Evaluation research on jiangsu green economy development capability: a case study of Xuzhou

Fuhua Sun, Haiyu Liu, Zhaoxia Wang

Business School of Hohai University, Business School Environment Accounting and Assets Management Institute, Nanjing, P.R.China

E-mail: 233789768@qq.com

Abstract. As a national leading province of economic development and demonstration area of ecological civilization construction, Jiangsu makes a scientific and rational evaluation to its green economy development capability through the construction of index system and model, which is significant for better grasping its green development condition, implementing the "green" development concept and promoting Jiangsu to be a new Jiangsu with "good economy, rich public, favourable environment and civilized society degree". The paper constructs the evaluation system of green economic development capability based on factor analysis method, adjusts indexes at all levels through factor analysis, calculates the factor score, determines the main influencing factors, analyzes the influence factor score, and puts forward the corresponding policy according to the practical situation of Jiangsu Province.

1.Introduction

In 1989, the economist Pearce firstly put forward the concept of green economy in his book *Blueprint for a Green Economy*. He believed that economic development must be undertaken by natural environment and human beings, people should save natural resources to keep sustainable economic development and never blindly pursue for production growth, thus avoiding ecological crisis and social disruption. Therefore, the green economy starts from the social ecological conditions to establish an affordable economy.

Now, speeding up the transformation of economic development, developing green economy, resource-saving and environment-friendly society and achieving sustainable development is not only the mainstream economic development model for countries and regions, but also the essential measurement that Jiangsu responds to national policy and improves provincial competitiveness. The government department should correctly understand the connotation, importance, development model, development status and conditions and other issues of green economy in promoting its development. These researches are of great value to find out the main factors that restrict the development of green economy in Jiangsu and put forward the effective methods and policy suggestion of developing green economy.

2. Research Review

At present, scholars have the same understanding to the core content of green economy, that is, the green economy contains such two aspects as "green" and "economy", both are indispensable. Therefore, green economy is defined in this paper as an economic model that both produces good economic benefits and favorable environmental benefits.

From the existing research results, foreign scholars more focus on the qualitative research of the

development of green economy, including the importance of new energy for the green economy, the policy influencing the development of green economy and the role of government, academia, enterprises for low-carbon economy and green economy and so on. Chinese scholars have carried on some research on the green economy with certain theoretical value and practical significance. However, meanwhile, limited papers conduct the quantitative and quantitative analysis of the green economy, and there are few researches integrating both parties. Therefore, this paper establishes the evaluation index system of Jiangsu green economy, and uses the factor analysis method to try to find out the factors restricting the development of green economy scientifically, and then puts forward the development methods and relevant countermeasures.

3. Construction of the Evaluation Model for Green Economy Development Capability

3.1 Construction of the Evaluation Index System for Green Economy Development Capability

According to the significance and principle of the construction of the evaluation index system of green economic development capability, this paper constructs the index system as shown in Tab. 1, which is divided into 4 first-class indexes and 9 second-class indexes. The first-class indexes are: economy indexes, including three indexes as per capita GDP, urban per capita disposable income, total amount of industrial profits above designated size; social population indexes, including a second-class index of natural population growth rate; natural resources indexes, including three second-class indexes of forest coverage, total amount of water resources, coal reserves; ecological environment indexes, including two second-class indexes of discharge amount of industrial wastewater, environmental protection investment.

Tab. 1. Variable Table

	First-class index	Second-class index	Unit
Green econo-my develo-pment capabil ity	Economy	Per capita GDP	yuan
		Urban per capita disposable income	yuan
		Total amount of industrial profits above designated size	100 million yuan
	Society, population	Natural population growth rate	%
	Natural resources	Forest coverage	%
		Total amount of water resources	100 million cubic meters
		Coal reserves	Ten thousand tons
	Ecological environment	Discharge amount of industrial wastewater	Ten thousand tons
		Environmental protection investment	100 million yuan

3.2 Construction Idea of the Evaluation Model of Green Economy Development Capability

To construct the evaluation model of green economic development capability, it mainly adopts the factor analysis method. The basic principle of factor analysis is to construct a few representative common factors from a large number of initial variables, which requires a strong correlation between the original variables. Otherwise, it's difficult to synthesize factor variables that reflect the common characteristics of partial variables from variables that are not strongly related. Before using the factor analysis method, it is necessary to test whether the constructed index system is suitable for factor analysis, that is, the correlation analysis on the original variables.The general model is as follows:

Suppose there are observable P-dimensional indexes $X_1, X_2, \cdots, X_p$, m unobservable factors $F_1, F_2, \cdots, F_m$, then the factor analysis model is described as follows:

$$X_1 = \alpha_{11}F_1 + \alpha_{12}F_2 + \alpha_{13}F_3 + \alpha_{14}F_4 + \cdots + \alpha_{1m}F_m + \varepsilon_1$$
$$X_2 = \alpha_{21}F_1 + \alpha_{22}F_2 + \alpha_{23}F_3 + \alpha_{24}F_4 + \cdots + \alpha_{2m}F_m + \varepsilon_2$$
$$X_3 = \alpha_{31}F_1 + \alpha_{32}F_2 + \alpha_{33}F_3 + \alpha_{34}F_4 + \cdots + \alpha_{3m}F_m + \varepsilon_3$$
$$\cdots$$

$$X_p = \alpha_{p1}F_1 + \alpha_{p2}F_2 + \alpha_{p3}F_3 + \alpha_{p4}F_4 + \cdots + \alpha_{pm}F_m + \varepsilon_p$$

Where $m < p$,

The above model can also be expressed as follows by matrix and vector:

$$X = AF + \varepsilon \quad (1)$$

We denote $F = (F_1, F_2, \cdots, F_m)$ as the common factors of X, the mean vector $E(F) = 0$, the covariance matrix $Cov(F) = 1$, that is, the components of the vector are uncorrelated, special factors $\varepsilon = (\varepsilon_1, \varepsilon_2, \cdots, \varepsilon_p)$ are also independent of each other, that is, $E(\varepsilon) = 0$, and the common factors are also uncorrelated with special factors. The matrix $A = (\alpha_{ij})$ is called the factor loading matrix, where α_{ij} is called the factor loading. In fact, the factor loading is the correlation coefficient between the i-th and the j-th factor, and larger loading suggests closer relation; otherwise, and more alienated relation.

4. Evaluation of Green Economy Development Capability in Xuzhou, Jiangsu

4.1 Source of Data

The sample of this study mainly comes from the statistical yearbook and the environmental status bulletins provided by the Bureau of Statistics, the Environmental Protection Agency and the Water Conservancy Bureau of each city. In this paper, the data of Xuzhou, Jiangsu from 2006 to 2015 was selected to reduce the adverse effects of regional development differences, to make the analysis model and the results more timely and specific. The study was analyzed by means of SPSS16.0 software.

4.2 Factor Analysis

The analysis steps for factor analysis of the data are as follows:

(1) Import the original data for standardization

Firstly, in the third-class indexes, positive treatment should be carried out to Engel coefficient and discharge amount of industrial wastewater. Two indexes can be positive according to the index positive formula $X_i' = (X_{max} - X_i)/(X_{max} - X_{min})$.

Secondly, this paper uses the equalization method formula $y = x_{ij}/\overline{x_j}$ to nondimensionalize the data.

(2) Applicability test

Factor analysis requires the construction of representative principal factors in the original variables, and there be a strong correlation between these variables; otherwise, it is impossible for factor analysis. Therefore, Bartlett Test of Sphericity and KMO Test are adopted to verify and analyze the standardized data. The results are as shown in Tab. 2.

Tab. 2. KMO Test and Bartlett Test of Sphericity

KMO Test		0.608
Bartlett Test of Sphericity	Approx. Chi-Square	100.472
	df	36
	Sig.	.000

According to the analysis results in Table 3-1, the KMO value used to test the factor analysis is 0.608, indicating that the data for the factor analysis is appropriate; the value for the significance of the Bartlett Test of Sphericity is 0.000, indicating that the sample data has a good correlation, which is suitable for factor analysis.

(3) Extraction of common factor

In this paper, the principal component analysis method is used to calculate the eigenvalue, variance contribution rate and cumulative variance contribution rate of the common factor, and the total variance total variance explained table is shown in Tab. 3.

Tab. 3. Total Variance Explained Table

Component	Initial eigenvalue			Rotation factor and loading		
	Total	Variance %	Accumulation %	Total	Variance %	Accumulation %
1	6.475	71.950	71.950	3.876	43.066	43.066
2	1.129	12.550	84.500	3.729	41.434	84.500
3	.661	7.345	91.845			
4	.489	5.430	97.275			
5	.180	1.995	99.270			
6	.043	.479	99.749			
7	.012	.138	99.887			
8	.008	.092	99.979			
9	.002	.021	100.000			

It can be learned from Table 3-2 that there are two common factors with the eigenvalue greater than 1, and the cumulative variance contribution rate of both is 84.5%, much higher than 80% of the basic requirements, indicating that the former two common factors have explained the original variable information well. The main role of these common factors is also to evaluate the green economy development capability, therefore these two factors are called as the evaluation factors in this paper.

(4) Name the common factors

The above two factors were selected to establish the initial factor loading matrix, however, its degree was not too obvious. In order to make the meaning of the factor more obvious, the initial factor loading matrix is rotated by the variance maximum orthogonal rotation method, the results of the rotated factor loading matrix are as shown in Tab. 4 and Tab. 5.

Tab.4. The Loading Value Table of Rotated Factor 1 and Factor 2

Component	Evaluation factor	
	1	2
Per capita GDP (yuan)	.533	.831
Total amount of industrial profits above designated size (100	.750	.585
Natural population growth rate (%)	.808	.279
Discharge amount of industrial wastewater (ten thousand	-.747	-.409
Environmental protection investment (100 million yuan)	-.020	.903
Coal reserves (ten thousand tons)	-.623	-.660
Total amount of water resources (100 million cubic meters)	-.875	-.019
Urban per capita disposable income (yuan)	.468	.873
Forest coverage (%)	.668	.660

Tab.5. Factor Evaluation System of Jiangsu Green Economy Development Capability

Component	Evaluation factor	Second-class index
1	Population and resources factors	Total amount of water resources Natural population growth rate Total amount of industrial profits Discharge amount of industrial Forest coverage Coal reserves
2	Economy and environmental governance factors	Environmental protection investment Urban per capita disposable income Per capita GDP

Among them, the evaluation factors 1 contain a total of six indexes: total amount of water resources,

natural population growth rate, total amount of industrial profits above designated size, discharge amount of industrial wastewater, forest coverage, coal reserves, which reflect the situations in population and resource and energy aspects, so the evaluation factors are named as population and resource factors.

Evaluation factors 2 include three indexes as environmental protection investment, urban per capita disposable income and per capita GDP, which reflect the overall situation of regional environmental governance and economic development, so the evaluation factors are named as economy and environmental governance factors.

(5)Determine the evaluation factor score coefficient matrix

The evaluation factor score coefficient matrix of green economy development capability is obtained after the factor rotation, as shown in Tab. 6.

Tab. 6. Factor Score Coefficient Matrix

No.	Evaluation index of green economy development capability	Evaluation factor 1	2
X_1	Per capita GDP	-.032	.246
X_2	Total amount of industrial profit above	.169	.036
X_3	Natural population growth rate	.310	-.147
X_4	Discharge amount of industrial wastewater	-.231	.056
X_5	Environmental protection investment	-.340	.486
X_6	Coal reserves	-.077	-.122
X_7	Total amount of water resources	-.439	.310
X_8	Urban per capita disposable income	-.080	.292
X_9	Forest coverage	.099	.106

(6) Determine the expression of evaluation factor score

The scores of each factor are linear combinations of all indexes, and the expression of two evaluation factor scores is as follows:

$$F_1=-0.032X_1+0.169X_2+0.310X_3+-0.231X_4+-0.340X_5+-0.077X_6+-0.439X_7+-0.080X_8+0.099X_9 \quad (2)$$

$$F_2=0.246X_1+0.036X_2+-0.147X_3+0.056X_4+0.486X_5+-0.122X_6+0.310X_7+0.292X_8+0.106X_9 \quad (3)$$

Tab. 7. Factor Score Covariance Matrix

Factor	1	2
1	1	0
2	0	1

It can be seen from the factor score covariance matrix that the matrix is a unit matrix, indicating that the two evaluation factors extracted are irrelevant, that is, the information contained in the two common factors is not important.

(7) Calculate the evaluation factors score, determine the evaluation score ranking

The evaluation factors score of Jiangsu green economy development capability from 2006 to 2015 can be acquired with the use of regression method, and then the contribution rate could be obtained by multiplying the aforementioned evaluation factor score and the score of $F_1 - F_2$, that is, $F = 0.43F_1 + 0.47F_2$.

The rankings of each factor evaluation score and total score can be seen in Tab. 8.

Tab. 8. Total Score of Jiangsu Green Economy Development Capability Factor from 2006 to 2015

Year	Population and resource	Economy and environmental	Total factor
2006	-0.74129	0.845522	0.078641
2007	-1.24355	1.160121	0.010533
2008	-0.91829	1.002498	0.076308
2009	-1.07499	1.135813	0.071587
2010	-0.23457	0.676605	0.217141

2011	-0.2428	0.858705	0.299187
2012	0.057809	1.162476	0.571222
2013	0.05677	1.372771	0.669614
2014	-0.73775	1.990436	0.618274
2015	-1.13135	2.425051	0.653295

Tab. 8. Suggests that, since 2006, the total score of Jiangsu green economy development capability factor has gradually increased, which generally shows that the green economy development in Jiangsu Province is remarkable. The weight of both evaluation factors is almost the same, showing that if one factor doesn't keep pace with the other factor, the development process of green economy in Jiangsu will be seriously dragged.

5. Conclusion and Prospect

This paper constructs the evaluation index system of green economy development capability in Jiangsu Province, and selects the main factors by factor analysis method, re-arranges the factors, calculates factor score, finds out the main factors restricting the development of green economy in Jiangsu Province, and analyzes its influence degree. The results show that there are two main factors that restrict the development of green economy in Jiangsu Province, namely, economy and environmental governance factors as well as population and resource factors, and both play the similar role in the development of green economy in Jiangsu Province. To develop the green economy in Jiangsu Province, both should be considered and developed at the same pace. Therefore, policy recommendations should be given correspondingly for the future development of green economy in Jiangsu Province:

In the aspect of policy idea guidance, firstly, Jiangsu government should be committed to the formulation and improvement of local economic regulations for the development of green economy in Jiangsu Province, resolutely implement relevant national laws and regulations about green economy and sustainable development. Secondly, the government should also promote the publicity and education of green economy. Regarding technical innovation, the government should take the road of combining production, learning with research, to achieve "win-win" situation for industry, government, universities, research institutes and the public. As for capital and material investment, at first, Jiangsu government should increase the investment in environmental pollution control in the financial expenditure, and it should give full play to the role of non-governmental organizations, and make joint efforts to develop green economy.

Acknowledgment

This paper is supported by the following projects, give thanks in this: Social Science Foundation of Jiangsu Province: the theoretical and practical research on Jiangsu's first exploration of green GDP accounting system(14EYC006); Fundamental Research Funds for the Central Universities of Hohai University : Study on the Application of Accounting Method of Ecological Environment(2014B09314).

References

[1] Zhang Xiaogang. On Constraints and Path Chosen of Green Economic Development in Chang-Zhu-Tan Urban Agglomeration. Journal of Xiangtan Universit(Philosophy and Social Sciences), Vol. 35, Issue 5, 2011, p.87-90.

[2] Zhang Yue, Qiao Qi, Yao Yang, Fang Lin, Guo Jing, Bai Weinan. Evaluation of Green Development Performance in National Economic and Technological Development Zones [J/OL]. Chinese Population, Resources and Environment, Vol. 25, Issue 6,2015, p. 12-16. Http://kns.cnki.net/kcms/detail/37.1196.n.20150520.1443.003.html

[3] Hao Hanzhou, Tang Jinhua, Zhai Wenxia, Tang Min, Su Yue. Spatial Pattern Analysis and Diagnosis of Green Development Index in Hubei Province [J]. World Geography Research, Vol. 26, Issue 2,2017, p. 91-100.

[4] Zhu Jing, Sun Xinzhang, Liu Xuemin, Song Min. Study on the China's Green Economy Strategy [J]. Chinese Population, Resources and Environment, Vol. 22, Issue 4, 2012, p. 7-12.
[5] Mark A Cohen, Michael P Vandenbergh. The Potential Role of Carbn LabeLing in a Green Economy. Energy Economics, Vol. 34, Issue 5, 2012, p. 53-63.
[6] Raul Gouvea, Sul Kassicieh, Montoya M J R. Using the Quadruple Helix to Design Strategies for the Green Economy. Technological Forecasting & Social Change, Vol. 80, 2013, p. 221-230.
[7] Ligita Melece. Challenges and Opportunities of Circular Economy and Green Economy. Engineering for Rural Development, Jelgava, Issue 5, 2016. p.25.-27.