Environment, Resource and Ecology Journal (2023)
Clausius Scientific Press, Canada
DOI: 10.23977/erej.2023.070707
ISSN 2616-3756 Vol. 7 Num. 7

Establishment of Relationship Model between GGDP and Climate Based on Grey Method

Xiangyu Sun

School of Electronic and Information Engineering, University of Science and Technology Liaoning, Anshan, 114051, China

Keywords: GGDP, GDP, SEEA, Gray predictive model, Exponential regression analysis

Abstract: The aim of this paper is to develop a gray prediction model to predict climate impacts. Firstly, GGDP is accounted for through the asset-liability accounting method, i.e., resource depletion costs and environmental degradation costs are deducted from GDP. This is calculated by deducting the cost of environmental resources and the cost of environmental resource protection services from the current total GDP, i.e., GGDP = Traditional GDP - Resource Reduction Costs - Environmental Maintenance Costs. Second, to determine the use of carbon dioxide as a predictor, monthly global carbon dioxide emissions from 1959 to 2022 were collected from the National Bureau of Statistics of China. Then, based on the analysis of the intrinsic trend of the data and the series rank ratio test after the translation transformation, the use of the gray prediction model to predict carbon dioxide concentration was justified. Then, using the historical data fitting, the average relative error of the model is calculated to be 0.958%, which indicates that the model fits well and predicts that the carbon dioxide concentration in the coming year will increase from 411.372 ppm to 412.936 ppm on a monthly basis, paving the way for the prediction of global climate change. Finally, global temperature values were collected from NASA from 1992 to 2021. An exponential regression analysis was performed to analyze the temperature changes. The results show that the temperature shows a clear upward trend.

1. Introduction

1.1 Background

In recent years, the global climate is warming, the ecological environment degradation is serious and the sustainable development of all countries is also facing a great threat[1-3]. If only measure a country's economic health based on algorithms that calculate current production and do not consider the sustainable development of resources and the health of the ecological environment, continue to arbitrarily deprive natural resources and break the ecological environment, the living environment of human beings will eventually be seriously damaged. It can be seen that it is more important for countries to establish the concept of green development. As a result, countries can change the way they evaluate and compare economies to promote policies and programs that benefit the health of the planet's environment[4-6]. That is, "green" GDP (GGDP) is a good indicator to measure a country's economic health on the premise of protecting the environment and sustainable development[7]. It is an economy that values people and nature, it can significantly reduce environmental risks, and improve human well-being and social equity[8]. If countries can agree on this kind of GGDP and then launch a global movement to develop a green economy, then significant progress may be made in mitigating environmental aspects such as the climate crisis and promoting sustainable development, thereby promoting harmonious coexistence between people and nature and sustainable socio-economic development[9-12].

1.2 Problem Restatement

Based on the background information and constraints identified in the problem statement, it is hoped that the world will recognize GGDP as a major indicator of a country's economic health, what changes can be expected after using GGDP as an indicator and the impact of these changes on the environment. Then the following issues need to be addressed:

(1)Among the many recommended methods for calculating GGDP that have already been developed, choose one that your team believes could have a measurable impact on its subsequent climate mitigation.

(2)Using GGDP as a measure, build a simple model that is easily defendable to estimate the expected global impact of climate mitigation.

2. Solution of Problem 1

2.1 The Problem Background

GGDP is an indicator of the total amount of newly created real national wealth after deducting the loss of natural assets including resources and environment. It refers to the total value of all final products and services produced by all permanent resident units in a country or region in a certain period a time without reducing the existing capital and asset level, or the sum of the added value of all permanent residential units without reducing the existing capital and asset level. So far, GGDP accounting has only covered sustainable development in the natural sense, including the cost of environmental damage and the net consumption of natural resources.

2.2 Accounting Method of GGDP

Since March 2005, the National Bureau of Statistics and the State Environmental Protection Administration have carried out GGDP accounting pilots in ten provinces and cities including Beijing, and proposed the first "China Green National Accounting Research Report" Among them, there are two ideas for GGDP accounting, a total of five methods [1], summarized in Figure 1 below:

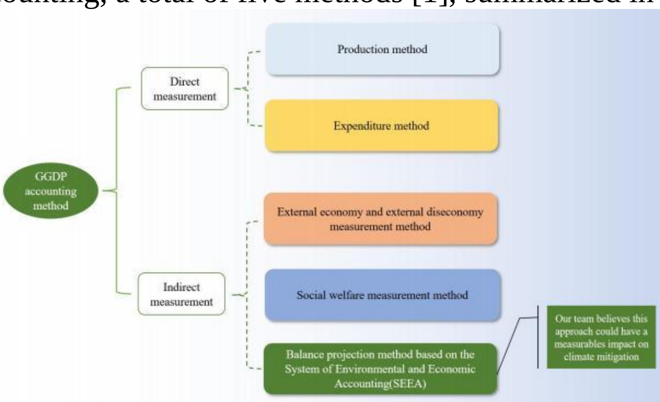

Figure 1: Accounting method of GGDP

These five approaches are clearly visible in the figure, where our team believes that balanced extrapolation based on the System of Environmental-Economic Accounting (SEEA) can have a measurable impact on climate mitigation.

2.2.1 Method I: Balanced Extrapolation Based on the System of Environmental-Economic Accounting (SEEA)

The method of accounting for GGDP through the asset-liability accounting method is as follows:

$$\text{GNDP} = \text{NDP} - \text{Non}-\text{productive Natural Assets used in Production} \;\; \text{NDP} = \text{Gross Output} - \text{Intermediate Inputs} - \text{Loss of Fixed Assets} \tag{1}$$

$$GGDP = GNDP + Loss\ of\ Fixed\ Assets \tag{2}$$

$$GNDP = (NE + Final\ Consumption + Net\ Capital\ Formation) - Net\ Consumption\ of\ No - Productive\ Economic\ Assets - Downgrading\ and\ Reduction\ of\ Natural\ Assets \tag{3}$$

This means deducting the environmental cost from GDP. So:

$$GGDP = Traditional\ GDP - Environmental\ Cost \tag{4}$$

Environmental cost include resource consumption cost, environmental degradation cost and environmental maintenance cost, but the cost of environmental degradation is mainly the cost of economic losses caused by environmental pollution caused by untreated and non- compliant discharges, but this part of the data cannot be found, therefore, it is ignored.

2.3 Results

The specific calculation method is to deduct the cost of environmental resources and the cost of environmental resources protection services for the total current GDP, namely:

$$GGDP\ Traditional\ GDP - Cost\ of\ Resource\ Reduction - Cost\ of\ Environmental\ Maintenance \tag{5}$$

3. Solution of Problem 2

The impact on the global atmosphere is mainly manifested in three aspects: ozone layer destruction, Global warming, acid rain corrosion. Select one air index as the main factor affecting the global atmosphere.

3.1 Method II: Analytic hierarchy and entropy weight method

(1)Collected from the A-AO and A-BP websites to 2009 worldwide, CH_4, CO_2, CO, N_2O, SF_6 five greenhouse gas data. The results are shown in Table 1 below.

Table 1: The content of five gases in 2009

Year	month	CH4	SF6	N2O	CO2	CO
2009	1	1748.81	6.5	322.08	385.07	71.17
2009	2	1746.38	6.54	322.35	385.49	65.78
2009	3	1762.65	6.6	322.52	386.4	78.15
2009	4	1766.74	6.62	322.25	385.42	80.55
2009	5	1756.26	6.58	321.57	384.62	66.51
2009	6	1756.28	6.57	321.33	385.39	63.49
2009	7	1763.37	6.63	321.75	385.88	68.45
2009	8	1765.91	6.68	322.16	386.28	75.95
2009	9	1763.56	6.69	322.26	386.39	85.77
2009	10	1757.25	6.69	322.31	386.37	82.56
2009	11	1753.92	6.72	322.46	386.8	73.49
2009	12	1752.76	6.76	322.65	387.01	72.58

(2)Averaging--Fill in the judgment matrix--Build a subjective evaluation matrix. The results are shown in Table 2 below.

Table 2: Judgment matrix

Index	SF6	CO	N2O	CO2	CH4
SF6	1	0.333	0.2	0.2	0.111
CO	3	1	0.333	0.333	0.143
N2O	5	3	1	0.5	0.143
CO2	5	3	2	1	0.2
CH4	9	7	7	5	1

(3) The weights of these greenhouse gases were analyzed using analytic hierarchy and entropy weights. The results are shown in Table 3 below.

Table 3: AHP hierarchy results

Index	Feature vectors	Weight value (%)	Maximum feature root	CI
SF6	0.272	3.429		
CO	0.544	6.865		
N2O	1.014	12.796	5.294	0.073
CO2	1.431	18.059		
CH4	4.663	58.851		

The weight calculation results of the analytic hierarchy method (square root method) show that the weight of SF6 is 3.429%, the weight of CO is 6.865%, the weight of N2O is 12.796%, the weight of CO2 is 18.059%, and the weight of CH4 is 58.851%. Draw Figure 2 below:

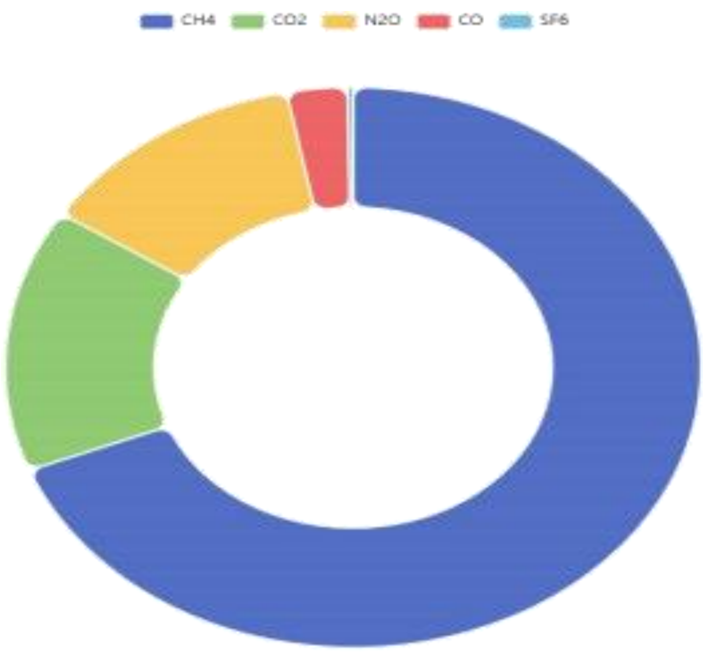

Figure 2: Five gas weight chart

(4)Use the consistency test to determine whether the constructed judgment matrix has logic errors, and if it fails, the judgment matrix needs to be reconstructed. The results are shown in Table 4 below.

Table 4: Consistency test results

Maximum feature root	CI	RI	CR	Consistency test results
5.294	0.073	1.11	0.066	Pass

The calculation results of the analytic hierarchy method show that the maximum feature root is 5.294, and the corresponding RI value is 1.11 according to the RI table, so CR = CI / RI = 0.066 < 0.1, which passes the one-time test.

(5)Further define the predictors

Through analytic hierarchy, methane is the most influential greenhouse gas, but according to data published by the IPCC, CH_4 GWP is 21 times that of CO_2, making it the second largest greenhouse gas after CO_2.

a) The total amount of CH4 is not as high as CO_2 emissions even if converted into 21 times that of CO_2.

b) CH4 does not last as long in the atmosphere as CO_2.

c) The production of CH4 mainly comes from coal, oil and gas systems, ruminants, etc., which is relatively scattered, difficult to centrally treat, and the cost of treatment is high.

However, countries are working very CH4 governance, the United States has proposed a CH_4 control plan, and China is also following up with China's CH4 control goals.

In summary, CO_2 is the most controllable factor affecting greenhouse gases, so CO_2 is used as a predictor of climate change(Figure 3).

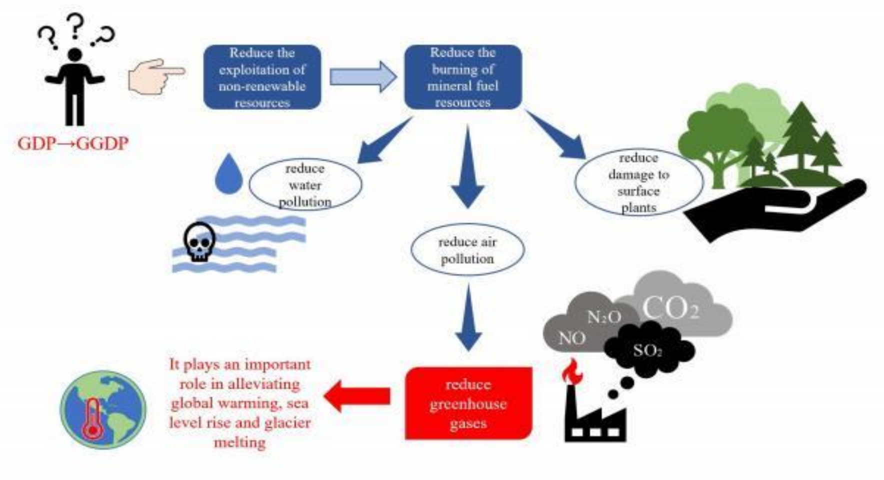

Figure 3: GDP to GGDP

3.2 Model I: Gray Predictive Model

In order to explore the trend of global carbon dioxide emissions and the trend of global warming before the adoption of GGDP, a forecast model is adopted:

(1)The grey prediction is made through the global carbon dioxide emissions during 1959-2022:

Before establishing the gray prediction model GM (1, 1), the time series is tested for the time series (because there are too many data and the table is too long, it will not be specifically shown in the article), if all the rank ratio values are located in the interval $(e^{(-2/(n+1)}, e^{(2/n+1)})$, the data is suitable for model construction. If the cascade test is not passed, the sequence is "translated transformed" so that the sequence after the translation transformation satisfies the cascade ratio test. From the data analysis in the table, it can be found that all the step ratios of the translated series are located in the interval (0.997, 1.003), indicating that the series after the translation transformation is suitable for constructing a gray prediction model.

(2) Build a gray prediction model

Table 5: Gray prediction model GM (1,1)

Development factor a	Gray action amount b	Posterior difference ratio C
0	1148.885	0.02

If the posterior difference ratio C< 0.35, the model accuracy is high. The analysis in the above table 5 shows that C = 0.02, so the model accuracy is high(Table 5).

(3) Fit the gray prediction model (there is more tabular data which is not shown in detail in this article)

Under normal circumstances, Normally, if the relative error value is less than 20%, the fitting is good. The average relative error of this model is 0.958%, which means that the model fitting effect is good.

(4)Model fitting prediction graph

According to the fitting table of the prediction model, the concentration of CO2 from 1959 to 2022 was obtained. This is shown in Figure 4.

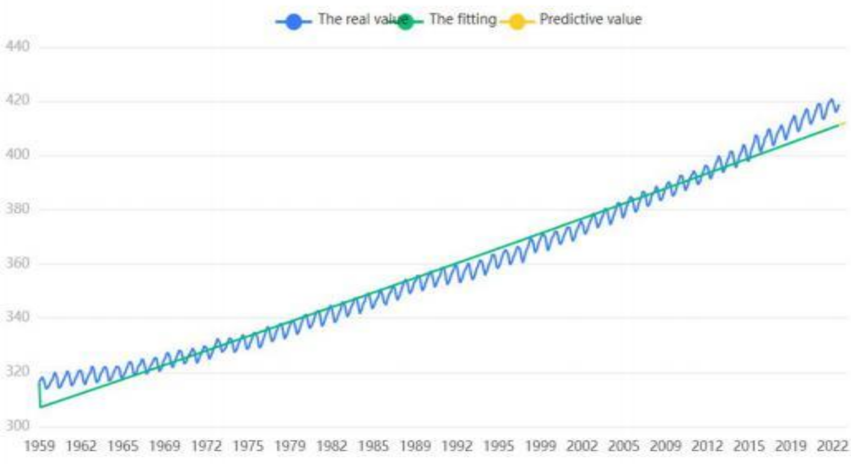

Figure 4. Model fitting prediction graph

(4) Model prediction results table

According to the forecast chart, the monthly CO2 concentration in 2023 is listed in Table 6 below:

Table 6: Table of model prediction results

Prediction order	Predicted value
1	411.372
2	411.514
3	411.656
4	411.798
5	411.941
6	412.083
7	412.225
8	412.367
9	412.510
10	412.652
11	412.794
12	412.936

It can be seen that carbon dioxide emissions continue to rise. If effective measures are not taken, CO2 emissions will continue to rise in the coming year. A greenhouse effect will result, leading to higher temperatures and eventually changes in the global climate. This series of phenomena will have an unpredictable impact on the economy and the environment.

3.3 Model II: Exponential Regression Analysis Model

An exponential regression analysis was carried out on the changes of land and ocean temperature indexes for consecutive 30 years from 1992 to 2021 [5] (code is in appendix). Plot the regression curve and find the regression equation: $y = 0.35e^{0.04x}$, y represents temperature, x represents the growth of the year. This is shown in Figure 5:

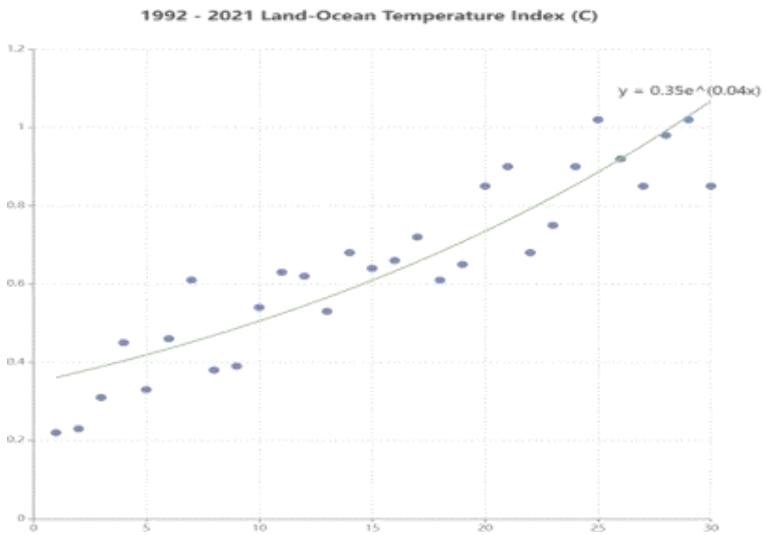

Figure 5: Temperature change plot

It can be seen from the figure 5 that the global land and ocean temperature is still in a clear upward trend.

Sum up, the climate problem is already a very serious problem in today's society and according to the forecast, GDP will continue to be used as a measurement indicator and the climate problem will further worsen in the future. Undoubtedly, this will inevitably bring unstable factors to society, hinder the positive development of society and break the healthy life of human beings.

3.4 Pollutant Emissions

Taking China as an example, some indicators of China's annual consumption of non- renewable resources in 2021 are selected as shown in Table 7.

Table 7: Table of China's main non-renewable resource consumption in 2021

Index	Consumption (10,000 tons)	Discount standard coal coefficient/kg	Standard coal (10,000 tons)
coal	404860	0.7143	289191.50
coke	48310	0.9714	46928.33
gasoline	12767.16	1.4714	18785.60
kerosene	3352.1	1.4714	4932.28
diesel fuel	14282.7	1.4571	20811.32
fuel oil	5364.6	1.4286	7663.87

According to the statistics of main indicators of non-renewable resource consumption, and then calculated by standard coal coefficient, China's consumption of standard coal for non-renewable resources in 2021 were 3,883, 129 tons.

Then, according to scientific calculations, burning 1 ton of standard coal will produce 2620kg of carbon dioxide, 8.5kg of sulfur dioxide and 7.4kg of nitrogen oxides. In 2021, China will consume 3,883, 129,000 tons of non-renewable resources equivalent to standard coal, producing 10. 173 billion tons of carbon dioxide, 33,006,600 tons of sulfur dioxide and 28,735,200 tons of nitrogen oxides. Global carbon dioxide emissions even reached 36.3 billion tons in 2021, dramatically accelerating global warming. In China, for example, if GGDP is adopted as the main standard, it will gradually replace fossil energy with new energy, ideally reducing billions of tons of carbon dioxide per year. The global use of GGDP to replace GDP can reduce tens of billions of tons of carbon dioxide emissions and other pollutant emissions which has a very large effect on climate mitigation.

4. Conclusions

The purpose of this paper is to develop a gray prediction model to predict climate impacts. First, GGDP is accounted for through the asset-liability accounting method, i.e., resource depletion costs and environmental degradation costs are deducted from GDP. This is calculated by deducting the cost of environmental resources and the cost of environmental resource protection services from the current total GDP. Second, to determine the use of carbon dioxide as a predictor, monthly global carbon dioxide emissions from 1959 to 2022 were collected from the National Bureau of Statistics of China. Then, based on the analysis of the intrinsic trend of the data and the rank-ratio test of the series after translational transformation, the reasonableness of using the gray prediction model to predict the CO2 concentration was demonstrated. Then, using historical data fitting, the average relative error of the model was calculated to be 0.958%, indicating that the model fits well and predicts that the carbon dioxide concentration will increase from 411.372 ppm to 412.936 ppm month by month in the coming year, which paves the way for predicting global climate change. Finally, NASA collected global temperature values from 1992 to 2021. An exponential regression analysis of temperature changes was conducted. The results showed a clear upward trend in temperature.

References

[1] Shifu Cheng, Liu Qian. Green GDP accounting and authentication [J]. Journal of statistics and decision, 2010, No. 324 (24): 7- 10.
[2] Scientific Platform Serving for Statistics Professional 2021. SPSSPRO. (Version 1.0. 11) [Online Application Software]. Retrieved from https://www.spsspro.com.
[3] Julong Deng. Grey Prediction and Grey Decision [M]. Wuhan: Huazhong University of Science and Technology Press, 2002.
[4] Jinlei Li. Green development calculation of Daihai Basin based on GGDP, GEP and GEEP [D]. Inner Mongolia University, 2021.
[5] Liang Xie. Research on the contribution of technological progress to Provincial Green GDP [D]. China University of Petroleum (Beijing), 2021.
[6] Jianping Zhu,Xiaoxiao Liu,Xianxin Jin, et al. Calculation of Environmental Degradation Cost based on GGDP and BP-Neural Network[C]//Wuhan Zhicheng Times Cultural De- velopment Co.,Ltd.Proceedings of 2nd International Conference on Business, Economics, Management Science(BEMS 2020). [publisher unknown], 2020:7.
[7] Merhaba Maraimeti, Enivar Nyjimu. Green GDP and green economy development in China [J]. China Commerce and Trade, 2013, No.597(36):142- 143.
[8] Lu Deng, Xiaodong Li, Chunxia He, et al. Study on Green GDP Accounting -- A Case study of Xinjiang from 2003 to 2009 [J]. Anhui Agricultural Science Bulletin, 2012, 18(16):30-34.
[9] Duogui Yang, Zhitian Zhou." International background of "green GDP" accounting and progress of China's practice [J]. Soft Science, 2005(05):27-30.
[10] Yan Zhang. Innovative industrial clusters and green economic development[D]. Dongbei University of Finance and Economics, 2021.
[11] Chao Tong. Reconstruction of theory and method of green GDP accounting[D].Shanxi University of Finance and Economics, 2020.
[12] Zheping Liang. Invalid GDP estimation based on the perspective of environmental pollution [D].Hebei University, 2015.