Analysis of Green GDP and Global Temperature Forecast Based on Time Series Model

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Abstract. GDP is the most well-known and widely-used indicator of a country's economic health. Yet, because the GDP does not include natural resources, it does not take environmental protection and resource utilization into account. Thus, green GDP should be considered a significant measure of a nation's economic health. Using principal component analysis, this research identifies several representative primary factors. Then, the relationship between the primary components, GGDP, and global mean temperature is studied, along with the impact of each factor on the temperature forecast for 2020–2040. A model for predicting the global temperature decline has been established. The results show that the probability of positive correlation between the positive growth rate of GGDP and the 50-year temperature change is 74%, indicating that: (1) GGDP can reflect the rule of temperature change, and its factor change is significantly correlated with temperature; The effect of greenhouse gases on ocean temperature is more significant. In different countries, the main variable as a percentage of GDP varies according to climate.

Keywords: GGDP · Global temperature prediction model · Sustainable development

1 Introduction

GDP represents the total market value of all final goods and labor services produced by a country or region's economy and reflects the positive features of national economic activities. But, the economic activities that produce these positive outcomes have resulted in varying degrees of damage to and strain on natural resources and the environment, with dire consequences. So, the negative consequences of economic activity should be subtracted from GDP when calculating the level of economic development, yielding green gross domestic product (GGDP) as a measure of national economic development. CGDP essentially shows the net positive impact of economic expansion. The GGDP/GDP ratio increases when the positive impact of national economic growth increases and the negative impact decreases, and vice versa.

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Table 1. Notations

Symbols	Definition
S_t	Total land area
$\overline{P}$	Average productivity
PCD	Depreciation of physical capital
NRD	Depletion of natural resources
ESI	Energy sustainable indices
IESI	Energy sustainable index
ELR	Energy yield

2 Notations

We list the symbols and notations used in this paper in Table 1.

3 GGDP Global Temperature Mitigation Forecast Model Based on IESI

This task constructed an IESI-based GGDP global temperature mitigation prediction optimization model, which was used to synthesize the corresponding values of various factors related to natural resources and describe the correlation between each factor and global temperature as well as GGDP and global temperature.

3.1 Model Principle

3.1.1 PCA

Principal component analysis can replace more new variables with fewer new variables, and it is these fewer new variables as much as possible to retain the original reflected information.

Steps of PCA algorithm:

1) The original data is composed of m rows and n columns matrix X by columns;
2) Zero average each row of X (representing an attribute field);
3) Find the covariance matrix $C = \frac{1}{m}XX^T$.
4) Find the eigenvalues and corresponding eigenvectors of the covariance matrix;
5) Arrange the feature vectors into a matrix from top to bottom according to the corresponding eigenvalues, and take the first k rows to form matrix P;
6)$Y = PX$, $Y = PX$ is the data after dimensionality reduction to k.

3.1.2 ARIMA

ARIMA model is a combination of autoregressive model, moving average model and difference model which is one of the methods of time series prediction and analysis. The symbol is ARIMA (*p*,,*q*).

Table 2. Factor load coefficient table

	Factor loading coefficient	Common degree
energy	0.93	0.865
forest	0.495	0.245
water	0.179	0.032
CO2	0.979	0.958

By combining AR(p) and MA(q), a general autoregressive moving average model ARMA(p,q) is obtained:

$$X_t = \alpha_1 X_{t-1} + \alpha_2 X_{t-2} + \ldots + \alpha_p X_{t-p} + \varepsilon_t + \beta_1 \varepsilon_{t-1} + \beta_2 \varepsilon_{t-2} + \ldots \beta_p \varepsilon_{t-p}$$

Analysis procedure

Before the grey prediction model GM(1,1) is established, the time series is tested by level ratio. If it passes the stage ratio test, it indicates that the sequence is suitable for constructing the grey model; if it fails the stage ratio test, the sequence is "translated", so that the new sequence meets the stage ratio test. The grey prediction model can only be judged reasonable after being tested, and only the model that passes the test can be used for prediction. The system mainly tests the grey prediction model through the posterior difference ratio C value.

3.2 Establishment of Global Temperature Mitigation Prediction Model

3.2.1 Principal Factor Selection

Through principal component analysis, a total of 14 secondary factors were screened for secondary dimension reduction, and the following 4 principal factors with characteristics were obtained (Table 2), (Fig. 1).

As can be seen from the above table and the figure above, there is no correlation between the four factors selected, indicating that these four factors can be used as the main variables for further analysis (Table 3).

According to the above table, the posterior difference ratio is 0.117, indicating that the model is highly accurate. The analysis shows that all of the original sequence's stage ratios fall within the range (0.962, 1.04), indicating that the original sequence is suitable for the construction of a grey prediction model. The model's average relative error is 0.99%, indicating that it has a good fitting effect.

3.2.2 Numerical Solution of Model

In view of the preliminary model obtained in problem 1, each factor is calculated first. The units are described as follows (Table 4).

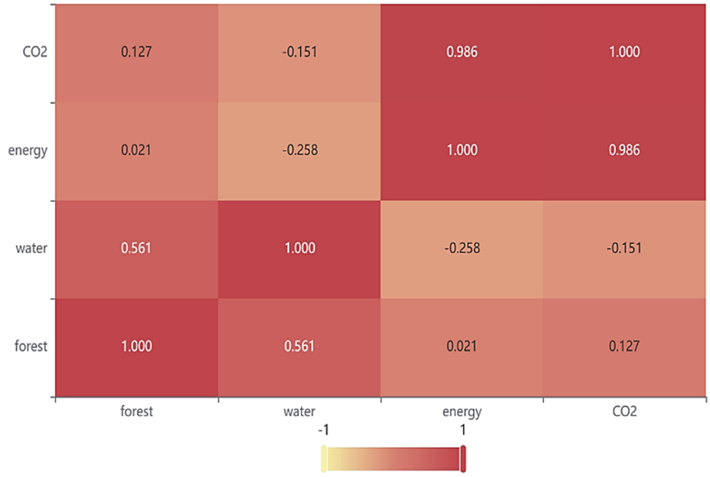

Fig. 1. Correlation coefficient heat map

Table 3. Grey model construction

Development coefficient A	gray action B	posteriori ratio C value
-0.002	13.753	0.117

Table 4. Model parameters of Tien Shan

Parameters	Country area	Land area	Agri land	GDP	Forest land
Value	$1000hm^2$	$1000hm^2$	$1000hm^2$	*Trilliondollars*	$1000hm^2$
Parameters	Inland waters	Glo water	CO_2 emiss ions	Oil prices	value added
Value	$1000hm^2$	$1m^3$	*ton*	$\$/ton$	*%ofGDP*

In the actual solving process, it is found that some factors have too little influence on GGDP, so the factors that account for less than 2% are eliminated, and the main four factors are respectively energy consumption, carbon dioxide emission, water resources utilization and wastewater treatment (as one item), and utilization of woodland and agricultural land area. The latest model is as follows: (Fig. 2)

$$GGDP = GDP - LD - (WRC + ST) - EC - \boldsymbol{CO_2}D$$

As shown in the graph, total energy consumption accounts for the greatest proportion of the four factors influencing GGDP, followed by carbon dioxide. As a result, more research into the relationship between these two factors and the impact of global temperature is required (Fig. 3).

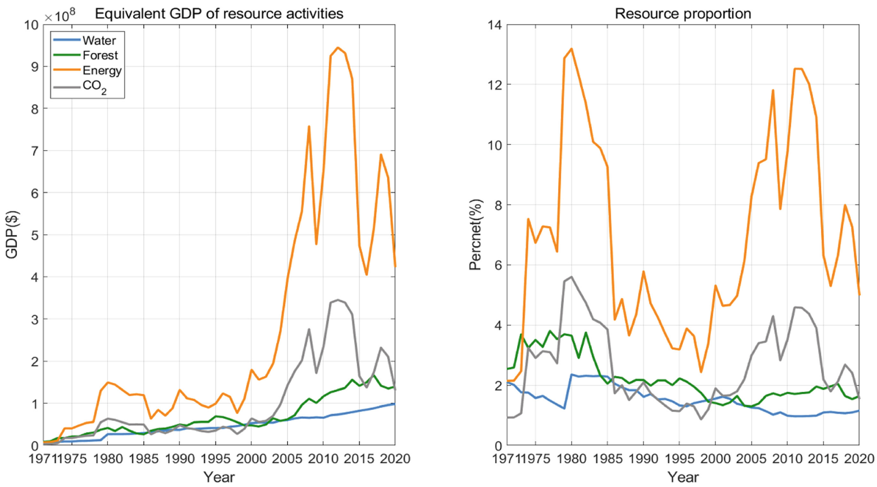

Fig. 2. Decadal distribution of sea surface temperature from 1990 to 2020

3.3 Results Presentation and Description

As shown in the graph above, the global average temperature is rising, while GDP and GGDP are slightly decreasing. According to this analysis, as global average temperature rises, GDP and GGDP fall. If the average temperature rises by 4 degrees Celsius, GDP will fall by about 1 percentage point, while GGDP will fall by 1.4 percentage point.

Many factors contribute to productivity loss, according to an analysis of many studies on the macroeconomic effects of temperature on human activities. These factors include: Human health suffers when temperatures rise. For example, there may be an increase in cases of heart disease in the United States, as well as an increase in deaths from dengue and malaria in some developing countries (Fig. 4).

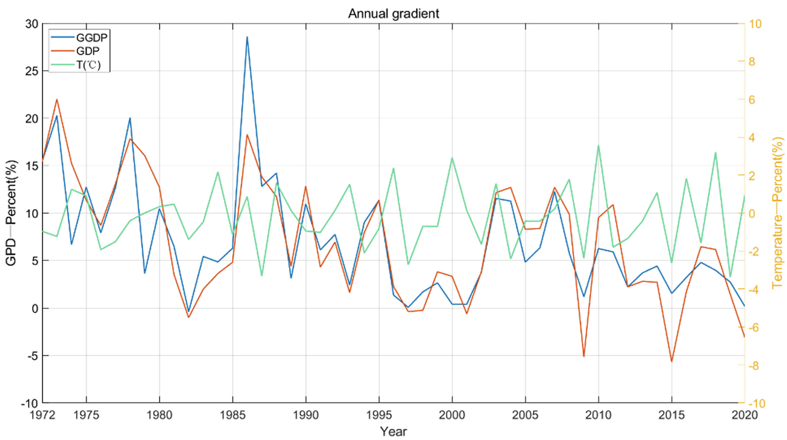

Fig. 3. Graph of the relationship between GGDP, GDP and temperature

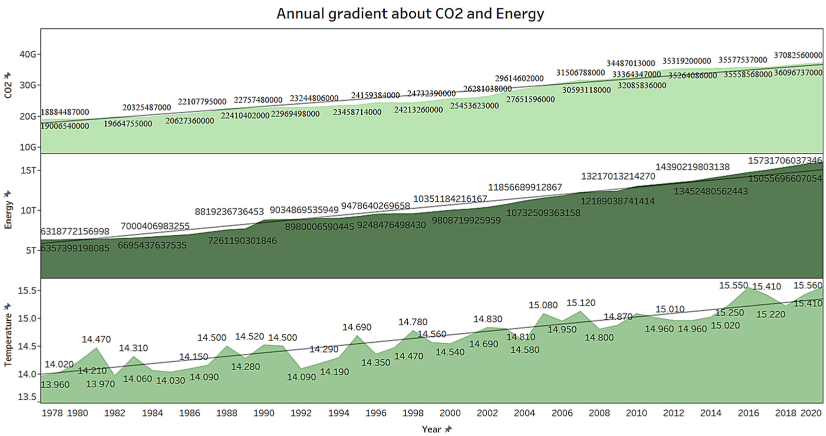

Fig. 4. The relationship between carbon dioxide content, energy use and global temperature

4 Conclusion

1. Global land temperature has been on the rise since 1970; And in the next 20 years, the ocean temperature overall will also increase.
2. With the change of years, energy consumption, carbon dioxide emissions and global mean temperature all show a steady rising trend, so it can be shown that global mean temperature has a strong positive correlation with the two main factors of natural resources in GGDP.
3. Excessive emissions of carbon dioxide have a certain impact on global climate change, and the forecast results show that carbon dioxide emissions will increase year by year in the future, which is consistent with the trend of global warming and the increasing difference between GGDP and GDP. Therefore, reducing excessive emissions of carbon dioxide is one of the important means to slow down global warming.
4. While the increase of CO2 concentration causes the dramatic rise or change of global temperature in different regions, the change of precipitation pattern will also lead to the increase or decrease of water resources in different regions, with a amplitude of about 10%; However, the absolute value of the correlation coefficient between energy consumption and global mean temperature is higher and correlated.

From the above results, the model of the expected global impact on climate mitigation established is reasonable, and therefore the GGDP can be used as the main measure of a country's economic health.

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