Examining the Viability of GGDP as an Alternative to GDP as the Only Indicator of National Economic Development

Weijian Liu[1, *, †], Tianhao Ren[1, †] and Kun Zou[1, †]

[1]Department of Computer Science and Technology, Shandong University of Finance and Economics, Jinan, China

*Corresponding author: 15376401562@163.com

†These authors also contributed equally to this work

Abstract. This paper studies whether GDP can be replaced by GGDP and become the sole indicator of the nation's economic development. As we know, GGDP is a key indicator of measuring the country's economic health. So the total amount of carbon dioxide emission was chosen as an index to measure the climate, and the correlation between the total amount of GGDP and the total carbon dioxide emission was analyzed using the Spearman correlation coefficient. We calculate the weight of each country's total carbon dioxide emissions, using TOPSIS algorithm based on entropy weight method, and then carry out the least squares linear regression for the total carbon dioxide emission and GGDP in each country, and obtain the linear regression equation. Add the weights to the six linear regression equations, and get the linear regression equation of the total carbon dioxide emission and GGDP. Through the analysis of the resulting model, GGDP can be used as one of the criteria to measure the health of a country's economy, because it can really reflect the impact on climate change and, under certain circumstances, the economic level. Due to the uncertainty and unfairness of GGDP, GDP as a measure of national economy is still the mainstream and cannot be replaced by GGDP.

Keywords: Spearman correlation coefficient, Topsis algorithm, Least squares linear regression.

1. Introduction

GDP is currently the most widely applied, and it can be said to be an important indicator for measuring the economic conditions of the country and the region. GDP is a fixed degree of policy. However, the impact of development has increased day by day due to the deteriorating environment and the scarce nature of natural resources. GDP calculations are quantifying our production and consumption, but ignoring social costs and environmental consequences and causing irreversible damage to the natural environment, GDP cannot be a good measure of the national health status. If environmental factors are added to the assessment and comparison criteria of the economy, the national government will develop its premise to ensure the health of the environment, and may change its behavior to achieve sustainable development, so that it may change its behavior in order to achieve sustainable development, and it is hoped to introduce the natural resources value into GDP and obtain a measure of the health status of the new national economy, namely, "green" GDP: GGDP. "Green" refers to the environment and sustainable viewpoints and elements.

We can find the relevant indicators that can measure the climate, build a simple model, analyze the relationship between GGDP and the world's climate, and use GGDP as a major measure of health in the nation's economy to predict the impact of global climate relaxation. Comparing the GDP and GGDP of the selected countries, it is necessary to analyze the impact of the selected countries on the GGDP as a key measure of the country's economic health.

2. Models

2.1. Data acquisition

Due to the large number of accounting indicators and countries of GGDP, and considering the difficulty of data collection, in order to conduct comprehensive analysis of GGDP from the world and country levels, we selected six countries with GDP ranking in the top ten in the past eight years: India, China, United States, Russia, Brazil, Indonesia. We try to ensure that these six countries are distributed around the world to ensure the representativeness and globality of the analysis results.

2.2. GGDP Accounting Model

There are many ways to calculate GGDP. Considering the calculation cost and climate measurement, the calculation model of GGDP selected by our team is as follows [1]:

$$Green\ GDP = GDP - (EPC + RDC) \tag{1}$$

EPC: Environmental pollution cost
RDC: Resource depletion cost

3. Empirical analysis

3.1. GGDP accounting analysis

By searching the data, we calculated and obtained the GDP and GGDP of six countries from 2017 to 2021: India, China, United States, Russia, Brazil and Indonesia:

Table 1. GDP and GGDP of six countries from 2017 to 2021

Country	Metrics	2017	2018	2019	2020	2021
India	GDP	26514.7	27029.3	28315.5	26672.9	31763.3
	GGDP	20681.4	20001.6	22369.2	19471.2	23504.6
China	GDP	123104.1	138948.2	142799.4	146876.7	177340.6
	GGDP	89865.99	104211.1	107099.5	111626.2	133005.4
United States	GDP	194773.4	205330.6	213809.8	210604.7	233150.8
	GGDP	142184.5	156051.2	151804.9	164271.6	177194.6
Brazil	GDP	20635.1	19169.5	18732.7	14485.6	16089.8
	GGDP	15476.3	13993.7	13862.1	11443.6	11906.4
Indonesia	GDP	10156.2	10422.7	11191.0	10586.9	11860.9
	GGDP	7515.5	7504.3	8057.5	7516.6	9251.5
Russia	GDP	15742.0	16573.3	16931.1	14883.2	17758.0
	GGDP	11491.6	12595.7	13375.5	11013.5	14028.8

3.2. Climate index analysis

Indicators to measure climate are: Greenhouse gas concentration, temperature, sea level rise, extreme weather, etc. In order to simplify the study of the relationship between GGDP and global climate, we decide to choose temperature and greenhouse gas concentration for the study. Considering that the rise of global temperature is closely related to greenhouse gas emissions [2]. Moreover, temperature data cannot well analyze and study the relationship between GGDP and global climate, so we choose the index of carbon dioxide emission intensity of a country to measure the impact of GGDP on global climate [3]. The following figure shows the scatter diagram of total carbon dioxide emission and GGDP of six countries.

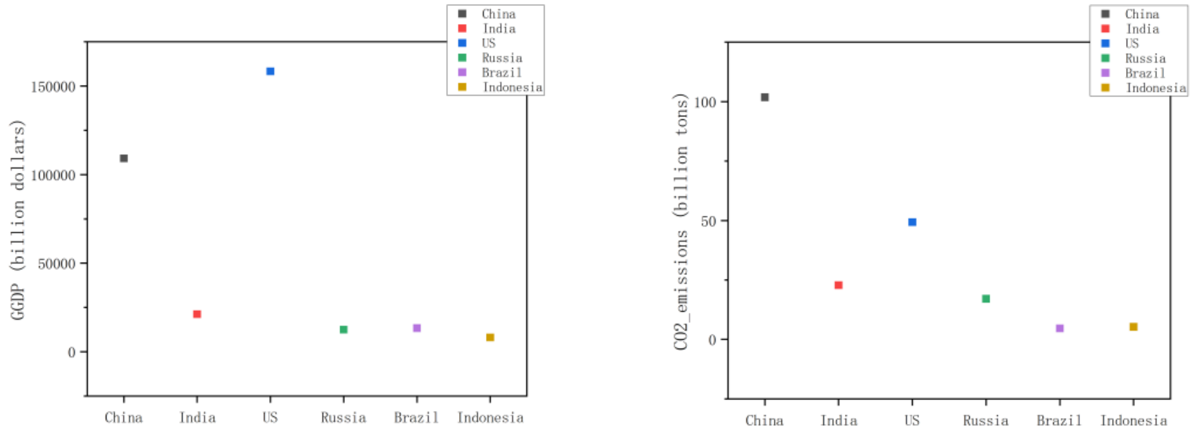


Fig. 1 Scatter plot of GGDP and total CO2 emissions in six countries

Source: Authors' calculation

3.3. Correlation analysis between GGDP and CO_2_emissions

Spearman rank correlation coefficient is a non-parametric measure of rank correlation. Spearman correlation examines the strength of the monotone relationship between two random variables, which is colloquial to what extent they keep pace in the trend of increasing or decreasing, even if they do not maintain the proportionality relationship. Spearman correlation coefficient is calculated using the data sample ranking value.

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \tag{2}$$

d_i represents the difference between the positions of the ith data pair

n is the total number of observed samples

Analysis of correlation between GGDP and Carbon dioxide emissions. Here are the examples of the US and China: (see appendix for data on other countries)

Table 2. U.S. table of correlation coefficients

United States	GGDP/ Billions of dollars	CO2_emissions/ billion tons
GGDP/ billion dollars	1(0.000***)	-0.956(0.011**)
CO2_emissions/ billion tons	-0.956(0.011**)	1(0.000***)

Table 3. China table of correlation coefficients

China	GGDP/ Billions of dollars	CO2_emissions/ billion tons
GGDP/ billion dollars	1(0.000***)	0.821(0.089*)
CO2_emissions/ billion tons	0.821(0.089*)	1(0.000***)

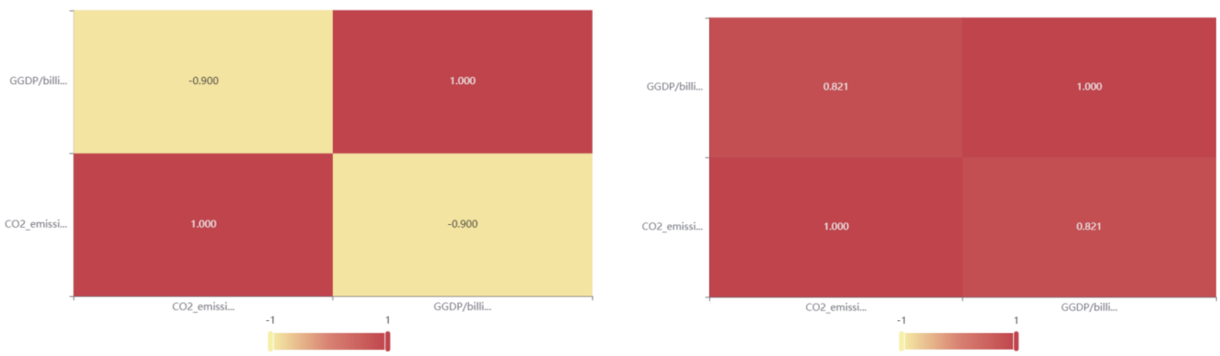


Fig. 2 Correlation coefficient heat map

In summary, we believe that there is a correlation between GGDP and total carbon dioxide emissions.

3.4. TOPSIS Model Based On Entropy Weight Method

We found that carbon dioxide emissions of different countries vary greatly in the collected data, so we need to add corresponding weights for carbon dioxide emissions of different countries [4]. And how should we calculate the corresponding weights? Considering that the basic element of social activities is people, some countries are vast in territory and sparsely populated, such as Australia, while some countries are moderate in area [5]. And the population density is huge, like India. In conclusion, we decide that it is more appropriate to use the total population of each country to calculate the weight, and the method we choose is Topsis model based on entropy weight method.

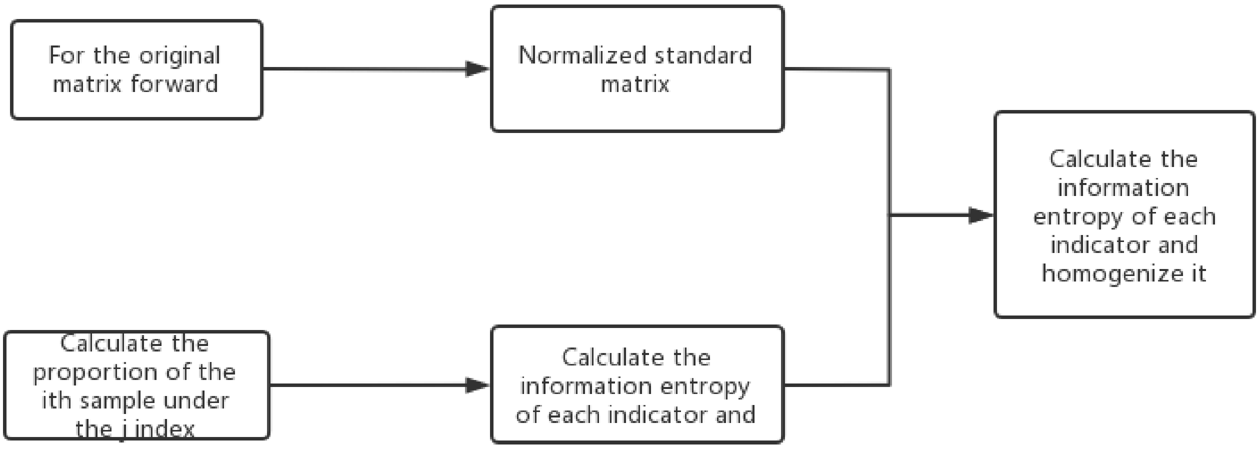


Fig. 3 Flow chart of TOPSIS algorithm based on entropy weight method

Suppose there are $\boldsymbol{n}$ objects to be evaluated, and $\boldsymbol{m}$ evaluation indicators (which have been positively modified) constitute the positive matrix as follows:

$$X=\begin{bmatrix} x_{11} & \cdots & x_{1m} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nm} \end{bmatrix} \tag{3}$$

Then its normalized matrix is denoted as $\boldsymbol{Z}$, and each element of $\boldsymbol{Z}$:

$$z_{ij}=\frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \tag{4}$$

And then get the normalized matrix $\boldsymbol{Z}$:

$$Z=\begin{bmatrix} x_{11} & \cdots & x_{1m} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nm} \end{bmatrix} \tag{5}$$

Calculate the distance between the $\boldsymbol{ith}$ evaluation object and the maximum/minimum value:

$$D_i^{+}=\sqrt{\sum_{j=1}^{m} w_j\left(Z_j^{+}-z_{ij}\right)^2} \tag{6}$$

$$D_i^{-}=\sqrt{\sum_{j=1}^{m} w_j\left(Z_j^{-}-z_{ij}\right)^2} \tag{7}$$

So we get:

Table 4. Weight table of total carbon emissions of each country

Country	Positive ideal solution distance(D+)	Negative ideal solution distance(D-)	Composite score index w_i	Sort
China	0.57640883	0.54648938	0.252388	2
India	0.37624992	0.70418067	0.337998	1
United States	0.48906205	0.421584	0.240083	3
Russia	0.77682277	0.09236119	0.0551068	5
Brazil	0.80078976	0.08257611	0.0484776	6
Indonesia	0.76421461	0.11133942	0.0659467	4

3.5. Linear Regression Model

We assume the linear regression equation between the total carbon emission of each country and GGDP [6]:

$$\mathrm{CI_i} = \mathrm{k_i} * \mathrm{GGDP_i} + \mathrm{b_i} \ \ (\mathrm{i} = 1,2 \ldots 6) \tag{8}$$

Then the weighted total global carbon emissions:

$$\mathrm{CI_{sum}} = \sum_{i=1}^{6} \mathrm{w_i} * \mathrm{CI_i} \tag{9}$$

$$\mathrm{CI_{sum}} = \sum_{i=1}^{6} \mathrm{w_i} * \mathrm{k_i} * \mathrm{GGDP_i} + \sum_{i=1}^{6} \mathrm{w_i} * \mathrm{b_i} \tag{10}$$

We choose to use $\mathrm{CI_{sum}}$ sum to measure the global climate, and carry out regression analysis on the data through Matlab, as shown in the figure below:

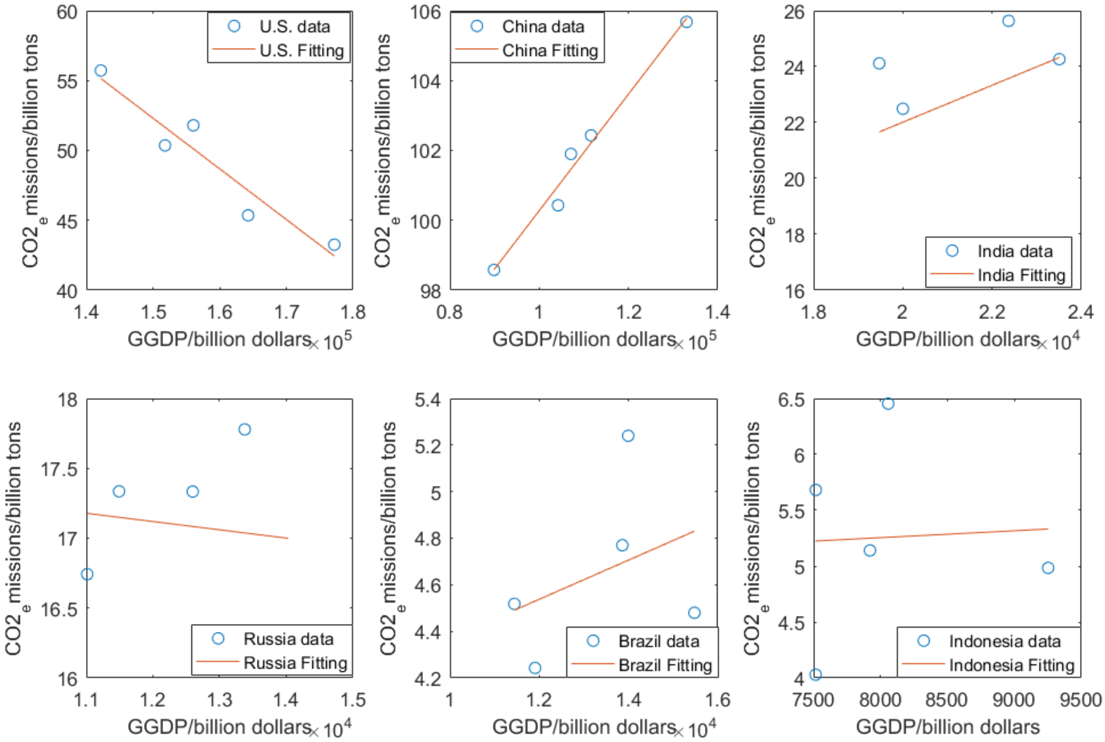


Fig. 4 Linear regression graph

We get the following system of equations:

$$\mathrm{CI_1} = -0.000363 * \mathrm{GGDP_1} + 106.701 \tag{11}$$

$$\mathrm{CI_2} = 0.000167 * \mathrm{GGDP_2} + 83.592 \tag{12}$$

$$\mathrm{CI_3} = 0.000661 * \mathrm{GGDP_3} + 8.781 \tag{13}$$

$$CI_4 = -5.928e-05 * GGDP_4 + 17.831 \quad (14)$$

$$CI_5 = 8.4163e-05 * GGDP_5 + 3.528 \quad (15)$$

$$CI_6 = 6.1739e-05 * GGDP_6 + 4.761 \quad (16)$$

In summary, the linear regression equation using GGDP to measure global climate is obtained:

$$CI_{sum} = 0.000183 * GGDP_{sum} + 51.1504 \quad (17)$$

Using the same calculation method for GDP, we get:

$$CI_{sum} = 0.000215 * GDP_{sum} + 51.1191 \quad (18)$$

3.6. Linear Regression Model Analysis

Take the world economy in 2021 as an example of US $9,610,019 billion, Assuming that the ratio of GGDP to GDP is 10:8, when the global economic aggregate increases by 1%, it can be calculated that: if GDP is used as the main measure of national economic health, The total increase in global carbon emissions is 1656.2 million tons, Using the GGDP as the main measure of national economic health, the added global carbon emissions total is 1410.65 million tons.

According to our calculation, the total carbon emission change obtained by GGDP is closer to the actual data, so the data obtained by GGDP is more suitable for the global climate change. Many natural resources related to the environment, such as water resources and land, are included in the calculation of GGDP. Therefore, in terms of climate, the calculation method of GGDP is undoubtedly superior to GDP, which also shows that it is feasible to establish a baseline for the quality of natural resources in the ecosystem and the savings it provides. The ability of a country to further sustainable development can also be further reflected through the ratio of GGDP and GDP. For global climate, the data of GGDP can also more intuitively reflect the loss of resources and provide reference for future climate change in the world.

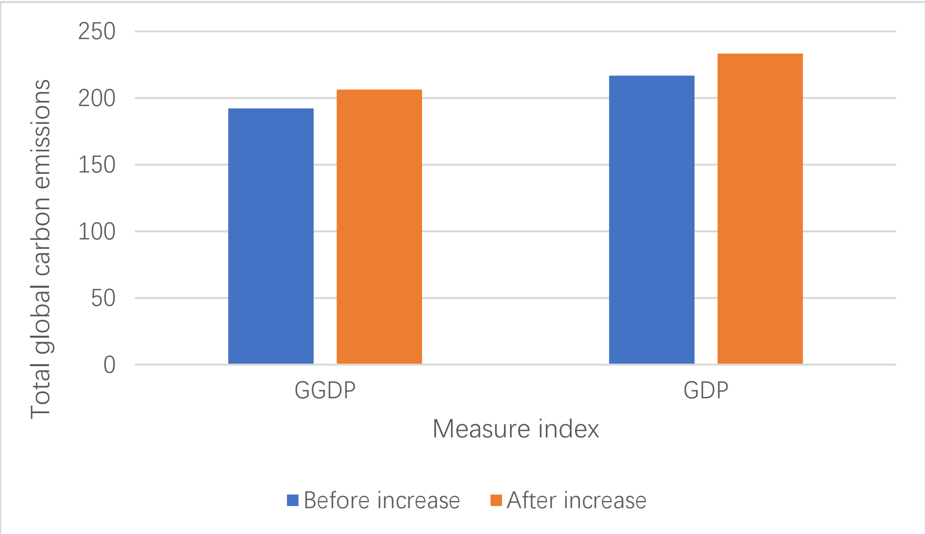


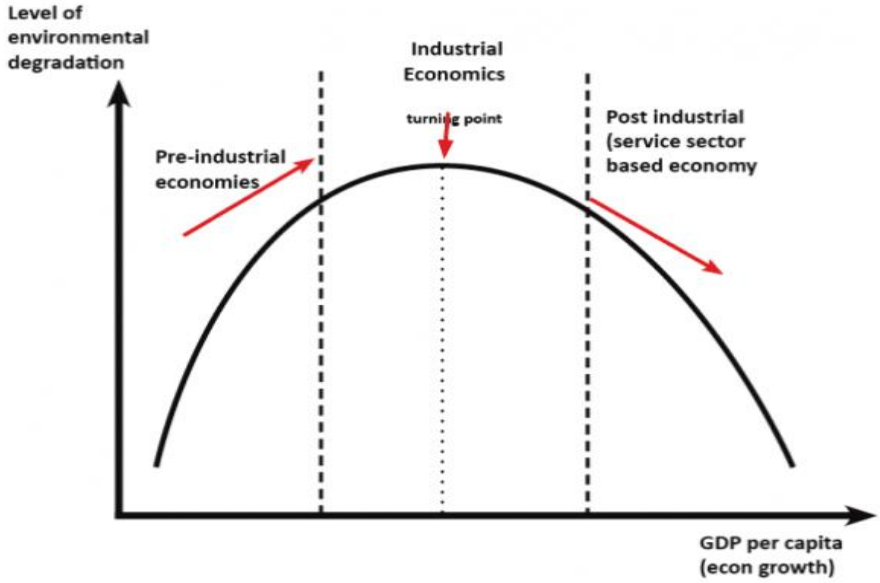
Fig. 5 Total global carbon emissions before and after the global economy increases by 1%

4. Summary and conclusion

4.1. Summary

First of all, combining the above models and conclusions, it can be concluded that the prediction and measurement of the impact of GGDP on the environment and climate are more accurate. Therefore, to some extent, the natural environment can be improved by adjusting the GGDP. However, relative to GDP, GGDP is also uncertain and unfair. Because the global distribution of natural resources is not uniform, the proportion of natural resource consumption and energy utilization is not the same when calculating the GGDP of each country. Therefore, a unified measurement standard cannot be formed globally. As a result, if you choose different criteria, you can get any ranking, so that China, the United States, India and Russia can rank first. Secondly, there are also problems in the measurement of GGDP. When quantifying the data of environmental pollution and natural resource consumption, the accuracy is controversial, and the results may only be estimated or even speculated. This will greatly affect the credibility and accuracy of GGDP.

At the same time, it is unfair for some countries to take GGDP as the main measure of national economic health. For example, the GDP level of a country with developed tourism industry such as Thailand ranks in the top 20 in the world, however, if the GGDP is taken as the measurement standard, the economy in the governance environment cannot dominate the national economy, so the GGDP cannot fully reflect the real economic level of a country. Moreover, the changes of GGDP and GDP are not always consistent. According to Grossman and Kruger, the concept of EKC7 is assumed by using the concept of Simon Kuznets, Explains the relationship between the degree of environmental damage and GDP growth. With the development of science and technology in developed countries such as the United States, the cost of environmental governance and resource consumption will also decrease. While GDP is growing steadily, GGDP will also rise. But for some developing countries such as China and India, economic growth will inevitably cause environmental damage. It will lead to a large gap between GGDP and real GDP. If we take GDP as the standard to measure the national economy, it will also lead to a further widening of the economic gap between developed countries and developing countries. Therefore, such a standard is also unfair.



Source: Panayotou (2003).

Fig. 6 The Environmental Kuznets Curve (EKC)

4.2. Conclusion

GGDP can be used as one of the criteria to measure the health of a country’s economy, because it can really reflect the impact on climate change and, under certain circumstances, the economic level. However, GGDP can never replace GDP as a measure of economic health. GGDP is also derived from GDP through calculation. On the basis of GDP measurement, we can let GGDP assist GDP to guide national economic development and make corresponding adjustments to environmental improvement, so as to make economic development more healthy. However, due to the uncertainty and unfairness of GGDP, GDP as a measure of national economy is still the mainstream and cannot be replaced by GGDP.

References

[1] Calculation of datong's green GDP by seea-2012[C]// based on Chinese Society for Environmental Sciences. Chinese environmental science society 2022 born science and technology theory collection (1) China academic journals (disk system), maybe you'll have a electronic magazine co., ltd., 20 22:6. Doi: C-nkihy. 2022. 016176.

[2] Huang L, Hu X W. Estimation and evolution trend of Qinghai green GDP based on SEEA[J]. Environmental Ecology, 2002, 4(06): 35-40.

[3] Wang Yuchen, Xu Gangan. Research on the development level of green GDP in Northeast China[J]. Heilongjiang Science, 2021, 12(24): 7-12.

[4] Research on measurement theory and model of green GDP from the perspective of ecological civilization[J]. Coastal Enterprises and Technology, 2021, No.203(04): 3-10.

[5] Li Z. Vulnerability assessment and obstacle degree analysis of Marine economic system in Shandong Province based on entropy weight TOPSIS model[J]. Ocean development and management, 2023, 40 (01) : 94-103. The DOI: 10.20016 / j.carol carroll nki hykfygl. 20230202. 007.

[6] WANG J J. Calibration model of air quality monitoring data based on Partial least squares regression model[J]. Science and technology, 2021(10): 31 to 37. DOI: 10.13774 / j.carol carroll nki KJTB. 2021. 10. 006.