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GGDP Accounting Model and Advantages

Hong-ding Wang and Qi-zhi Wang

Abstract. With the development of human economy the problem of environmental protection has become increasingly serious, which is related to the sustainability of development. Although GDP can effectively reflect the development level of a country, it can not measure the utilization of natural resources. Therefore, it is necessary to formulate a new calculation standard to combine economic development with environmental protection, and the model of GGDP was born. First of all, we choose a model developed according to The System Of National Accounts (SNA) and including four dimensions from the existing GGDP calculation models. There are 8 first-class indicators in the four dimensions, which are calculated by 19 factors. After the values of the four dimensions are calculated separately, we can get the GGDP values of a series of countries. Secondly, we choose the GGDP of 5 countries from 2000 to 2014 as independent variables, and the global carbon dioxide emissions as dependent variables, and establish a stepwise regression model. We find that the GGDP of China and Canada is positively correlated with global carbon dioxide emissions, while that of other countries is negatively correlated. Then, through the intuitive comparison between GGDP and GDP in countries, combined with the correlation degree between in stepwise regression model, we get the feasibility of replacing GDP with GGDP. Through systematic cluster analysis, the GGDP of 29 countries is divided into three categories, and the rank is different from the world ranking of GDP, can measure the advantage of environmental protection. By analyzing the calculation method of GGDP and the model, we can find the disadvantage of GGDP. After that, we select Japan to further analyze the results of using GGDP instead of GDP. Among the 29 countries, Japan ranks first in GGDP. Through the GGDP calculation, except GDP, NRD has the greatest influence on the reduction of GGDP. Therefore, Japan can improve by adjusting the secondary indicators under NRD. In recent years, the achievement of Japan's sustainable development goals is gradually declining, so it is beneficial to implement GGDP. Finally, according to the current economic and ecological situation of Japan, combined with the calculation method and model of GGDP selected in this paper, we prepared a convincing report to support the implementation of GGDP in Japan.

Keywords. Green Gross Domestic Product; Sustainability; Stepwise regression analysis; Policies

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1. Background

With the development of human economy and society, environmental protection has become increasingly severe. Environmental problems such as global sea level rise and Arctic temperature rise have gradually emerged, and have become major social and economic issues of common concern to all countries, which are related to the sustainability of development. Although the traditional indicator GDP, which measures a country's economic development, can effectively reflect a country's development level, it cannot measure the degree of human protection and utilization of natural resources.

Therefore, it is necessary for us to formulate a new calculation standard to effectively combine economic development with environmental protection, and the concept of green GDP was born. On the basis of traditional GDP, it improves the construction standard of resource and environmental accounting system, which can reflect the degree of natural resource depletion and environmental pollution damage caused by human production activities.

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1. Restatement of the problem

-Task 1: Choose an algorithm from existing models for calculating GGDP that can effectively measure the effectiveness of climate mitigation.
-Task 2: If GGDP is used as the main measure of economic health, a simple model of its predictive effect on the impact of climate change is developed and a measure of the impact of climate change is determined.
-Task 3: Determine the feasibility, advantages and disadvantages of replacing GDP with GGDP and explain it with the model of Task 2.
-Task 4: Select a country to analyze the impact of replacing GDP with GGDP in depth, and use the calculation principles of the two to select the corresponding indicators for example.
-Task 5: Write a 1 page of reports for leaders of countries selected by Task 4 on which 1 calculation method to measure economic health better.

2. Model Preparation

3.1 Assumptions and Their Justifications

Assumption 1: Each country's method of calculating GDP follows a unified standard. Considering the impact of other factors on GDP would over-complicate our model.
Assumption 2:We assume that the statistics we collected from the websites and reports are reliable and accurate.The data we use in our model is mainly collected from some statistics websites such as World Bank Open Data [1], China Earthquake Networks Center [2].
Assumption 3: Assume that the error term of the regression model obeys a normal distribution with a mean of 0. This is one of the prerequisites for establishing a multi-linear regression model.

3.2 Data Pre-Processing

3.2.1 Data Collection

We select a panel of data for 29 countries from 2000 to 2014. To ensure the comprehensiveness and authority of our data, we choose the websites in Table 1 as our data sources.

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Table 1. Data sources

Data	Data Source	Website
oil consumption	World Bank Open Data	https://data.worldbank.org.cn/
current oil price	National Data	https://data.stats.gov.cn
the area of cultivated land change	World Bank Open Data	https://data.worldbank.org.cn/
water consumption reduction	World Bank Open Data	https://data.worldbank.org.cn/
NO emissions	World Bank Open Data	https://data.worldbank.org.cn/
PM2.5 emissions	World Bank Open Data	https://data.worldbank.org.cn/
major earthquake and damage information	China Earthquake Networks Center	https://news.ceic.ac.cn
tuberculosis incidence	World Bank Open Data	https://data.worldbank.org.cn/
life extension	World Bank Open Data	https://data.worldbank.org.cn/
average salary	World Bank Open Data	https://data.worldbank.org.cn/
forest cover	World Bank Open Data	https://data.worldbank.org.cn/
CO_2 emissions	World Bank Open Data	https://data.worldbank.org.cn/

3.2.2 Data Filling

Some data are missing because the database construction of some countries is not perfect or not reported to the world database in time, so we use the following methods to supplement or adjust the missing data.
-If there is a linear trend in the changes in the data, we use linear interpolation to fill in the missing values.
-If the missing data is in the middle of two known data, we take the mean of the data at both ends as the missing data.

3.3 Symbol Table

Table 2.Symbols and meanings

Symbol	Meaning
y_{ij}	The value of the j-th index in i-th point of time
x_{ij}	The value of the i-th country's j-th index
GDP	Gross Domestic Product
GGDP	Green Gross Domestic Product
NRD	Natural resources depletion
ECV	Energy consumption value
OC	Oil consumption
COP	Current oil price
ALCV	Arable land consumption value
ACL	The area of cultivated land
CLP	Current land price
WRCV	Water resources consumption value
WCR	Water consumption reduction
CWP	Current Water Price
EPD	Environmental Pollution Depletion
EGE	Exhaust gas emissions
PC	Processing Cost
EDV	Environmental degradation value
EBL	Ecological benefit loss
LPH	Loss of physical health
BEI	Benefits of Environmental Improvement

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BLE	Benefits from life extension
LE	Life extension
AS	Average salary
CC	Correlation coefficient
GEB	Garden ecological benefits
FC	Forest cover
OPF	Oxygen production per hectare of forest
IOPC	Industrial oxygen production cost
SDGs	Sustainable Development Goals

3. Analysis of Specific Issues

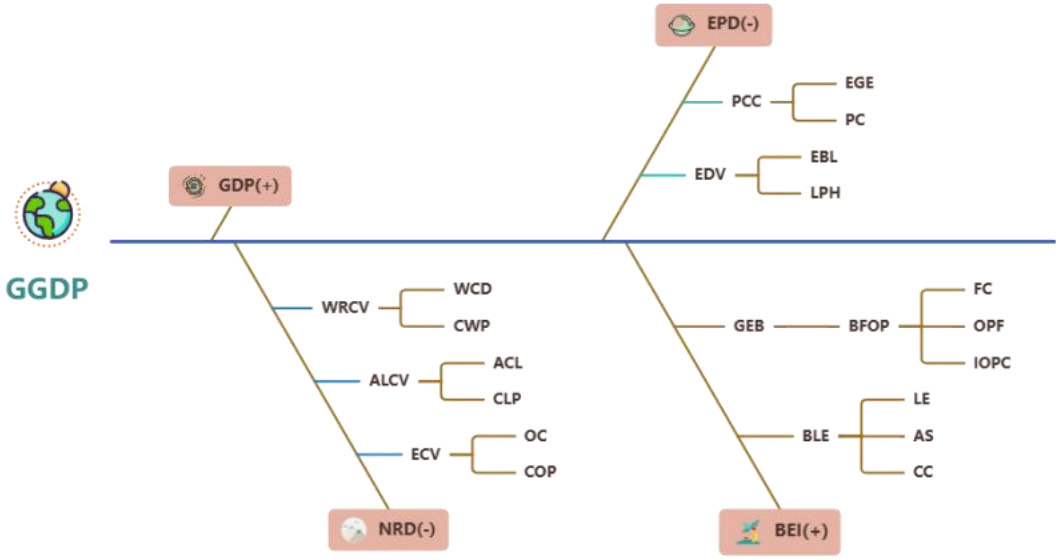

Figure 1. Fishbone diagram of indicator system

4.1Analysis of Problem 1

By reading a large number of documents, this paper chooses the following method to calculate GGDP: according to the SNA system, the natural resource depletion caused by human production activities is deducted from the resources depletion(NRD) and the environmental pollution damage accounting environmental pollution depletion(EPD), and a series of positive benefit benefits of environmental improvement(BEI) caused by climate improvement are added, and the accounting result is green GDP.

$$GGDP = GDP\text{-}NRD\text{-}EPD + BEI \quad \text{(Eq. 3-1)}$$

4.2 Analysis of Problem 2

Through formula 3-1, the GGDP of all countries in the world is calculated. Comparing the differences between GGDP and GDP in different countries in different years, it can be concluded that GGDP has been adopted as the main standard to measure a country's economic health, which is meaningful. To analyse the expected global impact of climate mitigation, we use global carbon dioxide emissions for each of the years 2000-2014 as the climate indicator yj. As for independent variables, five countries whose difference between GDP and GGDP in 2014 is higher than the

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average difference are selected from 29 countries where complete data can be found in the world, and then their GGDP in this 15-year period is taken as independent variable xij for gradual regression, and a simple model for predicting global climate change by using GGDP of various countries can be obtained.

4.3 Analysis of Problem 3

This paper will observe the sign and significance of regression coefficient through the stepwise regression model shown in Task 2, and understand the influence of GGDP on measuring global carbon dioxide emissions, so as to obtain the feasibility of replacing GDP with GGDP. From the definition of GGDP, through its calculation method and cluster analysis, we can measure the degree of environmental damage in various countries and understand its advantages for sustainable development. The disadvantages of GGDP are mainly reflected in the difficulty in obtaining specific data of various countries, which makes it difficult to substitute into stepwise regression model, and the calculation method is still not comprehensive enough, which does not consider the cultural value brought by environmental protection. For example, in China's "Jiangnan Water Town", the humanistic impact brought by protecting water towns cannot be measured by GGDP.

4.4 Analysis of Problem 4

In this paper, Japan is selected for analysis. By observing the coefficient of Japan in the model established in Task 2, the impact of Japan's GGDP rising by US $1 on global carbon dioxide emissions can be obtained. Then by comparing Japan's GDP ranking with the cluster analysis of GGDP in Task 3, we can judge the impact of Japan's current development on the environment.
By analyzing the specific values of the three major factors (NRD,BEI,EPD) that affect GGDP in the country except GDP, find out which 1 factors have the greatest impact on the reduction of GGDP, so as to make reasonable suggestions on the improvement of GGDP and the practices of protecting natural resources according to this factor and the secondary indicators covered by it.
By observing Japan's current total GDP and the trend of achieving Japan's sustainable development goals, it can be judged whether the adoption of GGDP is beneficial to Japan.

4. Models

5.1 Analysis and Solving of Question One

Compared with GDP, GGDP contains the views and factors of environment and sustainable development. At present, many accounting systems have been developed. The calculation method of green GDP we choose is based on GDP and according to SNA system, which deducts natural resource depletion caused by human production activities natural resources depletion(NRD) and environmental pollution damage accounting environmental pollution depletion(EPD). At the same time, a series of positive benefit benefits of environmental improvement(BEI) caused by climate improvement have been added to the green GDP accounting index system, combining "subtraction" and "addition" to comprehensively and objectively reflect the "environmental cost" of economic growth, effectively improving the current SNA system, and the accounting result is green GDP.

$$GGDP = GDP\text{-}NRD\text{-}EPD + BEI \quad \text{(Eq. 4-1)}$$

5.2 Discussion of the Indicators

5.2.1 Natural Resources Depletion

$$NRC = ECV + ALCV + WRCV \quad \text{(Eq. 4-1)}$$

First of all, the ECV in this paper is obtained through OC x COP, according to the World Bank's public data, to obtain the oil consumption value of each country from 2000 to 2004. ACL×CLP gets ACLV;WCR×CWP gets WRCV. The data source of ACL and WCR is the public data of the World Bank. CLP and CWP have no direct source and are

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obtained through data processing and calculation.[3]

5.2.2 Environmental Pollution Depletion

EPD = PCC + EDV (Eq. 4-2)

Second, in this paper, EGE and PC are obtained from the public data of the World Bank, and PCC is obtained by multiplying them. EDV contains EBL and LPH, in the statistics of EBL data, this paper uses the economic loss caused by the environmental pollution caused by the earthquake as the loss value of the environment to the production efficiency, the reason is that the economic loss caused by the earthquake to the country is larger, the impact on GGDP is more significant. LPH mainly accounts for the economic losses of human health caused by air pollution. Due to the limitation of data sources, tuberculosis is selected as the main health disease in this paper, and the revised human capital method is used to calculate it.

5.2.3 Benefits of Environmental Improvement

BEI = BLE + BFOP (Eq. 4-3)

Third, BLE = LE×AS×CC×P, where LE,AS,P come from the world bank's public data, CC is the contribution and weight of environmental improvement to life extension, and the regression coefficient of environment to life expectancy -0.1686 obtained by Qi Yu through systematic GMM method, FC and OPF can be quoted in the world bank's public data when calculating BFOP. IOPC = 0.4546 at 0 ℃ and 1 standard atmospheric pressure. [4]

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Table 3.The Calculation Method of GGDP

Type of Account	First-order Index	Second-order Index	Accounting M
GDP(+)	GDP		total regional GDP
Natural Resources Depletion(-)	energy consumption value		oil consumption×current oil price
	arable land consumption value		the area of cultivated land ×price (both in current year)
	water resources consumption value		water consumption reduction ×current water price
Environmental Pollution Depletion(-)	pollution control cost		exhaust gas (smoke, NO, etc.)emissions×processing cost
	environmental degradation value	ecological benefit loss	losses caused by natural disasters
		loss of physical health	toll of lung disease from air pollution
Benefits of Environmental Improvement(+)	Benefits from life extension		life extension×average salary×correlation coefficient×population
	Garden ecological benefits	Benefits of forest oxygen production	forest cover×oxygen production per hectare of forest×Industrial oxygen production cost

5.3 Analysis and Solving of Question Two

Before establishing the model, this paper uses the GGDP calculation method selected in Task 1 to calculate their GGDP values from 29 countries in the world where complete data can be found by searching the data on the relevant websites mentioned above.

5.3.1 Multivariate regression model

To analyse the expected global impact of climate mitigation, we use global carbon dioxide emissions for each of the years 2000-2014 as the climate indicator yj. As for independent variables, five countries (BRA, CAN, CHN, JPN, TUN) whose difference between GDP and GGDP in 2014 is higher than the average difference are selected from the selected 29 countries, and then their GGDP in this 15-year period is taken as independent variable xij for stepwise regression, and a simple model for predicting global climate change by using GGDP of various countries CAN be obtained.

When there are five independent variables, the linear regression model of random variable y and general variable x is:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_5 x_5 + \varepsilon$$

When 15 sets of observation data (x1, x2,..., x5, yi) from 2000 to 2014 are obtained, i=1, 2,..., 15, the linear regression model can be expressed as:

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$$\begin{cases} y_1 = \beta_0 + \beta_1 x_{11} + \beta_2 x_{12} + \ldots + \beta_5 x_{15} + \varepsilon_1 \\ y_2 = \beta_0 + \beta_1 x_{21} + \beta_2 x_{22} + \ldots + \beta_5 x_{25} + \varepsilon_2 \\ \qquad\qquad \ldots\ldots \\ y_n = \beta_0 + \beta_1 x_{n1} + \beta_2 x_{n2} + \ldots + \beta_5 x_{n5} + \varepsilon_n \end{cases} ,n = 15 \text{(Eq. 4-4)}$$

From the matrix form of multi-distance linear model Y = X β + ε, it can be seen that if the estimator of model parameter β is known, the estimator of Y can be determined. The residual ei can be obtained by subtracting the estimator of Yi from the actual value of Yi. Accord to that principle of least square method, The estimation method of parameter β should be that the residual ei between the estimated value of Yi and the observed value reaches the minimum at all sample points. According to the principle of calculus extremum, the derivative of Q to β is equal to 0, and the estimated value of β that makes Q reach the minimum can be estimated, thus obtaining the regression equation of predicting global climate change with GGDP of five countries.

5.3.2 Stepwise regression method

If the variable xi is added to the regression equation, it is called introducing the variable xi; If the independent variable xi already in the regression equation is to be deleted from the regression equation, it is called eliminating the variable xi. Regardless of introducing variables or eliminating variables, we should use F test to introduce significant variables into regression equation and eliminate insignificant variables from regression equation. AIC criterion can be used to judge whether a variable should be introduced or eliminated.

The step-by-step screening method means that with the change of its contribution to the regression equation, every independent variable may be introduced into the regression equation or eliminated at any time, so that the independent variables in the final regression model are significant and the independent variables not in the regression equation are insignificant.

In this paper, a stepwise regression model is established by stepwise screening method and least square estimation. The p value results of the whole model and each parameter are shown in the following figure, and the coefficients before each variable are shown in the following table. The p value of each coefficient estimator is < 0.16, the adjusted R2 value of the model is 0.9982, and all five independent variables enter the model, indicating that the model is reasonable and the error is within the allowable range. If the GGDP of the next five countries in the k year is substituted into the model, the carbon dioxide emissions in the k year (thousands of tons) can be effectively predicted.

Table 4. Estimations and p-values

Country	Estimate	p-value
intercept	1.76 E+07	2.46 E-10
TUN	-0.000002738	0.1558
JPN	-1.921 E-07	0.0933
BRA	-0.000001499	0.0104
CHN	4.338 E-07	0.000049
CAN	0.000009733	1.26 E-08
model	/	5.93 E-13

5.4 Analysis and Solving of Question Three

5.4.1 Viability

1) Analysis from the perspective of theoretical meaning

GGDP is revised and adjusted on the basis of GDP. It still follows the principle of national economic accounting, will not lose the basic interests of various countries, and is different from GDP, so it is theoretically feasible.

GGDP considers resource consumption and environmental costs in the economic process, which can more truly reflect the relationship between the real economic level and the environment of a country or region, and is one of the important indicators reflecting the sustainable development of a country or region. Therefore, GGDP also has practical significance.

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2) Visual analysis by graphic method

As can be seen from the size of the circles in Figures 3 and 4, also in 2014, the total amount and ranking of GGDP and GDP of the same country are quite different. This means that many countries only attach importance to economic development, while ignoring the importance of ecological environment protection. Protecting the ecological environment can maintain the sustainable development of the country. Countries should not be limited to immediate interests, but also consider long-term development. Economic development should not be at the expense of destroying the homeland where human beings live. The implementation of GGDP can make more countries aware of this important issue.

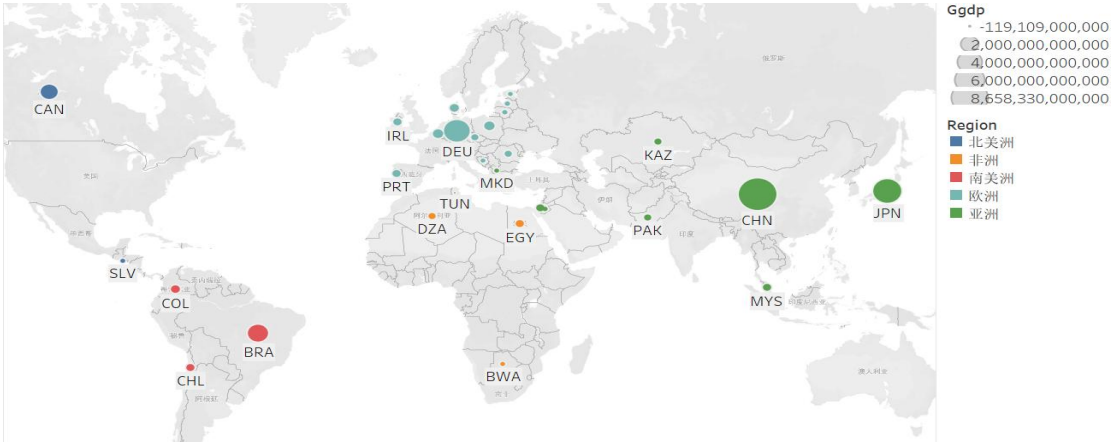

Figure 2. GGDP of 29 countries in 2014

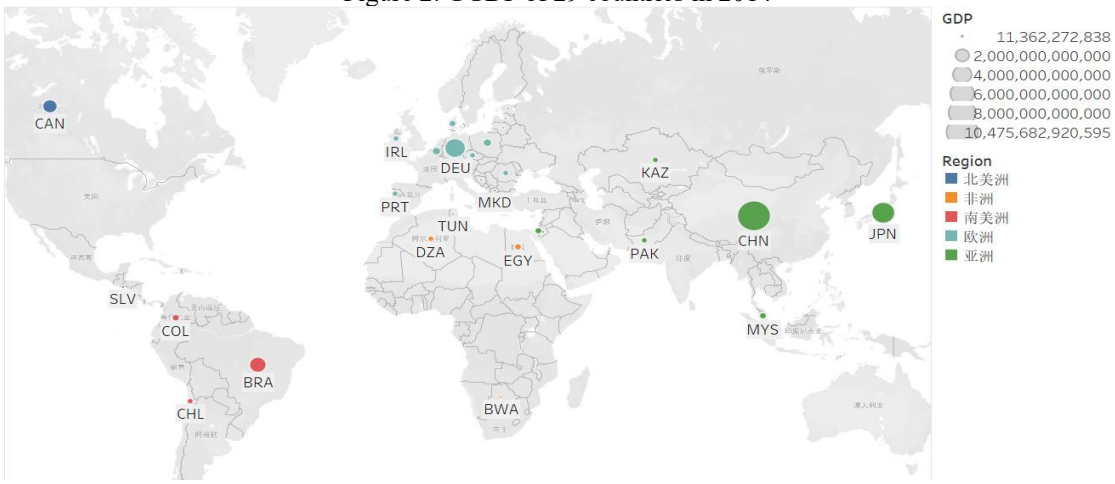

Figure 3. GDP of 29 countries in 2014

3) **Stepwise regression model analysis**

From the stepwise regression model obtained by Task 2, it can be seen that there is a significant correlation between global carbon dioxide emissions and GGDP of five countries. If GGDP is used instead of GDP as a new economic index, the future global carbon dioxide emissions can be directly predicted by calculating the GGDP of various countries, which is of great help to alleviate the increase of global carbon dioxide emissions, formulate more reasonable development plans and promote countries to attach importance to sustainable development.

5.4.2 Advantages of GGDP

1) Analysis from the perspective of theoretical meaning

In short, GDP is a one-dimensional index to measure a country's economic development level. GGDP is a multi-dimensional index to measure a country's development.

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GDP is the primary index to measure the economic development of various countries, but the consumption of natural resources and the damage caused by economic activities to the ecological environment can not be reflected, nor can it reflect the advanced and sustainable development level of the country or region in all aspects of society. As a result, the more pollutants are discharged, the greater the GDP. GGDP should be paid more attention to in developing countries which depend on the development of mineral resources, land resources, aquatic resources and forest resources to obtain important income.

Paying attention to the improvement of climate and environment caused by GGDP has a significant effect on improving people's quality of life and prolonging their life span.

2) Clustering analysis of system by shortest distance method

In order to express the GGDP of 29 countries more intuitively, this paper discusses the trade-off degree between economic development and environmental protection of various countries by using systematic cluster analysis method.

The principle of systematic clustering analysis in this paper is: firstly, 29 countries are divided into 29 categories, and each country belongs to one category, then two categories with the smallest distance, that is, the closest GGDP, are merged every time, and the distance between classes is recalculated after merging. This process lasts until all samples are classified into one category, and this process is made into a cluster diagram.

In the whole process, a systematic clustering method is adopted, in which the distance between categories is equal to the distance of GGDP of the nearest country in the two categories, which is also called the shortest distance method. D (p, q) = min is used to describe the distance between the GGDP of a class and the nearest country in the class. If the class is merged with the class, the distance between the class and other classes is:$\{d_{ij} \mid i\epsilon G_p, j\epsilon G_q\} G_p G_q G_p G_q G_r G_r G_s$

$$D(r,s) = \min\{D(p,s), D(q,s)\} \quad \text{(Eq.4-5)}$$

In practice, firstly, the data is standardized and the distance between classes is calculated. Secondly, through the gravel map, the best classification number is observed, and the conclusion that it is divided into three categories is the best. Finally, the cluster analysis of these 29 countries is carried out according to the above methods, and the systematic cluster diagram is drawn.

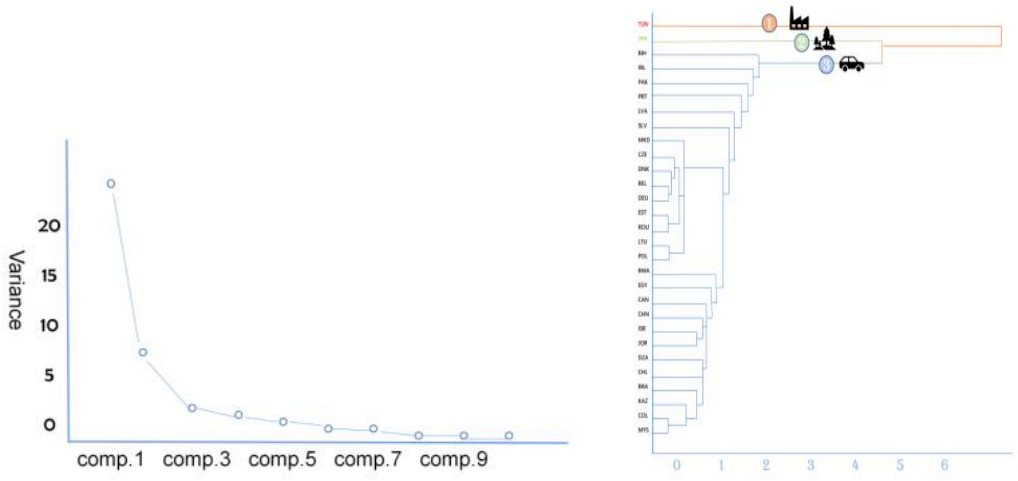

Figure 4. Detritus map and system cluster diagram

It can be seen that TUN is in the first category, JPN is in the second category, and the remaining 27 countries are in the third category. When calculating class spacing, GGDP is absolute, while TUN's GGDP is negative and JPN's GGDP is positive, so it can be seen that JPN is the country with the best natural resources protection, TUN is the country with the worst natural resources protection, and the other 27 countries are in the middle position. This information cannot be reflected in the calculation method of GDP.

5.4.3 Disadvantages of GGDP

Analysis from the perspective of theoretical meaning. It is difficult to calculate GGDP, and it is difficult to monetize

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environmental losses such as NRD, EPD and BEI. The cost of pollution is often estimated according to the cost of pollution control, which requires monitoring and evaluation of environmental pollution first. However, no country can monitor the pollution accurately.

The value of culture closely related to ecosystem is also difficult to quantify. For example, in China's "Jinxiu Water Town", the culture of this place has nurtured generations of water town people, and food, clothing, housing and transportation are closely related to their ecological environment. "Jiangnan Water Town" is not only an ecology, but also a culture, and the humanistic value of protecting it is difficult to estimate.

At the same time, the implementation of GGDP needs to strengthen the supervision of enterprises discharging sewage, waste and solid waste, and strengthen people's awareness of environmental protection. Many enterprises only pay attention to immediate interests, and help enterprises win excess profits at the expense of ecological environment.

Stepwise regression model analysis. To establish a stepwise regression model, it is necessary to calculate the GGDP of each country, which requires data from all aspects of each country, including GDP, NRD, EPD, BEI, etc. There are many secondary indicators in each primary indicator, which puts forward high requirements for a country's statistical system. Some less developed countries have not yet formed national statistical institutions, and only rely on enterprises to report their own sewage discharge, which cannot ensure the accuracy of GGDP calculation.

5.5 Analysis and Solving of Question Four

This paper selects Japan for further analysis. From the coefficient before the 1 independent variable of Japan in the stepwise regression model, it can be seen that for every US $1 million increase in Japan's current GGDP, global carbon dioxide emissions will be reduced by 1921 tons. This shows that Japan's current development is beneficial to the ecological environment. According to the GDP ranking, Japan was [5] the third largest economy in the world in 2014. However, through the calculation and cluster analysis of GGDP of various countries in task 1, Japan's GGDP is at the first level in the world among the 29 countries where complete data can be found, which means that Japan is an environment-friendly country.

In Japan's GGDP calculation process, the three major factors that affect GGDP in addition to GDP are shown in Figure 5. This shows that NRD has the greatest impact on GGDP reduction, EPD has the least impact on GGDP reduction, and BEI has no small impact on GGDP increase. It can be seen that Japan's GGDP output value is less than the total GDP value, which means that Japan still has room to further optimize environmental protection measures. We can further propose solutions for ECV,ALCV and WRCV in NRD, such as increasing land recycling rate and water recycling rate. Moreover, the results of soil pollution survey in Japan show that the number of cases exceeding the soil environmental standard is increasing year by year, so soil protection should be paid attention to to reduce the consumption of cultivated land. And new energy vehicles should be implemented instead of traditional fuel-consuming cars.

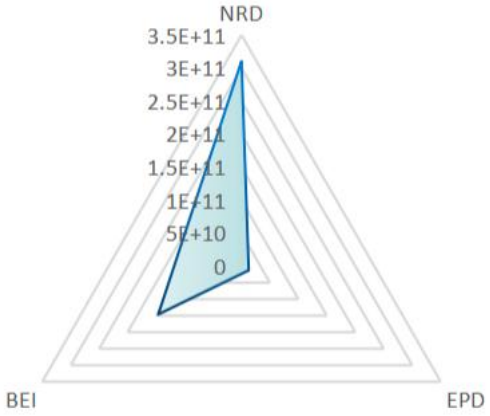

Figure 5.Three green dimensions of Japan's GGDP in 2014

In the past 2022, Japan will remain [6] as the world's third largest economy. While the economy is in good shape, its

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capacity for sustainable development is weak. According to the Asahi Shimbun [7] report, the achievement of Japan's sustainable development goals (SDGs) has gradually declined in recent years, and has now dropped to the 19th place in the world. Therefore, Japan should pay more attention to the sustainable development of its national ecological resources, and the implementation of GGDP is beneficial to Japan.

5. Strength and weakness of the models

6.1 Strength

1 Simple versatility
Although the method of calculating GGDP in our model seems relatively simple, it covers four independent aspects (GDP,NRD,EPD,BEI) and can more comprehensively reflect the relationship between the development of a country and the protection of the ecological environment.
2 rigor
In our regression model, GGDP is calculated by 17 independent indicators, and the five countries selected to enter the model are selected from 29 countries for which data are available. The difference between GDP and GGDP in 2014 is greater than the average. 2014 is the latest time for all data to be cut off, and the difference between GDP and GGDP can more effectively judge the degree of green development of a country.
3 Predictability
By using the GGDP of the five countries in 2000-2014 as the independent variable and the global carbon dioxide emissions as the dependent variable to establish a regression model, the impact of the variables over time can be fully demonstrated. And it is possible to substitute the GGDP of each country in the future into the regression equation to predict future global carbon dioxide emissions.

6.2 Weakness

6.2.1 Accuracy relies on statistics

Since the calculation of GGDP in our model requires data from many specific indicators of economic development, natural resources, environmental pollution, environmental improvement, etc., the accuracy of the model is closely related to the statistical accuracy of each country. This requires ensuring that countries have complete and open and transparent statistical systems.

6.2.2 Subjective

Since the methods used to calculate GDP vary from country to country, the size of GDP is [8]subjective. The GDP is included in the calculation of GGDP, which leads to certain differences in GGDP.

6.2.3 Incomplete measurement of natural disasters

Since the value of EDV contained in EPD is difficult to accurately estimate, this paper selects the economic losses caused by earthquakes of magnitude 8 and above in various countries from 2000 to 2014 as the value of EDV, but the economic losses caused by natural disasters such as volcanic eruptions, tsunamis and tornadoes are not taken into account.

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6.2.4 The impact of cross-regional flow of pollutants is not considered

The theoretical framework of this paper is based on the SNA(2008) [9] and SEEA(2012) [10]on the concept of permanent residence and the general definition of economic boundaries. The pollutant flow between countries has not been taken into account.

6. Sensitivity analysis

We analyzed the sensitivity of GGDP of these five countries. Increasing each country's GGDP by 20% each yields a new forecast of global carbon dioxide emissions. This process shows the linear relationship between GGDP and global carbon dioxide emissions. Figure 6 is the result drawn by taking logarithms.

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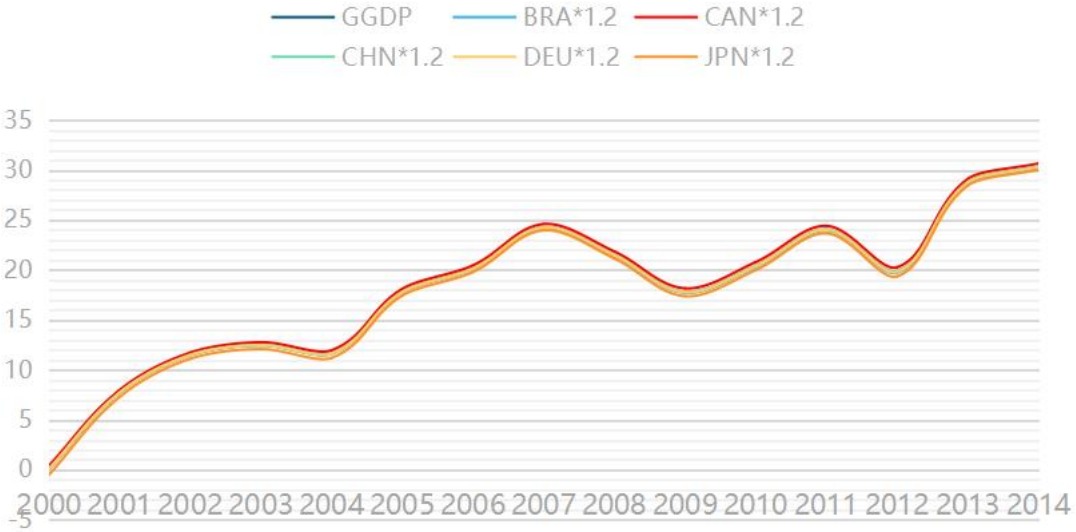

Figure 6 Sensitivity analysis

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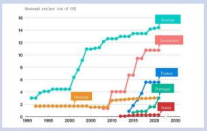
Japan is a distinctive country in environmental protection. It has created economic miracles, got rid of the image of "a big country with public hazards" in a short period of time, and maintained a win-win situation in environmental protection and economic development for a long time, creating miracles in environmental protection. From "a big country with public hazards" to "an advanced country with public hazards control", I have seen Japan's determination and perseverance in ecological and environmental protection. I have prepared a report for you. As the leader of such a country, I believe you will attach importance to the views put forward in this report and seriously consider them.

According to the model we choose to calculate GGDP, Japan's GGDP ranks first in the world. **Therefore, we hope that Japan can set an example for the whole world and take the lead in using GGDP as an indicator to measure the national development level.** The specific model is: *According to SNA system, the natural resources depletion (NRD) and environmental pollution depletion (EPD) caused by human production activities are deducted, and a series of positive benefits of environmental improvement (BEI) caused by climate improvement are added, and the accounting result is green GDP.*

In October 2020, Prime Minister Yoshihide Suga (then) issued the Net Zero Declaration to achieve Net Zero emissions of greenhouse gases by 2050. It can be seen that Japan actively responded to the international call to reduce carbon emissions and stimulated the determination of enterprises and people to save energy and reduce emissions through political policies. But Japan still has a long way to go to protect its ecology. If Japan chooses GGDP instead of GDP, then driven by policies, Japan will do better in all aspects of the model and become an environment-friendly country.

The survey results of soil pollution in Japan show that the number of cases exceeding the soil environmental standards is increasing year by year, so soil protection should be paid attention to to **reduce the consumption of cultivated land**. In terms of **reducing energy consumption**, Japan will actively develop new renewable energy and reduce the use of coal and oil. After the Fukushima nuclear power plant leak in 2011, there have been contradictions among Japanese people about the scale of nuclear energy. In order to increase GGDP, investment will go to other renewable energy sources. Moreover, thermal power is critically called "the chief culprit of global warming", and only Japan among the G7 countries of the United Nations has made it clear that it will keep thermal power. If Japan implements GGDP, it will become a foregone conclusion to reduce the use of coal and oil, and its carbon emissions will be significantly reduced. Another problem with Japan's energy policy is the slow development of a "carbon pricing mechanism", which has gradually become the mainstream practice in countries to promote the transformation of a zero-carbon society through policy incentives. At present, Japan's "global warming response tax" is extremely low, with only 298 yen per ton of carbon dioxide, and the tax rate will not change with the increase or decrease of CO_2 emissions. This is not conducive to the transformation of Japan's energy structure. These two problems will lead to a decrease in GGDP, which should attract the attention of the Japanese government.



In the spring of 2023, a large amount of nuclear waste water stored in Fukushima Daiichi Nuclear Power Plant in Japan will be discharged into the ocean, which is extremely **irresponsible to the whole nature**. This will greatly increase environmental pollution. Both for the sake of GGDP and for the sake of our responsibility to the planet, we should stop this behavior and use other less polluting treatment methods instead.

In order to **improve the global climate**, Japan has formulated "Japanese-style green GDP", which will calculate national wealth according to decarbonization. The mechanism for setting the new target is to convert Japan's domestic carbon dioxide emissions into money. If emissions increase, additional emission reduction funds are needed, so GDP will decline; On the contrary, if the measures to reduce emissions are promoted, GDP will rise. With the international community paying close attention to climate change, the new indicators play a role in supporting domestic emission reduction work. Even though "Japanese-style green GDP" has gradually entered the Japanese people's field of vision, it includes a single dimension. The protection of ecological environment and the construction of people's beautiful home need not only climate mitigation, but also the joint action of multiple dimensions. Therefore, GGDP mentioned in this report is a better choice.

If Japan succeeds in implementing it, it will become an example among all countries in the world. In a few years, when the world takes GGDP as the most important index to measure its national strength, the economy will flourish, the air will be fresher, the sky will be bluer, the average life span of the people will be longer, more economic benefits will be created, and the society guided by GDP will be more harmonious than today.

Figure 7 The non-technical report for Japan

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