Study On the Establishment and Potential Impact of GGDP Accounting System

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Abstract. GDP is one of the best known and most commonly used indicators to measure the health of a country's economy, but the rapid growth of GDP does not adequately take into account resource and environmental factors. In order to choose an appropriate method to construct the GGDP, the article considers various indicators affecting the environment from multiple perspectives, and uses hierarchical analysis and global entropy weighting to calculate the importance of each indicator, assigning weights to each indicator, and through weighted summation can calculate the GGDP of each country, and compares the GDP and GGDP of five countries, followed by using regression models to calculate the two level The regression model was then used to calculate the contribution of the two first-order indicators to GGDP and GDP, and it was concluded that the use of GGDP accounting can reduce the cost of environmental downgrading and increase the benefits of environmental improvement. Finally, the benefits and drawbacks of using GGDP are summarized.

Keywords: GGDP, Grey correlation analysis, Linear regression models.

1. Introduction

Gross National Product (GDP), the core indicator of the current System of National Accounts (SNA), is the market value of all final goods and services produced in the economy of a country or region during a certain period of time (a quarter or a year) and is one of the most well-known and commonly used indicators to measure the health of a country's economy. It can reflect not only the economic performance of a country, but also the national strength and wealth of a country. However, GDP also has many shortcomings: first, it cannot fully reflect all indicators of economic aggregates; second, it cannot fully reflect people's welfare and equity status, mainly other welfare and equity indicators other than income; third, GDP only considers the maximization of gains for the current generation, not the long-term maximization (intergenerational equilibrium), is sustainable development issues.

It is based on the current statistical GDP and deducts the cost of economic losses caused by environmental pollution, degradation of natural resources, low levels of education, uncontrolled population size and mismanagement, in order to arrive at the real total national wealth. The higher the proportion of GGDP to GDP, the higher the positive effect of national economic growth and the lower the negative effect, and vice versa.

The rapid growth of GDP has not taken into account the resources and climate environment, and many countries have increased their GDP while destroying biodiversity and ecosystems with impunity, which is undoubtedly detrimental to the health of the planet's environment.

The creation of a "green" GDP (GGDP) is a result of the desire to ensure economic growth without damaging the environment or saving energy, and GDP cannot determine whether a country's income level is sustainable. The introduction of GGDP is a good way to find the right combination between economic development and climate mitigation to achieve sustainable development. With the implementation of sustainable development strategy, the coordination between resource, environment and economy is on the agenda.

GGDP is a prerequisite and basis for the formation of a sustainable development mechanism, and GGDP has a strong early warning function [1] .We believe that the main factors affecting the growth of GGDP should be selected according to the specific situation of each region, and the correlation between the growth rate of the main influencing factors and the growth rate of GGDP in the region

should be evaluated to find out the correlation degree of each influencing factor and the reasonable ranking of GGDP [2] .Then using a regression model, find the regression function of the primary indicators on GDP and GGDP, know the magnitude of the contribution of the indicators to GDP and GGDP by looking at the coefficients of the indicators, derive the impact of adopting GGDP to account for the level of economic health of the country by comparing them, make a simple classification of countries, select one representative country from each of the five continents, compare the five countries adopting GGDP with GDP summarize the benefits and drawbacks of adopting GGDP.

2. Data source

The research period of this paper is 2010-2019, the selected data from the International Statistical Yearbook, China Statistical Yearbook and the World Bank.

3. Building a GGDP

3.1 Establishment of GGDP model

In 1993, the United Nations Bureau of Statistics (UNBS) and the World Bank collaborated to develop a systematic and integrated environmental and economic accounting system that incorporated the costs of resources and pollution into the national economic accounting system, thus introducing the concept of GGDP. In the past studies, different scholars have tried to elaborate on green development in terms of sustainable development, ecological economy, circular economy, low carbon economy and green economy [3, 4] .Different definitions of GGDP will lead to changes in its accounting ideas and calculation formulas, which will also bring about far different accounting results [5] .Considering the availability of data, the GGDP constructed in the article is obtained on the basis of GDP indicators, after deducting the cost of environmental degradation and adding the benefits of environmental improvement [6, 7, 8]. The specific GGDP formula is as follows.

$$\mathrm{GGDP} = \mathrm{GDP} - \mathrm{F}_1 + \mathrm{F}_2 \tag{1}$$

3.1.1 Cost of environmental downgrading

In terms of the economic cost of the environment, we have combined the most representative indicators from the five countries, namely arable land area (U_1), CO2 emissions (U_2) and fertilizer consumption (U_3). The specific formulae are as follows:

$$\mathrm{F}_1 = \mathrm{U}_1 + \mathrm{U}_2 + \mathrm{U}_3 \tag{2}$$

3.1.2 Environmental improvement benefits

Environmental improvement benefits are mainly economic benefits due to gradual environmental improvements. the more positive indicators the better for the environment. These include mainly changes in forest area due to plantation (U_4), renewable freshwater resources per capita (U_5) and changes in forest cover (U_6). The specific equations are as follows:

$$\mathrm{F}_2 = \mathrm{U}_4 + \mathrm{U}_5 + \mathrm{U}_6 \tag{3}$$

3.2 Determination of weights

Then, the model is improved to assign different weights α1 and α2 to the direct and indirect factors. The model improvement formula is as follows:

$$\mathrm{GGDP} = \mathrm{GDP} - \alpha_1 \times \mathrm{F}_1 + \alpha_2 \times \mathrm{F}_2 \tag{4}$$

As the data for the five countries are to be analysed the article uses hierarchical analysis and global entropy weighting for α_1 and α_2, the different indicator values for GGDP are weighted differently. As shown in Table 1:

Table 1: Weightings for the six indicators

Primary indicators	secondary indicators	Unit	Directionality	AHP	EWM
F_1	U_1	Million hectares	-	0.1554	0.1665
	U_2	Million tons	-	0.0979	0.1670
	U_3	Kilograms per hectare of arable land	-	0.2467	0.1671
F_2	U_4	million square kilometers	+	0.0747	0.1664
	U_5	Cubic meters	+	0.2371	0.1665
	U_6	%	+	0.1882	0.1665

4. Grey correlation analysis

Gray correlation analysis is based on the gray correlation degree, which analyzes the degree of association between the factors of the system by comparing the similarity of the data sequence geometry and curve geometry. It proceeds as follows.

Step 1 : Determine the characteristic series and the parent series.

The comparison sequence is

$$[X_1' \quad X_2' \quad \cdots \quad X_n'] = \begin{bmatrix} x_1'(1) & x_2'(1) & \cdots & x_n'(1) \\ x_1'(2) & x_2'(2) & \cdots & x_n'(2) \\ \cdots & \cdots & \cdots & \cdots \\ x_1'(m) & x_2'(m) & \cdots & x_n'(m) \end{bmatrix} \tag{5}$$

The parent series (evaluation criteria) are.

$$X_0' = (x_0'(1), x_0'(2), \cdots, x_0'(m))^T \tag{6}$$

Step 2: The index data are normalized. In order to reflect the actual situation and avoid the influence of different units of indicators and the difference between the orders of magnitude of their values, it is necessary to standardize the indicators.

Step 3: Calculate the correlation coefficients The correlation coefficients of each comparison series and the corresponding elements of the reference series are calculated separately by the following formula.

$$\gamma\big(x_0(k), x_i(k)\big) = \frac{\Delta min + \rho \Delta max}{\Delta_{ik} + \rho \Delta max} \tag{7}$$

$$\Delta min = \min_i \min_k |x_0(k) - x_i(k)| \tag{8}$$

$$\Delta max = \max_i \max_k |x_0(k) - x_i(k)| \tag{9}$$

$$\Delta_{ik} = |x_0(k) - x_i(k)| \tag{10}$$

The smaller the discrimination coefficient, the greater the difference between the correlation coefficients and the stronger the differentiation ability, which is usually taken as 0.5.

Step 4: Calculate the correlation degree. The weighted average of the correlation coefficients between each index and the corresponding element of the reference sequence is calculated separately to reflect the correlation between each manipulated object and the reference sequence, and is called the correlation degree, denoted as:

$$r_{0i} = \frac{1}{m}\sum_{k=1}^{m} W_K \varsigma_i(k) \tag{11}$$

Step 5: Analyze the calculation results. According to the magnitude of the gray weighted correlation, the correlation degree of each evaluation object is established. The larger the correlation degree is, the more important the evaluation object is to the evaluation criteria. The larger the number, the stronger the correlation is.

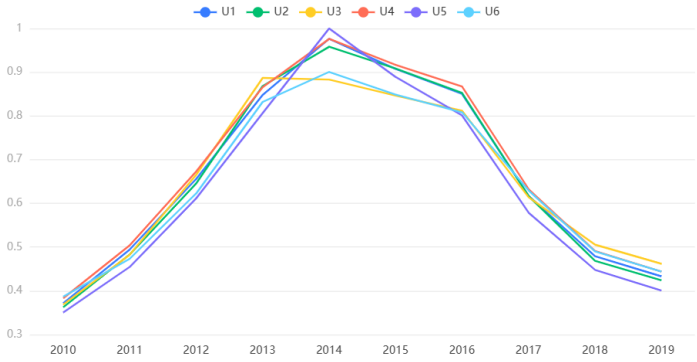

Figure 1: Correlation coefficients of different indicators with GGDP

As can be seen from Figure 1, grey correlation analysis was carried out on six evaluation items (U_1, U_2, U_3, U_4, U_5 , U_6) and GGDP, using GGDP as the "reference value" (parent series) to study the correlation between the six evaluation items and it. When grey correlation analysis was used, the discriminant coefficient was 0.5, and the correlation coefficient value was calculated by combining the correlation coefficient formula, and then the correlation coefficient value of the evaluation judgement was calculated based on the correlation coefficient value. The correlation coefficient indicates the value of the degree of correlation between this sub-series U_1, U_2, U_3, U_4, U_5 , U_6 pairs and the corresponding dimension of the parent series (the larger the number, the stronger the degree of correlation).

PS: The discriminant coefficient $\rho \in (0, \infty)$, the smaller the(ρ, the greater the discriminant power, generally the value of ρ ranges from (0, 1), the specific value can be determined according to the situation. The best discriminatory power is achieved when $\rho \leq 0.5463$, generally taken as $\rho = 0.5$.

Table 2: Relevance and ranking of different indicators with GGDP.

Relevance results		
Evaluation items	Relevance	Ranking
U_4	0.675	1
U_1	0.663	2
U_2	0.659	3
U_3	0.653	4
U_6	0.644	5
U_5	0.634	6

As can be seen from Table 2, U_4 (changes in forest area due to plantation) has the highest rating and the highest correlation coefficient with GGDP, followed by U_1 (arable land area) with a correlation of 0.663, U_2 (CO2 emissions) and U_3 (fertilizer U_2 (CO2 emissions) follow with

correlations of 0.659 and 0.653, and finally U_6 (changes in forest cover) and U_5 (renewable freshwater resources per capita), which have a smaller impact on GGDP.

5. Linear regression models

Linear regression is a statistical analysis method that uses regression analysis in mathematical statistics to determine the quantitative relationship between two or more interdependent variables and is widely used. The expression takes the form $y = w'x + e$, with e being the error following a normal distribution with mean 0. A regression analysis in which only one independent variable and one dependent variable are included and the relationship between the two can be approximated by a straight line is called a linear regression analysis. If two or more independent variables are included in the regression analysis and the relationship between the dependent and independent variables is linear, the regression analysis is called multiple linear regression analysis.

In general, linear regression can be found by least squares or gradient descent to find its equation, which can be calculated as a straight line for $y = bx + a$. Taking the least squares method as an example in general, there is often more than one factor affecting y. Assuming that there are $x_1, x_2, \cdots, x_k, k$ factors, the following linear equation can usually be considered.

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + \varepsilon \tag{12}$$

n sets of observations $(x_{t_1}, x_{t_2}, \cdots, x_{t_k}), t = 1,2, \cdots, n(n > k + 1)$ are obtained by making a number of independent observations of y and $x_1, x_2, \cdots, x_k$ simultaneously, which satisfy the relation

$$y = \beta_0 + \beta_1 x_{t_1} + \beta_2 x_{t_2} + \cdots + \beta_k x_{t_k} + \varepsilon_t \tag{13}$$

where $\varepsilon_1 \ldots \varepsilon_n$ are mutually uncorrelated are random variables that are identically distributed with ε. To express the above equation in matrix terms, let

$$Y = X\beta + \varepsilon \tag{14}$$

Using least squares to obtain a solution for β

$$\hat{\beta} = (X^T X)^{-1} X^T Y \tag{15}$$

The article conducted a linear regression analysis of data for five countries for 2017-2019, yielding the results, as shown in Table 3:

Table 3: Linear regression analysis results

Linear regression analysis results(n=15)									
	Non-standardised coefficients		Standardisation factor	t	P	VIF	R^2	Adjustment of R^2	F
	B	Standard error	Beta						
Constants	1.068	0.097	-	11.016	0.000***	-	0.686	0.634	F=13.126 P=0.001***
F1	-0.316	0.062	-0.892	-5.117	0.000***	1.161			
F2	0.106	0.049	0.374	2.145	0.053*	1.161			
Dependent variable: GGDP									
PS: ***、**、*represent 1%, 5%, 10% level of significance respectively									

Graph description:

The table above shows the results of the analysis of this model, including the standardised coefficients, t-values, VIF values, R^2, adjusted R^2, used to test the model and to analyse the model's equations.

1. The linear regression model requires that the overall regression coefficient is not zero. there is a regression relationship between the variables. The model is tested against the F-test results.
2. R^2 represents the degree of fit of the curve regression, the closer to 1 the better the effect.
3. The VIF value represents the severity of multicollinearity and is used to check whether the model presents cointegration. there is a highly correlated relationship between the explanatory variables (VIF should be less than 10 or 5, strictly 5) If the VIF appears inf, it means that the VIF value is infinite and it is recommended to check for cointegration or use ridge regression.
4. B is the coefficient for the case with constants.
5. Standard error = B/t value.
6. The standardised coefficient is the coefficient obtained by normalising the data.
7. VIF is the covariance.
8. F(df1,df2) is df1 equals the number of independent variables; df2 equals the sample size - (number of independent variables + 1).
9. The F-test is to determine whether there is a significant linear relationship and R^2 is to determine how well the regression line fits this linear model. In linear regression the main concern is whether the F-test passes, while in some cases there is no necessary relationship between the size of R^2 and the degree of model interpretation.

The analysis of the results of the F-test yields a significance p-value of 0.001***, which presents significance at the level and rejects the original hypothesis of a regression coefficient of zero, so the model basically meets the requirements.

For the performance of variable co-linearity, VIF is all less than 10, so the model has no problem of multiple co-linearity and the model is well constructed.

the regression model equation for GGDP can be obtained as follows:

$$y = 1.068 - 0.316 \times F_1 + 0.106 \times F_2 \tag{16}$$

Similarly, the regression model equation for GDP can be obtained as follows:

$$y = 1.05 - 0.164 \times F_1 - 0.049 \times F_2 \tag{17}$$

By comparing the model equations for GDP and GGDP, we know that to increase GGDP, we need to focus more on reducing F_1 (Cost of environmental downgrading) and increasing F_2 (Environmental improvement benefits), while to increase GDP, we need to reduce both F_1 and F_2.

6. Whether GGDP can replace GDP

6.1 Comparison of GGDP and GDP

The article uses a linear weighting method to calculate GGDP for the five countries for 2010-2019 and compares it to GDP, using a line graph to visualise the trend in both, as shown in Figure 2 below:

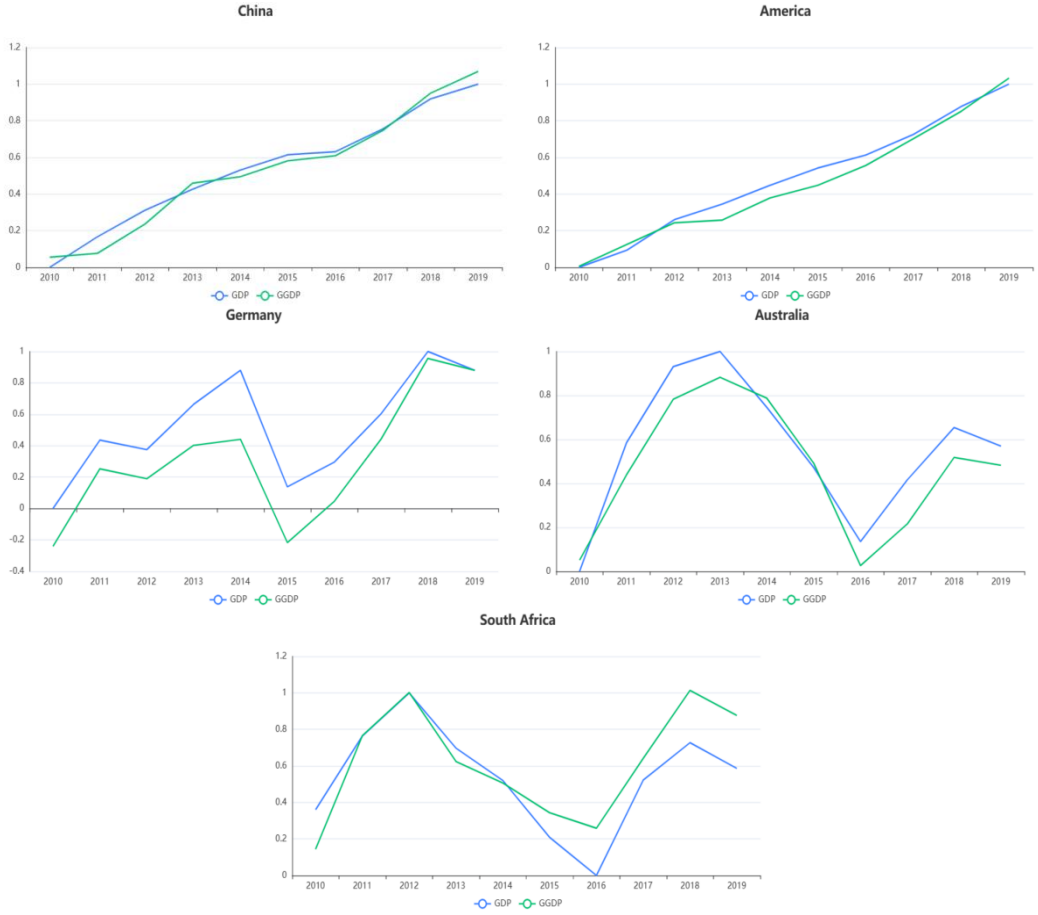

Figure 2: Trends of GGDP and GDP in five countries, 2010-2019

As can be seen from the above results, the results obtained from using GDP and GGDP as the main indicators of a country's economic health vary, but not significantly, and the overall trend is consistent.

It is calculated that, under the influence of environmental downgrading costs and environmental improvement benefits, the proportion of GGDP to traditional GDP in China and the United States is in a state of continuous growth; in Germany, after taking into account these two factors, GGDP is significantly lower than GDP, indicating that the relevant policies launched in Germany in the future should take more environmental aspects into account; in Australia, GGDP has been lower than GDP in recent years, and it is also necessary to consider the coordinated development of the ecological economy; South Africa is significantly less volatile in the early part of the period than in the late part of the period with flat differences in the early part and significant differences in the late part, characterised by higher levels of green development in the late part of the period.

6.2 Benefits of adopting GGDP for climate change mitigation

The implementation of the GGDP has promoted the active participation of the general public in practical actions to reduce resource depletion and environmental pollution and has gathered tremendous power to jointly promote the sustainable development of the world's ecology and environment, as well as to promote universal action to mitigate climate pollution.

In addition, we have put a price on the environment and imposed severe penalties on those who discharge pollutants that cause serious damage to the environment. The general public has increased awareness of green lifestyles such as using clean and renewable resources, using alternative resources, conserving freshwater resources, reducing vehicle emissions, and traveling with low carbon emissions.

Furthermore, enterprises have attached importance to the construction of green scientific and technological talents, increased green investment, focused on the development and adjustment of

green industries, and carried out a series of green actions such as tree planting and land reclamation. Industries have focused on energy-efficient buildings, renewable energy, sustainable transportation, sustainable agriculture, fresh water and ecological infrastructure, which have improved the energy mix to a certain extent, increased CO2 pooling, curbed the global warming trend and slowed down climate change.

6.3 The potential downside of adopting GGDP for the economy

Environmental protection requires the participation of all people, so if the implementation of the GGDP is hindered by the low awareness of citizens, it may lead to a certain degree of economic investment.

In addition, the implementation of GGDP in each country usually involves a series of environmental policies, economic policies, etc., and the implementation of these policies is usually assigned to specific departments, which may result in the dispersion of economic investment in each department and the failure to implement economic policies.

In addition, the implementation of GGDP will cause a large part of human, material and financial resources investment, so in the process of implementation of the slightest carelessness, it will cause bad results. In addition, many countries do not understand the concept and meaning of the newly proposed GGDP, so it is very easy to find the direction of implementation and how to implement a series of problems, which is not conducive to the development of the national economy and can't play a real role in promoting their economies but may cause obstacles.

7. Conclusion

Gross national product (GDP) is one of the best-known and most commonly used indicators of a country's economic health, but rapid GDP growth without adequate consideration of resource and environmental factors is detrimental to the health of the planet's environment and has limitations in terms of social progress and economic performance. A model of economic development that relies too heavily on natural resource consumption can lead to a widening gap between total GDP and GGDP, affecting the level of sustainable development [9]. Therefore, creating GGDP is an inevitable choice to promote green economic development. Promoting the transition from a GDP accounting system to a GGDP accounting system is an effective response to the current neglect of the ecological environment in economic development. The government introduces relevant policies and supervises the implementation of enterprises in production, and citizens take the concept of green development to heart to promote green development with GGDP and achieve a green path to meet the people's good life [10].

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