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Evaluation of Green Economic Efficiency in Anhui Province

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Abstract

In order to better promote the healthy and sustainable development of green economy in Anhui Province, The ultra-efficiency DEA-SBM model was used to evaluate the green economic efficiency of 16 cities in Anhui province from 2005 to 2020, Based on this basis, Select the inputs of capital, energy, labor, land resources and water resources from the input and output dimensions through the relevant literature, And the expected output and non-period output as indicators to establish a green economic efficiency index evaluation system for the evaluation of green economic efficiency in Anhui Province, Through the evaluation of the efficiency of green economy development in 16 cities in Anhui province for more than ten years from 2005 to 2020, Calculated by the DEA-SBM model, Finally, the evaluation results are obtained for the comparison of the major cities in Anhui province, Prior to 2012, The green economy in Ma'anshan is more efficient than that in other cities, After 2012, Huangshan city is the green economic efficiency of the development rate of the best city; From the regional situation, The development efficiency of the green economy in southern Anhui is obviously better than that in northern Anhui and central Anhui.

Keywords

Anhui Province; Green Economic Efficiency; Evaluation and Development; System Simulation.

1. Introduction

In recent years, the economy of Anhui Province has been developing rapidly. Anhui Provincial Statistics Bureau announced that the GDP of Anhui Province in 2020 and 2021 is 3868.06 billion yuan and 4295.92 billion yuan respectively, among which the added value of the secondary industry is 1567.17 billion yuan respectively; 1761.32 billion yuan, becoming one of the provinces with the fastest economic development in central China. In the process of rapid economic development of Anhui province's economy, energy consumption is also increasing rapidly, and the resulting environmental pollution and energy consumption are becoming more and more obvious. These two important issues have a significant and far-reaching impact on the healthy and sustainable economic development of Anhui province. For the lasting and healthy development of Anhui economy and combined with the actual situation of economic development in Anhui Province, the People's Congress of Anhui Province adopted and promulgated the newly revised Energy Conservation Regulations of Anhui Province in July 2020, which was implemented on September 1,2020. In 2021, the Department of Ecology and Environment issued the Notice on Strengthening the Ecological Environment Prevention and Control to all cities and districts of the province [1]. Strengthening the efficiency evaluation of green economy in Anhui Province is of great significance for analyzing the development status of green economy in Anhui Province, putting forward ecological protection policies, improving the efficiency of resource allocation, and taking the road of green and sustainable development.

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2. Establish an Efficiency Index System for Green Economy

Since the efficiency of green economy includes many different aspects, in the process of the evaluation of green economy efficiency, it is necessary to choose a number of different and representative indicators, and then build the evaluation index system, and then conduct scientific evaluation of the efficiency of green economy. Thus, a variety of different, with representative green economic efficiency index, is the basis of building green economic efficiency index system, and green economic efficiency index system is the foundation of green economic efficiency evaluation, green economic efficiency index system of green economic efficiency evaluation plays a decisive role, has a very important influence on its accurate evaluation [2, 3].

2.1. Construct the Efficiency Model of Green Economy Development

In order to evaluate the decision-making unit (DMU), in the 1970s, relevant scholars established DEA (data envelope analysis), which is widely used in various industries and departments. It can evaluate the similar DMUs with class N input and output without predicting the parameters. The production and operation of enterprises can not only create the expected output of benefits, but also produce the negative side, produce the unexpected output that puts pressure on the environment and ecology, and affect the accuracy of DEA model [4, 5]. Therefore, Tone has innovated and established the DEA-SBM model based on it. The model mainly includes the following expressions:

$$\text{Defined input m, } x \in R^m, \quad X=(x_1, x_2 \cdots, x_n) \in R^{m \cdot n}, x_i > 0;$$

$$\text{Expected output s1, } y^g \in R^{g1}, y^g = (y_1^g, y_2^g, \cdots, y_n^g) \in R^{g1 \cdot n}, y_i^g > 0;$$

$$\text{undesirable output s2, } Y^b = (y_1^b, y_2^b, \ldots, y_n^b) \in R^{g1 \cdot n}, y_i^b > 0;$$

$$\text{Production possibility set P, P= } \{(x, y^g, y^b) \mid x \geq X\lambda, y^g \leq y^g\lambda, y^b \geq y^b\lambda, \lambda > 0\}$$

$$\begin{cases} x_0 = x\lambda + s^- \\ y_0^g = y^g\lambda - s^g \\ y_0^b = y^b\lambda + s^b \\ s^- \geq 0, s^g \geq 0, s^b \geq 0, \lambda \geq 0 \end{cases} \tag{1}$$

$$p^* = \min \frac{1 - \frac{1}{m}\sum_{i=0}^{m} \frac{s_i^-}{x_{i0}}}{1 + \frac{1}{s_1 + s_2}\left(\sum_{r=1}^{g_1} \frac{s_r^g}{y_{r0}^g} + \sum_{r=1}^{g_2} \frac{s_r^b}{y_{ro}^b}\right)}$$

The meaning represented by the DEA-SBM model is shown in Figure 1.

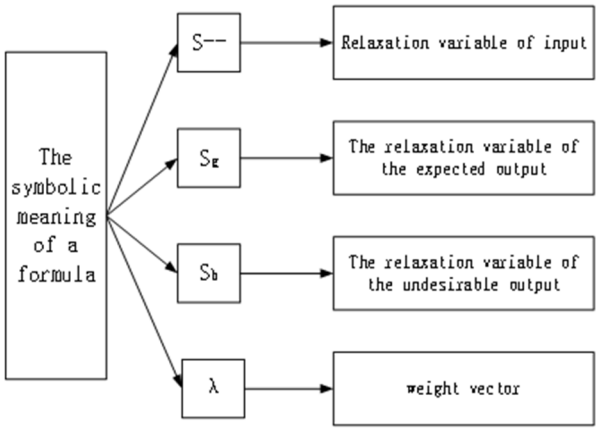

Figure 1. Symbolic implications in the DEA-SBM model formula

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$$s.t.\begin{cases} \bar{x} \geq \sum_{j=1}^{n} \neq 0 \lambda_j x_j \\ \bar{y}^{g} \leq \sum_{j=1}^{n} \neq 0 \lambda_j y_j^{g} \\ \bar{y}^{b} \geq \sum_{j=1,}^{n} \neq 0 \lambda_j y_j^{b} \\ \bar{x} \geq x_0, \bar{y}^{g} \leq y_0^{g} \bar{y}^{b} \geq y_0^{b}, \lambda \geq 0 \end{cases} \tag{2}$$

$$p^{*} = \min \frac{\frac{1}{m} \sum_{i=1}^{m} \frac{\bar{x}_1}{x_{io}}}{\frac{1}{s_1 + s_2} \left(\sum_{r=1}^{s_1} \frac{\bar{y}_r^{g}}{y_{ro}^{g}} + \sum_{r=1}^{s_2} \frac{\bar{y}_r^{b}}{y_{ro}^{b}} \right)}$$

One disadvantage of this model is that the original face of the DEA-SBM model will change when the efficiency value is equal to 1. To this end, scholars have established the ultra-efficient DEA-SBM model. The advantage of this model is that it is beneficial to conduct computational analysis of decision-making problems with multiple inputs and multiple output goals.

2.2. Determination of Data Sources and Indicators

2.2.1. Data Source

This paper uses the annual data of 16 cities including Hefei, Lu'an, Huangshan, Anhui province over the past 2005-2020 to estimate the development efficiency of green economy. The relevant data required in the calculation are all selected from the Anhui Statistical Yearbook and the public annual reports of the 16 municipal governments, which is true, reliable and highly authoritative.

2.2.2. Selection of Green Economic Efficiency Indicators

Table 1. Description of input and output indicators

	metric	definition
put into	capital input	Total social investment in fixed assets (RMB 100 million yuan)
	Energy input	Energy consumption index value (ton of standard coal / ten thousand yuan)
	Labor force input	Number of year-end employment (person)
	Investment in land resources	Built-up area (km^2)
	Water investment	Total water resources supply in related cities (ten thousand cubic meters)
output-input ratio	Expect output	GDP(100 million)
	Undesired output	Total discharge of industrial wastewater (ten thousand tons)
		Industrial exhaust gas emissions (100 million standard cubic meters.)
		General solid waste production capacity (ten thousand tons)

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This study uses the DEA-SBM model to estimate the efficiency of green economy development in Anhui Province, and then refer to Cao Minggui and Gao Qi [6] The two scholars' elaboration on the input and output variables in the study of green economy efficiency in China are borrowed from the relevant indicators and explanations of the input and output in this paper, as shown in Table 1.

3. Efficiency Evaluation of Green Economy Development in Anhui Province

3.1. Efficiency of Green Economy Development in All Cities of Anhui Province

Because the economic development status of each city is different, the ultra-efficiency DEA-SBM model is adopted to calculate the green economic development efficiency of these 16 cities from 2005 to 2020[7]. As shown in Table 2:

Table 2. Efficiency of green economy development in all cities of Anhui Province from 2005 to 2020

	2005	2008	2010	2012	2014	2016	2017	2018	2019	2020
Hefei	1	1	1	1	1	1	1	1	1	1
Huaibei	0.766	0.866	0.811	0.801	0.816	0.792	0.73	0.746	0.745	0.752
Bozhou	1.13	1.043	1.008	0.937	1.017	1	1.015	0.872	1.006	0.742
Suzhou	1.003	1.016	0.845	0.78	0.756	0.73	0.695	0.685	0.703	0.732
Bengbu	1.268	1.156	1.17	1.16	1.239	1.233	1.307	1.142	1.105	1.064
Fuyang	0.779	0.795	0.762	0.775	1	0.689	0.634	0.646	0.63	0.605
Huainan	0.839	0.908	1.014	1.051	0.937	1.007	0.906	1.009	1.012	1.041
Chuzhou	0.732	0.697	0.695	0.719	0.741	0.739	0.713	0.723	0.738	0.751
Lu'an Mountain	0.793	0.731	0.738	0.721	0.721	0.723	0.735	0.785	0.83	0.847
Ma'anshan	1.694	1.733	1.406	1.274	1.144	1.141	1.086	1.042	1.035	1.046
Wuhu	0.666	1.052	1.005	1.003	0.843	0.859	0.849	0.856	0.817	0.862
Xuancheng	0.755	0.751	0.733	0.799	0.818	0.804	0.806	0.782	0.774	0.758
Tongling	1.162	1.344	1.22	1.233	1.166	1.175	1.155	1.053	1.054	1.055
Chizhou	1.263	1.127	1.114	1.129	1.152	1.146	1.146	1.158	1.164	1.157
Anqing	0.725	0.662	0.73	0.803	0.783	0.805	1.014	0.803	0.761	0.715
Mount Huang	1.279	1.319	1.264	1.197	1.256	1.275	1.334	1.363	1.374	1.379

According to the DEA-SBM model, if the efficiency result of green economy is greater than 1, it shows that the green economy of the city is good, that is, on the premise of referring to the unexpected output factors, the city can plan the relationship between ecological civilization and economic construction. On the contrary, if the efficiency of green economy development is less than 1, it indicates that the development of green economy in the city is not very good, indicating that the city is not able to balance the development of both economic construction

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and ecological civilization, that is, further efforts are needed in the construction of ecological civilization.

According to the results of Table 2, the change trend of green economy development efficiency in all cities in Anhui Province is shown in Figure 2 below:

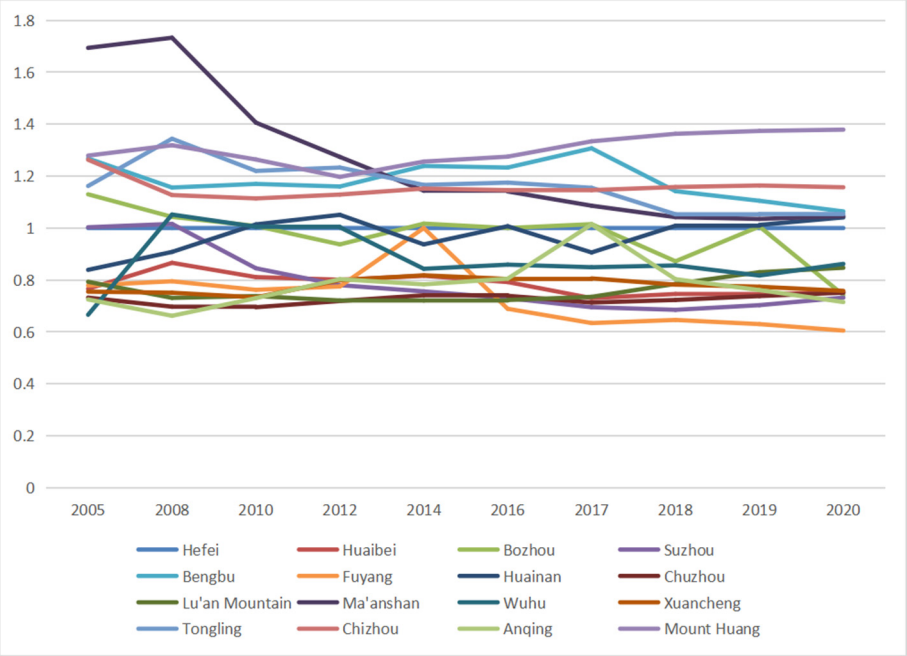

Figure 2. Trend chart of green economy development efficiency in Anhui Province

From the above table 2 and figure 2 can get, up to 2012, ma on city green economy has been at the top, but since then, Huangshan city is beyond the ma on shan, leading, in 2005 to 2009, Anqing city green economy development lags behind other city, but since 2009, Chuzhou began at the lowest position, after 2012, regarding Lu'an was Chuzhou city to become the most backward green economy development, after 2016, Fuyang city has been in the last.

The analysis reason is that Huangshan city has a superior geographical location, abundant resources, beautiful cultural heritage, tourism developed, so that it will not form too much industrial waste gas and waste water, therefore, its green economic development efficiency is very high. Ma'Anshan has a large number of iron ore resources, to promote the rapid development of the economy, the expected output is particularly large. Fuyang and Anqing are both with agriculture as the main body, so the industrial development is relatively weak, so its unexpected output is very small. But agriculture basically relies on natural resources, the use of energy is not large, the use of capital is not to mention, the output of agriculture is very small, so its green economic efficiency is very small.

3.2. Comparison of Green Economy Development Efficiency in Northern Anhui, Central Anhui and Southern Anhui

The development history, distribution of natural resources, planning decisions and policies of various cities in Anhui province are different. Here, according to the location of each city, it is divided into three parts, northern Anhui, central Anhui and southern Anhui, as shown in Figure 4.

It can be clearly seen from the line Figure 3 that from 2011 to 2020, the development efficiency of green economy in southern Anhui tends to be between 1 and 1.09, and the order between them is: Southern Anhui, North Anhui and Central Anhui. The reason is mainly caused by the different resource structure of different cities. The resource structure in northern Anhui is

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mainly coal, such as Huaibei city and Bengbu city, promoting the coal industry, which is easy to cause a large amount of unexpected output, industrial waste water, waste gas, solid waste, etc. As a result, the development of green economy is slow and the efficiency is reduced; due to geographical reasons, the industrial structure of Bozhou and Suzhou is based on agriculture, so that the undesired output is small, resulting in low energy and capital input and low output, and the efficiency of agricultural development is lower than that of southern Anhui.

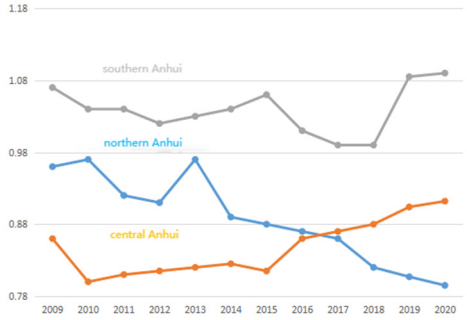

Figure 3. Efficiency change of green economy development in the three regions of Anhui province

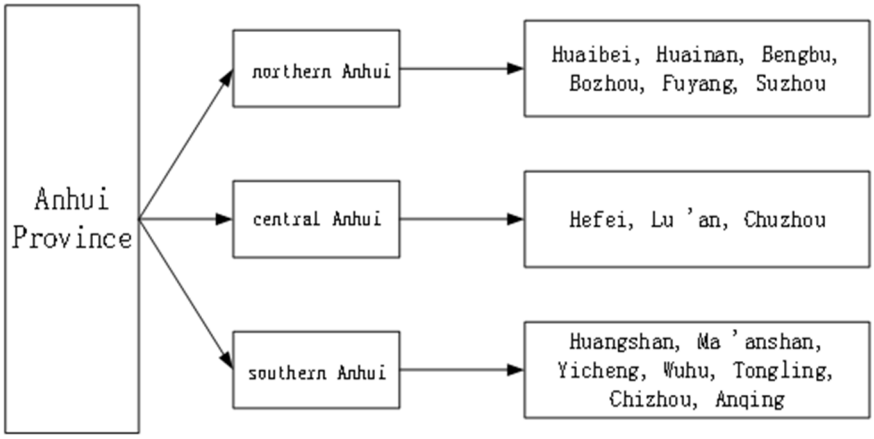

Figure 4. Geographical location distribution map of various cities in Anhui Province

4. Summary

The development of green economy includes two aspects. On the one hand, economic development should consider environmental protection; on the other hand, economic development should be considered in the process of strengthening environmental protection. These two seem to be contradictory, but they are closely related. At present, China is in a critical period of economic transformation. The development of green economy has become a new driving force for China's economic growth in the new period, which can promote the transformation of China's economic development model under the new normal, and can successfully achieve sustainable economic growth and transformation and upgrading, so Chinese governments at all levels attach great importance. The evaluation of the efficiency of green economy development is the most important tool to test the development level of green economy, which is of great significance for analyzing the development status of green economy in a region, formulating ecological protection policies, improving the efficiency of resource allocation, and taking the road of green and sustainable development. This paper selects 16 cities of Anhui Province as the research object to scientifically evaluate the development efficiency of green economy in this province. The evaluation results show that the green economic efficiency of Ma'Anshan is better than that of other cities, and after 2012, Huangshan

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is the city with the best green economic efficiency in Anhui Province, and the green economic development efficiency of northern Anhui and Central Anhui.

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