Problem Chosen	2023 MCM/ICM Summary Sheet	Team Control Number
F		2301560

GGDP: A Better Indicator for Improving the Health of Economy

Summary

GDP is arguably the most famous and commonly used measure of a country's economic health. However, with the contradiction between economic development and resource environment constraints, the appeals for the establishment of a green accounting system are becoming more and more strong. Green accounting system refers to including the consideration of resource environment factor into the national economic accounting. Our goal is to persuade world leaders to change the way they evaluate economies at present, to take GDP into account, so as to advance the construction of ecological civilization in the near future.

Firstly, among the many green GDP accounting methods, considering the universality and adaptability of the accounting method, we chose the green GDP accounting method published by the United Nations Statistics Office in 1993, where **Green GDP = Gross Domestic Product - Cost of Environmental Resources - Cost of Environmental Resources Conservation Services**, as the main measure of economic health.

Secondly, we selected five indicators, namely **CDE, MRCR, ELR, TAFW, and FCR**, ranked each index in the order of importance degree, and assigned corresponding values based on general perception. We then calculated climate mitigation by using the **TOPSIS model** combined with the **AHP evaluation method**. Considering that economic health consists of climate change and other factors, which are irrelevant variables in our study and can be ignored, then, we set up a linear regression model, with GDP an argument and climate mitigation a dependent variable. We then compared the potential upsides and downsides of the switch from GDP to GDP as an economic health criteria. It is concluded that GGDP can better promote the healthy development of economy in the long run.

Thirdly, we did a case study. We selected four countries with large resource consumption rates, but different resource reserves. By subrogating data from each country into our model, we managed to derive a positive correlation between economic health and GGDP, leading to the conclusion that the transition from GDP to GGDP had a positive impact globally. Next, we chose Brazil for an in-depth analysis. Targeted policy recommendations were made in the light of the current economic situation of the country and its ability to support future generations. Then we wrote a one-page non-technical report to Brazil' s leaders to support the country' s conversion of GDP to GDP as a more effective measure of the country' s economic health.

Finally, we analyzed the advantages, disadvantages and practical effects of the whole scheme.Taking into all these factors, we recognized that the global rollout of GGDP will be difficult, but we look forward to seeing this become the future trend of the world.

All in all, we hope that countries around the world should not just go for economics, but can pay attention to the protection of the environment and resources and reserve sufficient space for human development in the future.

Keywords: GDP Environment and Resources TOPSIS AHP

Contents

1 Introduction

1.1 Background

GDP is arguably the most famous and commonly used measure of a country's economic health. It provides a full image of the economic situation and is often used in determining the purchasing power and access to loans for a country, providing motivation for nations to propose policies and projects that boost their GDPs. However, it has its own shortcomings, which cannot be ignored: it can not reflect the contribution of natural resources to economic development and the great economic value of ecological resources. For example, a country rich in forests could increase its current gross domestic product through deforestation and the production of large quantities of wood furniture, regardless of biodiversity loss and other negative environmental consequences, without penalty.

With the increasingly prominent contradiction between economic development and environmental constraints , the simple GDP target is being questioned and criticized more and more, and the calls of society for the establishment of a green accounting system are increasing. A green accounting system refers to a system that includes resources and environment into the national economic accounting system. At present, there is no successful experience in the world for reference. It is of great significance to the construction of a shared future between man and nature, to explore the establishment of a green accounting system, a resource-saving society and to promote an ecological civilization. If countries change the way they assess and compare economies, governments may change their behaviour to promote the policies and projects that are more conducive to the environmental health of the planet. Could GREEN gross domestic product (GGDP) be a better measure than the current conventional GDP?

1.2 Problem Restatement

Multilateral changes are extremely challenging, but it is also worthwhile if it leads to significant progress in mitigating the climate crisis through national efforts to combat climate change. Our goal is to convince countries to agree to this new GDP as a substitute for GDP, and to consider the world recognizing GGDP as the primary measure of the health of a nation's economy.

Task 1: Among the many methods that have been developed to calculate GGDP, choose one as the primary measure of economic health to replace GDP. Develop a model to estimate the global impact of GGPA on climate change mitigation, with an optional measure of climate change.

Task 2: By comparing the potential benefits of mitigating climate change with the potential harms of replacing the status quo, determine if your model indicates that the switch from GPA to GGPA has global value.

Task 3: Select a country and further analyse how this shift might impact them. For example, what specific changes would you expect to see in how this country uses or preserves its natural resources -both now (using current GDP) and after using GDP? Considering both their current economic situation and ability to support future generations, are these changes good for this specific country? Make sure your analysis is explicitly tied to the changes in the calculation from GDP to GDP.

Task 4: Based on your analysis of a specific country, write a one-page non-technical report to the leader of that country on whether to support the shift to GDP or reject the shift and maintain GDP as the primary measure of the country's economic health.

1.3 Our Work

First, we chose Green GDP accounting method, published by the United Nations Statistics Office in 1993, where Green GDP = GDP -Cost of Environmental Resources(CER) -Cost of Environmental Resources Conservation Services(CERCS), as the primary measure of economic health.[1]

Next, we selected five indicators, and use the TOPSIS comprehensive evaluation method to calculate climate mitigation. Considering that economic health is composed of climate factor and other factors, which are irrelevant variables in our study and can be ignored, we set up a linear regression model, where climate mitigation is an argument and GDP and GGDP are dependent variables, to compare the potential upside and downside, and therefore determine which would be a better measure of economic health.

Then, we did a case study. We chose four countries with different reserves of resources and put their data into our model, and we could conclude that the switch from GPA to GGPA has a global value.

After that, we selected Brazil for an in-depth analysis. Based on the country's current economic situation and ability to support future generations, we provided targeted policies recommendations. Then we wrote a one-page non-technical report to Brazil' s leaders, supporting the country' s conversion of GDP to GDP as a more effective measure of economic health.

Finally, we analyze the strengths and weaknesses and practical effects of the whole project. We recognize that the global implenmentation of the GGPA will be difficult, but we look forward to seeing it become a development tendency globally in the future.

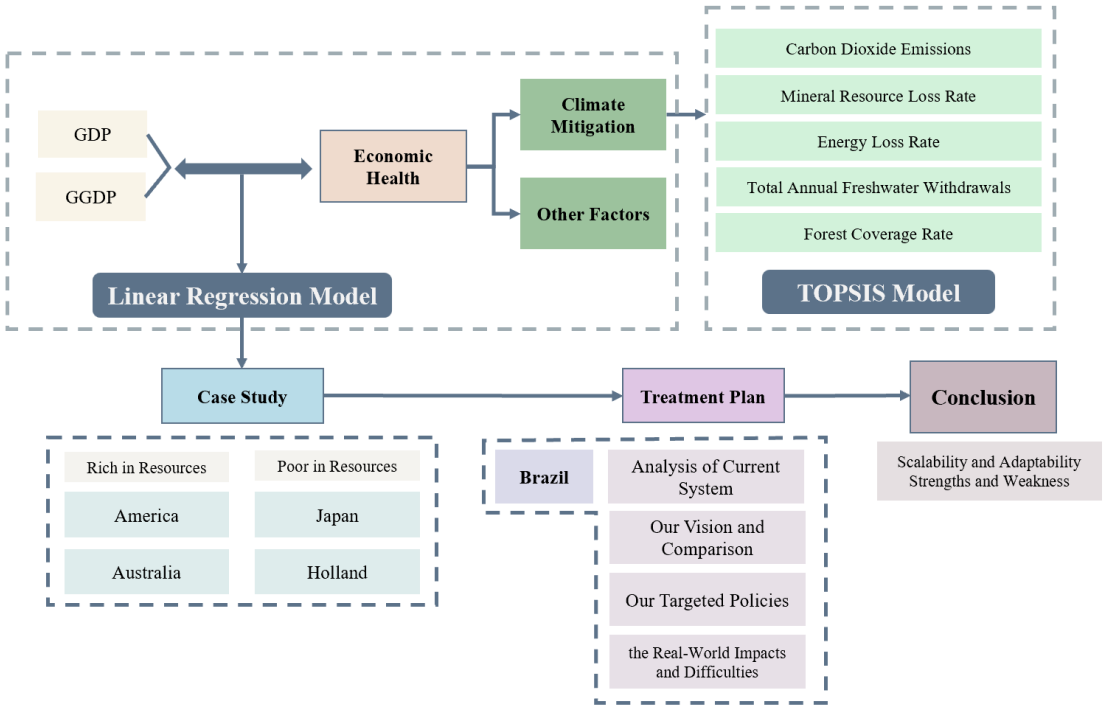


Figure 1: Flow Chart

2 General Assumption and Symbol Explanation

2.1 General Assumption

In order to simplify our model and better address subsequent problems, we have made the following reasonable assumptions.

1. **We hypothesized that the main climate influences could replace all of them.** The idea is to give a combined weight of 1 to the indicators we choose to judge the climate, ignoring the impact of other non-major factors on the climate environment. Although the factors affecting climate change are too complex, when we choose to study the whole country or even the whole world, only a small number of dominant factors will make a significant difference to the climate. It is therefore reasonable to assume that major factors can cover all the other factors when we research such globally-based problems.

2. **We assume that the weight of climate impact indicators is consistent for each country.** This hypothesis means that when measuring the climate environment in different countries through data, we can use the same set of weightings to process the relevant indicators. Due to the differences in geographical factors, the differences in the development process of countries and other reasons, the weight of factors affecting the climate environment in each country may vary, but this difference does not cause a significant change in weight, nor does it alter the relative weight of the two indicators, i.e., the dominance of one factor over another is not diminished, so we conclude roughly that the weight of each indicator is the same for each country.

3. **We assume that the economic situation of the country will be relatively stable for a long time.** The assumption is that there will be no major upheaval leading to large and unusual changes in the country's economy. However, the global economic development situation is relatively stable. Occasional events will not change the overall trend of future development, so our model is useful for predicting some of the future data.

2.2 Symbol Explanation

Symbol	Description
CDE	Carbon Dioxide Emissions
MRCR	Mineral Resources Consumption Rate
ELR	Energy Loss Rate
TAFW	Total Annual Freshwater Withdrawals(1 billion cubic meters)
FCR	Forest Cover Rate
C.R.	Closeness Rate
TOPSIS	Technique for Order Preference by Similarity to an Ideal Solution
LASSO	Least Absolute Shrinkage and Selection Operator

3 Main Factors and Data Selection

3.1 Main Factors

Greenhouse gas emissions are the leading cause of climate change, with the burning of fossil fuels – coal, oil and gas – accounting for more than 75 percent of global greenhouse gas emissions and nearly 90 percent of all carbon dioxide emissions. In addition to this, deforestation and the extraction of freshwater resources also contribute to global water heat exchange, which leads to climate change. We expect to see the use of GDP as a measure have a positive impact on climate change, leading to a slowdown in climate change. In order to have a comprehensive assessment of the mitigation of climate change, we need to take into account the factors that contribute to climate change, namely the gas emissions, natural resources, energy, etc..

Based on the above definitions, we have compiled the five indicators to reflect climate mitigation, which will be described below.

3.1.1 Carbon Dioxide Emissions(CDE)

Negative factor: Carbon dioxide gas accounts for 74 per cent of greenhouse gases and has a significant impact on climate change. It acts as a heat absorber and insulator, like an invisible quilt that prevents the heat radiating from the sun to Earth from spreading into outer space.

3.1.2 Mineral Resources Consumption Rate(MRCR)

Negative factor: the process of exploitation of mineral resources can have an impact on the topography, soil and water environment, and seriously harm surface and underground space and produce large quantities of pollutants; the exploitation of mineral resources releases large quantities of harmful gases, triggers acid rain and aggravates the greenhouse effect, thus affecting climate change.

3.1.3 Energy Loss Rate(ELR)

Negative factor: Energy is very closely related to the environment. In the process of acquiring and using energy, the original natural environment will be changed and a large amount of waste will be produced. If not treated properly, the environment on which people depend will be destroyed and polluted.

3.1.4 Total Annual Freshwater Withdrawals (1 billion cubic meters)(TAFW)

Negative factor: Freshwater resources refer to freshwater resources on land. Only 3 percent of the earth's water is fresh water, which determines the distribution of life on Earth. Increasing total freshwater extraction as a result of population growth and economic development will lead to further water scarcity and direct climate change. Since resources are limited, series of social problems caused by water scarcity may also lead to environmental change in the future.

3.1.5 Forest Cover Rate(FCR)

Positive factor: Forest photosynthesis absorbs carbon dioxide while releasing oxygen, constantly updating the air and maintaining the balance of oxygen in the atmosphere; At the same time, forests play an important role in climate regulation because surface vegetation absorbs more heat than bald soil, bringing moisture into the atmosphere, and then freeze and concentrate to produce rain.

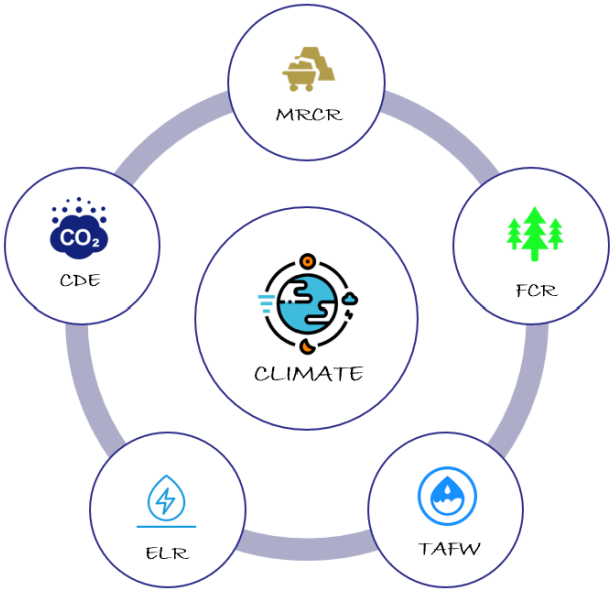


Figure 2: Main Factors Related to Climate Mitigation

3.2 Data Selection

Valid and accurate data is the most fundamental step for designing the evaluation system. Our data is collected from many official websites or statistics researches such as The World Bank, the OECD, the OPEC, the NBS(National Bureau of Statistics) and so on.

Due to the limitation of available data on the website, We collected data from five countries over a period of 10 years, from 2010 to 2019.

4 Climate Mitigation Assessment Model

The factors affecting environmental resources are diverse and fluctuant, and in order to explore and use GDP or use GGDP as a measure to assess the differences of the climate environment, the model we chose should meet the following requirements:

- The model should be universal, that is, it should be applicable to the vast majority of the world's countries, so the indicators we choose must be comprehensive.

- The assessment of the climate environment by the model should be comprehensive and objective, and therefore the dominant influencing factors should be selected in the selection of indicators in order to assess more accurately the strengths and weaknesses of environmental resources.
- The model should be implementable and the indicators selected should be easily accessible to national Governments in order to facilitate their adoption by government agencies in order to help determine the future development of the country.

4.1 The Calculation Method of GGDP

There is currently no global consensus on how to account for GGDP, which, according to the core view of GGDP accounting, takes the resource and environment factors into account, but the specific definition of the resources and environment is still not clear.[2] Based on the fact, our team divided the resource and environment into consumption of natural resources and the cost of environmental management to carry out quantitative calculations.

Finally, we selected GGDP formula[3] as:

$$GGDP(j) = GDP(j) - I(j) - K(j) \tag{1}$$

$$I(j) = P(1) \cdot S(1) + P(2) \cdot S(2) \tag{2}$$

$$K(j) = P(3) \cdot S(3) \tag{3}$$

In the formula, I (j) refers to the consumption of natural resources, which are extremely diverse, taking into account the need for statistical generality and the availability of indicators.

We approximate the consumption of natural resources to the total value of the water and energy consumed. Both are obtained by multiplying their respective unit prices by the total consumption amount. While K (j) refers to the total cost of the environmental governance, which is also approximate to the cost of the treatment of waste water, waste gas, solid waste and garbage. Therefore, the formula of GDP adjusted by excluding factors of the environmental resources can better meet the core idea of GGDP.

4.2 TOPSIS Model

In order to build the TOPSIS model, we need to select representative indicators to caculate. In our research, we found that the factors affecting the climate are numerous, complex and distinct, and the proportion of different factors to climate impacts also varies. Under these conditions, our team chose the TOPSIS decision model, which uses Analytic Hierarchy Process (AHP) to assign respective weights to different factors.

On one hand, this method takes into account the general understanding of the importance of different factors; on the other hand, it uses objective data. We combined both sides to reach more accurate conclusions.

4.2.1 Determination of Indicators

In order to make the model indicators more valuable, we looked up a variety of indicators that can assess climate. Given that in our formula for calculating GGDP, we classified the measure of

natural resources as two parts — both in terms of resource consumption and the cost of managing the environment. Meanwhile, the impacts of natural resources and human activities on climate should also be included. The consideration should also be given to positive and negative impacts of climate change. To sum up, our group identified five indicators, including CDE, MRCR, ELR, TAFW, and FCR, for measuring climate quality.

For the specific explanation of the meaning of each indicator, please refer to the third part, which will not be expanded here.

4.2.2 Data Normalization

After the evaluation indicators are identified and accurate data are obtained, we need to standardize the data and remove their dimensions before we can weight different types of data. As stated above, the data can be divided into two categories: Positive and Negative. Among them, CDE, MRCR, ELR, and TAFW are negative ones; while FCR has positive impacts.

We used the following standardized formula for data processing:[4]

$$\tilde{x_{ij}} = \frac{x_{ij} - min\{x_i\}}{max\{x_i\} - min\{x_i\}} \tag{4}$$

$$\tilde{x_{ij}} = \frac{max\{x_i\} - x_{ij}}{max\{x_i\} - min\{x_i\}} \tag{5}$$

4.2.3 Weight Calculation

In order to determine the weights of different indicators on climate impacts , we used AHP to process the data. AHP is essentially a judgment analysis between each two indicators. First of all, we need to construct judgment matrices. In order to construct the judgment matrix, we took expert advice and gave the relative weight relationship between each two elements, by using the Santy Scale according to the table below.[5]

Santy Scale	Indication
1	Two elements are of equal importance.
3	The former is slightly more important than the latter.
5	The former is more important than the latter.
7	The former is much more important than the latter.
9	The former is significantly more important than the latter.
2, 4, 6, 8	In the middle of the above importance degree.
The reciprocal of 1 to 9	The importance degree after exchanging the order of corresponding elements.

Since we selected five indicators to evaluate climate, we can construct a judgment matrix of 5×5 :

$$A = (a_{ij})_{m\times n} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1j} \\ a_{21} & a_{22} & \cdots & a_{2j} \\ \vdots & \vdots & \vdots & \vdots \\ a_{i1} & a_{j2} & \cdots & a_{ij} \end{bmatrix} \tag{6}$$

At this point, the judgment matrix is constructed. Next, we need to rank the elements in the matrix. Hierarchical singularity refers to comparing elements in a standard layer with each other and sorting them in the importance degree. At the same time, the elements should be normalized and converted to a percentage, whose total is 1. First, we calculated the weight vector, multiplied the elements in each row of the matrix, and then found the square root of 5.

$$\vec{W}_i = \sqrt[n]{\prod_{j=1}^{n} a_{ij}} \qquad i, j = 1, 2, ..., n \tag{7}$$

Since the sum of the weight vectors obtained from each row is not one, we need to normalize the weight vectors of each row to make the total be one, so as to intuitively reflect the ratio of different indicators to climate impacts.

$$W_i = \frac{\vec{W}_i}{\sum_{i=1}^{n} \vec{W}_i} \tag{8}$$

Since the initial weighting judgement is based on the general opinion, there may be logical errors in the relative importance of the two elements during the completion of the judgement matrix, so we need to make consistency judgements of the calculated weight vectors to ensure that the results we get are accurate. First, we need to calculate the maximum characteristic root of the matrix:

$$\lambda_{max} = \frac{1}{n} \sum_{i=1}^{n} \frac{(AW)_i}{W_i} \tag{9}$$

AW refers to the sum of the product of a (ij) and W (j). Then calculate the consistency indicators:

$$C.I. = \frac{\lambda_{max} - n}{n - 1} \tag{10}$$

Consistency indicator R.I was obtained based on the results of 1,000 Satty simulations. The table of values is shown in the table below:

Matrix Dimension(n)	1	2	3	4	5	6	7	8	9	10	11	12	13
R.I.	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.54	1.56

$$C.R. = \frac{C.I.}{R.I.} \tag{11}$$

When C.R. $<$0.1, the consistency of the weight vectors obtained through the judgement matrix is indicated to the extent permitted; if C.R. $<$0.1, the value of judgement matrix A should be revised and the consistency judgement repeated until the conditions are met.

4.2.4 Closeness Calculation

The weighting ratios for the five indicators have been calculated above, and standardized data need to be weighted in order to obtain the relative strength of each country's annual wait.

For each country, construct a matrix Z for $i \times j$, with rows representing the number of indicators is "i", columns representing years, and organize matrix R as follows:

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1j} \\ r_{21} & r_{22} & \cdots & r_{2j} \\ \vdots & \vdots & \vdots & \vdots \\ r_{i1} & r_{j2} & \cdots & r_{ij} \end{bmatrix} \tag{12}$$

Weighted transformation of matrix R results in matrix B, in which wj represents the weight of each indicator. It is important to note that for indicators with negative effects, W_j takes a negative(-) value, and for indicators with positive effects, W_j takes a positive(+) value.

$$b_{ij} = r_{ij} \cdot W_i \tag{13}$$

$$B = \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1j} \\ b_{21} & b_{22} & \cdots & b_{2j} \\ \vdots & \vdots & \vdots & \vdots \\ b_{i1} & b_{j2} & \cdots & b_{ij} \end{bmatrix} \tag{14}$$

For each country's j year climate relative, t_j is the sum of the elements in the "j" row of the B matrix.

$$t_j = \sum_{i=1}^{n} b_{ij} \tag{15}$$

At this point, we have been able to use the selected indicators to obtain the corresponding climate judgment values. The larger the value of the climate judgement, the better the quality of the climate environment, that is, there is a positive correlation between the outcome of the climate judgement and the quality of the climate environment. But the model's calculations have no baseline value, and the judgment used by the analysts can only be used to analyze the trend of climate change from year to year. It is still impossible to determine whether the climate of the year meets the good standards, and it is difficult to really provide constructive reference for the government's means of protecting the environment. **Therefore, we decided to judge the quality of the climate environment by calculating the distance of ideal solution and then determining the closeness of the data.**

First, the weighted matrix B is used to determine the optimal solution and the worst solution of the evaluation index, which are as follows:

$$Z_i^+ = \left\{ Z_i^+ = \max_{i \le j \le n} Z_{ij}, i = 1, 2, ..., n \right\} \tag{16}$$

$$Z_i^- = \left\{ Z_i^- = \min_{i \le j \le n} Z_{ij}, j = 1, 2, ..., n \right\} \tag{17}$$

Then the elements in matrix B are calculated to the optimal and inferior distances of D + and D -:

$$D_j^+ = \sqrt{\sum_{i=1}^{n}(Z_{ij} - Zi^+)^2} \tag{18}$$

$$D_j^- = \sqrt{\sum_{i=1}^{n}(Z_{ij} - Zi^-)^2} \tag{19}$$

If the relative proximity of each element to the optimal solution is closer to 1, the environmental quality of the evaluated object is better. Conversely, the environmental quality of the evaluated object below 0.5 means it is in urgent need of improvement. At the same time, the relative closeness can achieve the same effect as the climate judgment value, which can be used to quantify the trend of climate environment change year by year.

$$C_j = \frac{D_j}{D_j^+ + D_j^-} \quad j = 1, 2, ...n[6] \tag{20}$$

5 Case Tracking: Model Application on Different Countries

The health of the economy is determined by environmental factors and other factors together. However, since we are comparing GDP and GGDP this time, and the difference between GGDP and GDP lies in environmental resources, other factors have the same impact on GDP and GGDP, so other factors can be ignored as irrelevant variables in the analysis. Therefore, when studying this problem, we assume that environment plays a decisive dominant role in measuring economic health. **Therefore, considering the relationship between GGDP and economic health is equivalent to considering the relationship between GGDP and environment.**

We hope to judge the advantages and disadvantages of GDP and GGDP by analyzing the relationship between them as indicators of national economic health and the overall national economy and natural resources, and predict the impact of two different indicators on future economic development, so as to determine which indicator should be used as the international unified standard at present.

According to the above data processing, we have obtained the measurement index of ecological environment as the independent variable and the data of GDP and GGDP as the dependent variable. Because the difference between the calculation formulas of GGDP and GDP lies in whether the impact of natural resources is taken into account, **we can find that GGDP is correlated with environmental conditions, and so is GDP.**

We hope to study the specific relationship between the independent variable and the dependent variable, but there are many results obtained by the ordinary linear regression method, and it is difficult to make accurate prediction for the model with a large amount of data, so we adopt LASSO model to fit the data. The basic idea is that under the constraint condition that the absolute sum of the regression coefficients is less than a constant, the residual sum of squares is minimized, so that some regression coefficients strictly equal to 0 can be generated, and then the fitting line between them can be obtained.

The process of determining the regular term coefficient alpha in Lasso model:

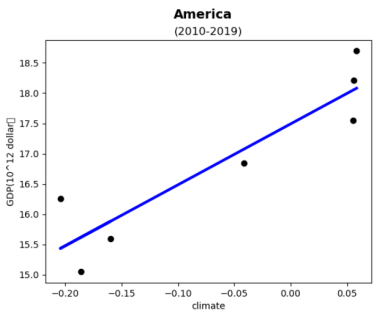
> Introduce the evaluation function Score (x, y), and the result is the determination coefficient R^2 of linear regression.

The specific parameter adjustment method is as follows:

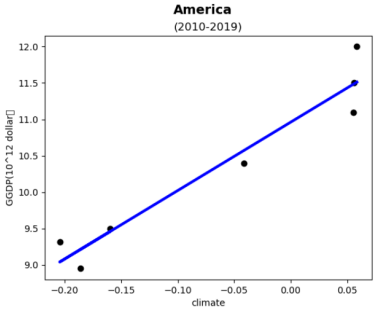
1. Give a value with a smaller alpha, such as 0.1.
2. Increase or decrease the parameter value by 10 times according to the accuracy of verification set (mainly observing the value of R^2).
3. After finding the appropriate order of magnitude, fine-tune the coef_ on this order of magnitude based on the standard (coef_ corresponds to the coefficient of each feature of X, the closer the absolute value is to 1, the stronger the correlation will be, until the more appropriate coef_ is found), such as: [0.001,0.01,0.1,1,10,100]

Next, we will show the fitting results and make a comprehensive analysis to draw a conclusion.

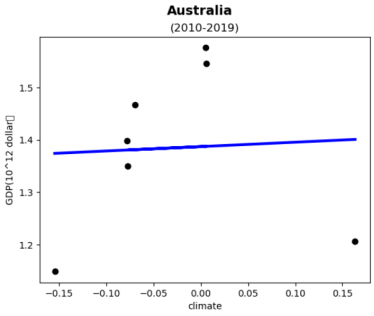
5.1 Analysis on Models of Different Countries



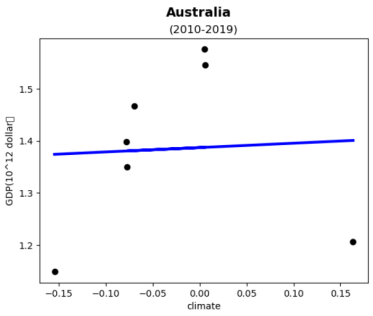
(a) America GDP-Environment



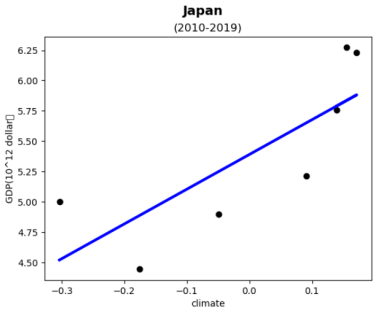
(b) America GGDP-Environment



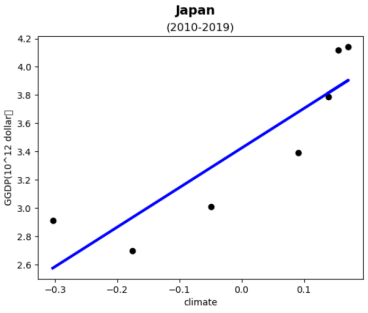
(c) Australia GDP-Environment



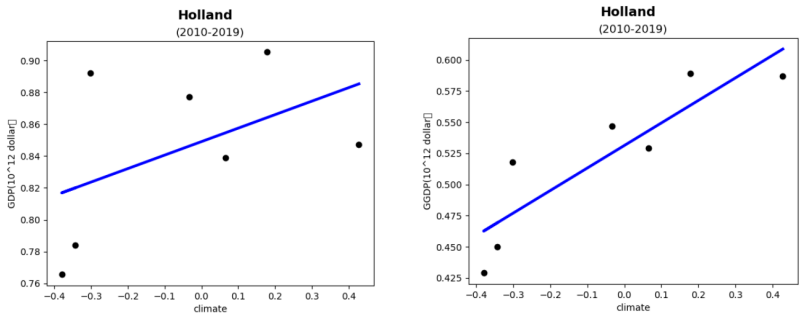
(d) Australia GGDP-Environment



(e) Japan GDP-Environment



(f) Japan GGDP-Environment



(g) Holland GDP-Environment (h) Holland GGDP-Environment

Figure 3: GDP-Environment and GGDP-Environment models of different countries

The above eight fitting lines are GDP-Environment and GGDP-Environment models of four countries, and we can find the following findings:

- The value of GGDP has been lower than GDP in the short term, and the growth rate of GGDP is more gentle compared with the growth rate of GDP in the same period.
- The linear slope of GGDP and environment is significantly greater than GDP, and the dispersion degree of GGDP data points is smaller than GDP.
- Except for Japan, in years with high GDP, the horizontal coordinate of other countries is more inclined to the left, which proves that most countries will sacrifice the natural environment in exchange for economic benefits when taking GDP as the development indicator.

5.2 Conclusions Based on Models

According to the above findings, the first conclusion is that GGDP presents a significant positive correlation with environmental conditions, and the obtained linear slope is larger, while the correlation between GDP and environmental conditions in recent years presents a significantly lower slope than GDP. Therefore, we can draw a conclusion that long-term use of GDP as a measurement indicator will make the early warning effect not obvious, and combined with the analysis of the obtained data, it will also lead to the gradual deterioration of the environment. On the contrary, GGDP can well reflect the current ecological situation, send a strong early warning to the national government in time, and effectively curb the development of environmental problems to a serious direction. On the other hand, observing the degree of dispersion of data points in the figure, the linear correlation between GGDP and environmental conditions is much stronger than GDP. **Therefore, the connection between GGDP and environment is closer, which confirms our conclusion above.**

However, if the GGDP is used as a measure, the source of the national economy will be reduced as the over-exploitation of natural resources is prevented, resulting in the national economy being lower than when GDP was used. We will answer this question based on the analysis of the data.

According to the analysis of the image, using GDP as an indicator, there is a high probability that the current natural environment will be damaged and the ecological condition will gradually deteriorate. Above, we have analyzed the main factors affecting the environment, including mineral resources, energy, water resources, forest resources and other essential basic conditions for economic

development. Taking ecological destruction as an auxiliary means of economic development may lead to a significant increase in GDP in the short term, but from a longer term perspective, such measures are bound to lead to a substantial reduction in the country's economic sources, making the country's development prospects bleak. On the contrary, using GGDP as a necessary indicator to measure whether the economic development is healthy can slow down the growth of the national economy in the short term, but can keep the sustainable and stable development of the country. According to the calculation formula of GGDP mentioned above, with the enhancement of the protection of natural resources, the consumption of natural resources and the cost of environmental governance will be greatly reduced, and the value of GDP itself will gradually increase with each year. **As a consequence, in the end, GGDP will always maintain growth in the long run, and the growth rate will rise year by year.** In comparison, GGDP is a wise choice for now.

6 Treatment Plan: Case Study on the GAS in Brazil

6.1 The Analysis of Current System

Based on the data found in the database and our analysis using the TOPSIS model above, here are the results:

	CDE	MRCR	ELR	TAFW	FCR
Weight	0.2830	0.0665	0.0392	0.1540	0.4570

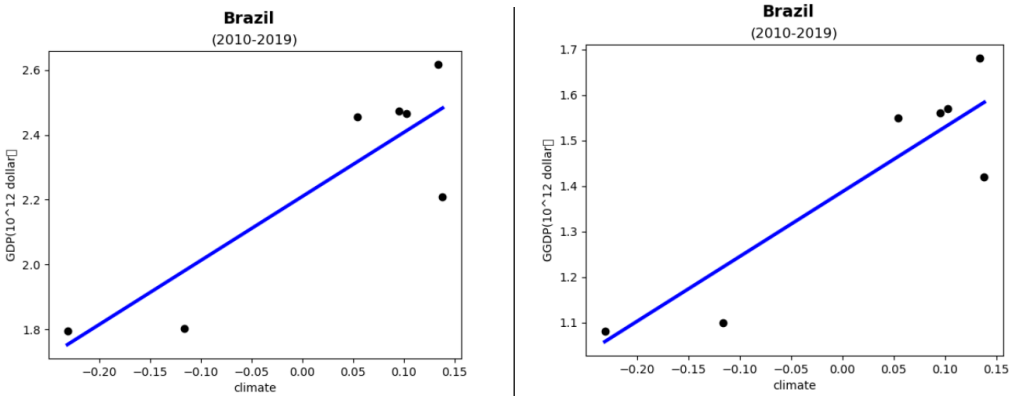
According to the model of GGDP - climate environment model, we found that the Brazilian government has been destroying the natural environment on a large scale due to the gradual deterioration of the economic situation in recent years, when it is difficult for the national policy to macro-regulate the economy to make it positive. The parameters for measuring the environment have been gradually reduced from 0.05 to around -0.3, and there has been no trend for the better. At the same time, without considering the overexploitation of environmental resources, Brazil's GDP showed a relatively large downward trend in the period 2017-2019, which shows that the policies currently adopted by Brazil to destroy the ecology in order to achieve economic development goals have not achieved substantial results. While the long-term use of GDP as an indicator of the health of the country's economy can be difficult to detect errors in current economic development and lead to irreversible deterioration of the economic situation after severe damage to the climate environment in the future.[7]

6.2 Our Vision and Comparison

On the basis of these considerations, we hope to be able to use GGDP as an indicator of the health of the country's economy so that Brazil can achieve sustainable and stable growth in the long run. In order to get a more direct view of the current economic development of the country, the actual advantages and disadvantages of the climate environment, we used the TOPSIS model to calculate the C.R. to have a deeper consideration.

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
America	C.R.	0.347	0.486	0.496	0.43	0.398	0.384	0.393	0.433	0.410	0.441
Japan	C.R.	0.370	0.366	0.361	0.367	0.448	0.602	0.478	0.488	0.435	0.340
Brazil	C.R.	0.405	0.400	0.391	0.359	0.409	0.451	0.515	0.519	0.464	0.387
Australia	C.R.	0.377	0.475	0.389	0.394	0.458	0.421	0.358	0.368	0.364	0.376
Holland	C.R.	0.337	0.378	0.408	0.440	0.394	0.490	0.478	0.507	0.486	0.457

Before 2017, when Brazil's economy was flattening out, the value of the country's C.R. is about 0.5, and the protection of rainforest and other natural resources is sufficient and the development level is suitable. But after 2017, there is a significant decrease in the value of C.R., with a significant deviation of 0.5 points, which supports the conclusion above, obtained through the State of the Climate Environment Model, that the climate environment in Brazil has been damaged in recent years. Thus, C.R. numbers can indeed be used to determine trends in the development of environmental resources in recent years, as well as to analyse the extent of damage to the environment in that year in order to ensure sustainable economic development. According to the model, there is a positive correlation between the value of GGDP and environmental resources. If we use GDP as a measure, then we know from projections that the environment will improve dramatically in the future. According to the GGDP formula chosen by us, the improvement of environmental quality will greatly reduce the consumption of natural resources and the cost of environmental governance. This means that the increase in the GGDP indicator will enable Brazil to improve its economic situation while achieving sustainable social development.



(a) Brazil GDP-Environment (b) Brazil GGDP-Environment

Figure 4: GDP-Environment and GGDP-Environment models of Brazil

6.3 Treatment Plan: Our Targeted Policies

On the basis of the above analysis of the Brazilian situation, we hope that policy changes will promote the Brazilian economy to develop positively. At the same time, the results of all policy implementation are evaluated by the C.R. of the year. and GGDP, for environmental and economic assessments, respectively.

- **Policy 1:** We hope that the country could change the general approach of the State to regulating the economy and to reduce or even prohibit excessive exploitation of natural resources. And set other economic policies to seize opportunities for global growth, rather than just solve the problems of the moment, which would darken the prospects for national development.

- **Policy 2:** After analysing the positive factors affecting the environmental climate, we found that forest cover rate has a great impact. Therefore, we hope to enhance the protection of rainforest resources, stop the large-scale deforestation of the rainforest, and avoid its conversion into an industrial rubber zone in the future, re-establishment of natural resource protection areas to increase Brazil's forest cover.

- **Policy 3:** After analysing the negative factors affecting the environmental climate, we found that carbon dioxide accounts for the largest weight of emissions. Therefore, we hope to improve the energy structure and increase the usage rate of new sources of energy in order to reduce domestic consumption of energy and mineral resources, such as oil. At the same time, as a result of the optimization of the energy structure, the country's economic income can be effectively increased by increasing the amount of oil available for sale on the international market, owing to the fact that the total amount of oil extracted is essentially constant and domestic consumption has decreased.

6.4 The Real-World Difficulties and Solutions

- **Difficulty 1:** The use of GGDP as an indicator of development may lead to the reduction or even disappearance of some of the country's original sources of economic income, which in a short period of time may worsen Brazil's economic situation and make it difficult to maintain the normal functioning of the country.

  Solution: In the early stages of using GGDP as a measure, restrictions on the exploitation of natural resources could be gradually increased in the light of Brazil's current economic situation, leaving a buffer period for the country's economic transition. Moreover, in large part, the imbalance in the country's economic development was due to errors in economic decision-making by the Government, which needed to reorient itself in the right direction, rather than simply using natural resources to fill the economic gap.

- **Difficulty 2:** The use of GDP as an indicator of development may make it difficult to implement policies owing to restrictions or bans on some activities to exploit natural resources, as well as resistance from some businesses and individuals.

  Solution: Though activities to exploit natural resources are limited, natural resources can be relied upon to develop sustainable industries, provide a direction of change for businesses and create new jobs for practitioners. For example, the restoration of the former rubber industrial park as a rainforest resource reserve will allow for the development of automated agriculture centred on cash crops, which will continue to fill the country's economic gap while protecting the environment.

6.5 Letter of Recommendation

Dear president,

Our society is making rapid progress. In the past, we have made full use of all kinds of resources of the country: human resources, social resources, environmental resources, etc., which have brought prosperity to our lives. However, with the passage of time, the era of heavy industry with no restrictions on development has passed away. We should pay more attention to how we can develop the country's economy in a sustainable and efficient way while protecting the environment. And the fact that we still use GDP as a key indicator of the health of the national economy could have unpredictable consequences for the long-term future. Therefore, we recommend that countries switch to a new measure of GDP.

Based on a study of climate ,GGDP and GDP in several countries in recent years, we found that the vast majority of countries' recent GDP growth has been based on gradual environmental damage. In the short run, using GDP as an indicator could lead to a significant increase in our economy, but the results of the fitted data suggest that the scarcity or even depletion of natural resources in the future will have an irreversible and devastating impact on the country's economic development, and people's living conditions will deteriorate dramatically.

Compared with GDP, using GGDP as an indicator is an effective way to avoid this. In the traditional GDP calculation method, the consideration of natural resources is increased, such as the consumption of natural resources and the expenditure of environmental governance. Our research shows that there is a clear link between GGDP and environmental resources, and we can calculate GGDP to reflect the current state of the country's environment while reflecting the level of economic development, so as to choose appropriate policies to guide the country's development according to the trend of environmental development. The results show that the environmental resources of most countries are at a relatively poor level and are still deteriorating year by year. It is urgent to adopt GGDP as an indicator.

We really appreciate it that we have the opportunity to exchange ideas on national economics. We really want to be able to use GGDP to make our country more prosperous. If you have anything confused about GGDP, please feel free to ask us!

Yours sincerely,

MCM 2023 Team

7 Strengths and Weaknesses

7.1 Strengths

1. In order to solve the regression model of GGDP and climate, we used the traditional least square method for fitting at the beginning, but found that the simple use of least square method was easy to cause overfitting, that is to say, the complexity of the model was too high. The fitting effect for the training set was very good, but the fitting effect for the test set was obviously relatively poor. Therefore, we refer to relevant literature[8]. After that, we used Lasso regression model. By introducing the regular term coefficient alpha to punish the model with high complexity. Although the model is not accurate in fitting the training set, it is obviously better in fitting the test set, which reflects better generalization of Lasso regression model.

2. The consideration of model indicators is mainly objective and comprehensive . We selected five indicators to measure the climate environment, each representing a category of impact factors and including both positive and negative factors, such as forest cover rate and carbon dioxide emissions. Five objective indicators make it more accurate to judge the health of the economy.

3. The model algorithm is suitable for selection. By using the TOPSIS hierarchical analysis method, the weight is first considered subjectively, then the weight is rationally examined by the consistency judgment, so that the proportion of each influencing factor is very reasonable, so that the data results are more accurate.

4. Innovative use of AHP algorithm models. By using the AHP algorithm model, the climate environment factors which are difficult to quantify can be visualized by using data and weighted computation, which provides a predictive basis for the future development of environmental resources. It also makes it well documented to judge the environment as a whole.

7.2 Weaknesses

1. The selection of model indicators is somewhat crude. Positive factors are taken into account but are too small, and indicators are somewhat narrow in scope, with no stratification of indicators, making the use of the TOPSIS model insufficient. The relationship between GDP and the climate should be clearer.

2. The amount of data in the country is not large enough. Although we have selected five countries with different characteristics for the study of the relationship, there are insufficient data sources, too few countries, a lack of statistical significance, and a lack of convincing.

3. Environmental factors other than climate are ignored. Because of the lack of data for quantitative analysis of the environment, we equate climate factors with environmental factors for the efficiency of the analysis. But there was a difference in practice, which may have contributed to some errors in the final results, which were not very satisfactory.

4. We assume that the economic situation of the country will be relatively stable for a long time. The assumption is that there will be no major upheaval leading to large and unusual changes in the country's economy. Although events such as disasters still occur from time to time, on

a global scale, international Since the economic development situation is relatively stable and occasional events will not change the overall trend of future development, it is useful for us to establish models to forecast some of the data in the future.

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8 Appendices

Input Python Source:

```
#Import computing and drawing libraries such as numpy, pandas, and matplotlib
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
from sklearn import datasets, linear_model
from sklearn.metrics import mean_squared_error, r2_score

# Reading a csv file
csv_path = r'file_path'
df = pd.read_excel(csv_path,index_col=0)

# Slice the first and second rows of data
x=df.iloc[0]
y=df.iloc[1]

# After slicing, the data is converted into dataframe object, which will be
                                        converted into two-dimensional array for
                                         fitting calculation into the model
x=x.array.reshape(-1, 1)
y=y.array.reshape(-1, 1)
# Divide the data set into a training set and a test set
x_train=x[:-3]
x_test=x[-3:]
y_train=y[:-3]
y_test=y[-3:]


"""Call the linear regression model in sklearn library (Lasso regression model)
Adjust parameters: Set a small initial value for alpha, then adjust the value of
                                        alpha according to the values of R^2 and
                                         coef_ coefficient"""
regr = linear_model.Lasso(alpha=0.01, fit_intercept=True, normalize=True,
 precompute=False,  copy_X=True, max_iter=1000,tol=1e-4,
 warm_start=False, positive=False, random_state=None,
 selection='cyclic')
regr.fit(x_train,y_train)
# Make predictions on the test set and check for errors
y_pred = regr.predict(x_test)
print(' coefficient: \n', regr.coef_)
# Outcome evaluation
print(' Mean square error: %.2f'
% mean_squared_error(y_test,y_pred))
print(' Coefficient of determination (R^2): %.2f'
% r2_score(y_test, y_pred))

fig = plt.figure()
# Add a subgraph of type 1*1
ax=fig.add_subplot(1, 1, 1)

# Set the title of the entire chart
```

```
fig.suptitle('Country', fontsize=14, fontweight='bold')
# Sets the label of the subgraph
ax.set_title("(2010-2019)")
# Set the X and Y axis labels
ax.set_xlabel("climate")
ax.set_ylabel("GGDP(10^12 dollar)")

# drawing
plt.scatter(x_test, y_test,  color='black')
plt.plot(x_test, y_pred, color='blue', linewidth=3)
plt.show()
```