Research on GGDP Accounting Systems Based on The Entropy Weight Method and Coefficient of Variation Method

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Abstract. GDP is a standard indicator of economic development. However, it ignores resource consumption and other factors and does not effectively reflect the inherent defects of the economic growth level. To comprehensively measure the sustainability of economic and environmental conditions, this paper, based on the GDP accounting system, considers resource consumption and environmental pollution in the development process and establishes the GGDP accounting system reflecting sustainable development. Specifically, this paper defines GGDP and analyzes four direct and three indirect influences of GGDP on environmental consumption cost. It uses the entropy weight method - coefficient of variation method to build the GGDP optimization model and finally gets the direct factor weight of 0.522 and indirect factor weight of 0.478.

Keywords: Entropy Method-Coefficient of variation method; GGDP; Sustainable development; Environmental pollution.

1. Introduction

GGDP can effectively compensate for the defects of ignoring the loss of energy efficiency and environmental pollution in the traditional GDP evaluation and play an essential role in promoting the transformation and upgrading of industrial structure and transforming the mode of economic and social development[1]. Suppose the conversion of GDP to GGDP is adopted as a new metric, and significant progress is made in the international campaign to mitigate the global climate crisis. In that case, governments may adopt policies that promote a healthier environment for the planet. To establish a GGDP accounting system reflecting sustainable development, the United Nations Statistical Commission released the System of Integrated Environmental and Economic Accounting in 2012(SEEA-2012)[2], the first international unified and standardized resource economical and environmental accounting system the most studied system at present. American economist Henry M. Peskin established ENRAP system[3]; Eurostat developed the SERIEE system[4]; The Netherlands Statistics Bureau designed the NAMEA system[5]. In addition, China, Japan, the United Kingdom, Germany, France, Finland, Norway, Austria, Sweden, Chile, Canada, India, Indonesia, Malaysia and other countries or regions are also conducting environmental and economic accounting research and practice[6]. Accounting methods for GGDP are mainly divided into two categories: First, direct measurement, whose principle is the same as that of GDP, including production method and expenditure method. The production method, that is, the total output obtained from the output of various industrial sectors after deducting the intermediate inputs, which include both the economic assets consumed and the natural assets; In the expenditure method, the output value of the depletion of natural resources is added to the original accounting. The other is the indirect calculation, which calculates GGDP by adding resources, environment, society and other indicators based on the original[7]. However, most of the international community is based on the United Nations SEEA accounting system, and a unified, complete, mature and standardized GGDP accounting system has yet to be formed. Therefore, it is essential to establish a standard accounting system to measure countries' economic health levels worldwide. Calculation formula according to GGDP model:

GGDP=GDP-(cost of environmental resources *C1+ cost of environmental resources protection service *C2)[8]. Considering that climate change is affected by different influencing factors, we modify the formula as GGDP=GDP-(consumption cost of direct climate factors *C1+ consumption cost of indirect climate factors *C2). Then, the Entropy-weighting method[9] and Coefficient of variation method[10] are used to calculate the weight of direct and indirect impact factors in the model to correct the model. Finally, a new GGDP measurement model is obtained.

2. Notations and Definitions

2.1. Notations

The key mathematical notations used in this paper are listed in Table 1.

Table 1 Notations used in this paper.

Symbol	Description	Unit
GGDP*	GGDP based on climatic factors	-
C1*	Climate direct influencing factors' cost of consumption	-
C2*	Climate indirect influencing factors' cost of consumption	-
NMRC	(Direct influencing factors) National Mineral Resources Consumption	Percentage of GNI
NCEC	(Direct influencing factors) National Comprehensive Energy Consumption	Percentage of GNI
NFRC	(Direct influencing factors) National Forest Resources Consumption	Percentage of GNI
NAFW	(Direct influencing factors) National Annual Freshwater Withdrawals	One billion cubic meters
InNNOE	(Indirect influencing factors) National Nitric Oxide Emissions	100,000 metric tons of CO2
InNPD	(Indirect influencing factors) National Population Density	%
InNER	(Indirect influencing factors) National Energization Rate	%

2.2. Definitions

Gross Domestic Product(GDP)：one of the greatest inventions of the 20th century, refers to the final result of production activities of all resident units of a country or region in a certain period of time. It is a standard to measure the development degree of a country or region, especially the economic strength [11].

Green Gross Domestic Product (GGDP): The core indicators in the comprehensive environmental economic accounting system and truly reflect the total growth of social and economic wealth. Green GDP can supplement the deficiency of GDP, measure economic and social development to a certain extent, and is widely used by all circles [12].

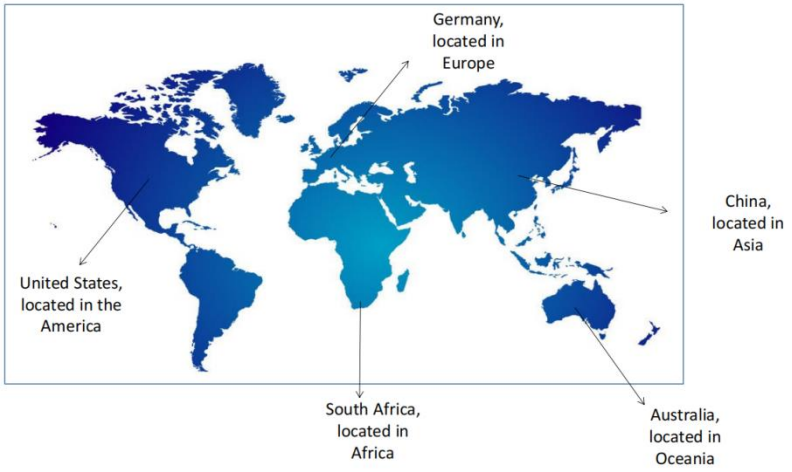
3. Modeling and solving

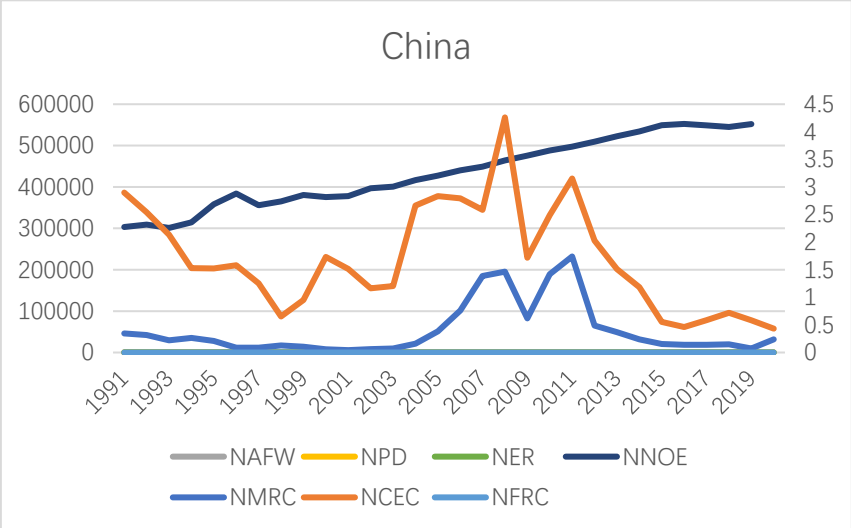
3.1. Determination of indicators and Data Collection

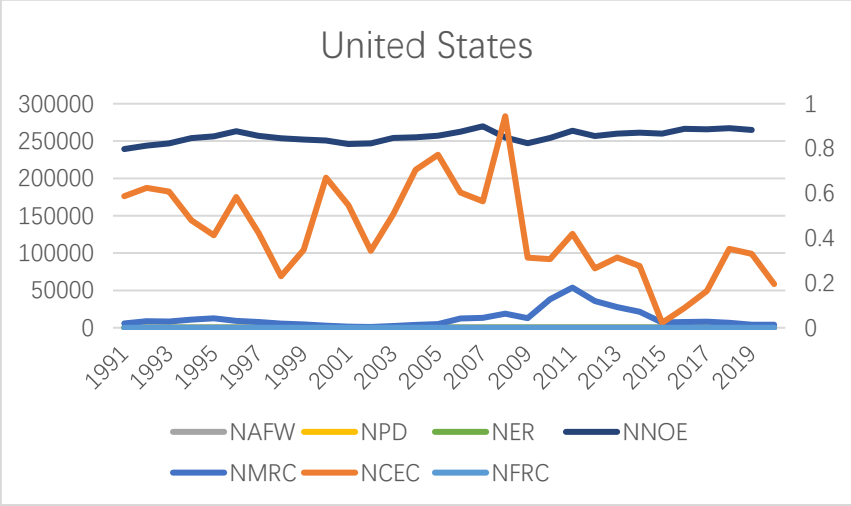
By reviewing relevant literature, this paper collected seven indicators of related influencing factors, namely National Mineral Resources Consumption, National Comprehensive Energy Consumption, National Forest Resources Consumption, National Annual Freshwater Withdrawals, National Nitric Oxide Emissions, National population density, and National Energization Rate. Meanwhile, this paper collected the change trends of different indicators in different countries from 1990 to 2020 and represented the overall global change trends through five continents (Asia, Europe, America, Africa, and Oceania), and selected one representative country in each continent as the overall change level

of the continent. The representative country in Asia is China, in Europe is Germany, in America is the United States, in Africa is South Africa, and in Oceania is Australia.

This paper first visualized the changes of GGDP influencing factors for each representative country to facilitate subsequent calculations. The results of the visualization are shown in Figure 1.







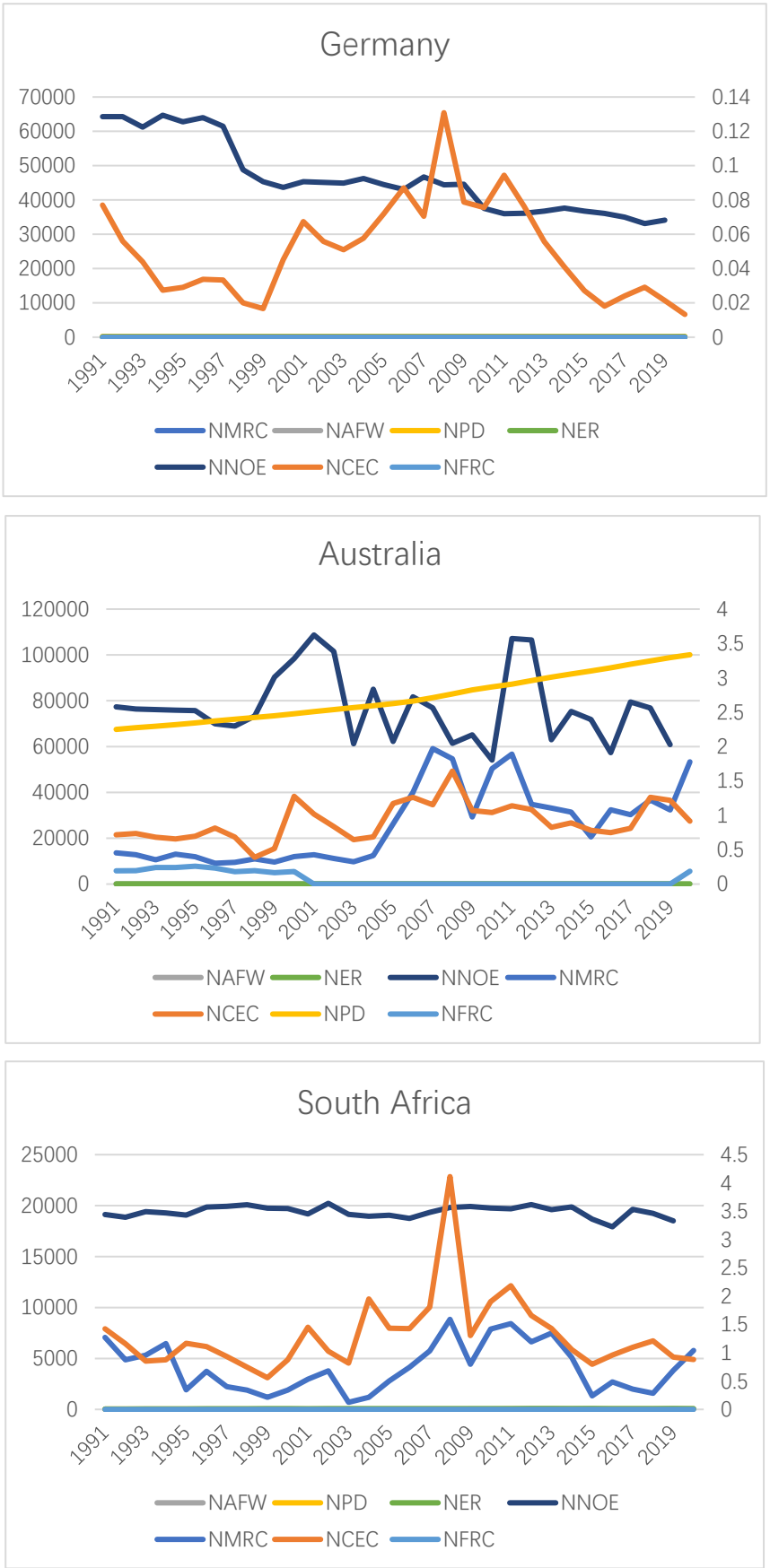


Figure 1 Images of data on climate impact factors for five representative countries

3.2. The GGDP model based on meteorological factors

GGDP is the core indicator in the integrated environmental-economic accounting system, incorporating resource and environmental factors based on the current GDP. GGDP is the portion of the total current GDP left after deducting the cost of environmental resources and the service fees for environmental resource protection. The existing GGDP model formula is:

$$GGDP = Total\ \ GDP - \left(C_1 + C_2\right) \tag{1}$$

This eaasy replace the Cost of environmental resources and Service fees for environmental resource protection on this basis, considering their impact on climate change based on different climatic factors, with Climate direct influencing factors' cost of consumption and Climate direct influencing factors' cost of consumption, based on the green GGDP* influenced by climate factors The formula is as follows.

$$w_{ij} = \frac{1 - e_i}{m - \sum_{i=1}^{m} e_i} (j = 1, 2, \cdots, m) \tag{2}$$

(1) Climate direct influencing factors' cost of consumption

$$C1^* = NMRC + NCEC + NFRC + NAFW \tag{3}$$

(2) Climate indirect influencing factors' cost of consumption

$$C2^* = InNNOE + InNPD + InNER \tag{4}$$

This eaasy collected typical representative countries from five continents for analysis, including China, Germany, South Africa, Australia, and the United States, and the data covers the period from 1990 to 2020.

3.3. Optimizing the GGDP model

$$GGDP^* = TotalGDP - (\beta_1 C_1{}^* + \beta_2 C_2{}^*) \tag{5}$$

First, the original model is improved by assigning different weights to the direct and indirect influencing factors, and the model improvement formula is as follows. Then, this eaasy used the Entropy Method and Coefficient of Variation to combine the weighting for the collected data.

The smaller the better type function is chosen to standardize the data. Let the indicator set Xi= {x1, x2,...,xn}, after normalization as:

$$Y_i = \frac{X_{ij} - \min\left(X_i\right)}{\max\left(X_i\right) - \min\left(X_i\right)} \tag{6}$$

he normalized non-negative interval. Denote the matrix pij as the characteristic weights under the jth indicator of the ith evaluation object.

$$p_{ij} = \frac{Y_{ij}}{\sum_{i=1}^{n} Y_{ij}} (i = 1, 2, \cdots, n; j = 1, 2, \cdots, m) \tag{7}$$

Calculate the entropy value ei of the ith evaluation object as:

$$e_i = -\frac{1}{\ln n} \sum_{i=1}^{n} p_{ij} \ln p_{ij} (j = 1, 2, \cdots, m) \tag{8}$$

When pij=0, let pij×lnpij=0 and calculate the entropy weight of each indicator.

$$w_{ij} = \frac{1 - e_i}{m - \sum_{i=1}^{m} e_i} (j = 1, 2, \cdots, m) \tag{9}$$

3.3.1 Coefficient of variation method

The coefficient of variation method is an objective weighting statistical method. The idea connotation is to obtain the corresponding weights of different indicators in the system through mathematical calculation of the information contained in each indicator and then carry out the aggregate calculation of the indicators endowed with weights. The basic logic adopted by this test method is as follows: in the evaluation index system, the greater the difference in the value of the index, the more difficult it may be to realize the index fully. In this way, the evaluation index obtained should be more accurate and fully reflect the gap of the evaluated units[13].Calculating weights by the coefficient of variation method is as follows.

In the following formula, i is the standard deviation coefficient of the ith item, and the coefficient of variation of each index can be expressed as:

$$V_i = \frac{\sigma_i}{x_i} \left(j = 1, 2, \cdots, n \right) \tag{10}$$

Calculation of indicator weights:Model

$$W_i = \frac{v_i}{\sum_{i=1}^{n} v_i} \tag{11}$$

3.3.2 building and solving

This essay assign weights based on the weights W_{1i} derived from the entropy weight method and the weights W_{2i} derived from the coefficient of variation method, combining these two data to assign weights.

$$W_i = \frac{W_{1i} + W_{2i}}{2} \tag{12}$$

The direct and indirect indicator weights of climate impact factors for different representative countries are shown in the Table 2.

Table 2 Indicator weights for different representative countries solved by entropy weighting method and coefficient of variation method.

Representative countries	Methods	NMRC	NCEC	NFRC	NAFW	InNNOE	InNPD	InNER
China	CV	0.004	0.356	0.335	0.001	0.053	0.191	0.065
	EEM	0.182	0.074	0.075	0.027	0.235	0.183	0.226
United States	CV	0.006	0.324	0.445	0.002	0.062	0.045	0.117
	EEM	0.182	0.074	0.075	0.027	0.235	0.183	0.226
Germany	CV	0.005	0.135	0.270	0.002	0.319	0.259	0.015
	EEM	0.182	0.074	0.075	0.027	0.235	0.183	0.226
South Africa	CV	0.005	0.433	0.243	0.001	0.168	0.033	0.119
	EEM	0.182	0.074	0.075	0.027	0.235	0.183	0.226
Australia	CV	0.004	0.260	0.153	0.312	0.170	0.023	0.083
	EEM	0.182	0.074	0.075	0.027	0.235	0.183	0.226

The combined weight coefficients under different representative countries are finally solved, as shown in Figure 2.

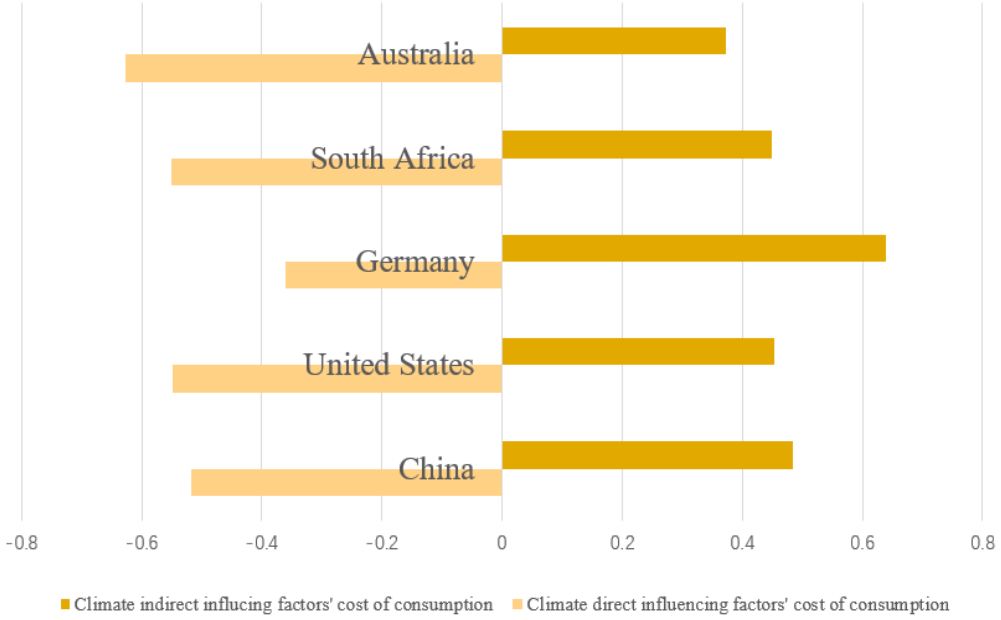


Figure 2 Weighting of individual meteorological direct and indirect impact indicators in different countries

Data results: the weight of the direct influence factor in the model is 0.522, and the weight of the indirect influence factor is 0. 478. The main factors affecting climate mitigation in different countries are some indicators that indirectly influence climate. In the subsequent analysis of the problem, this essay will introduce subjective factors, consider the actual situation, and analyze the changes in the model with different weights. The relationship between GDP and GGDP for the five representative countries under the combination weighting approach is finally solved, as shown in Figure 3.

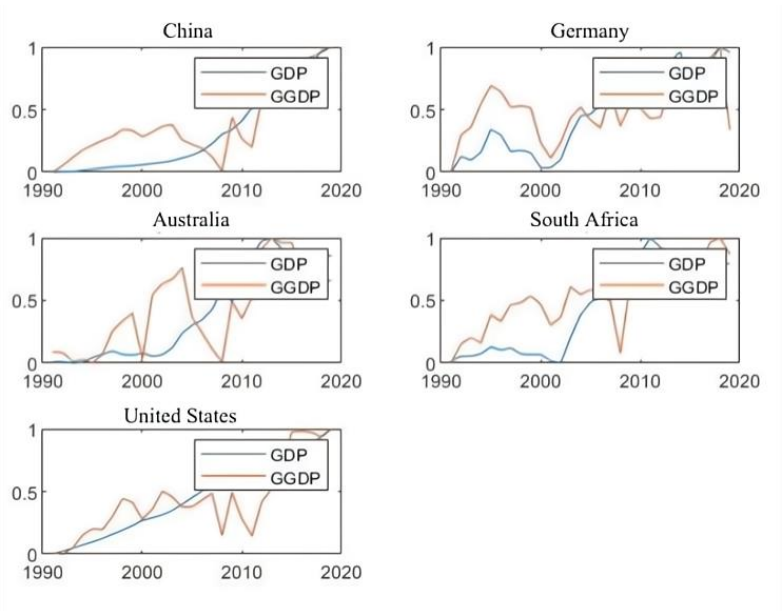


Figure 3 The relationship between GDP and GGDP change of five representative countries under combination weighting approach.

4. Conclusion

Through comparative analysis of GDP and GGDP, this essay choose to use GGDP to measure the actual economic health of a country, establish a GGDP model related to climate change mitigation,

and determine the weights of indicators by combining the entropy weight method and coefficient of variation method, and further determine the GGDP accounting system.

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