GGDP VS GDP, Who Win?

Mengyao Yang
Anhui University of Finance and economics, Bengbu 233030, China.

Summary: GGDP is the core indicator in the integrated environmental-economic accounting system, which incorporates resource and environmental factors based on the current GDP... Specifically, GGDP deducts from GDP the cost of economic losses due to environmental pollution, natural resource degradation, low education, uncontrolled population size, and mismanagement. This indicator essentially represents the net positive effect of national economic growth. To promote the spread of GGDP and convince countries around the world to change the way they evaluate and compare their economies and promote policies and programs that are more beneficial to the health of the planet's environment, we need to clarify the pros and cons of GGDP and explain the beneficial effects and potential risks to economic life through mathematical models.
Keywords: Linear Regression; GGDP; Pearson Correlation; Ridge Regression; GM(1,1)

1. Introduction

The traditional GDP, as a measure of the value of final goods and services produced by a country in a given period, is often calculated in a way that is beneficial for the production of the moment, but not for the conservation of resources,. Therefore, we consider that we should choose another indicator that can measure the economic situation of a country - GGDP.

2. Basic Assumption

- Assuming a change in the way economies are evaluated and compared, governments would change their behavior.
- Assuming that such changes could trigger a global movement of individual countries working for climate.
- Assuming no major disasters or related policy changes in the year of data collection.

3. Models

3.1 Select a Reasonable GDDP Calculation Formula

GGDP is the core indicator in the comprehensive environmental economic accounting system, which is the inclusion of resources and environment into statistical indicators, deducting the cost of economic losses caused by environmental pollution, resource abuse and natural disasters, and truly reflecting the total growth of social and economic wealth. The implementation of green GDP is to focus on economic development while also paying attention to the protection of the natural environment, making up for the GDP calculation method that focuses solely on economic growth[2].

3.2 The choice of GGDP Formula

There are many proposed formulas for calculating GGDP, but it is not difficult to find the commonality: it is based on the existing SNA system to calculate the GDP based on the downgrading and loss of natural resources and the environment caused by the acquisition of GDP.Here our chosen formula for calculating GDP[3] is：

$$\mathrm{GGDP} = \mathrm{GDP} - \mathrm{DFA} - \mathrm{NRD} - \mathrm{ERD}\#(1)$$

DFA=Depreciation of fixed assets

NRD=Natural resource depletion

ERD=Environmental resource depletion

3.3 Analysis and Solving of Question Two

3.3.1 Model Preparation

(1) Data Processing

First we compute the global GGDP as in question I。The annual extraction of GDP (dollars) 、freshwater resources (m^3)、The consumption of petroleum fuels (kilotons) and the country's investment cost in environmental degradation for the period 2000-2014 were collected from various countries worldwide.

(2) Assumption

It assumed that some of the data about the countries that are not collected is small enough relative to the overall data, which will not affect the subsequent calculation.It assumed that there have not been major natural disasters or contaminant spills during 2000-2014.

3.3.2 Model Establishment

Step1: correlation analysis

The main measures of bivariate coefficient measurement are chi square class measurement, Spearman correlation coefficient, Pearson correlation coefficient, etc. Because the data for GGPS and impacts on climate change are scaled data, the Pearson correlation coefficient is used to judge when testing the correlation between the two.The formula is：

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}} \#(2)$$

Pearson's simple correlation coefficient test statistic is：

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} \#(3)$$

$\boldsymbol{T-statistics}$ follows a t-distribution with n-2 degrees of freedom.

Step2: regression analysis

Univariate regression analysis is a regression analysis method to study the relationship between multiple variables, determining the possible form of the number between variables, and expressing it in mathematical models as follows：

$Y = \beta_0 + \beta_1 X \quad + \varepsilon, \beta_0$ is the intercept term，$\beta_1$is the partial regression coefficient, and ε is the residual term.

Step3:Ordinary least squares for parameter estimation

A known set of sample observations {（X，Y）: i=1，2，., n}， Ordinary least squares requires the sample regression function to fit this set of values as well as possible, i.e., the "" overall error "" on the regression line of the sample to the true observation y is as small as possible.

$$Q = \sum_{i=1}^{n} e_i^2 = \sum_{i=1}^{n} \left(Y_i - \widehat{Y}_i\right)^2 = \sum_{i=1}^{n} \left(Y_i - \left(\widehat{\beta}_0 + \widehat{\beta}_1 X_i\right)\right)^2 \#(4)$$

is the smallest,that is,$\widehat{\beta}_0$、$\widehat{\beta}_1$. is chosen-under the-given sample-observations, which minimizes the sum of squares of the difference between$Y_i$and$\widehat{Y}_i$.

According to the operations of calculus, Q reaches its minimum when the first-order partial derivative of Qversus$\widehat{\beta}_0, \widehat{\beta}_1$is 0. as follows:

$$\begin{cases} \dfrac{\partial Q}{\partial \widehat{\beta}_0} = 0 \\ \dfrac{\partial Q}{\partial \widehat{\beta}_1} = 0 \end{cases} \#(5)$$

The following equations can be deduced for estimating $\widehat{\beta}_0, \widehat{\beta}_1$:

$$\begin{cases} \sum\left(Y_i - \widehat{\beta}_0 - \widehat{\beta}_1 X_i\right) = 0 \\ \sum\left(Y_i - \widehat{\beta}_0 - \widehat{\beta}_1 X_i\right) X_i = 0 \end{cases} \#(6)$$

3.3.3 Results

First, we first conduct a correlation analysis between GGDP and carbon emissions, which follows:

As can be seen in the table, the Pearson correlation of carbon emissions with GGDP is 0.987, and the Pearson correlation with GDP is 0.995, both of which are obviously relevant and can be fitted by linear regression, and the progressive estimates of carbon emissions under different variables in the future.

From the table, we see that P>Itl =0.000， less than 0.01, in the model test results for carbon emission and GGDP, and P>Itl =0.000，less than 0.01, in the model test results for carbon emission and GDP, indicating that both linear fitting models are significant.

$$\mathrm{y} = 2.88^{*}10^{-7} x_{GG} + 1.62 * 10^{8} \#(7)$$

$$y = 2.5^{*}10^{-7} \mathrm{x}_{\mathrm{G}} + 1.45^{*}10^{8} \#(8)$$

(x_{GG} is GGDP variable , x_G is GDP variable)

Then we calculate the difference in carbon emissions when 0.2-fold increases in GGDP and GDP, respectivel. We then calculate the difference in carbon emissions when the means of GGDP and GDP are elevated 0.2-fold, respectively.

$$\mathrm{y_s} = \left(1.2 * 2.88^{*}10^{-7} * 315438727.7 + 1.62 * 10^{8}\right) - \left(1.2 * 2.50^{*}10^{-7} * 242890220 + 1.45^{*}10^{8}\right) \#(9)$$
$$= 72548507.68 \text{ Mt} \#$$

3.3.4 Analysis of the Result

The results show that carbon emissions are lower when GGDP policies are implemented than when GDP is implemented, if both GGDP and GDP means rise by 0.2-fold. Because the case for climate change is dominated by carbon emissions, the results can illustrate how replacing GDP by GGP can greatly mitigate the climate shift.

3.4 Analysis and Solving of Question Three

3.4.1 Model Preparation

For this one problematic scenario, we need to build models to verify that the switch is worthwhile on a global scale, and comparing the potential advantages of climate mitigation impacts with the potential disadvantages of the effort required to replace the status quo is the main purpose of applying mathematical models.

3.4.2 Indicators Determination

Here we select indicators from two perspectives: economic and environmental, we choose global population (GP), Central Government Debt(CGD), and World average unemployment rate (WAUR) as representative indicators. We choose global energy usage (GEU), global temperature (TEM), nitric oxide emissions (NOE), and other greenhouse gas emissions (GEU) as representative indicators. global carbon dioxide emissions (GCE).

3.4.3 Model Building

(1) Pearson Correlation Coefficient

Step1:Determining correlations

- We first applied Kendall's consistency coefficient to determine the relationship between our selected variables.

Step2：Calculate Pearson Correlation

- We first tested the existence of a statistically significant relationship between two indicators, judging whether the value presents a significant p ($p<0.05$).

(2) Ridge Regression

Step1：K values were determined by ridge trace plots.

The K value is chosen based on the principle that the standardized regression coefficient of each independent variable is the minimum value when it tends to be stable. In general, the smaller the value of K, the smaller the deviation.

$$\widehat{\beta}(\mathrm{K}) = \left(X'X + \mathrm{K}I\right)^{-1} X'y \#(11)$$

We show the situation when the standardized coefficients of each independent variable of this model tend to stabilize by visual formalism, as shown below, with K = 0.145 determined according to the variance expansion factor method.

Step2:Analysis of the fit

According to the final results, our formula for the GGDP model is as follows.

$$GGDP =- 905085694850221.2 + 767368.16 \times \mathrm{GCDE} + 6997.674 \times \mathrm{GP} - 618956222245.151 \times \mathrm{CGD} + 2.319 \times \mathrm{GEU} - 10078078933465.648 \times TEM - 17307796493748 \times WAUR - 16626233.13 \times NOE \#(12)$$

Table 6 Results of ridge regression analysis

K=0.145	*Non-standardized coefficient*		*Standardization coefficient*	*t*	*P*	*R²*	*Adjusted R²*	*F*
	B	Standard error	Beta					
Constant	-9.05086E+14	1.77481E+14	-	-5.1	0.000	0.98	0.968	84.193
GCDE	767368.16	95267.388	0.189	8.055	0.000			
GP	6997.674	677.796	0.24	10.324	0.000			
CGD	-6.18956E+11	8.2597E+11	-0.028	-0.749	0.468			
GEU	2.319	0.194	0.246	11.974	0.000			
TEM	-1.00781E+13	6.72252E+13	-0.007	-0.15	0.883			
WAUR	-1.73078E+13	1.20156E+13	-0.067	-1.44	0.175			
NOE	-16626233.13	1498749.794	0.22	11.093	0.000			

(3) Grey relational analysis

Step1:The analysis series is first determined

We set the parent series Y as GGDP for analysis, and the discriminant coefficient is taken as 0.50 when using gray correlation analysis. subseries X_i is the data series composed of individual indicators.

$$Y = Y(k)|k = 1,2 \ldots \mathrm{n}$$

$$X_i = X_i(k)|k = 1,2 \ldots n, i = 1,2 \ldots m$$

Step2: Solving for gray correlation values

The data are dimensionless, and the values in different units are homogenized and initialized.

Averaging formula：$x_i(k) = \frac{x_i(k)}{x_i(1)}, k = 1,2 \ldots n; i = 0,1,2 \ldots \mathrm{m}$

Initialization formula：$x_i(k) = \frac{x_i(k)}{\bar{x}_i}, k = 1,2 \ldots n; i = 0,1,2 \ldots m$

$$\xi_i(k) = \frac{\min_i \min_k |y(k) - x_i(k)| + \rho \max_i \max_k |y(k) - x_i(k)|}{|y(k) - x_i(k)| + \rho \max_i \max_k |y(k) - x_i(k)|} \#(13)$$

Step3：Analyze the degree of correlation of each indicator

The correlation coefficient is weighted by the above correlation coefficient results, and the correlation degree value is used to rank the 7 evaluation objects; the correlation degree value is between 0 and 1, and the larger the value is, the stronger the correlation between it and GGDP, which means the higher the evaluation. From the above table, it can be seen that GCDE has the highest evaluation with a correlation of 0.684, followed by GEU with a correlation of 0.678 for the 7 indicators.

Table 8 Relevance results

Item	*Correlation*	*Ranking*
GCDE	0.684	1
GEU	0.678	2

TEM	0.651	3
NOE	0.627	4
GP	0.625	5
WAUR	0.549	6
CGD	0.529	7

(4) Analysis of results

Meanwhile, combining the results of the ridge regression analysis equation and gray correlation analysis we know that GCDE, GP, CGD, GEU, and GGDP are a completely positive relationship, and TEM, WAUR, NOE, and GGDP are opposite relationships, among which GCDE has the highest degree of influence and CGD has the largest degree of influence.

References

[1] Callan, T. (2023). Gross Domestic Product: An Economy's All. International Monetary Fund,

Economics Concepts Explained.

[2] Qu GP. China's Environment and Development [M]. Beijing: China Environmental Science Press, 1992.

[3] Yang MJ. The revision of GDP [J]. Statistics Education, 2001(05):7-8.

[4] Tong C. Theoretical and Methodological Reconstruction of GGDP Accounting[D]. Shanxi University of Finance and Economics, 2020.