ISSN 2522-3488 Vol. 6, Issue 4: 38-44, DOI: 10.25236/IJNDES.2022.060406

Construction of the Evaluation Index System of China's Green Economy Development Level-Based on the Dual Model of Entropy Value Method and Coefficient of Variation Method

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Abstract: *China's economy has officially shifted from high speed development to high quality development, which means that concepts such as green development are increasingly important and the level of China's development needs to be examined from multiple perspectives. This paper applies a dual model of entropy value method and coefficient of variation method to evaluate China's green economic development level from 2016 to 2020 by selecting 12 secondary evaluation indicators based on three dimensions: economic level, social and livelihood, and green ecology. The results show that although there are fluctuations, China's overall green economic development level is on an upward trend, and there is significant progress in the economic level and social livelihood dimensions, and slight turbulence in the green ecology dimension. This paper suggests that the government should pay more attention to ecological environment, promote the reform of green mechanism and system, innovate green ecological science and technology, and promulgate relevant policies favorable to China's green development, promote the process of renewable and clean energy to replace fossil and other non-renewable energy sources, actively popularize relevant green knowledge to the nationals, and promote China's green economic development from the perspective of multiple subjects, including the state, society, and individuals.*

Keywords: *green economy; entropy method; coefficient of variation method; evaluation index system*

1. Introduction

China's "New Development Concept" insists on green development, aiming to create a green economy and lifestyle in which people and nature live together in harmony and sustainability. Along with the over-exploitation of natural resources and the environmental pollution, water scarcity and greenhouse effect brought about by the technological progress of heavy industry, people are increasingly aware that a green economy is the only way for human beings to shift from high-speed development to high-quality development.

At the same time, theoretical innovations and empirical analysis related to green economy began to appear in academia, in terms of theory, Eleonore Loiseau et al. (2016)[1] explored the impact of the concept of green economy on strong and weak sustainability and proposed the conclusion that there are alternatives between environmental and economic benefits, and practicing green economy requires more or less changing people's lifestyles, Wang Yongqin (2014)[2] pointed out that people should The traditional development concept of blindly using natural resources should be thoroughly rethought, and the harmonious unity between human and nature should be pursued on the basis of practicing green economic development. In terms of empirical analysis, academics generally focus on how to evaluate and measure the degree of development of an economy's green economy, where Wei Zhang (2021)[3] selected 30 provinces across China as the research object, 3 sub-indicators, and 20 specific indicators to construct an evaluation system The evaluation of each province's score using factor analysis was conducted to explore the common and individual imbalance that causes the development of green economy among cities, and an important conclusion was drawn about the fact that the degree of green economy development is also relatively higher in regions with relatively developed economic levels. Xiang Shujian (2013)[4] constructs an index evaluation measurement model, defines China's green economy development index as the first level, and splits it into secondary indices named China's green ecology, consumption, and production indices, and gives the conclusion that China's green economy is still in the primary embryonic stage and needs continuous practice until the green economy in the real

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sense after the assignment and quantitative evaluation. Zeng Xiangang (2014)[5] selected the framework of the indicator system proposed by the United Nations environmental planning, and took the degree of progress and well-being achievement, greenness of resource utilization, and effective economic transformation as the first-level indicators, and innovatively established the second- and third-level indicators, first used the principal component analysis to reduce the dimensionality, and then clustered the indicators that are close to each other, and used the specific indicators of the third-level as the explanatory variables, and the integrated indicators of the first-level as the explanatory variables, and conducted Multiple linear regression was performed, and it was analyzed that the five regions where China's green economy development level lags behind are all in the western region, and the regression coefficients of environmental protection-related indicators such as effective irrigation area, nature reserve area, forest coverage rate and other tertiary specific indicators have large values, which are important indicators for examining whether the green economy development level is effective.

The innovation of this paper is to combine the entropy value method and the coefficient of variation method to build a double evaluation model, and further weight the weights obtained from the two models by using Lagrange multipliers to build a relatively stable and scientific evaluation system of green economic development level.

2. Construct green economy evaluation index system

In this paper, when constructing the evaluation index system, we adhere to the concept of from whole to part and from macro to micro, and on the basis of quantifiable indicators, we go from primary to secondary indicators to establish a logical and organically unified index system, and its specific construction ideas are as follows.

2.1 Establishing first-level indicators

In the literature related to the evaluation of green economy, most indicators are subdivided from the perspectives of economic development, environmental protection, and green ecology, which fits with the approach that green economy as a noun can be split into green and economic. Therefore, the two first-level indicators of economic development and green ecology are selected, while taking into account the national conditions of China and the characteristics of China's large population base and intensive labor endowment, this paper selects a total of economic levely_1 , social livelihoody_2 green ecologyy_3 In this paper, three level 1 evaluation indicators are selected.

2.2 Establishing secondary indicators

Economic level: economy is the foundation of a country, and this paper selects four indicators to reflect the economic level, among which disposable income per capita (x_1) is the decisive factor of a country's consumption expenditure, which can effectively reflect the living standard of a country's residents and the level of economic development. The gross domestic product index (x_2) is calculated by taking 1978 as the base year and the change of relative GDP, which is the sum of the market value of final goods and services produced by a country in a certain period of time, and is the core indicator of a country's economic level. Gross capital formation (x_3) is an indicator reflecting the total amount and stock of capital, the greater the amount of capital, the higher the level of productivity and the more developed the economy in general. Engel coefficient (x_4) reflects the proportion of food expenditure to total consumption expenditure, the richer a country is, the smaller the Engel's coefficient.

Social livelihood: the living standard of the people, infrastructure, social security and the amount of national funds invested in this area are closely related, and can reflect the economic strength of a country sideways. Among them, health costs as a percentage of GDP (x_5) measures the economic resources provided to improve people's health at the medical level, the share of education population (x_6)The higher the education level of residents, the higher the overall cognitive level of society and the more peaceful the development. The budgetary accounts of financial resources for poverty alleviation (x_7) reflects the investment of national funds and revenues in poverty alleviation, which is conducive to reducing the gap between the rich and the poor in society, and the urban registered unemployment rate (x_8) can evaluate the employment situation of a country, the degree of national perfection in labor protection and the strength of protection measures, the lower the unemployment rate, the stronger the social stability.

Green ecology: In this paper, four secondary indicators are selected to measure green ecology, among which ecological and environmental protection expenditure (x_9) reflects the national financial investment

ISSN 2522-3488 Vol. 6, Issue 4: 38-44, DOI: 10.25236/IJNDES.2022.060406

in ecological protection and is a quantitative reflection of the country's fulfillment of its responsibility for environmental protection, and the amount of water resources per capita (x_{10}) is the ratio of freshwater resources available to the country to the total number of people, reflecting a country is the degree of resource scarcity. The total area of afforestation (x_{11}) reflects the amount of artificial afforestation, and the increase of afforestation also reflects the decrease of wasteland dunes. The amount of domestic waste removed (x_{12}) refers to the total amount of domestic waste that can be sent to the landfill or transfer site, which can reflect the total amount of domestic waste generated in a country, the rate of removal and recycling, and the lower the indicator, the clearer the green ecological development.

The specific index system is shown in Table 1.

Table 1: Green evaluation index system

Tier 1 Indicators	Secondary indicators	Indicator number	Unit	Indicator Type
Economic level	Disposable income per inhabitant	x_1	Yuan	Positive
	Gross Domestic Product Index	x_2	1978 = 100	Positive
	Total capital formation	x_3	Billion	Positive
	Engel's coefficient	x_4	Percentage	Negative
Society and People's Livelihood	Health costs as a percentage of GDP	x_5	Percentage	Positive
	Share of educated population	x_6	Percentage	Positive
	Financial poverty alleviation funds budget final account	x_7	Billion	Positive
	Urban registered unemployment rate	x_8	Percentage	Negative
Green Ecology	Eco-environmental protection expenditure	x_9	Billion	Positive
	Water resources per capita	x_{10}	Cubic meter/person	Positive
	Total afforestation area	x_{11}	million hectares	Positive
	Domestic waste removal volume	x_{12}	million tons	Negative

3. Dual model construction of entropy value method and coefficient of variation method

3.1 Standardization of positive and negative indicators

The entropy method and coefficient of variation method used in this model are methods to determine the weights, and the essence of the weights and data analysis lies in the numerical values, and the non-uniformity of the unit scale between the numerical values will have a great "unfair" impact on the overall data analysis. The standardization can help improve the accuracy of the model and promote the convergence of the model. For the positive and negative indicators, this paper adopts different treatment.

Positive indicator treatment.

$$x_{ij}' = \frac{x_{ij} - \min(x_{1j}, x_{2j}, \cdots, x_{nj})}{\max(x_{1j}, x_{2j}, \cdots, x_{nj}) - \min(x_{1j}, x_{2j}, \cdots, x_{nj})} \tag{1}$$

Negative indicator treatment.

$$x_{ij}' = \frac{\max(x_{1j}, x_{2j}, \cdots, x_{nj}) - x_{ij}}{\max(x_{1j}, x_{2j}, \cdots, x_{nj}) - \min(x_{1j}, x_{2j}, \cdots, x_{nj})} \tag{2}$$

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3.2 Entropy value method

Entropy is a thermodynamic concept in physics, which is used to measure the degree of confusion and uncertainty of a certain system. The entropy value can be used to judge the discrete uncertainty degree of a certain indicator in the comprehensive evaluation method, the more information it has, the smaller the uncertainty, the smaller the information entropy value, the greater the discrete degree of the indicator, the greater the weight of the indicator to the comprehensive evaluation, and conversely if the value of the indicator is all equal in different cases, the indicator is insignificant in the comprehensive evaluation. In the related literature, Zhang Xia (2022)[6] explores the principle characteristics and applicable scenarios of the entropy value method, and gives the conclusion that the entropy value method is applicable to solve the weighting problem. The specific steps of the entropy method are as follows.

Step 1: De-normalize the secondary indicators under each primary indicator, as described in 3.1

Step 2: Calculate the entropy value of the jth indicator using the formula x_{ij} denotes the value of the jth evaluation index of the ith sample, where n is the number of samples, the $k = 1/\ln(n) > 0, e_j \geq 0$

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}}, i, j = 1, 2, \cdots, m \tag{3}$$

$$e_j = -k \sum_{i=1}^{n} p_{ij} \ln(p_{ij}), j = 1, \cdots, m \tag{4}$$

Step 3: Calculate the information entropy coefficient of variation (redundancy)

$$d_j = 1 - e_j, j = 1, \cdots, m \tag{5}$$

Step 4: Calculate the weight of the jth indicator to all indicators

$$w_j = \frac{d_j}{\sum_{j=1}^{m} d_j}, j = 1, \cdots, m \tag{6}$$

3.3 Coefficient of variation method

The coefficient of variation method is an objective weighting method, the principle of which is to compare the ratio of the standard deviation to the mean of sample information under multiple indicators, the ratio is called the coefficient of variation (C.V.), the larger the coefficient of variation, the greater the degree of internal variation, the more clearly distinguish the evaluated object, that is, the indicator should be given a greater weight. The specific calculation steps of the coefficient of variation method are as follows.

Step 1: De-normalize the secondary indicators under each primary indicator, as described in 3.1

Step 2: Calculate the mean value of the ith indicator $\overline{x}_i$ and standard deviation σ_i , and G_{ij} denotes the observation of the ith indicator in the jth period, and n is the number of samples from

$$\overline{x_i} = \frac{1}{n} \sum_{i=1}^{n} G_{ij}, i, j = 1, 2, \cdots, n \tag{7}$$

$$\sigma_i = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (G_{ij} - \overline{x_i})^2}, i, j = 1, 2, \cdots, n \tag{8}$$

Step 3: Calculate the coefficient of variation (C.V.)

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$$v_i = \frac{\sigma_i}{x_i}, i = 1, 2, \cdots, n \tag{9}$$

Step 4: Calculate the weights and get the weights of each indicator

$$w_i = \frac{v_i}{\sum_{i=1}^{m} v_i}, i = 1, 2, \cdots, n \tag{10}$$

3.4 Lagrange multiplier method

The construction of the dual model inevitably faces the problem of how to weigh the combined results, and by reviewing the relevant literature of previous authors, Xiangding Hou (2021)[7] pointed out in the paper that the final weights can be determined by using the Lagrange multiplier method, whose specific formula is as follows, where p is the total number of evaluation indicators andw_{1i} is the weight of the ith indicator calculated by applying the entropy value method, and w_{2i} is the weight of the ith indicator calculated by applying the coefficient of variation method.

$$w_i = \frac{(w_{1i} w_{2i})^{0.5}}{\sum_{i=1}^{p} (w_{1i} w_{2i})^{0.5}} \tag{11}$$

4. Empirical analysis

4.1 Data pre-processing

The data for the secondary indicators in this paper are obtained from the 2016-2020 Chinese macroeconomic database and the Chinese urban database in the EPSDATA database, and are normalized for positive and negative indicators as in 3.1.

4.2 Results of index weights

Table 2: Indicator weights

Indicator Number	Entropy method			Coefficient of variation method		Lagrange's multiplier method
	Information entropy value e	Information utility value d	Weights w_{1i}	Coefficient of variation	Weights w_{2i}	Weights w_i
x1	0.751	0.249	9.362	0.780	7.912	0.080
x2	0.808	0.192	7.223	0.746	7.57	0.070
x3	0.711	0.289	10.87	0.900	9.126	0.100
x4	0.700	0.300	11.25	0.968	9.813	0.110
x5	0.751	0.249	9.362	0.939	9.523	0.090
x6	0.818	0.182	6.844	0.723	7.328	0.070
x7	0.789	0.211	7.481	0.806	8.172	0.080
x8	0.821	0.179	6.731	0.719	7.292	0.070
x9	0.801	0.199	7.481	0.760	7.705	0.080
x10	0.766	0.234	8.777	0.884	8.969	0.090
x11	0.817	0.183	6.880	0.740	7.507	0.070
x12	0.759	0.241	9.047	0.896	9.082	0.090

The processed data were weighted using the entropy value method and the coefficient of variation method, where the results of the weights calculated by the Lagrange multiplier method retained 0 decimal places and the sum of the weights was 100%, and the specific results were Table 2

The results in Table 2 show that under the dual model based on the entropy and coefficient of variation methods, the Engel coefficient should be given the greatest weight, followed by gross capital formation,

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and the GDP index, the share of educated population, the urban registered unemployment rate, and the total area of afforestation should be given the least weight.

4.3 Calculating the score

The value obtained by multiplying the indicators with the corresponding weights is summed up as the total green economic development score for that year, and the total score for 2016-2020, the score of the first-level indicators are repeatedly calculated and compared vertically, and the total score is set as S. The specific calculation formula is as follows.

$$\begin{cases} y_1 = x_1 w_1 + x_2 w_2 + x_3 w_3 + x_4 w_4 \\ y_2 = x_5 w_5 + x_6 w_6 + x_7 w_7 + x_8 w_8 \\ y_3 = x_9 w_9 + x_{10} w_{10} + x_{11} w_{11} + x_{12} w_{12} \end{cases} \quad (12)$$

$$S = x_1 w_1 + x_2 w_2 + \cdots + x_{12} w_{12} \quad (13)$$

The specific score results are shown in Table 3.

Table 3: Indicator scores

Year	2020	2019	2018	2017	2016
x1	1.000	0.826	0.527	0.257	0.000
x2	1.000	0.881	0.595	0.292	0.000
x3	0.768	1.000	0.000	0.861	0.031
x4	0.050	0.450	0.900	1.000	0.000
x5	1.000	0.477	0.39	0.159	0.000
x6	0.598	0.325	0.000	1.000	0.732
x7	1.000	0.885	0.466	0.256	0.000
x8	0.000	1.000	0.710	0.548	0.355
x9	1.000	0.832	0.000	0.247	0.645
x10	0.739	0.276	0.000	0.268	1.000
x11	0.000	0.611	0.490	1.000	0.361
x12	0.181	0.000	0.365	0.699	1.000
y1	0.232	0.277	0.183	0.237	0.003
y2	0.212	0.207	0.123	0.143	0.076
y3	0.163	0.134	0.067	0.177	0.257
S	0.607	0.618	0.373	0.557	0.336

Overall, the green economy score has shown an upward trend over the past five years from 2016 to 2020, with the total score almost doubling, with the most significant effect on the economic level, rising from 0.00 in 2016 to 0.23 in 2020, which is consistent with the central government's emphasis on economic construction as the central development concept. In terms of health care, China has a universal health insurance system to reduce the problem of "difficulty in seeing a doctor" due to the cost, and in terms of universal education, China has a nine-year compulsory education system and a secondary school examination at the end of nine years of junior high school. Students entering general high school will struggle for college three years later, while students in vocational high school will learn professional skills and generally enter the workforce earlier. In terms of poverty alleviation, China has already achieved full well-off, and will invest financial expenditures in transportation construction in poor and remote areas to increase the connection between regions and play a leading role. In terms of green ecology, the years 2016-2018 were slightly lacking, along with the introduction of the garbage classification system into the law in 2019 and the official implementation of new energy vehicle subsidies in 2018, which to a certain extent promote the development of environmental awareness among residents.

It is important to note that there is a reason why the scores from 2019 to 2020 are not increasing but decreasing. In late December 2019, the new crown broke out in the Wuhan region of China, and during the initial phase, China chose to manage it with a "dynamic zero" policy due to its high contagiousness and lack of relevant scientific research, from the closure of the city in Wuhan to the silence of the rest of China. China then devoted itself to the research of the new vaccine, investing a lot of money in the research of the vaccine, so the economic data showed a slight decline. The significant increase is related to the Chinese government's provision of uncompensated treatment and medical care for the newly crowned infected, a side-effect of the importance China places on its citizens. In terms of green ecology,

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the score was highest in 2016, then declined, and then showed an upward trend in 2018-2020, which means that China is slightly lacking in green ecology, the rapid development of urbanization makes the total area of afforestation decreasing year by year, and the unbalanced development of ecology and technology is a major problem that needs to be solved, which requires China to have more in-depth research in the direction of environmental economy.

5. Conclusion

After the completion of the preparation work, the dual model of entropy value method and coefficient of variation method was constructed to calculate the weights of the 12 secondary indicators, and the calculated scores were used to make a comprehensive evaluation of China's green economy development from 2016 to 2020. The results show that the overall development is gradually increasing, the economic level score is steadily increasing except for the force majeure factor in 2020, the social and livelihood level is increasing year by year, and the green ecological level is slightly lacking, China needs to pay more attention to the green ecological construction, promote the green mechanism and system reform, and further improve the green mechanism and system after the waste classification, new energy vehicles, sewage discharge standard, residential household China needs to pay more attention to green ecological construction, promote the reform of green mechanism and system, and further increase the use of clean energy, return farmland to lakes, plant trees, reduce environmental pollution, and actively explore the balance between economic development and green development in the context of continuous development of green technology.

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