The Establishment of Green Industry Evaluation Index System Based on Dynamic Clustering—an Empirical Study from Dalian in China

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***Abstract*—Use the method of spearman correlation analysis and dynamic clustering to delete indicators and build an evaluation index system of the green industry. The specialties and contributions of this paper lie in three aspects. Firstly, screen indicators according to the different effects on the clustering results of the evaluation objects from having or not having specific indicators, and delete the indicators that have no influence on the evaluation objects clustering results so as to guarantee that every selected indicator has effects on the clustering results. Secondly, delete the indicators with high correlation coefficient in the same criteria by spearman correlation analysis to avoid information duplication of the indicators. Thirdly, the eventually established indicator system reflects 94.18% of the original information by 27% of the indicators. In the future, we can establish a green industry evaluation software system. By using this system, the government can evaluate the development of green industry easily and establish policies to balance the development of different area.**

***Index Terms*—green industry, dynamic clustering, correlation analysis, duplication of information**

I. INTRODUCTION[1]

Screen indicators can reflect the status of green industry according to its connotation. Setting up a reasonable green industry index system is the key to evaluate green industry.

The first one is present situation of evaluation index systems of foreign authoritative institutions. The typical relating evaluation index systems are as follows International Energy Conservation Environmental Protection Association established the key points of international urban ecological construction [1]. United Nations Environment Program established the green economic indicator system and the cities integrated environmental assessment indicator system [2,3].The organisation for economic co-operation and development established the evaluation index system based on PSR of low carbon economy [4].

The second one is present situation of evaluation index systems of domestic authoritative organizations. The typical relating evaluation index systems are as follows Ministry of environmental protection of the People's Republic of China established the urban environment quantitative evaluation indicator during the eleventh five-year plan [5]. State Environmental Protection Administration, in 2003, launched construction indicator of ecological county, municipality and province [6]. Beijing Municipal Connission Development and Reform established the green Beijing indicator system [7].

The third one is present situation of evaluation indicators systems by sorting academic literatures. Qi [8]built a new evaluation index system about e-commerce enterprise image. Li [9] construct the power supply enterprise external service quality evaluation index system. Zhu [10] constructed an evaluation index system of land ecological safety. Then it discussed the ranges of indexes corresponding to each evaluation grade.

The main problems of the existing indicator system are stated as followed. One is that the indicator systems of current authoritative institutions from home and abroad focus only on the economic and environmental aspects etc., without basing on the connotation of green industry to build an index system which can reflect the development of the green industry. The other one is that the current index system is merely based on the nation-wide level, and there is no index system that reflects green industry development in different regions within the country itself.

II. THE CONSTRUCTION METHOD OF EVALUATION INDEX SYSTEM OF GREEN INDUSTRY

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A. The Construction of Extensive Index System

1) Extensively Choosing Indicator

Take green industry connotation [11] and domestic and international authoritative institutions classic view of the high frequency indicator [1-7] as the focal point, combined with literature review[8-10] and make the mass-election of the indicators, to choose the index system involving 75 indicators from three criterion layer of green industry, green consumption and green environment. To delete the mass-election indicators which can't be obtained from the data to ensure the quantization of the indicator system preliminarily screened.

TABLE I
INDEX SYSTEM OF GREEN INDUSTRY EVALUATION OF MASS-ELECTION

(1) Criterion layers	(2) Indictor layers	(3) Screening result	(4) Indictor layers	(5) Screening result
X_1 Green production	$X_{1,1}$increased value of the tertiary industry / GDP	Reserved	$X_{1,15}$ Noise reaching standard rate	Deleted by correlation analysis
	$X_{1,2}$ tourism revenues / GDP		$X_{1,16}$ Tertiary industry increased value	
	$X_{1,3}$environmental protection total investment/GDP		$X_{1,17}$ Gross Revenue of TourismIndustry	
	$X_{1,4}$ SO_2 emissions		$X_{1,18}$ Environmental protection total investment	
	$X_{1,5}$ Discharge amount of industrial waste water		$X_{1,19}$ Ten thousand yuan GDP industrial waste gas emissions	
	$X_{1,6}$over the scale of heavy industry output value/gross industrial output value		$X_{1,20}$ SO_2 emissions of unit GDP	
	$X_{1,7}$ Green industry increased value	Deleted by dynamic clustering	$X_{1,21}$ Smoke & dust emissions	
	$X_{1,8}$green industry increased value /GDP		$X_{1,22}$ Ten thousand yuan GDP industrial wastewater emissions	
	$X_{1,9}$ tertiary industry employment/all industry employment		$X_{1,23}$ Industrial solid waste disposal amount	
	$X_{1,10}$ Industrial solid waste disposal rate		$X_{1,24}$ Industrial solid waste comprehensive utilization	
	$X_{1,11}$ Chemical oxygen demand emissions		$X_{1,25}$ CO_2 emissions of ten thousand yuan output value of industry	Unavailability
	$X_{1,12}$ Over the scale of industrial comprehensive energy consumption	Deleted by correlation analysis	$X_{1,26}$ Resources yield improve	
	$X_{1,13}$ Over the scale of industrial ten thousand yuan GDP comprehensive energy consumption		$X_{1,27}$ Carbon productivity	
	$X_{1,14}$ Over the scale of industrial enterprise raw coal consumption		$X_{1,28}$ Ratio of zero carbon energy	
X_2 Green consumption	$X_{2,1}$ Wastewater year throughput	Reserved	$X_{2,9}$ Energy consumption elasticity coefficient	Deleted by correlation analysis
	$X_{2,2}$ Every ten thousand people own bus number		$X_{2,10}$ Passenger service vehicle	
	$X_{2,3}$Wastewater year emission		$X_{2,11}$ Domestic waste output	
	$X_{2,4}$ Living garbage treatment rate		$X_{2,12}$ Over the scale of industrial oil consumption	
	$X_{2,5}$ Agricultural fertilizer using decrement rate		$X_{2,13}$ Over scale of industrial energy consumption per capita	
	$X_{2,6}$ Pesticide using decrement rate		$X_{2,14}$ Energy-saving lamp using rate	Unavailability
	$X_{2,7}$ Over the scale of industry gas consumption		$X_{2,15}$ Green energy utilization	
	$X_{2,8}$ Central heating maintenance and construction capital spending			
X_3 Green environment	$X_{3,1}$ Artificial afforestation area	Reserved	$X_{3,17}$ Hazardous waste emission	Deleted by dynamic clustering
	$X_{3,2}$ Domestic sewage discharge		$X_{3,18}$ City life garbage processing rate	
	$X_{3,3}$ Center city SO_2 annual average value		$X_{3,19}$ Built area greening coverage	Deleted By correlation analysis
	$X_{3,4}$ Urban road traffic noise mean		$X_{3,20}$ Urban green coverage	
	$X_{3,5}$ Regional environmental noise average equivalent sound level		$X_{3,21}$ Water loss and soil erosion area	
	$X_{3,6}$ Total vehicle growth rate		$X_{3,22}$ Public green space area of per capita	
	$X_{3,7}$ Forest coverage	Deleted by dynamic clustering	$X_{3,23}$ Industrial waste gas emission	
	$X_{3,8}$ Urban sewage treatment rate		$X_{3,24}$ Ammonia-nitrogen removal amount	
	$X_{3,9}$ Industrial SO_2 emission reduce		$X_{3,25}$ Industrial SO_2 removal amount	
	$X_{3,10}$ Nitrogen oxides emission total reduce		$X_{3,26}$ Functional area environmental noise mean	
	$X_{3,11}$Chemical oxygen demand emission total reduce		$X_{3,27}$ Industrial solid waste production amount	
	$X_{3,12}$ Number of days of air quality reaches the national standard leve 1		$X_{3,28}$ Nature reserve coverage	Unavailability
	$X_{3,13}$ Number of days of air quality reaches and better than the national standard leve 2		$X_{3,29}$ Vegetation coverage	
	$X_{3,14}$ Proportion of air quality reaches or better than national standard leve 2		$X_{3,30}$ Emission of CO_2	
	$X_{3,15}$ Center city the annual concentration of particulates		$X_{3,31}$ Carbon emission coefficient	
	$X_{3,16}$ NO_2 annual average value		$X_{3,32}$ Carbon emission intensity	

2) Calculation of Energy Consumption Elasticity Coefficient

Let EC_t denotes energy consumption of t period, ECS_t denotes energy consumption growth rate of t period, G_t denotes GDP of t period, GS_t denotes GDP growth rate of t period, $ECEC_t$ denotes energy consumption elasticity coefficient of t period.

$$ECEC_t=ECS_t/GS_t=((EC_t-EC_{t-1})/EC_{t-1})/((G_t-G_{t-1})/G_{t-1}). \quad (1)$$

B. The Construction Steps of Index System

1) The Standardization of Indicators

(1) The standardization of positive indicators

The bigger of the positive indicator value, the better the green industry develops.

Let p_{ij} denotes the standardization of the i^{th} indicator and the j^{th} year. Let v_{ij} denotes the indicator data of the i^{th} indicator and the j^{th} year. Let n denotes the number of years [8].

$$p_{ij}=\frac{V_{ij}-\min\limits_{1\le j\le n}(V_{ij})}{\max\limits_{1\le j\le n}(V_{ij})-\min\limits_{1\le j\le n}(V_{ij})}. \quad (2)$$

(2) The standardization of negative indicator

The smaller of the negtive indicator value, the better the green industry develops [8].

$$p_{ij}=\frac{\max\limits_{1\le j\le n}(V_{ij})-V_{ij}}{\max\limits_{1\le i\le n}(V_{ij})-\min\limits_{1\le j\le n}(V_{ij})}. \quad (3)$$

2) Screening Indicator by Using Correlation Analysis

Step 1. Let r_{ij} denotes spearman rank correlation coefficient of the i^{th} indicator and the j^{th} indicator; J_{Ki} denotes rank of the i^{th} indicator of the k^{th} evaluation object; rank number according to the data from large to small, in order of positive integer 1,2, …; n denotes the number of evaluation objects. As per the calculation formula of spearman rank correlation coefficient, then [12]

$$r_{ij}=1-\frac{6\sum_{k=1}^{n}\left|J_{ki}-J_{kj}\right|^2}{n^3-n}. \quad (4)$$

Step 2. Reflect their linear relationship by using the calculation of two indicators spearman correlation coefficient.

3) Screening Indicator by Using Dynamic Clustering

Take "X_1-green production" criterion layer as an example, to show that screening indicator by using dynamic clustering.

Step 1. The original clustering results are obtained by cluster analysis on all the evaluation objects left by the "X_1-green production" standard based on correlation analysis, in this way, similar evaluation objects of green production are classified into one category, and different categories represent different level of green production.

Step 2. New results are obtained from the clustering analysis of the evaluation objects by deleting some indicator. After taking out some index X_i from the X_1 green industry criterion, ward clustering analyze the development of the green industry, achieving a new cluster without this very index.

Step 3. Let X denote original clustering result, $R(x_i)$ denote new clustering result of evaluation object without indicator x_i, $|\cdot|$ denote set contains the number of elements, β denote error threshold, $R_\beta(x_i)$ denote evaluation object can reflect the new classification β above information and classification results the same. We have "Reference [13]"

$$R_\beta(x_i)=U\left\{x\in U\left|\frac{|X\cap R(x_i)|}{|R(x_i)|}\ge\beta\right.\right\}. \quad (5)$$

According to experience, in this paper, we indicate that the error critical value β is 0.9 [13]. That is to say, if a new clustering result can reflect 90% or more information of the original one, we will consider this new clustering result can better reflect the original clustering information.

Let $|U|$ denote the number of all evaluation objects in the original clustering results, $I(x_i)^{(k)}$ denote the important degree of indicator x_i to evaluation result if clustering k category [13].

$$I(x_i)^{(k)}=1-\sum_{i=1}^{k}\left|R_\beta(x_i)\right|/|U|. \quad (6)$$

We should point out that the number of evaluation objects of each category in clustering results is preferred to be 2 to 5 [13]. There are altogether 10 objects in this paper, so it's better we make 3 to 5 classification.

Let $I(x_i)$ denote average important degree of indicator x_i to evaluation results, m denote number of clustering type to evaluation object (In this paper, the empirical analysis cluster 3, 4, 5 categorys respectively. So m should take 3).

$$I(x_i)=\sum_{k=3}^{5}I(x_i)^{(k)}/m\cdot \quad (7)$$

Step 4. Screening indicator

Through steps 1 to 3, this paper calculates the average important degree of each indicator belongs to "X_1 green production" criterion layer. The greater the average importance of the indicators, the greater their influences on the evaluation object clustering will be. That is, the indicator should be retained. Otherwise, it should be deleted.

4) The Rationality Judgment of The Established Index System

(1) The standard of judging the reasonability of established index system

If the established index system can reflect more than 95% original information by using less than 30% indicators, the screened index system is reasonable [8].

(2) Calculation of information content of the index system

Let In denote the variance contribution rate of the screened s indicators to the selected h extensive indicators. Let trS denote the trace of the covariance matrix, i.e. the sum of the main diagonal indicator variance in the covariance matrix. Let s denote the number of the screened indicators. Let h denote the number of the selected extensive indicators. Then "Reference [8]"

$$In=trS_s/trS_h. \quad (8)$$

III. EMPIRICAL STUDY ON THE INDEX SCREENING MODEL BASED ON GREEN INDUSTRY INDICATORS DATA IN DALIAN OF CHINA

A. Samples and Data Source

In July 2011, The WWF launched "2050 Shanghai low carbon development road map report" research [11] and established to realize city planning scheme of development of low carbon. In September 2011, Beijing municipal party committee issued the "Beijing the twelfth five-year plan period green Beijing development planning" [7] and put forward the "green Beijing" indicator system. Our research group basing on "low carbon Shanghai", "green Beijing" selects Dalian as sample and establishes the green industry evaluation index system of city development.

The green industry evaluation indicator original data except $X_{2,9}$ energy consumption elasticity coefficient derived from 2002-2011 "dalian statistics yearbook [14]. Energy consumption elasticity coefficient $X_{2,9}$ is calculated by Eq.(1). The results are shown in the 7th Column in the TABLE III.

B. The Standardization of Extensive Indicators Data

The standardization of the positive indicators and negative indicators in the 4th Column in the TABLE II, respectively by means of Eq.(2)- Eq.(3), are listed in the 15th to 20th in the TABLE II, as shown in the 15th to 24th in the Table II.

C. Indicator Screening

1) Spearman Correlation Analysis Screening Indicators

(1) Calculating the green industry evaluation indicators grade

The green industry evaluation indictor grade can be obtained, as shown in the 5th to 14th Column and the 1th to 64th Row in the TABLE IV.

(2) Spearman correlation analysis screening indicators

By means of Eq.(4), the indicators with the correlation coefficient above 0.9 are shown in the 3th to 4th Column in the TABLE V.

2) Dynamic Clustering Screening Indicators

Take "X_1 Green production" criterion layer as an example to show whether there is difference for the clustering results of evaluation object. The error critical value β is 0.9.

(1) Analysis data in the 15th to 24th Column and the 1st to 11th Row in the TABLE II by ward clustering. The original clustering result, clustering result is three categories, is obtained, as shown in the 3th Column in the TABLE VI.

(2) Deleting "$X_{1,1}$ increased value of the tertiary industry / GDP", Analysis data in the 15th to 24th Column and the 2th to 11th Row in the TABLE II by ward clustering. The new clustering result, clustering result is three category, is obtained, as shown in the 4th Column in the TABLE VI.

(3) Calculation the important degree of indicator to evaluation object

TABLE II.
THE ORIGINAL DATA AND STANDARD DATA OF GREEN INDUSTRY EVALUATION INDICATOR

(1) Serial number	(2) Criterion layers	(3)Indictor layers	(4) Indictor type	Original data of indicators			Standardized data of indicators		
				(5) 2001	…	(14) 2010	(15) 2001	…	(24) 2010
1	Green production X_1	$X_{1,1}$	Positive	0.445	…	0.42	0.851	…	0.326
…		…	…	…	…	…	…	…	…
24		$X_{1,24}$	Positive	69	…	95.9	0.100	…	1.000
25	Green consumption X_2	$X_{2,1}$	Positive	19282	…	25531	0.000	…	0.841
…		…	…	…	…	…	…	…	…
37		$X_{2,13}$	Negative	1.483	…	2.785	1.000	…	0.118
38	Green environment X_3	$X_{3,1}$	Positive	14 001.12	…	429 792.2	0.005	…	1.000
…		…	…	…	…	…	…	…	…
64		$X_{3,27}$	Negative	247	…	378.92	0.825	…	0.000

TABLE III
The Data of Calculating Energy Consumption Elasticity Coefficient

(1) Serial number	(2) t	(3) Energy consumption EC_t(ton of standard coal)	(4) Energy consumption growth rate ΔEC_t (%)	(5) GDP_t ((billion yuan)	(6) ΔGDP_t (%)	(7) Energy consumption elasticity coefficient e_t(%)
1	2000	772.56	——	1 110.8	——	——
2	2001	822.62	0.065	1 235.6	0.112	0.580
…	…	…	…	…	…	…
11	2010	1639.108	-0.051	5 158.1	0.168	-0.302

TABLE IV
THE GRADE NUMBER OF GREEN INDUSTRY EVALUATION INDICATOR

(1) Serial number	(2) Criterion layers	(3)Indictor layers	(4)Indictor type	Green industry evaluation indictor grade J_{ki}		
				(5)2001	…	(14)2010
1	Green production	$X_{1,1}$	Positive	3	…	8
…		…	…	…	…	…
24		$X_{1,24}$	Positive	8	…	1
25	Green consumption	$X_{2,1}$	Positive	10	…	3
…		…	…	…	…	…
37		$X_{2,13}$	Negative	1	…	8
38	Green environment	$X_{3,1}$	Positive	9	…	1
…		…	…	…	…	…
64		$X_{3,27}$	Negative	4	…	10

TABLE V
THE INDICATORS WITH THE CORRELATION COEFFICIENT ABOVE 0.9

(1) Serial number	(2) Criterion layers	(3) Reserved indicator	(4) Deleted indicator	(5) Correlation coefficient absolute value r_{ij}
1	Green production X_1	$X_{1,7}$	$X_{1,12}$	0.988
2			$X_{1,13}$	0.982
…			…	…
12			$X_{1,24}$	0.903
13		$X_{1,10}$	$X_{1,23}$	0.957
14			$X_{1,24}$	0.924
15	Green consumption X_2	$X_{2,2}$	$X_{2,10}$	1.000
…			…	…
18			$X_{2,13}$	0.964
19	Green environment X_3	$X_{3,2}$	$X_{3,27}$	0.988
20		$X_{3,8}$	$X_{3,25}$	0.918
21		$X_{3,14}$	$X_{3,19}$	0.942
…			…	…
24			$X_{3,22}$	0.924
…			…	…
27			$X_{3,26}$	0.936

TABLE VI
THE RESULT OF EVALUATION OBJECTS ARE CLUSTERED THREE CATEGORY

(1) Serial number	(2) Category	(3) Original clustering results X (not deleting indicator $X_{1,1}$)	(4) New clustering results $R(X_{1,1})$ (deleting indicator $X_{1,1}$)	(5) $R_{0.9}(X_{1,1})$
1	1^{th} kind	2001, 2002, 2003, 2004	2001, 2002, 2003, 2004	2001, 2002, 2003, 2004
2	2^{th} kind	2005, 2006, 2007	2005, 2006	2005, 2006
3	3^{th} kind	2008, 2009, 2010	2007, 2008, 2009, 2010	——

TABLE VII
THE IMPORTANT DEGREE OF INDICATORS OF GREEN PRODUCTION CRITERION LAYER

(1) Serial number	(2) Indictor layers	Indicator importance degree			(6)mean	(7) Screening result
		(3) Clustering three Category	(4) Clustering four Category	(5) Clustering five Category		
1	$X_{1,1}$	0.4	0.9	0.3	0.53	Reserved
2	$X_{1,2}$	0	0.9	0	0.30	Reserved
…	…	…	…	…	…	…
11	$X_{1,11}$	0	0	0	0	Deleted

① when clustering result is three category, calculation important degree of indicator to evaluation object

Taking original clustering result "X" and new clustering result "R($X_{1,1}$)" into Eq.(5), the "$R_{0.9}(X_{1,1})$" is obtained as shown in the 5^{th} Column in the TABLE VI.

Take "$R_{0.9}(X_{1,1})$" and "X" into Eq.(6). The "$X_{1,1}$" important degree ($I(X_{1,1})^{(3)}$(=1-6/10)=0.4) as shown in the 3^{th} Column and the 1^{st} Row in the TABLE VII.

Similarly, when clustering results are four and five category, the other indicators important degree are shown in the 4^{th} to 5^{th} Column in the TABLE VII.

② Calculation the mean of important degree of indicator to evaluation object

Taking the data in the 3^{rd} to 5^{th} Column and the 1^{st} Row in the TABLE VII into Eq.(7). The important degree mean of "$X_{1,1}$" is 0.53, as shown in the 6^{th} Column and 1^{st} Row in the TABLE VII.

③ Screening index

According to the "$X_{1,1}$" important degree mean is 0.53 as shown in the 6^{th} Column and the 1^{st} Row in the TABLE VII, shows that exist influence of "$X_{1,1}$" to evaluation object, "$X_{1,1}$" should be reserved.

According to the 6^{th} Column in the TABLE VII, deleting not influence indicators to evaluation object's clustering results (In other words, the indicators should be deleted which important degree is 0). The screening results of "X_1 Green production" are obtained, as shown in the 7^{th} Column in the TABLE VII.

The screening results of the other indicators can be obtained by following the above (1) to (3).

3) The Result of Screening Indicators

In conclusion, screening out twenty indicators from ninety extensive index system, as shown in the 3^{rd} Column in the TABLE I indicates the "Reserved".

4) The Reasonability Judgment of The Established Index System

Calculate the variance of each indicator using the original data in the 5^{th} to 14^{th} Column in TABLE II, and then take the variance sum of the screened indicators and the variance sum of the selected extensive indicators into Eq.(8). Then the established index system reflected 94.18% original information by using 27% (20/75=27%) indicators.

IV. CONCLUSIONS

From the connotation of green industry, based on the High-frequency indicators of classic view of domestic and international authority, this paper chooses green industry evaluation indicators extensively which include green production, green consumption and green environment. Use the method of spearman correlation analysis and dynamic clustering to delete indicators and build an evaluation index system of the green industry.

The result of this paper is based only on the data of Dalian. However, the index systems are changing if they are based on different cities in fact.

In the future, we can establish a green industry evaluation software system. By using this system, the government can evaluate the development of green industry easily and establish policies to balance the development of different area.

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REFERENCES

[1] International Energy Conservation Environmental Protection Association (IECEPA), *Ecological Safety Strategic Key Points of International Urban Ecological Construction,* October 24, 2010.

[2] United Nations Environment Program (UNEP), *Guidelines for AEO cities integrated environmental assessment and reporting*, United Nations Environment Program, pp. 52-143, 2005.

[3] United Nations Environment Program (UNEP), *Green Economy Cities Investing in Energy and Resource Efficiency*, Year of Publication, 2011.

[4] Y. Lu, "China's Circular Economy Evaluation Indicator System to Study Commentary," *Environmental Protection & Re-Cycling Economy*, No. 4, pp. 15-17, 2012.

[5] Ministry of environmental protection of the People's Republic of China, *The Urban Environment Quantitative Evaluation Indicator during The Eleventh five-year plan,* Http://www.zhb.gov.cn/news/xz/. November 14, 2011.

[6] State Environmental Protection Administration. Construction Indicator of Ecological County, *Municipality and Province (Trial Implementation). Environmental protection*, No. 9, pp. 21-28, 2003.

[7] Beijing Municipal Connission Development and Reform, *Green Beijing construction planning during the twelve five-year plan*, Beijing Municipal Connission Development and Reform, August 2011.

[8] W. Qi, J. Chen, "A Multi-granular Fuzzy Comprenhensive Evaluation Model for E-commerce Enterprise Image," *Journal of Computers,* Vol. 8, No. 4, pp. 1011-1015, 2013.

[9] W. Li, W. Dong, Y. Yuan, "Research on Evaluation of Power Supply Companies External Service Quality Based on Improved Grey Interrelated Analysis Method," *Journal of Computers,* Vol. 7, No. 4, pp. 982-987, 2012.

[10] J. Zhu, X. Tao, "Evaluation of Land Ecological Safety Based on Fuzzy Matter-Element Theory," *Journal of Computers,* Vol. 6, No. 12, pp. 2639-2646, 2011.

[11] WWF Sahnghai Low Carbon Development Roadmap Research Team, *2050 Shanghai Low Carbon Development Roadmap Report*, Beijing: Science Press, June 2011.

[12] W. Xu, *Statistical Analysis and SPSS Application*, Beijing: Renmin University Press, pp.134-139, November 2011.

[13] M. Guo, J. Zhu, "The Performance Evaluation in Logistics Service Supply Chain Based on Fuzzy-rough Sets," *Systems Engineering*, vol. 7, pp. 48-52, 2007.

[14] Dalian municipal bureau of statistics, *The national bureau of statistics dalian team. Dalian Statistics Yearbook 2007 -2010*, Beijing: Statistics Press, 2007-2010.

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