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Summer 6-30-2018

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Abstract: Businesses According to the theory of sustainable development, combining with the current development status of the social logistics industry and the characteristics of green logistics, constructing a green logistics evaluation index system. Using cloud model and Delphi method to calculate the cloud weight of green logistics evaluation index, qualitative and quantitative conversion of evaluation index is realized by cloud generator. Take Jiangsu Province as an example to do empirical research, using the cloud model and its algorithm to get the evaluation cloud of green logistics, observing the evaluation result directly and discovering problem easy by comparing the evaluation cloud chart with ruler cloud chart. The evaluation results show that the cloud model is more reasonable, and the credibility of the evaluation results is improved.

Keywords: cloud model , green logistics , evaluation index system , cloud chart

1. INTRODUCTION

The new technology and new application are emerging in the information society. The rapid development of e-commerce and cross-border e-commerce has prompted the rapid development of the logistics industry. At present, the steady and rapid development of Chinese economy has provided a good opportunity and macro environment for the development of logistics industry. In 2016, China's total social logistics amounted to 229.7 trillion RMB, up 6.1% over the previous year at comparable prices. In 2016, the total cost of social logistics was 11.1 trillion RMB, an increase of 2.9% over the previous year. The total social logistics cost-to-GDP ratio was 14.9%, 1.1% lower than in 2015(this ratio is commonly 8-9% in developed countries, in the USA is about 8%).This shows that China's logistics market is huge and promising, but the cost is higher than that of the developed countries. Logistics has become an important pillar industry in the development of national economy and social production. In order to realize the rapid and sustainable development of the logistics industry, the sustainable green logistics development strategy is necessary.

2. CONNOTATION OF GREEN LOGISTICS

In the mid-1990s, the concept of green logistics is proposed based on the theories of logistics management, environmental science, ecological economics and ecological ethics [1]. Green logistics uses advanced logistics information technology to reduce resource consumption in order to reduce pollution to the environment, make logistics and environment develop harmoniously but restrict each other, and realize the symbiotic development of logistics and resource environment [2]. Domestic and foreign experts and scholars have given different definitions of green logistics from different perspectives, but all think that green logistics can effectively reduce the harm to the ecological environment in the process of logistics activities, and all emphasize the green environmental protection. Green logistics utilizes advanced logistics technology to achieve a series of green logistics activities such as green transport, green storage, green packaging, green recycling (reverse logistics) and so on[2]. At present, green logistics is studied mainly from macro and micro aspects. On the macro level, from the perspective of supply chain, qualitative research on resource waste and environmental pollution caused by logistics is carried out, and a green logistics system is proposed to protect the environment and reduce

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pollution. At the micro level, the pollution of the various elements of the logistics is taken as the breakthrough point to reduce the pollution of the various elements of logistics to realize the green logistics. Logistics industry is a resource-driven and resource-consuming industry, how to use the limited resources to achieve efficient and lasting logistics activities are the problems to be solved by modern logistics. Green logistics uses information technology to achieve sustainable resources and friendly environment[3].

3. CONSTRUCTION OF EVALUATION INDEX SYSTEM OF GREEN LOGISTICS

Green logistics is an important measure for the sustainable development strategy of logistics industry, it and green manufacturing and green consumption constitute a green circular economy that conserving resources and protecting the environment. Green logistics promotes the development of green manufacturing through the reaction of circulation. Green logistics promotes green consumption through green management, effectively allocate and utilize social resources, and realizing the sustainable development of economy society. The rapid development of logistics industry and its enormous challenges all force logistics departments and logistics enterprises to speed up the adjustment of their industrial structure and promote their own sustainable development[4]. In order to achieve these goals, it is of great significance to carry out green evaluation of logistics. The evaluation system should use the perfect index to evaluate the development of regional Green logistics as far as possible, according to the evaluation result, find out the weak link of the development of green logistics, and provide suggestions for the development of regional green logistics [5], promote the rapid transformation of local traditional logistics , help to promote the upgrade of environmental protection concept.

The design and construction of the index system includes combing and judging the current research status, the primary selection of the index, the establishment and improvement of the index system. At present, the construction of green logistics evaluation index system in China is still in the research stage, and there is no perfect evaluation index system. The general index system is constructed on the basis of consulting and studying the literatures, statistic indexes and information at home and abroad. After the primary selection of index system is completed, in order to strive for index system to be hierarchical, comprehensive and scientific, use the maximal non-correlation analysis and the expert consultation method to screen and optimize the index. Because of the different researchers, the direction and emphasis of the logistics evaluation index system are different, but it is basically within a certain range. Although they have different perspective on the green logistics evaluation, but the basic focus is on green transport, green storage, green packaging, green recycling, green legal system, green technology and so on. Therefore, this paper will also consider these points in the study of green logistics evaluation, but it will also add other indicators to make the evaluation of logistics green degree more realistic.

Based on the theory of sustainable development[6], on the basis of the principles and methods of constructing evaluation index system, and drawing on the research results of experts and scholars, combining the current economic social logistics development present situation, the green logistics evaluation index system is constructed (Table 1).

4. GREEN LOGISTICS EVALUATION MODEL BASED ON CLOUD MODEL

4.1 Comparison and selection of evaluation models

The common evaluation methods are AHP [7], fuzzy comprehensive evaluation method[8],, cloud model[9],, grey relational degree analysis, etc., different research purposes correspond to different evaluation methods.

According to the statistic results, there are many evaluation models used in the comprehensive evaluation research, the cloud model and the AHP are the highest frequently used ones, the other models and their algorithms are affected by the instability factors in the solution, and the ambiguity is eliminated in the

evaluation. According to the purpose of the study, this paper considers the representativeness of the index in the establishment and application of the model. Based on the above analysis, as well as the advantages of the cloud model, its widespread use and high frequency, this paper selects the cloud model as the model for green logistics evaluation.

Table 1. Green logistics evaluation index system and the cloud weight of C-level index relative to B-level index

Target layer (A)	Standard layer (B)	Index layer (C)	(Initial) Ex	*Ex*	*En*	*He*
Green logistics evaluation index system A	Green transport (B1) (0.2513)	Vehicle load (C1)	0.73	0.1613	0.0743	0.0134
		100km fuel consumption (C2)	0.78	0.1719	0.2273	0.0213
		Green vehicle usage (C3)	0.76	0.1692	0.1175	0.0107
		Transport vehicle emission level (C4)	0.80	0.1766	0.0419	0.0054
		Solid waste discharge level (C5)	0.84	0.1855	0.0559	0.0083
		Noise pollution level (C6)	0.61	0.1355	0.0260	0.0038
	Green storage (B2) (0.1608)	Storage damage rate (C7)	0.59	0.2339	0.1377	0.0223
		Turnover rate of goods (C8)	0.63	0.2489	0.0783	0.0085
		Warehouse utilization (C9)	0.71	0.2797	0.0500	0.0018
		Scientific site of storage facilities (C10)	0.60	0.2375	0.2094	0.1373
	Green packaging (B3) (0.1811)	Packaging value (C11)	0.54	0.1594	0.1939	0.0157
		Packaging material recovery rate (C12)	0.67	0.1976	0.0473	0.0044
		Recyclable ratio of packaging materials (C13)	0.75	0.2222	0.0233	0.0044
		Packaging material degradation rate (C14)	0.71	0.2104	0.0892	0.0053
		Green packaging material ratio (C15)	0.71	0.2104	0.0892	0.0053
	Green recycling (B4) (0.1914)	Recovery site coverage (C16)	0.58	0.2960	0.0718	0.0089
		Recovery rate of damaged goods (C17)	0.70	0.3597	0.1435	0.026
		Recycled product sales (C18)	0.67	0.3443	0.1629	0.0147
	Green logistics legal system (B5)(0.2154)	Laws and regulations force (C19)	0.64	*0.5898*	*0.1067*	*0.0163*
		Policy regulation and control (C20)	0.44	*0.4102*	*0.031*	*0.0077*

4.2 Cloud model

The cloud model, proposed by academician Li Deyi in 1995, can effectively realize the mutual transformation between qualitative and quantitative, and has been successfully applied in the fields of evaluation decision, data mining and intelligent control [10]. Cloud model is the basis of this evaluation method.

4.2.1 The digital features of the cloud

Usually used $\mathrm{Cloud}(Ex, En, He)$ to represent the cloud model, where *Ex* expresses expectation, *En* is entropy and *He* is hyper-entropy, and they are the digital features of the cloud. The three numbers can be used to visualize the cloud chart composed of numerous cloud drops [11-12]. Expectation *Ex* is the most representative point of the qualitative concept *C* in the domain space[11]. Entropy *En* is used to measure the uncertainty of the qualitative concept *C* . The bigger the entropy, the bigger the range of values that the concept can accept, and the more fuzzy the concept becomes [11]. Hyper-entropy *He* is used to measure the uncertainty of entropy *En* , indicating the condensation and dispersion degree of cloud drops. The bigger the *He*, the bigger the randomness of membership, and the more the cloud drops tend to be discrete.

4.2.2 Cloud generator and methods for calculating cloud parameters

The normal cloud generator is a special algorithm implemented by computer [11], which establishes an interrelated mapping between qualitative concept and quantitative value, it mainly consists of forward cloud generator and backward cloud generator [13]. The forward cloud generator is a mapping from qualitative to quantitative, which produces cloud drops based on the digital features (Ex, En, He) of the cloud. The backward cloud generator is a conversion model from quantitative value to qualitative concept, it can convert a certain number of accurate data into qualitative concept represented by digital features (Ex, En, He) [11].

There are two main methods to determine cloud parameters: one is the backward cloud generator method, the other is the index approximation method. There are two algorithms: one is to use the determination degree

information algorithm, and one is to use the uncertainty degree information algorithm [11,14].

In this paper, a cloud parameters calculation method with uncertainty degree information is used in the backward cloud generator: based on the known information, the 3 digital features of cloud charts are obtained by the reverse cloud algorithm.

Based on the known information, three digital features (Ex, En, He) of cloud chart are obtained by backward cloud algorithm. The methods are as follows [11]:

Input: many cloud drops x_i, Sample point x_i $(i = 1, 2, \cdots, n)$.

Output: three digital features (Ex, En, He) of cloud reflecting the qualitative concept.

Step1: through cloud drops x_i compute sample mean, the expectation Ex of the cloud model:

$$Ex = \bar{X} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

Setp2: compute S^2: $S^2 = \frac{1}{n-1}\sum_{i=1}^{n}\left(x_i - \bar{X}\right)^2$

Setp3: compute En: $En = \sqrt{\frac{\pi}{2}} \times \frac{1}{n}\sum_{i=1}^{n} |x_i - E_x|$

Setp4: compute He: $He = \sqrt{S^2 - En^2}$

4.2.3 Weight design of evaluation index system based on cloud model

Using Delphi method, the 9 experts from logistics industry were invited to analyze and study each index of green logistics evaluation system, and then score for each index. Based on the scoring table, according to the importance of *Ci* for *Bi* and Bi for A to construct the judgment table, the corresponding cloud weight (cloud parameters) can be obtained by compute. Taking the cloud weight compute of "vehicle load index relative to green transport level" as an example, the experts' initial scoring is shown in Table 2.

Table 2. Vehicle load index relative to the green transport level of importance evaluation table

Expert number	1	2	3	4	5	6	7	8	9
$C_1 \to B_1$	0.60	0.90	0.65	0.70	0.80	0.90	0.60	0.90	0.50

Using the backward cloud generator formula to obtain the initial cloud weight: (0.7278,0.1640,0.0609), the cloud chart that is programmed by Matlab is shown in Figure 1, the initial cloud chart was scattered and the clouds were thicker, indicating that the experts' opinions were not agreed at this time. Due to differences in expert cognition scored 2-4 rounds. Finally, the perfect cloud chart is shown in Figure 2, at this time, the cloud weight of vehicle load index relative to the green transport index is: (0.7278,0.0734,0.0134), expressed the concept gradually formed.

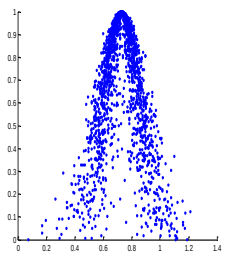

Figure 1. Initial cloud chart

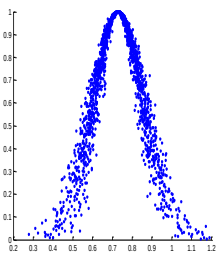

Figure 2. Corrected cloud chart

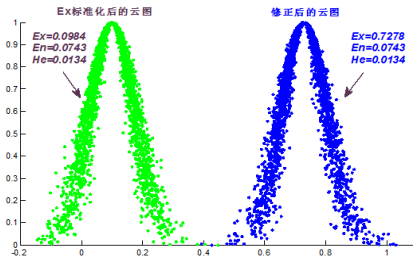

Figure 3. Cloud chart comparison

Use the same method to compute cloud weights for other indexes. Because it is the weight, *Ex* needs to be normalized. The normalized processing method is shown in the Formula (1).According to the connotation of *En* and *He*, it is decided that the improved *En* and *He* will not be normalized, this will keep the cloud shape unchanged, but shifted left(Figure 3.), cloud chart is still good at expressing concepts. The compute results of

each index cloud weight are shown in Table 1.

$$Ex_i = Ex_i / \sum_{i=1}^{j} Ex_i \qquad (1)$$

After the C-level index is calculated, the same method is used to calculate and improve the relative importance of the B-level index relative to the evaluation system A, the final calculation results in Table 3.

Table 3. Cloud weight integration of B-level index calculated by cloud model relative to evaluation system A

	Ex	*En*	*He*
$B_1 \to A$	0.2513	0.1347	0.0178
$B_2 \to A$	0.1608	0.1222	0.0176
$B_3 \to A$	0.1811	0.1685	0.0157
$B_4 \to A$	0.1914	0.1656	0.0152
$B_5 \to A$	0.2154	0.2695	0.0319

The Ex value of the B-level index of Table 3 shows that the degree of their impact on the total target A from large to small is the following: green transport, green logistics legal system, green recycling, green packaging, green storage. For the C-level index, the importance of the upper-level is mostly concentrated in 40%-60%, according to the half theory, it can be used as the basic index. This point also shows that in the process of index selection, the factors that cause the repetition of index caused by information sources and personal subjective are relatively small, because each index is more than half important for the upper-level index.

5. EMPIRICAL RESEARCH AND ANALYSIS

5.1 Determine the evaluation set

According to Professor Li Deyi's definition of five-layer normal cloud and evaluation index relative to the level of evaluation subject, the domain can be divided into five green logistics evaluation levels between[0,1]: deep-green (better), green (good), quasi-green (general), light-green (poor), non- green (bad)(Corresponding to Figure 5 from right to left of the cloud charts), the cloud models for five levels are: Clould1(1, 0.1031, 0.013), Clould2(0.691,0.064,0.008),Clould3(0.5,0.039,0.005), Clould4(0.309,0.064,0.008),Clould5(0,0.1031,0.013) [13].

5.2 Calculation of integrated cloud model

Integrated cloud is a higher level of the parent cloud, is the synthesis of two or more of the same type of sub-cloud generated. There are many clouds $Cloud1(Ex_1,En_1,He_1)$, $Cloud2(Ex_2,En_2,He_2)$, …, $Cloudn(Ex_n,En_n,He_n)$, composing integrated cloud model, the algorithm is as follows:

$$\begin{cases} Ex = \dfrac{Ex_1 + Ex_2 + \cdots + Ex_n}{n} \\ En = \dfrac{\max(Ex_1,\ Ex_2,\ \cdots,\ Ex_n) - \min(Ex_1,\ Ex_2,\ \cdots,\ Ex_n)}{6} \\ He = k \quad (\ k \text{ is a constant}\ ) \end{cases} \qquad (2)$$

5.3 Evaluation of green logistics level in Jiangsu Province

In order to save resources and reduce environmental pollution, Jiangsu logistics industry vigorously promote green low-carbon technology, actively promote the logistics supply side reform, advocate the concept of green logistics, take effective measures to reduce the overall energy consumption and pollutant emission levels of logistics industry, improve the utilization of logistics resources, and further accelerate

the logistics industry informatization and intelligent development, promote the logistics industry green Low-carbon development. In 2016, the total social logistics in Jiangsu Province was 2458684 billion RMB, an increase of 6.5%. In 2016, the total social logistics cost in Jiangsu Province was 1.09736 trillion RMB, an increase of 5.4% over the same period of last year. The total social logistics cost-to-GDP ratio was 14.4%, 0.5% lower than the national, which is 1.1% lower than that of Jiangsu Province in 2010 and 0.4% lower than that of 2015, indicating that the quality and efficiency of logistics operation in Jiangsu Province have been continuously improved. However, there is still a gap compared with developed countries.

Using this research method to evaluate the green logistics level in Jiangsu Province. Based on the above steps to build the cloud model, the 9 experts from logistics industry were invited to score and evaluate for Jiangsu green logistics. Using the scoring method of a given evaluation range, and then select the maximum and minimum of the experts from the evaluation results to calculate the maximum cloud model and the minimum cloud model, and then using integrated cloud to enhance the concept, then getting the integrated cloud evaluation model for each index. The following is an example of a cloud model for green transport index to describe the computational process.

Table 4. The result of expert scoring under the green transport C-level index

Index	Expert 1		Expert 2		Expert 3		Expert 4		Expert 5		Expert 6		Expert 7		Expert8		Expert 9	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
C1	0.8	0.6	0.8	0.6	0.7	0.5	0.9	0.6	0.6	0.4	0.9	0.4	0.9	0.3	0.5	0.5	0.8	0.7
C2	0.8	0.4	0.9	0.7	0.9	0.7	0.8	0.6	0.7	0.6	0.8	0.5	0.7	0.2	0.9	0.7	0.9	0.2
C3	0.6	0.4	0.8	0.6	0.8	0.6	0.8	0.6	0.6	0.3	0.7	0.2	0.9	0.7	0.8	0.4	0.7	0.2
C4	0.6	0.4	0.6	0.4	0.9	0.7	0.8	0.6	0.6	0.4	0.8	0.2	0.8	0.5	0.7	0.2	0.8	0.6
C5	0.6	0.4	0.4	0.2	0.8	0.8	0.9	0.7	0.6	0.4	0.8	0.5	0.6	0.1	0.9	0.7	0.7	0.2
C6	0.4	0.2	0.9	0.7	0.7	0.6	0.7	0.4	0.6	0.2	0.8	0.3	0.5	0.4	0.5	0.2	0.7	0.2

Using the data of Table 4 and the compute method of cloud parameters without determining the degree information of the backward cloud generator, the maximum and minimum cloud model of each C-level index of green Transport index is computed, and the comprehensive cloud model of C-level index is obtained by using the integrated cloud computing Method (formula (2)), as shown in Table 5.

From the calculation results, the index C1, C2, C4 between the quasi-green and green states, biased to green, the mean value that is expectation Ex is more than 0.6, according to the 3*En* rules of cloud model, it is known that the value of the 99.74%[11] falls in the interval. Using the same method to calculate the maximum and minimum cloud index of other C-level indexes, the comprehensive cloud model of each C-level index is obtained by Formula (2), the results are shown in Table 5. The B-level cloud model was calculated using each C-level integrated cloud model and the Formula (2), and the results are shown in Table 6. The results of Table 6 show that Jiangsu Province in five B-level indexes are in the “general” and “good”, in addition to green storage, the other four indexes are biased “good” grade.

Using each B-level index cloud model in Table 6 and the cloud weight of Table 3, according to the multiplication and addition rules of cloud model, the final cloud model of Jiangsu's green logistics level is calculated as:

$$AC = \sum_{i=1}^{5} B_i * W_{Bi} = (\ 0.5959\ ,\ 0.2417\ ,\ 0.0276)$$

Comparing the final cloud model in Jiangsu with the cloud chart of the scale, as shown in Figure 4, we can see that the level of green logistics in Jiangsu Province is between normal (quasi-green) and good (green), slightly close to the good state.

Table 5. The max, min and integrated cloud evaluation model of each C-level index

Index	Max Cloud Evaluation Model			Min Cloud Evaluation Model			Integrated Cloud Evaluation Model		
	Ex	*En*	*He*	*Ex*	*En*	*He*	*Ex*	*En*	*He*
C1	0.79	0.10	0.03	0.48	0.11	0.03	0.6350	0.0517	0.0082
C2	0.82	0.09	0.02	0.51	0.21	0.04	0.6650	0.0517	0.0116
C3	0.74	0.11	0.03	0.44	0.20	0.07	0.5900	0.0500	0.0091
C4	0.73	0.12	0.05	0.44	0.17	0.02	0.5850	0.0483	0.0051
C5	0.70	0.17	0.02	0.44	0.26	0.06	0.5700	0.0433	0.0039
C6	0.64	0.16	0.02	0.36	0.19	0.02	0.5000	0.0467	0.0047
C7	0.63	0.15	0.08	0.54	0.16	0.01	0.5861	0.0157	0.0028
C8	0.64	0.12	0.06	0.44	0.10	0.06	0.5389	0.0333	0.0026
C9	0.66	0.09	0.04	0.50	0.17	0.06	0.5806	0.0269	0.0047
C10	0.64	0.13	0.07	0.47	0.13	0.08	0.5556	0.0296	0.0021
C11	0.66	0.13	0.06	0.49	0.16	0.09	0.5723	0.0278	0.0051
C12	0.63	0.11	0.05	0.53	0.15	0.10	0.5833	0.0167	0.0035
C13	0.73	0.13	0.04	0.59	0.16	0.10	0.6611	0.0241	0.0035
C14	0.70	0.14	0.02	0.57	0.15	0.10	0.6334	0.0222	0.0091
C15	0.63	0.25	0.09	0.54	0.26	0.14	0.5861	0.0139	0.0056
C16	0.66	0.13	0.03	0.49	0.16	0.04	0.5723	0.0278	0.0062
C17	0.63	0.11	0.02	0.53	0.15	0.02	0.5833	0.0167	0.0034
C18	0.73	0.13	0.04	0.59	0.16	0.03	0.6611	0.0241	0.0054
C19	0.66	0.18	0.05	0.61	0.19	0.03	0.6356	0.0082	0.0039
C20	0.61	0.26	0.04	0.54	0.22	0.05	0.5772	0.0109	0.0019

Table 6. The final cloud model of each B-level index

	Ex	*En*	*He*
B1	0.5908	0.0275	0.0039
B2	0.5653	0.0079	0.0022
B3	0.6072	0.0148	0.0026
B4	0.6056	0.0148	0.0026
B5	0.6064	0.0097	0.0029

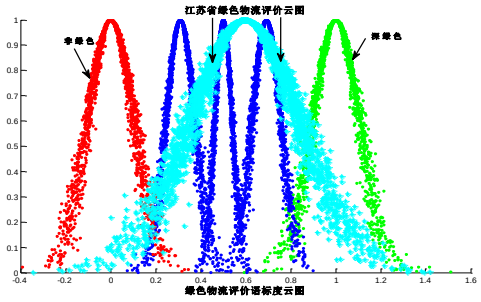

Figure 4. Evaluation level ruler cloud chart and Jiangsu Province green logistics evaluation cloud chart

6. CONCLUSIONS

By using the research method of this paper, studying and analyzing the green logistics level in Jiangsu Province, and the results show that the distribution of weights of each index calculated by using cloud model is more reasonable, which improves the credibility of the evaluation result and proves that the green Logistics evaluation method based on cloud model has certain theoretical and practical significance.

"Environment friendly" and "low carbonization" are the important embodiment of social sustainable development. To establish a sustainable society, vigorously promote green logistics is one of the important ways[15]. First of all, to speed up the construction of low environmental load cycle logistics system, such as multimodal transport, hanging transportation, common distribution and so on. Second, to encourage and support logistics enterprises to use green low-carbon technology, the establishment of a third-party standardized pallet

recycling network, promote the use of energy-saving, clean energy transport tools and logistics equipment. The third is to quicken the construction of the evaluation standard and cognizance system of green logistics, so as to make the green logistics evaluation norm, clear and credible. Four is to pay attention to and speed up the development of the Logistics recovery link, improve the service level of reverse logistics.

ACKNOWLEDGEMENT

This research was supported by the Research Project on Philosophy and Social Science of Universities of Jiangsu Province under Grant 2016SJD630083.

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