Research on the Interaction between Economy and Environment Based on GGDP

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Abstract. In the context of an increasingly severe global climate, GDP cannot attribute natural resources to natural resources. However, the GGDP can reflect the interaction between the economy and the environment. Therefore, we first use the entropy weight method to establish a climate change index model to measure the global GGDP, and then use principal component analysis and multiple regression method to establish a model of the impact of GGDP on climate change and predict the trend of GGDP. Finally, the potential advantages and disadvantages of climate release after the use of GGDP are discussed.

Keywords: CTPBS model, Pearson analysis, Holt Exponential Smoothing Method.

1. Introduction

In today's society, GDP is the most commonly used indicator to measure a country's economic health. With the progress of science and technology, the productivity has been greatly improved. The simple pursuit of rapid GDP growth has brought tremendous benefits to mankind, but also caused us to pay the huge cost of resources and environment.

Therefore, the scientific nature of traditional GDP index has been questioned more and more. As traditional GDP is a gross index that focuses on economic accounting, it fails to include resource and environmental factors and cannot fully reflect the real situation of social development, which runs counter to the concept of sustainable development of economic society. Therefore, GDP accounting has serious shortcomings.

Green GDP, on the other hand, includes environmental factors and sustainability factors. It deducts the cost of resource consumption and environmental loss caused by economic development on the basis of GDP. Therefore, it reflects the interaction between economy and environment to some extent, and is one of the most important indicators reflecting sustainable development.

2. GGDP accounting model based on SEEA

2.1. Construction of GGDP accounting index system

Globally, the United Nations SEEA accounting system is generally adopted as the framework for green GDP accounting. Here, the calculation method we choose takes Natural resources depletion cost, Environmental quality degradation cost and Resource and environment After comprehensive consideration of improvement benefits, the following GGDP accounting model is obtained:

$$GGDP = GDP - COST_{Resources} - COST_{Environment} - SAVE_{Resources-Environment} \tag{1}$$

$COST_{Resources}$ represents 'Natural resource depletion cost', $COST_{Environment}$ represents 'Environmental quality degradation cost', $SAVE_{Resources-Environment}$ represents 'Resource and environment improvement benefits'.

2.2. Accounting methods of GGDP

2.2.1 Natural Resource Depletion Cost

$$COST_{Resources} = NrDCc + NrDCf + NrDC\omega + NrDCe + NrDCm \quad (2)$$

Among them, $COST_{Resources}$ represents Natural Resource Depletion Cost, $NrDCc$ represents Cultivated Land Depletion Value, $NrDCf$ represents Forest Resource Depletion Value, $NrDC\omega$ represents Water Resource Depletion Value, $NrDCe$ represents Energy Depletion Value, $NrDCm$ represents Mineral Resource Depletion Value.

2.2.2 Environmental Quality Degradation Cost

Environmental quality degradation cost refers to the cost to be paid when the natural conditions of various regions deteriorate, including the loss of environmental pollution control and the loss of natural disasters. Among the indicators of pollution control, three pollution control costs of air pollution, water pollution and solid waste pollution are selected for calculation. The specific calculation formula is as follows:

$$COST_{Environment} = \sum_{i=1}^{n} Q_i \times X_i \quad (3)$$

Q_i represents pollutant discharge， X_i is the unit treatment cost of pollutants， i represents pollutant i， n indicates that there are n pollutants in total (n=3 in this section).

2.2.3 Resource and environment improvement benefits

$$SAVE_{Resources-Environment} = AREA_{Forest} \times (\sum MASS_{\varphi} \times C_{\varphi}) \quad (4)$$

In top equations, $AREA_{Forest}$ is the area of Forest, $MASS_{\varphi}$ is the mass of gas absorbed or released per hectare of forest， C_{φ} is the economic value per ton of gas treated.

According to the U.S. Forest Service, each hectare of forest can absorb about 16 tons of CO2 per year, each hectare of forest releases about 12 tons of oxygen per year, and absorbs about 1.5 tons of SO2.

3. Climate change index model——CTPBS

To measure the impact of climate change, we introduced five specific indicators, namely temperature and precipitation outliers, extreme weather index, sea level and biodiversity. Then, their weights are calculated using the entropy weighting method to obtain the Climate Change Index (CTPBS).

Temperature (T) and Precipitation(P)

Climate is the general state of the atmosphere in an area over a period of many years. The World Meteorological Organization (WMO) sets the general climate calculation time at 30 years. Various statistics of meteorological elements are the basis for the expression of climate. Since temperature and precipitation are greatly affected by geographical factors such as longitude, latitude and altitude, we use the variability of climate variables to measure climate change.

We define the annual temperature outlier as α_1, the annual precipitation outlier as α_2, the annual standard deviation of temperature as σ_1 and the annual standard deviation of precipitation as σ_2. If the annual outliers α_i($\alpha_1$or α_2) exceed the mean standard deviation σ_i (σ_1 or σ_2)of the past 30 years, it indicates that the climate is changing. The degree of difference between the two reflects the magnitude of climate change. Based on this, we get:

$$Y_P(Y_T) = \begin{cases} e^{\beta_1|\alpha_i|} - 1, & 0 \leqslant \alpha_i < \sigma_i \\ \beta_2|\alpha_i| + \beta_3, & \sigma_i \leqslant \alpha_i \leqslant 3\sigma_i \\ \beta_4 ln|\alpha_i| + \beta_5, & 3\sigma_i \leqslant \alpha_i \leqslant 5\sigma_i \end{cases} \quad (5)$$

The model includes three parts: exponential distribution, linear distribution and logarithmic distribution. The purpose of this model is to show the influence of temperature and precipitation anomaly on climate. Since the function is continuous, the values are the same at the boundary, we can calculate the value of $\beta_1 - \beta_5$, the formula can be obtained by bringing these value back to the original formula:

$$Y_P(Y_T)=\begin{cases} e^{\frac{\ln 1.1}{\sigma_i}|\alpha_i|}-1, & 0\leqslant\alpha_i<\sigma_i \\ \frac{0.6}{\sigma_i}|\alpha_i|-0.5, & \sigma_i\leqslant\alpha_i\leqslant 3\sigma_i \\ \frac{0.3}{\ln\frac{5}{3}}ln\left|\frac{\alpha_i}{5\sigma_i}\right|+1, & 3\sigma_i\leqslant\alpha_i\leqslant 5\sigma_i \end{cases} \tag{6}$$

Explain: In the calculation of world weather indicators, we can calculate the abnormal values of different regions and countries to average, or we can directly use the world average temperature and precipitation data.

Biodiversity of native species(B)

Climate change may affect the living environment of organisms, destroy and pollute the habitats of organisms, cause the extinction of species and weaken the biodiversity. Therefore, species diversity is an important indicator of climate change and ecosystem evaluation.

$$B=\frac{D}{\sqrt{N}} \tag{7}$$

$$Y_B = 1\Big/\frac{D}{\sqrt{N}} \tag{8}$$

B is the species diversity index; N is the total number of individuals; D is the total number of species. In this model, we invert B to get YB for ease of calculation. Then, we normalize it so that it is between (0,1).

Sea Level(S)

$$Y_S=\begin{cases} \ln\frac{h}{\mu}, & Coast=1 \\ 0, & Coast=0 \end{cases} \tag{9}$$

μ is the annual global sea level growth in the 19th century (1.5mm), h is the annual sea level appreciation. Coast=1 indicates global or coastal countries, Coast=0 indicates landlocked countries.

Extreme Weather(E)

In the measurement of extreme weather, we use CO2 emissions as an important measure. Using 1990 carbon dioxide emissions as the base period and each year since then as a control, we get the following formula for calculating extreme weather:

$$Y_E=5e^{\frac{CO_2(t)}{CO_2(T)}}\times 4\% \tag{10}$$

In the formula, CO2 (t) represents the annual CO2 emissions; CO2 (T) represents the CO2 emissions in 1990; 4% represents the annual probability of extreme weather occurrence. Finally, Finally, we multiply by 5 to put this index between (0,1)

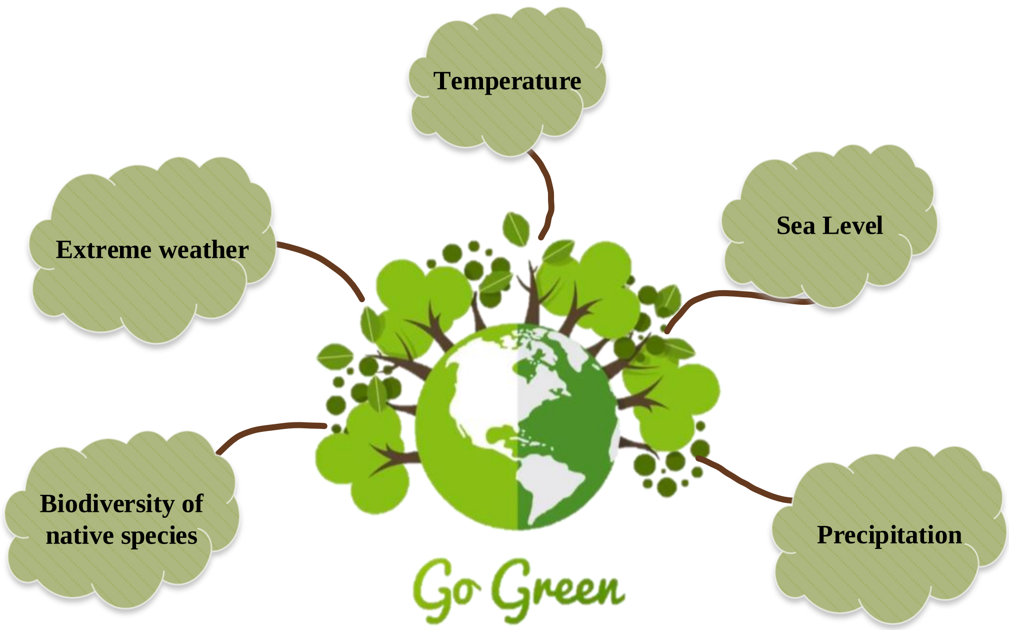

Fig 1. CTPBS model index selection

Using the above evaluation indicators, we further determine the weight of these indicators ω_i ,using the entropy weight method to exclude subjective factors, so as to get the combination of main indicators. The main idea of entropy weight method is to calculate the entropy weight of each index by using information entropy according to the dispersion degree of the data of each index. The greater the information entropy of the index is, the more information it will provide and the greater its role in comprehensive evaluation. The entropy weight method consists of the following steps:

1) Calculate the proportion of the index value of scheme *i* of the *j-th* index P_{ij}

$$p_{ij}=\frac{x_{ij}}{\sum_{i=1}^{n}x_{ij}}(j=1,2,\cdots,m) \tag{11}$$

2) Calculate the information entropy value of the J-th index measuring climate

$$e_j=-k\Sigma_{i=1}^{n}p_{ij}\ln p_{ij} \tag{12}$$

3) Calculate the information entropy redundancy of the index for the J-th term measuring climate

$$g_j=1-e_j \tag{13}$$

4) Calculate the weight of the J-th measure of climate

$$w_j=\frac{g_i}{\sum_{j=1}^{m}g_i} \tag{14}$$

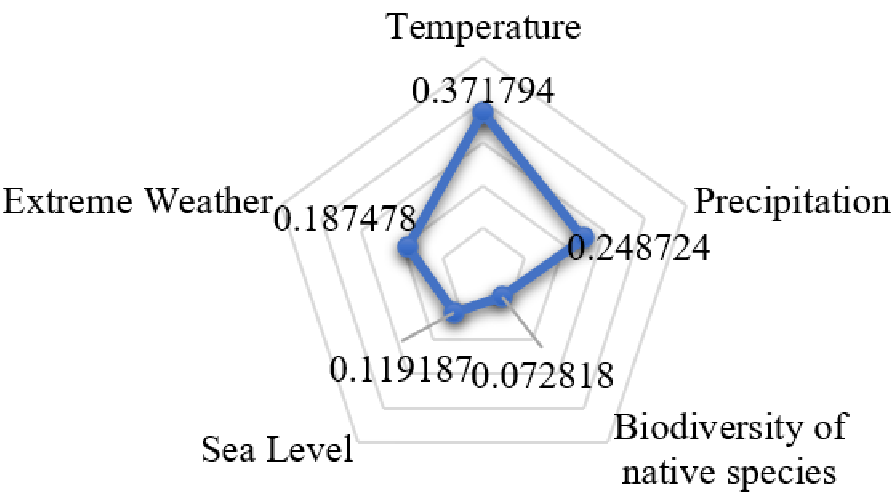

Fig 2. Weights of Indicators in CTPBS Model

After obtaining the weight of each indicator, we use the following formula to calculate the specific score of the climate index. Where, we multiply the original result by 10 to ensure that it is between (0,10).

$$Climate = 10 \times \sum_{i=1}^{m} \omega_i \times Y_i \tag{15}$$

4. The impact of GGDP on global climate mitigation

4.1. Mechanism analysis of climate mitigation by GGDP

Here, we selected the following indicators: pollutant emissions, forest area, energy transition investment, carbon dioxide emissions. The impact of GGDP on global climate is measured according to selected indicators. Since it takes a certain amount of time for all measures to take effect, we process the data one stage behind. Measures taken in 2010, for example, will affect the climate in 2011.

Next, we use Pearson analysis to study the impact of each index on climate change. The correlation coefficients are shown in the table below:

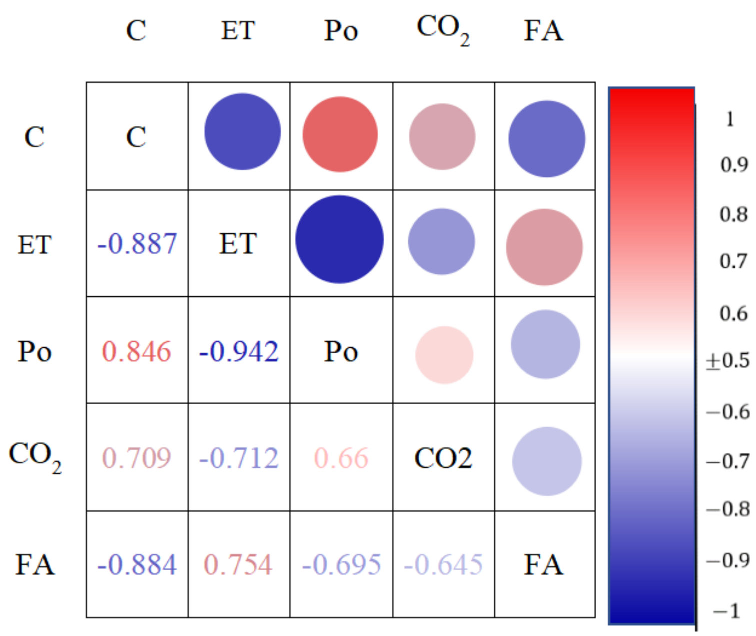

Fig 3. Pearson correlation analysis

We used SPSS for the above regression analysis. In the table above, C represents Climate, Po represents pollutant emissions, ET represents energy transition investment, FA represents Forest Area, CO_2 represents CO_2 emissions.

4.2. Regression model

Then, we developed regression model to measure the impact of environmental improvements on climate. Due to the strong correlation between the influence factors of climate factors, if the regression equation is directly established, part of the data will be lost. It will form the multicollinearity of the model, resulting in false regression, which is not conducive to our research. Therefore, we use the principal component analysis method to reduce the dimension of each factor, and transform the original variables with a certain correlation into a few comprehensive variables independent of each other, so as to retain the original information.

Table 1. Total variance interpretation

Numble	Initial Eigenvalue		Accumulation	Extract the Sum of Loads Squared		
	Total	PercentAge of Variance		Total	Percentage of Variance	Accumulation
1	3.212	80.299	80.299	3.212	80.299	80.299
2	0.396	9.894	90.194	0.396	9.894	90.194
3	0.340	8.494	98.687	0.340	8.494	98.687
4	0.053	1.313	100.000			

Table 2. Component score coefficient matrix

Composition	1	2	3
ET	0.298	0.523	-0.324
Po	-0.289	-0.742	0.534
FA	0.268	-0.119	1.492
CO2	-0.260	1.299	0.573

Table 3. General multiple regression results

	Unstandard Coefficient		Standardization Coefficient	t	Significance	95% Confidence Interval for β		Collinear Statistics	VIF
	β	SE				Lower limit	Upper limit	Tolerance	
(Constant)	2.998	0.032		93.308	0.000	2.925	3.070		
REGR factor score 1 for analysis 2	-0.257	0.034	-0.929	-7.665	0.000	-0.333	-0.181	1.000	1.000
REGR factor score 2 for analysis 2	-0.018	0.034	-0.064	-0.531	0.608	-0.094	0.058	1.000	1.000

Finally, we get the regression model as follows:

$$Y = 2.527 - 3.5 \times 10^{-6} ET - 9.44 \times 10^{-8} FA + 4.17 \times 10^{-6} CO_2 + 3.8 \times 10^{-5} Po \qquad (16)$$

4.3. Prediction of climate mitigation impacts using GGDP

We use the Holt exponential smoothing method to predict.

$$\hat{y}_{t+h|t} = l_t + h b_t \qquad (17)$$

$$l_t = a y_t + (1 - a)(l_{t-1} + b_{t-1}) \tag{18}$$

$$b_t = \beta \times (l_t + l_{t-1}) + (1 - \beta) b_{t-1} \tag{19}$$

We use this prediction method to predict the world's future carbon dioxide emissions, pollutant emissions, forest area and energy transition investment respectively.

We analyzed the efforts made by various countries to improve the GGDP after it was taken as the main indicator to measure a country's economic health. For example, reduce pollution emissions, moderately reduce fossil energy consumption, protect forests, increase investment in green innovation to increase the proportion of green industry in GDP, etc., so as to estimate the impact of GGDP on climate mitigation.

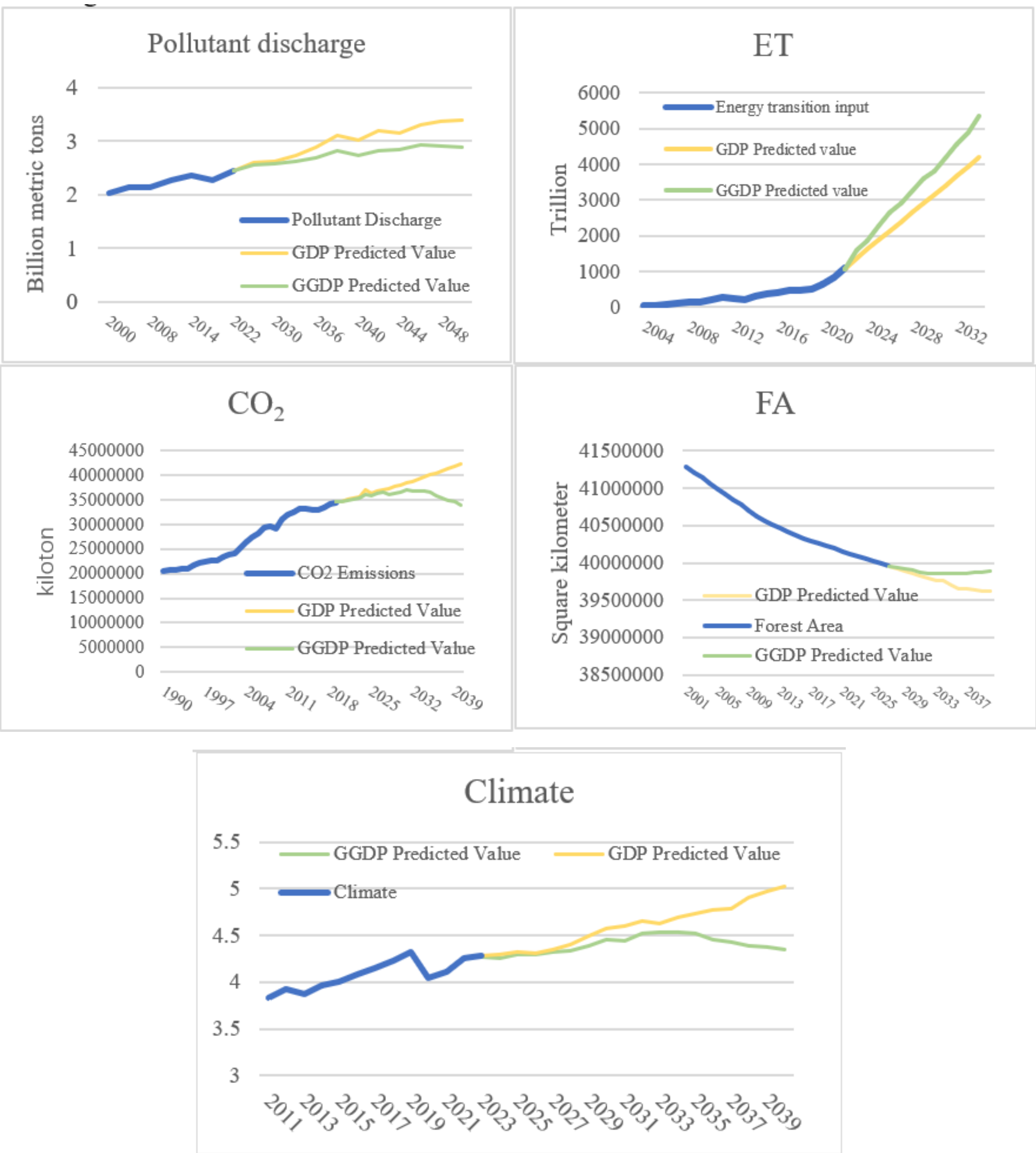

Fig 4. Climate index prediction

As can be seen from the figure above, when GDP is still used as the indicator of national economic health, the predicted pollutant emission and CO_2 emission will continue to maintain the original increasing trend, and the forest area will gradually decrease. However, when GGDP was used to replace GDP, the changes of the above four indicators all showed a positive trend.

5. Analysis of Advantages and Disadvantages of Using GGDP

5.1. Potential Upside of Climate Mitigation Impact

1) Alleviate the reduction in grain production
2) Reduce economic losses caused by natural disasters
3) Promote regional and world peace
4) Delay the rise of sea levels
5) Have a positive impact on human health

5.2. Potential Downside to Replace the Status Quo

1) Temporary Economic Downturn
2) Long-term Limitations of GGDP

6. Model Evaluation

6.1. Strengths

1) The GDP calculation method we choose is obtained by comparing with other methods and is more reasonable.

2) Our model takes into account five aspects: temperature, precipitation, sea level, extreme weather and biodiversity, which is very objective and comprehensive to describe climate change.

3) The data we collect is very comprehensive, so the analysis and prediction results are more accurate.

6.2. Weaknesses

1) Ignore some indicators, such as the impact of agriculture on climate change.

2) Ignore differences in climate and resources around the world and within countries may reduce model accuracy.

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