-896.
- [2] Ilsuk Kim, Hokey Min, "Measuring supply chain efficiency from a green perspective", *Management Research Review*, 2011, 34(11), pp. 1169-1189.
- [3] Benjamin T. Hazen, Casey Cegielski, "Diffusion of green supply chain management: Examining perceived quality of green reverse logistics", *The International Journal of Logistics Management*, 2011, 22(3), pp.373-389.
- [4] Maria Bjo`rklund, Uni Martinsen, Mats Abrahamsson, "Performance measurements in the greening of supply chains", *Supply Chain Management*, 2012, 17(1), pp. 29-39.
- [5] Karin Isaksson, Maria Huga-Brodin, "Understanding efficiencies behind logistics service providers' green offerings", *Management Research Review*, 2013, 36(3), pp. 216-238.
- [6] Huang XiaoWei, "Study on evaluation and countermeasures of low carbon development level of city -- Chengdu City as an example", *Chengdu: Chengdu Institute of Technology*,2012.