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Global Impact Analysis of Green GDP

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Abstract **– For a long time, ignoring the basic role of resources and environment has become a drawback of the national economic accounting system, the objectivity and authenticity of the accounting values. The lack of integration of resources and environment into the accounting system has made the existing national GDP questioned by academia and the international community, and cannot truly reflect the level of national economic development. Therefore, this paper constructs a green GDP accounting system on the basis of the traditional national accounting system and simulates the global impact of green GDP after replacing the traditional GDP. Taking global data as an example, firstly, we construct a global stagnant growth model with different demographic structures and analyze the future change trend of population size with different age structures under the influence of GDP and GGDP. Subsequently, the changes in the next 30 years are predicted based on LSTM. Then the future changes of temperature and diurnal carbon emissions were solved by constructing multiple regression models under different change trends. Finally, the comprehensive climate score for the next 30 years was solved by the entropy-weighted Topsis integrated evaluation method, which integrates the short-term disadvantages and long-term advantages of GGDP development. Further, we investigate the model in depth, using improved gray correlation analysis, adding data dimensions, time dimensions, and considering the impact of economic, technological, medical, and educational factors on the development of green GDP and the impact caused by the use or conservation of natural resources.**

Keywords **– Green GDP Accounting, LSTM, Entropy Topsis, Gray Correlation Analysis.**

I. Introduction

Gross domestic product (GDP), as the most important aggregate indicator in the System of National Accounts (SNA), accounts for the total value of final goods and services produced by all units of a country in a certain period of time, based on market transactions, in terms of the monetary value of the transactions. However, traditional GDP is a simple accumulation of the value of final goods and services produced by all units in a certain period of time, without measuring and accounting for the value cost of social production caused by the reduction of natural resources, environmental pollution and the impact of other social factors. Therefore, this kind of simple GDP growth is false and does not fully reflect the real situation of social and economic development level.

In order to make up for the many shortcomings of traditional GDP in terms of resource and environmental accounting, the Green GDP accounting system has come into being. Green GDP, on the basis of deducting the cost of repairing environmental damage and the cost of depleting non-renewable resources, also intends to add the value of ecological benefits generated by the ecosystem itself, which can objectively reflect the interaction and impact between the economy, society and environment of a country (region) and the level of social welfare. Green GDP reflects not only the growth rate of the economy, but also the real wealth and net welfare level of the society under the premise of sustainable development, as well as the real quality of life of the people. Green GDP can change people's previous understanding of economic growth, so that people’s attention is no longer only on the quantity of economic growth, but more on the quality of economic growth and the environment on which people live, which is very relevant.

II. Related Work

Back in 2012, Li analyzed the current difficulties affecting China 's urban green GDP accounting, discussed a more reasonable urban green GDP accounting method, and incorporated environmental, ecological and other factors into the GDP accounting system [1]. Taking the economic development of Hanchuan City from 2007 to 2009 as an example, Guo calculates the green GDP of Hanchuan City in the past three years through the county green GDP accounting system, and compares it with the traditional GDP to analyze the sustainable economic development of Hanchuan City. The research shows that the gross domestic product and green GDP value of Hanchuan City from 2007 to 2009 show a rising trend [2].

In 2014, based on the analysis of the literature, Jiang constructed a correlation model between environmental economic accounting system and local government performance evaluation system and conducted a compatibility design, trying to provide a framework model and an operable technical path for local government green performance evaluation system [3]. Cao studied the relevant experience of the United States, South Korea and China in implementing green GDP accounting, which has certain enlightenment and help for China to gradually establish and improve the green GDP accounting system in the future [4]. Li applied the energy value analysis method, took the solar energy value as the intermediate medium, converted various kinds of materials in Guangxi eco-economic system into the same standard solar energy value through the energy value conversion rate to get the green GDP of Guangxi in 2004 and 2012 [5].

In 2017, Wang monetized the environmental pollution loss of Zunyi city by the green GDP environmental pollution loss value accounting cost method, based on the environmental data of the city in 2014, and the results showed that the environmental pollution loss cost of Zunyi city in 2014 was larger [6]. Yao drew on the experience of domestic and foreign environmental resource economic accounting systems on the basis of SEEA-2012 system. The study found that the integrated green GDP objectively reflects the welfare provided by natural ecosystems to human beings and the value of services provided to economic activities [7].

In 2020, Tong addresses the shortcomings of the current research on Green GDP 1.0 and 2.0, and proposes a theoretical framework based on the accounting theory and the background of the current increasingly strict ecological and environmental policies: pollutants are generated and treated harmlessly by enterprises. On this basis, we construct a theoretical framework of green GDP accounting with clear input-output relationship [8].

In 2021, Tie selected 21 cities (states) in Sichuan Province as the sample unit, and used the resource and environmental value loss method to construct the green GDP accounting system [9]. Wang adopted the framework of SEEA-2012 accounting system to construct China’s green GDP accounting system and calculated the green GDP of 31 provinces from 2007 to 2016 in order to reveal the overall green development in China and the differences of green development in each region. The results show that: in the temporal pattern, China’s green GDP and traditional GDP maintain a synchronous upward trend [10].

In 2022, Yang quantitatively analyzed the traditional GDP account, resource and environmental depletion account, environmental pollution loss account, environmental improvement gain account and the green GDP account of Datong City from 2009 to 2019. According to the results, the growth trend of green GDP account is basically the same as that of traditional GDP, and the gap between them is decreasing year by year, which shows that the development momentum of "greening" of urban economy is good [11]. Taking three provinces and one city in the Yangtze River Delta as an example, Sun used the improved resource loss value adjustment method to calculate industrial green GDP from 2006 to 2019 as an output index, and used the super-efficiency SBM model to evaluate the efficiency of industrial green development [12]. Cai takes Chongqing as an example, calculates the green GDP formed in 2018-2020, and analyzes the green GDP of Chongqing. In 2018, its value was 18388.89 billion yuan, and in 2020 it became 2111.2 billion yuan [13].

III. Empirical Analysis

A. *Data Source*

We defined the concept of green GDP by reviewing data from other references such as statistical websites, and collected seven relevant impact factor indicators from the World Bank public database (https://data.world bank.org.cn/), namely mineral resource depletion, integrated energy depletion, forest resource via depletion, annual freshwater abstraction N2O emission change, population density change, and electricity access rate change. In order to understand the change trend of different indicators in different countries from 1991 to 2020, the overall change trend of the world is represented by five continents, and a representative city in each continent is selected as the overall change level of the continent. Among them, the representative country chosen for Asia is China, the representative country chosen for Europe is Germany, the representative country chosen for each week is the United States, the representative country chosen for Africa is South Africa and the representative country chosen for Oceania is Australia. Some of the data are shown in the table below.

Table 1. Data source.

	1991	1992	1993	...	2019	2020
USA	6.16E+12	6.52E+12	6.86E+12	...	2.14E+13	2.11E+13
China	3.83E+11	4.27E+11	4.45E+11	...	1.43E+13	1.47E+13
Germany	1.87E+12	2.13E+12	2.07E+12	...	3.89E+12	3.89E+12
Australia	3.26E+11	3.26E+11	3.12E+11	...	1.39E+12	1.33E+12
South Africa	1.35E+11	1.47E+11	1.47E+11	...	3.89E+11	3.38E+11

B. *Definition of Green GDP*

The main purpose of green GDP accounting is to visualize the change of resources and environment in monetary value. In economic activities, the depletion of resources and environmental degradation caused by the use of resources should be deducted as costs in the green GDP accounting. Therefore, the calculation of green GDP should be based on the traditional GDP with depreciation and resource and environmental costs removed, which should include resource depletion, ecological degradation and environmental pollution. Combining the traditional production method and income method of accounting, and adjusting the traditional GDP, we can conclude that the green GDP from the production perspective should be the total output minus intermediate inputs and resource and environmental costs, in other words, the sum of natural and economic assets minus inputs. Therefore, the expression of green GDP is determined as follows: green GDP = traditional GDP – natural resource depletion cost and environmental loss cost (environmental degradation cost and environmental curfew cost). Thus, the green GDP of the five countries is found, which is the basis for the later analysis.

C. *Analysis of the Advantages and Disadvantages of Green GDP*

First we will specifically analyze the advantages and disadvantages to climate caused by replacing GDP with GGDP. Therefore, we need to make projections of Green GDP and GDP and find some additional indicators to evaluate the changes before and after the GGDP replacement. It is also necessary to find out the relationship with temperature and CO2 emissions.

(1) *Green GDP Prediction Model Based on LSTM Neural Network*

LSTM mainly uses the gating mechanism to control the rate of information accumulation, which includes selective addition of new information and selective forgetting of previously accumulated information, thus improving the long-term dependence of RNN, i.e., recurrent neural network, and mitigating the gradient disappearance during long-sequence training. The table of network parameters is shown in Table 2.

Table 2. Parameter Meaning.

Parameters	**X**	**F**	**C**	**C**	**L**
Meaning	Current moment of input	Forgotten gate Control signal	Previous moment of memory cell	Information candidate state	Input gate control signal
Parameters	C	G1	H	o	h
Meaning	Current moment	cell	Previous moment of external state	Output gate control signal	Current moment of external valve state

The structure of the LSTM neural network and the hyperparameter settings are shown in Table 3.

Table. 3. LSTM neural network structure and hyperparameter settings.

Parameter	**Value**
Mean Features	1
Mean Responses	1
Max Epochs	300
Gradient Threshold	1
Initial Learn Rate	0.005
Learn Rate Drop Period	120
Learn Rate Drop Factor	0.25

The green GDP and GDP changes over time and the forecast results are shown in Figure 1.

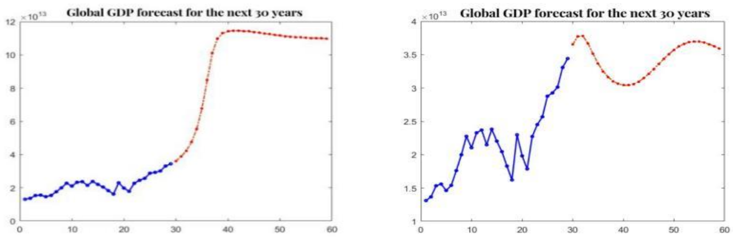


Fig. 1. GDP and Green GDP projection results for the next 60 years (2020 to 2080).

As can be seen from Figure 1, the GDP shows a slow growth trend in the next 30 years, and eventually tends to level off gradually, while the green GDP shows a future trend of falling and then rising, indicating that said future climate and other factors have a greater impact. Then, we subsequently analyze the changing relationship of the world population of different age groups under the different influences of GDP and green GDP.

(2) *Projected Growth Model for the Organization of the World Population Size by Age Group*

Leslie model is an age-grouped population growth model, which is different from the two models, exponential growth and organizational growth model. In this paper, according to the question, we need to consider factors such as age structure, sex ratio, and fertility policy, and only the model can satisfy this need. Therefore, based on the Leslie model, we analyze the changes in the number of people under the age of 15, the number of people between 15 and 65, and the number of people over 65 over the next 30 years under the influence of GDP and green GDP, as shown in Figure 2:

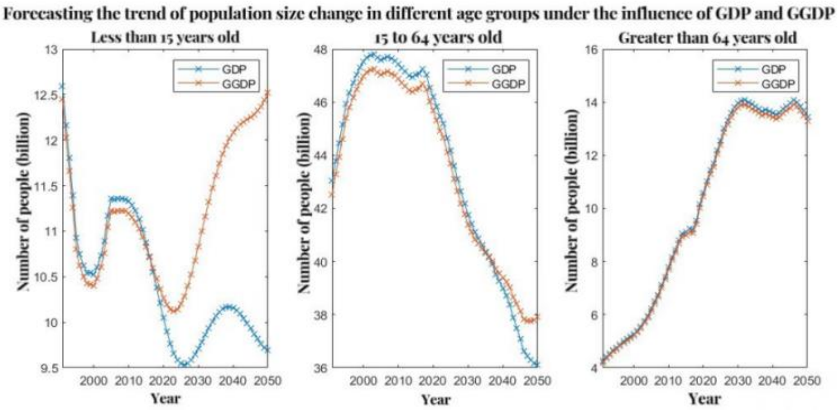
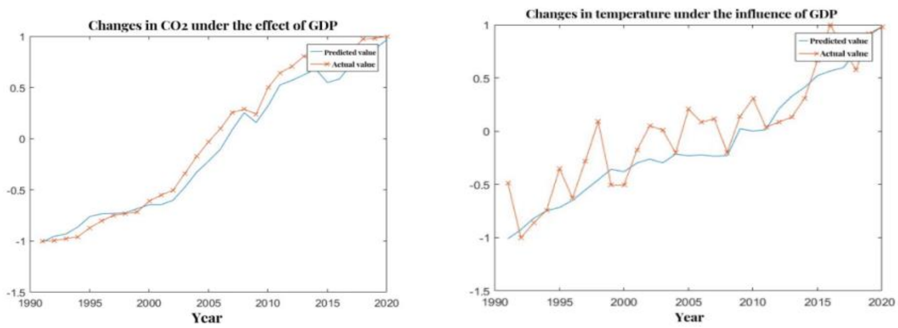


Fig. 2. Number of different demographics projected for the next 30 years.

Considering the above six points, the reputation coefficient was introduced to correct the model, and the fertility changed from 0.015 to 0.043 under the effect of green GDP, and the relationship between the number of different population structures before and after the change was analyzed.

(3) *Multiple Regression Model of Population Size, Green GDP and Climate Change*

After predicting the future population size in different age groups, we analyze the relationship between the world population size, green GDP and the change of temperature and CO2 before the influence of green GDP, and the relationship between the world population size and the change of temperature and CO2 under the influence of GDP through a multiple regression model, which is solved by MATLAB programming to produce the results shown in Figure 3.



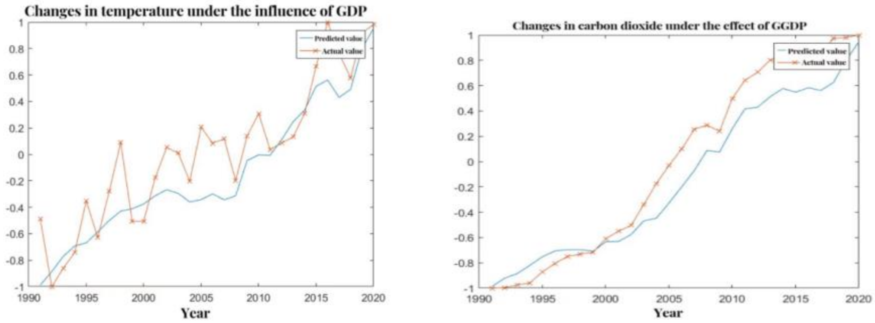


Fig. 3. Trend of climate change under the influence of green GDP and GDP.

The predicted values of the number of different population structures and the predicted values of GDP green GDP for the next 30 years are substituted into the model at the different impacts of temperature and carbon dioxide changes are shown in Figure 4.

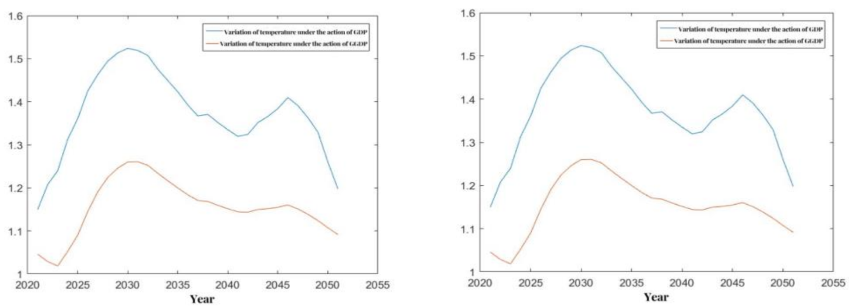


Fig. 4. Changes in temperature and CO2 emissions over the next 30 years.

(4) *A Climate Evaluation Model Based on Entropy Weight Topsis*

TOPSIS comprehensive evaluation method is a commonly used intra-group comprehensive evaluation method, which can make full use of the information of the original data and accurately reflect the gap between the evaluation solutions. In this paper, we evaluate the data of climate and solve the change of the composite score under the influence of GDP and green GDP. The flow of the topsis algorithm based on the entropy weight method is shown in Figure 5.

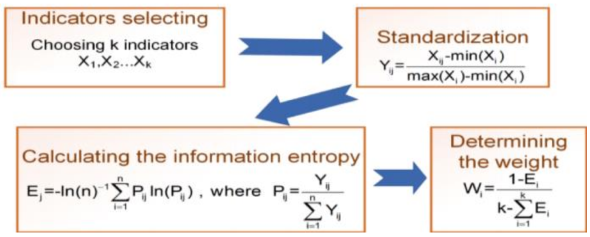


Fig. 5. Entropy power topsis algorithm flow.

According to the above calculation method, ①GGDP②GDP is selected as the benefit-type indicator, considering the world population size as the interval-type indicator. Since it is difficult to quantify, this paper assumes that the population size is a benefit-type indicator, and determines the weight of each indicator according to the entropy weighting method, so as to correct the comprehensive evaluation of TOPSIS, and first calculates the positive and negative ideal solution results shown in Table 4, taking the green GDP impact analysis as an example.

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Table 4. Positive and negative ideal solution results for green GDP.

Indicator	Positive Ideal Solution	Negative Ideal Solution
<15 years (GGDP)	0.24347585	0
15~65 years (GGDP)	0.18601971	0
>65 years (GGDP)	0.18176931	0
World (GGDP)	0.19003772	0

Subsequently, the entropy weight method was used to calculate the weight of each indicator, and the specific results are shown in Table 5, where the smaller the information entropy of the indicator, the smaller the uncertainty of the information expressed by the indicator, and the greater the help to decision-making in the comprehensive evaluation, i.e., it should have a larger weight.

Table 5. The entropy weight method solves for the weights corresponding to the indicators.

Indicator	Information Entropy	Information Utility Value	Weighting
<15 years (GGDP)	0.935	0.065	29.53892
15~65 years (GGDP)	0.941	0.059	26.81196
>65 years (GGDP)	0.943	0.057	26.07796
World (GGDP)	0.962	0.038	17.57116

After normalizing the indicator vectors, the weighted normalization matrix is calculated using the weights obtained by the entropy value method, and then the positive and negative ideal solutions are determined, the Euclidean distance between each alternative and the positive and negative ideal solutions is calculated to assess the proximity to the positive and negative ideal solutions, and finally the distance ratios are ranked according to the calculated distance ratios, and the comprehensive score index and corresponding category labels of each report are output, in descending order of score the ranking is done in descending order.

(5) *Reasonableness Test of the Model*

The CO2 data and temperature data are planned and averaged as a composite climate impact factor, which is used as the dependent variable for evaluation. Population size and green GDP are used as input variables. The results are shown in Figure 6, where the entropy-weighted Topsis is used to solve for the composite score at different time periods and to observe the advantages and disadvantages of GGDP for the future.

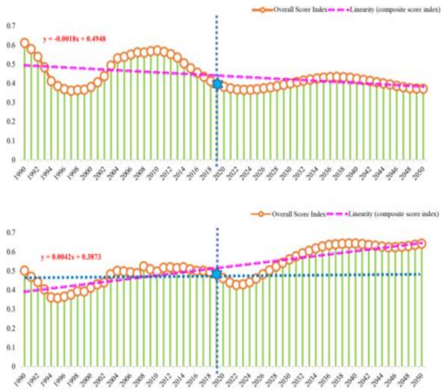

Fig. 6. Trend of the composite score of climate impact under GDP influence, 1990-2050.

The overall score of GDP influencing future climate shows a decreasing trend in Figure 7. And the overall score situation after 2020 is smaller than the overall score situation before 2020, which indicates that under the influence of GDP, the number of population structure and climate of different age groups in the future has changed significantly, such as the change of population structure and serious aging, which indirectly has a certain negative impact on the development of GDP. Under the effect of GGDP, it can be seen that the overall composite score index after 2020 is greater than the score index before 2020 even, and the index shows a smooth linear growth trend. It indicates that the demographic structure under the influence of green GDP shows a good development trend and has been improved afterwards, which contributes to the development of GGDP.

D. *Transformation Impact Analysis of Green GDP*

We then delve into an analysis of the factors influencing green GDP in the United States, adding horizontal considerations and vertical considerations to discuss what specific changes to make in how natural resources are used or conserved. An improved green correlation analysis model is constructed to improve the discriminant coefficients based on the traditional gray correlation analysis. And through the sensitivity analysis of the model, it indicates what specific changes are made and finally the effect of green GDP impact is derived.

We consider economic status and future ability to provide for future generations in depth. Taking the UK as an example, we analyze its impact on the change of green GDP in depth and reconstruct the green GDP model with economic status consideration and future ability to provide for future generations considering research expenditure and hospital expenditure, vertically considering the time dimension of 1980-2020 and horizontally adding the characteristic dimension to arrive at the green GDP considering economic status, status consideration and future ability to provide for future generations. the model equation is :

$$GGDP_c' = GDP - \alpha_1 \times M_1' - \alpha_2 \times M_2' + \beta_1 N_1 + \beta_2 N_2 + \beta_3 N_3$$

Where, β_1,β_2,β_3 are the correction coefficients after adding the perturbation.

Step 1. Introduce new models for transformation

To address the shortcomings of the traditional gray correlation analysis model, this paper introduces the dynamic discrimination coefficient and the topsis method to improve it. It can be seen that the advantage of topsis method is to represent the distance between different series of data, which can just compensate the defect that the traditional gray correlation analysis model can not well reflect the difference between data.

The results of the β_{ij} calculation of the correlation coefficient are related to the value of ρ and the volatility of the series of influencing factors, when the volatility of the series of influencing factors is small. Δmax and Δ ij are close to each other. If ρ is taken as 0.5, it will lead to a small value of the correlation coefficient and the distribution is very close, when the influence factor sequence is more volatile, Δmaxρ is much larger than Δij and Δmin, if ρ is still taken as 0.5 at this time, the role of Δij is ignored, and the final calculated correlation coefficient are close to 1. Therefore, this paper introduces the judgment coefficient ρΔi to indicate the volatility of an influence factor sequence. The mathematical expression of the judgment coefficient is $\rho_{\Delta_i} = \frac{\frac{1}{n}\sum_{j=1}^{n}\Delta_{ij}}{\Delta_{max}}$

Step 2. Determine the judgment coefficient

With 0.5 as the cut-off value, when the judgment coefficient is greater than 0.5, it means that the sequence of influencing factors is smoother and its arbitrary can enhance the variability between correlations, when it is less than 0.5, it means that the influencing factor accumulation fluctuates more, at this time, smaller values should be taken to reduce the influence on the calculation results. In this paper, we take $\rho=4\rho^2$

Step 3. Improved correlation representation

The gray correlation degree in gray correlation analysis can be seen as the distance between the sequence to be evaluated and the positive ideal series. The core idea of gray correlation analysis can be understood as the evaluation of superiority and inferiority by comparing the distances of different sequences to be evaluated with the positive ideal series. When the sequence X to be evaluated has the same distance relative to the positive ideal sequence X, the superiority and inferiority judgment cannot be made in the X line. Introducing the idea of topsis method, let the negative ideal sequence be, then the judgment that X is superior to X can be made by observing the distance of X relative to X. Putting this idea Introducing the gray correlation analysis, the mathematical expression of the overall gray correlation of the ith influencing factor with the negative ideal sequence X is shown below.

$$\varphi_i^- = \frac{1}{n}\sum_{j=1}^{n}\beta_{ij}^-(i=1,2,\cdots,m)$$

Thus, through the integrated gray correlation degree. Indicates the degree of influence of each influencing factor on gray and green GDP, as shown in the formula. In performing the solution, we take 0.5 as the cut-off value, and in the solution, we take the contemporary evaluation sequence X relative to the positive ideal sequence X. The superiority and inferiority cannot be judged between X when the distances are the same.

Finally, the sensitivity of the model was analyzed with different perturbations to the resource-related data, which were included. Used to simulate the use or conservation of natural resources, the relationship between the reconstructed green GDP data and the original GDP data under the addition of three more indicators is finally analyzed, and the results are shown in Figure 7.

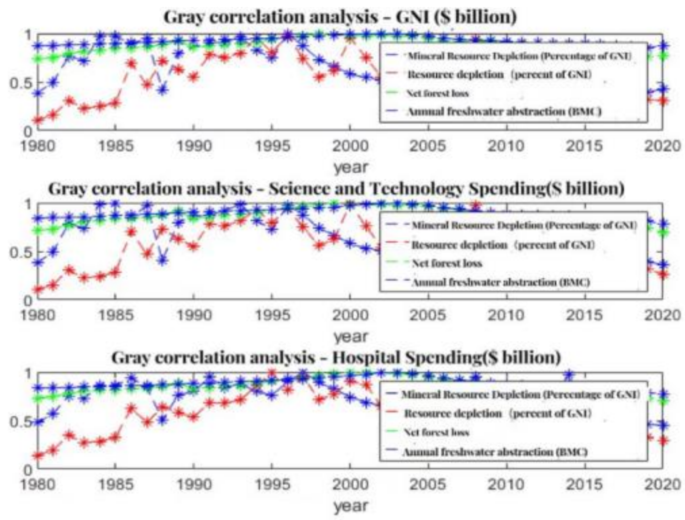

Fig. 7. The relationship between the reconstructed green GDP data and the original GDP data.

From the above figure, it can be seen that the model has a strong correlation between green GDP and GDP under different perturbations, i.e., saving or using resources in the range of up to 40%, and also explains the strong stability of the model.

IV. Conclusion

In this paper, we build an accounting model of green GDP to analyze the global impact of green GDP after replacing traditional GDP, and conduct an in-depth analysis of the original green GDP model by adding impact indicator dimensions. We deeply analyze the possible resistance and the change of human population during the replacement process, construct an organizational growth model, and analyze the change of different parameters in the model under different roles of green GDP and GDP, and construct LSTM neural network model, multiple regression model, and comprehensive evaluation model to analyze the potential advantage and disadvantage issues in the future based on the prediction results. Finally, we conduct an in-depth study of the model by using improved gray correlation analysis, adding data dimensions, time dimensions, and considering the impact of economic, technological, medical, and educational factors on the development of green GDP and the impact on it under the use or conservation of natural resources. In view of the current global green development situation, countries should accelerate the transformation from a rough economic development mode to an intensive economy, and vigorously promote technological innovation to realize the efficient and recycling of energy and resources; at the same time, governments should introduce green development-related policies and increase publicity to raise the general public's awareness of conservation and participate in green development in person.

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