The Impact of the US Withdrawal From the Paris Agreement on the World

Qiushaung Chen[1, a], Yang Li[1, b]

[1]College of Materials and Chemical Engineering, China Three Gorges University, Yichang 443002, China.

[a]qiushuang2436@foxmail.com, [b]893036920@qq.com

Abstract

The global warming trend caused by human behavior is indisputable, and the impact may have a major impact on global development direction and production methods. After entering the mid-20th century, emissions of greenhouse gases (such as CO2 and methane) have increased dramatically and some other human factors have become the main drivers of global warming. Therefore, a clear carbon emission reduction responsibility will contribute to the realization of carbon emission targets. The Paris Agreement has taken care of national conditions through the implementation of the principle of "respective capabilities" and has played down the controversy faced by many previous emission reduction obligations sharing programs. However, the "National Independence Contribution" program has weakened the enforcement of emission reduction obligations while emphasizing flexibility. The new US President Trump announced on June 1, 2017 that the United States will withdraw from the Paris Agreement. The withdrawal of the United States from the Paris Agreement not only directly affects global carbon emissions and temperature rise control, but also affects the future economic growth of countries around the world. This paper examines the impact of the US exit on the Paris Agreement on carbon emissions, temperature, and economy in the world and in other countries. Through the corresponding data, the gray forecasting model, the regression forecasting model, the combined forecasting model, etc. are predicted to predict the future carbon emissions, temperature and GDP, and the impact of the US exit from the agreement is analyzed.

Keywords

Regression analysis, polynomial regression, stepwise elimination, combined prediction.

1. Introduction

Climate change has become one of the important challenges in the current human society. The problem of climate warming due to greenhouse gas emissions from industrialization has become an important issue in global governance [1]. In response to climate change, on the basis of the United Nations Framework Convention on Climate Change, reached in 1992, the State party promoted global joint action in the form of negotiations. The Paris Climate Change Agreement, adopted in December 2015, has established a new institutional arrangement for global climate change governance beyond 2020 [2, 3]. It is a landmark global climate change agreement and an international climate change climate negotiation trend. And the development of the new global climate governance model plays a key guiding role. The Paris Agreement is the third milestone in the history of human beings to address climate change following the 1992 United Nations Framework Convention on Climate Change and the 1997 Kyoto Protocol. It will form a global climate governance pattern after 2020.

The main objective of the Paris Agreement is to control the global average temperature increase in this century to within 2 degrees Celsius and to control the global temperature rise to within

1.5 degrees Celsius above the pre-industrial level. The agreement pointed out that all parties will strengthen the global response to the threat of climate change, control the global average temperature to 2 degrees Celsius above the pre-industrial level, and strive to control the temperature rise within 1.5 degrees Celsius. Only by achieving global peak greenhouse gas emissions as soon as possible, and achieving zero net greenhouse gas emissions in the second half of this century can reduce the ecological risks brought about by climate change and the survival crisis brought to humanity [4].

The United States signed the agreement on April 22, 2016, but announced on June 1, 2017 that the United States will withdraw from the Paris Climate Change Agreement, which has a strong global response to this decision of the new US administration. The withdrawal of the United States from the Paris Agreement not only directly affects global carbon emissions and temperature rise control, but also affects the future economic growth of countries around the world. Therefore, the prediction and research on the impact of the US exit agreement on global carbon emissions and the global economy can provide a basis for decision-making on how the international response can be made. Through the corresponding data, this paper establishes gray forecasting model, regression forecasting model, combined forecasting model, etc. to predict future carbon emissions, temperature and GDP, and makes a concrete analysis of the impact of the United States after withdrawing from the agreement.

2. Data Collection and Analysis

2.1. Data Collection

The carbon emission data of this paper comes from the Carbonation Information Analysis Center of Oak Ridge National Laboratory. The annual average temperature data of the world comes from the earth policy institute. The global GDP of the world and China are from the World Bank. The income of the three industries in China from 1998 to 2013 and the proportion comes from the National Bureau of Statistics.

2.2. Data Analysis

2.2.1. Analysis of US Carbon Emissions

By comparing the carbon emissions of the United States with other countries, the impact of the US exit agreement on global carbon emissions is studied, as shown in Figure 1. The United States has a large difference in carbon emissions with other countries in the world, but it accounts for a large proportion of the total global carbon emissions. It can be speculated that the increase in carbon emissions after the US exits the agreement will have an impact on global carbon emissions. It may affect the economic and industrial structure of other countries.

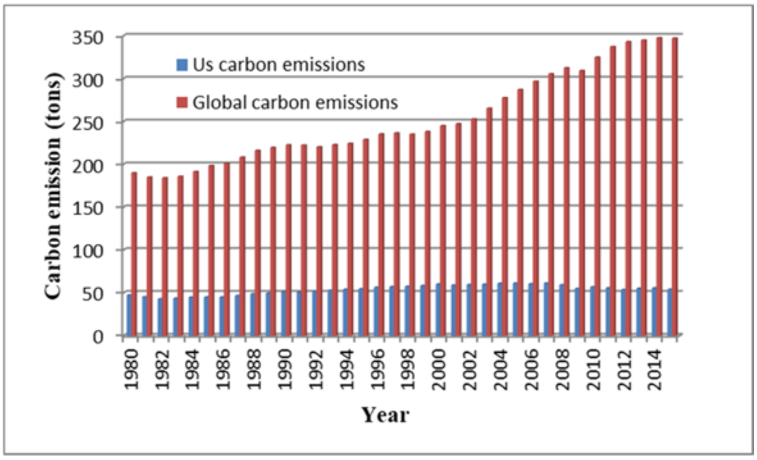

Figure 1. Comparison of us and global carbon emissions

2.2.2. Global Annual Temperature Analysis

To study the impact of the US exit agreement on global temperature, we first need to know the law of temperature changes, so as to get the global temperature without agreement. According to various restrictions, the global temperature before and after the United States participates in the agreement is calculated. Therefore, the analysis of the global average annual temperature is shown in Figure 2. It can be clearly seen from the figure that the temperature fluctuation from 1980 to 2015 is large, but the temperature is generally rising, so it can be fitted to the regression relationship to obtain the temperature in a certain year.

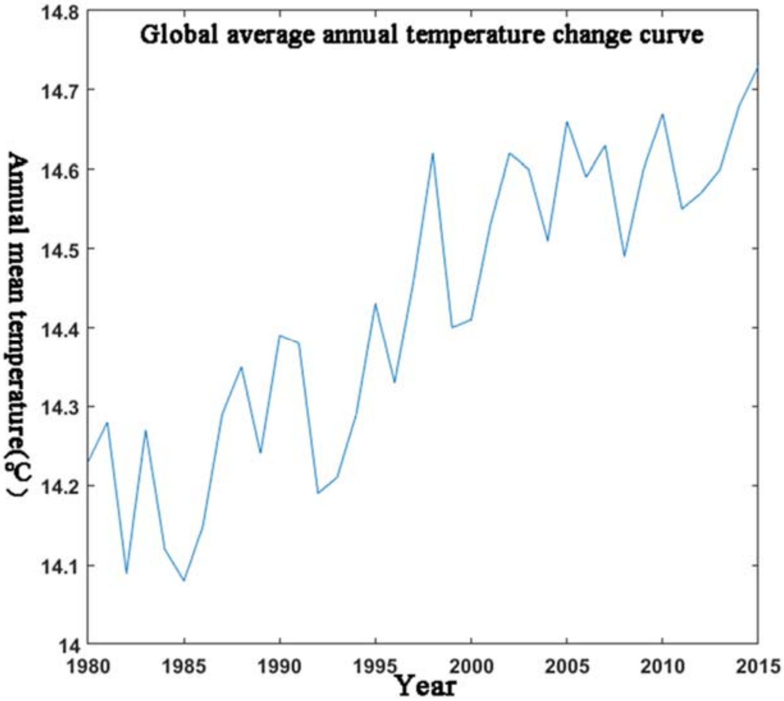

Figure 2. Global average annual temperature over time

2.2.3. Analysis between Temperature and Carbon Emissions

Since global warming is caused by a large amount of greenhouse gas emissions, carbon emissions have a certain impact on temperature. Using matlab software to make a three-dimensional analysis of the world average temperature, world carbon dioxide emissions and US carbon dioxide emissions (Figure 3), roughly observe the relationship between the three. It can be seen from Figure 3 that there is a certain high-order regression relationship between temperature and carbon emissions, so carbon emissions have a certain impact on temperature changes. Therefore, in the Paris Agreement, in order to achieve the purpose of temperature control, it is first necessary to reduce global carbon emissions.

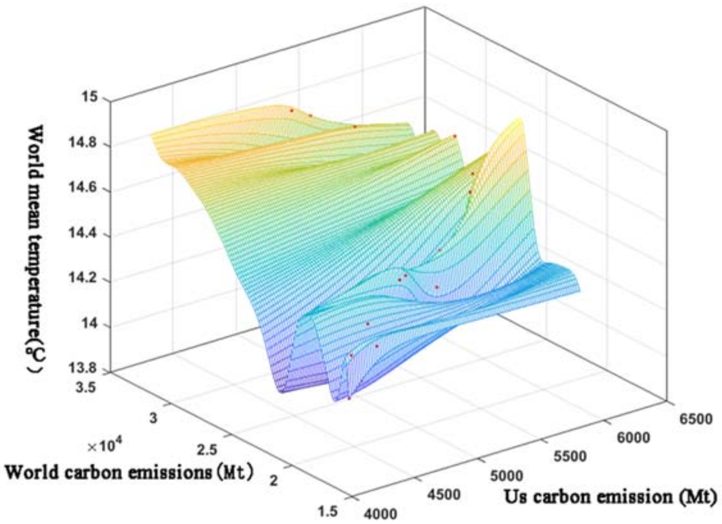

Figure 3. Relationship between temperature and carbon emissions

3. Impact of the US Exiting the Agreement on Global Carbon Emissions

3.1. Forecast When the Agreement Is Not in Force

3.1.1. Forecast of US Carbon Emissions

The gray system seeks the law of change by sorting out the original data. This is a way to seek the realistic law of data in terms of data, that is, the generation of gray sequences. All gray sequences can weaken their randomness and show their regularity through some kind of generation. Therefore, using the collected historical carbon emissions data from 1980 to 2015, the gray forecasting method [5,6] is used to predict the future carbon emissions of the United States.

Step 1: Level test

In order to ensure the feasibility of the gray system modeling method, it is necessary to perform the necessary inspection and processing on the original data. The time series for establishing the total wastewater discharge data for the previous ten years is as follows:

$$x^{(0)}=\left(x^{(0)}(1),x^{(0)}(2),x^{(0)}(3),\cdots,x^{(0)}(n)\right)$$

1) Level ratio $\lambda(k)$

$$\lambda(k)=\frac{x^{(0)}(k-1)}{x^{(0)}(k)},\quad k=2,3,4\ldots n$$

Then there is $\lambda=\left(\lambda(2),\lambda(3),\lambda(4),\cdots,\lambda(n)\right)$

2) Level ratio judgment

Since the level ratio $\lambda(k)$ has a capacity coverage interval $\Theta=(e^{-\frac{2}{n+1}},e^{\frac{2}{n+2}})$, the level ratio $\lambda(k)\in\Theta$ obtained by the above experience indicates that all the level ratios fall within the reachable area, so the series $x^{(0)}$ can be modeled as satisfactory $GM(1,1)$.

Step 2: $GM(1,1)$ modeling

1) Make an accumulation of the original data $x^{(0)}$, ie:

$$\begin{aligned}x^{(1)}&=(x^{(1)}(1),x^{(1)}(2),\cdots,x^{(1)}(n)\\&=(x^{(1)}(1),x^{(1)}(1)+x^{(0)}(2),\cdots,x^{(1)}(n-1)+x^{(0)}\left(n\right))\end{aligned}$$

2) Construct data matrix B and data vector Y

$$B=\begin{bmatrix} -\frac{1}{2}\left(x^{(1)}(1)+x^{(1)}(2)\right) & 1 \\ -\frac{1}{2}\left(x^{(1)}(2)+x^{(1)}(3)\right) & 1 \\ \vdots & \vdots \\ -\frac{1}{2}\left(x^{(1)}(n-1)+x^{(1)}(n)\right) & 1 \end{bmatrix} \quad Y=\begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ x^{(0)}(4) \\ \vdots \\ x^{(0)}(n) \end{bmatrix}$$

3) Calculation $\hat{u}$

$$Y=Bu \ \hat{u}=\begin{bmatrix} \hat{a} \\ \hat{b} \end{bmatrix}=\left(B^T B\right)^{-1} B^T Y=\begin{pmatrix} -0.0075 \\ 4.6733 \end{pmatrix}$$

So you can get $a=-0.0624 \quad b=156.62$

4) Modeling

$$\frac{dx^{(1)}(t)}{dt}+ax^{(1)}(t)=b$$

Then the solution is $x^{(1)}(t)=\left(x^{(0)}(1)-\frac{b}{a}\right)e^{-a(t-1)}+\frac{b}{a}$

Then get the predicted value

$$x^{(1)}(k+1)=\left(x^{(0)}(1)-\frac{b}{a}\right)e^{-ak}+\frac{b}{a}=\left(x^{(0)}(1)-\frac{4.6733}{-0.0075}\right)e^{0.0075k}+\frac{4.6733}{-0.0075} \quad k=1,2,3\ldots n$$

5) Find the number of columns $\hat{x}^{(1)}(k+1)$ and the model restore value $\hat{x}^{(0)}(k+1)$

Let $k=1,2,3\ldots n$, from the above time corresponding function can calculate $\hat{x}^{(1)}$, which takes $\hat{x}^{(1)}(1)=\hat{x}^{(0)}(1)=x^{(0)}(1)=93.1$, from $\hat{x}^{(0)}(k)=\hat{x}^{(1)}(k)-\hat{x}^{(1)}(k-1)$, take $k=1,2,3\ldots n$, then it can be calculated: $\hat{x}^{(0)}=\left(\hat{x}^{(0)}(1),\hat{x}^{(0)}(2),\hat{x}^{(0)}(3),\cdots,\hat{x}^{(0)}(n)\right)$

Step 3: Test predictive value

1) Residual test

Let the residual be $\varepsilon(k)$, calculate $\varepsilon(k)=\dfrac{x^{(0)}(k)-\hat{x}^{(0)}(k)}{x^{(0)}(k)} \quad k=1,2,3\ldots n$

Here $\hat{x}^{(0)}(1)=x^{(0)}(1)$, if $\varepsilon(k)<0.2$, it can be considered to meet the general requirements; if $\varepsilon(k)<0.1$, it is considered to meet the higher requirements

2) Level deviation test

First, the step ratio $\lambda(k)$ is calculated from the reference data $x^{(0)}(k-1)$, $x^{(0)}(k)$ and the corresponding step ratio D is obtained by the development coefficient $\rho(k)=1-\left(\dfrac{1-0.5a}{1+0.5a}\right)\lambda(k)$.

If $\rho(k)<0.2$, it can be considered to meet the general requirements; if $\rho(k)<0.1$, it is considered to meet the higher requirements

3) In order to test the accuracy of the data predicted by this model, the various test index values of the model are calculated. The specific calculation results are shown in Table 1.

Table 1. Various test values for the model

Year	actual value	Predictive value	Ratio deviation	Residual	Relative error
1980	47.19	47.19	1	0	0
1981	45.32	47.26	-0.04916	-0.04287	0.042872
1982	43.03	47.62	-0.06112	-0.10661	0.106609
1983	43.38	47.98	0.00062	-0.10592	0.105922
1984	44.72	48.34	0.022482	-0.08106	0.081058
1985	44.89	48.70	-0.00364	-0.08499	0.084991
2010	56.99	58.75	0.028571	-0.03077	0.030766
2011	55.70	59.20	-0.03112	-0.06285	0.062847
2012	53.62	59.64	-0.04651	-0.11228	0.112275
2013	55.14	60.09	0.020228	-0.08978	0.089776
2014	55.65	60.54	0.001788	-0.08783	0.087828
2015	54.11	61.00	-0.03622	-0.12723	0.127229

Step 3: Predictive broadcast

Use the model established above to predict the annual carbon emissions in the United States from the mid-century (2020-2050) after the agreement comes into effect. See Table 2 for the results.

3.1.2. Global carbon emissions forecast

The global carbon emissions forecast for the future is the same as the US forecast for its future carbon emissions. Both use the gray prediction model and use MATLAB software to solve the problem. The specific results are shown in Table 2.

Table 2. US and global carbon emissions projections when the agreement is not in force

Year	2020	2021	2022	2023	…	2047	2048	2049	2050
US (Billion tons)	61.46	61.92	62.39	62.86	…	77.55	78.14	78.73	79.32
Global (Billion tons)	358.10	365.37	372.79	380.36	…	667.89	681.45	695.29	709.42

From the data in Table 2, it can be seen that global carbon emissions have nearly tripled from 2020 to 2050, indicating that if no measures are taken, the global environmental problems will not be optimistic due to the large amount of carbon emissions.

3.2. US Predictions When Participating in the Agreement

3.2.1. Global Carbon Emissions Forecast

According to the analysis between the carbon emissions and the annual average temperature in the data analysis, there is a certain high-order regression relationship between temperature and carbon emissions [7]. Therefore, the global annual carbon emissions are fitted to the global annual average temperature from 1980 to 2015. The annual temperature before 2050 must not exceed 2 °C in 2020, so the regression can be used to calculate the global carbon emissions under the US participation agreement.

Model establishment

Looking for the relationship between global carbon emissions and temperature, there are $y = f(x) + \varepsilon$

Where y is the global carbon emission, x is the global average temperature, $f(x)$ may be a linear function or a nonlinear function, and the specific relationship of $f(x)$ is needed to be solved by regression analysis.

1) First set the relationship to a linear model, then set the model to $y = \beta_0 + \beta_1 x + \varepsilon$

Based on historical data from 1980 to 2015, estimates of regression coefficients were calculated using MATLAB software and least squares.

$$\beta_0 = (-2.196e+04) \qquad \beta_1 = 3624$$

Therefore, the regression equation is $\hat{y} = (-2.196e+04) + 3624x$

Then the multiple decision coefficients: $R = \sqrt{\frac{S_R}{S_T}} = 0.765$

Therefore, the linear regression model has a good fitting effect and can be used when the accuracy is not high.

2) Set the model to other fits, fit it and calculate the multiple decision coefficients. See Table 3 for specific data.

Table 3. Correlation model and decision coefficient

Fitting model	Decision coefficient R
$y = \beta_0 + \beta_1 x + \varepsilon$	0.765
$y = \beta_0 + \beta_1 x + \beta_2 x^2 + \varepsilon$	0.8861
$y = \beta_0 + \beta_1 x + \beta_2 x^2 + \beta_3 x^3 + \varepsilon$	0.9398
$y = \beta_0 + \beta_1 x + \beta_2 x^2 + \beta_3 x^3 + \beta_4 x^4 + \varepsilon$	0.9675
$y = \beta_0 + \beta_1 \exp x + \varepsilon$	0.1204
$y = \beta_0 + \beta_1 \log_{10} x + \varepsilon$	0.8193

From the data listed in Table 3, $y = \beta_0 + \beta_1 x + \beta_2 x^2 + \beta_3 x^3 + \beta_4 x^4 + \varepsilon$ fits best, so this model is chosen as the relationship between global carbon emissions and global temperature.

Model solution

According to the analysis of the problem 1, the annual temperature before 2050 should not exceed the 2 °C constraint of 2020 and the global temperature of 2020 is 14.88 °C when the agreement is not in force. Therefore, the global temperature is not 2050 after the agreement takes effect. More than 16.88 ° C. Assume that after the agreement takes effect, the temperature in 2050 is the maximum value that can be increased by 16.88 °C. Bringing into the above $y = \beta_0 + \beta_1 x + \beta_2 x^2 + \beta_3 x^3 + \beta_4 x^4 + \varepsilon$ fitting relationship can calculate the maximum global carbon emissions of 52.567 billion tons in 2050 after the agreement takes effect.

From the official implementation of the agreement, the global carbon emissions growth will be controlled every year to ensure that global carbon emissions do not exceed 52.567 billion tons in 2050. Assuming that the annual growth rate of carbon emissions is α , then the annual carbon emissions Y_n after 2020 is:

$$Y_n = Y_{2020} \times (1+\alpha)^{(n-2020)}$$

There is $Y_{2020} = 388.09$, and when $n = 2050$, $Y_{2050} = 525.67$ then $\alpha = 0.0102$ can be solved, and then the annual carbon emission Y_n expression after 2020 is

$$Y_n = Y_{2020} \times 1.0102^{(n-2020)}$$

Bringing in numerical values to solve the global carbon emissions of the United States when participating in the agreement, the specific results are shown in Table 4.

3.2.2. US Carbon Emissions Forecast

Step 1: Calculation of global emission reductions

According to the results of the agreement without agreement and the global carbon emissions under the agreement, the annual global emission reductions under the agreed conditions can be obtained.

Step 2: The proportion of emissions reductions the United States has to undertake under the agreement

Each country directly affects each country's carbon emissions because of its population, land area, and GDP. Therefore, it is necessary to establish a carbon emission allocation model. The carbon emission allocation model can deduce the responsibility for emission reduction. When the United States withdraws from the Paris Agreement, the responsibility for reducing emissions that it originally had to undertake will be allocated to the corresponding countries in proportion. It will have a greater impact on economic growth and industrial structure development.

1) The greater the population, the more carbon dioxide is exhaled and the greater the carbon emissions allocated.

2) The larger the land area, the greater the carbon emissions allocated.

3) The higher the GDP, the greater the impact on the environment and the greater the carbon emissions that should be allocated.

4) Carbon emissions are mainly caused by industrial development, so GDP has the greatest impact on carbon emissions. Many countries have a large proportion of land area and a large population, but their carbon emissions are not large. Therefore, the impact of land area and population is slightly smaller.

Therefore, the carbon emissions X_i of a country are:

$$[\frac{1}{4}\bullet\frac{\text{National population}}{\text{World Population}}(A)+\frac{1}{4}\bullet\frac{\text{Country area}}{\text{World area}}(B)+\frac{1}{2}\bullet\frac{\text{Country GDP}}{\text{World GDP}}(C)]*\text{Global carbon emissions(X)}$$

$$X_i = [0.25(A+B)+0.5C]*X$$

The responsibility for emission reduction Y_i in a country is

$$\text{Emissions from a country}(X_i) \Big/ \text{Carbon emissions of a country under constraints}(Z_i)$$

This is $Y_i = \frac{X_i}{Z_i}$

The specific emission reduction responsibility allocation is shown in Table 4.

Table 4. Responsibility for emission reductions undertaken by the United States in the agreement

	Population ratio(%)	Land area ratio(%)	GDP Ratio(%)	Final reduction in emissions(%)
US	0.0442	0.0642	0.2432	0.2
Other country	0.9558	0.9358	0.7568	0.8

Step 3: Carbon emissions calculations when the United States participates in the agreement

When the United States participates in the agreement, the carbon emissions are the non-contracted US carbon emissions minus the carbon emissions that the United States should bear in the agreement. The solution results are shown in Table 5.

Table 5. US and global carbon emissions and global temperatures when the United States participates in the agreement

Year	2020	2021	2022	2023	…	2047	2048	2049	2050
US (million tons)	63.33	63.02	62.69	62.34	…	45.97	44.87	43.74	42.57
Global (million tons)	388.09	392.03	396.02	400.05	…	509.95	515.14	520.38	525.67
Global temperate(°C)	14.88	14.94	15.07	15.13	…	16.67	16.74	16.81	16.88

As can be seen from Table 5, after the agreement comes into effect, the annual carbon emissions in the United States are gradually decreasing, and the global carbon emissions are gradually slowing down. The development of industry mainly leads to carbon emissions. Therefore, if the United States participates in the agreement, it will have a greater impact on the economic development of the country.

3.3. Forecast after the US Withdraws from the Agreement

According to the analysis, after the entry into force of the agreement, the global and US carbon emissions and the global average annual temperature after the US exit are as follows:

a) US carbon emissions in the case of US exit agreements = US carbon emissions in the absence of an agreement

b) Global carbon emissions in the case of US exit agreements = global carbon emissions without US withdrawal + carbon emissions that the US needs to reduce in the agreement

c) Global annual average temperature in the case of US exit agreement = global average annual temperature without US exit + temperature value that the US needs to reduce in the agreement

The global carbon emissions projections for various situations are obtained. After the US exits the agreement, the global and US carbon emissions and the global average annual temperature are predicted as shown in Table 6.

Table 6. US carbon emissions, global carbon emissions, global average annual temperature forecast after the US exits the agreement

Year	2020	2021	2022	2023	⋯	2047	2048	2049	2050
US (million tons)	63.33	63.81	64.29	64.77	⋯	77.55	78.14	78.73	79.32
Global (million tons)	388.09	392.82	397.62	402.48	⋯	541.54	548.40	555.36	562.42
Global temperate(°C)	14.88	14.95	15.01	15.08	⋯	18.53	18.80	19.08	19.38

It can be seen from Table 6 that after the United States withdrew from the agreement, the global carbon emissions in 2050 were 56.242 billion tons, which is a significant increase compared with the maximum carbon emissions of 52.567 billion tons calculated in 2050 under the agreed temperature constraints. It is seen that the US exit agreement has an impact on global carbon emissions.

3.4. Analysis of the Impact of US Exit Agreements on Carbon Emissions

3.4.1. Impact on Global Carbon Emissions

In order to analyze the impact of the US exit on the agreement on global carbon emissions, the global carbon emissions results will be compared when the solution is not valid, when the United States participates in the agreement, and after the United States withdraws from the agreement, as shown in Figure 4.

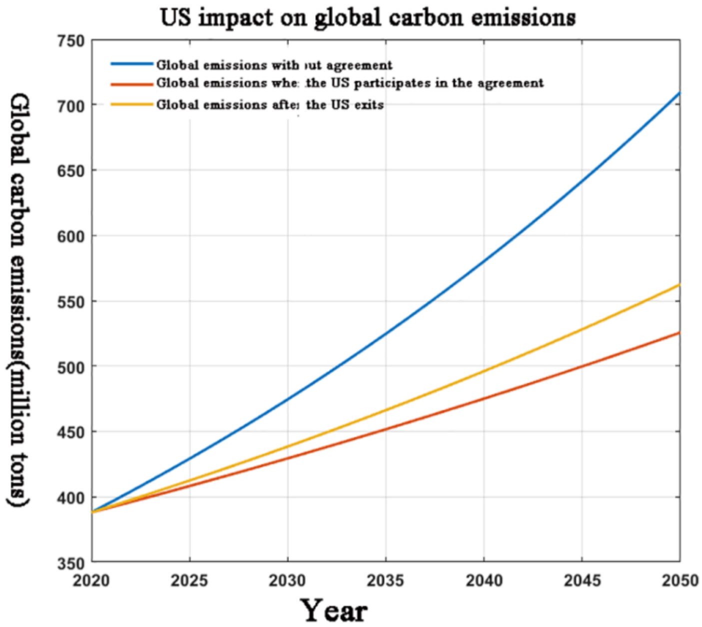

Figure 4. US impact on global carbon emissions

It can be seen from Figure 4 that global carbon emissions are growing rapidly without agreement, so it is necessary to control carbon emissions through the Paris Agreement. After the US exit, global carbon emissions and the United States participate in the agreement when there is a certain difference in global carbon emissions, it can be seen that the United States has a certain impact on global carbon emissions.

3.4.2. Impact on US Carbon Emissions

When the United States participates in the agreement, it needs to plan its own carbon emissions according to the global emission reduction plan and its own allocation. In order to analyze whether the United States participates in the agreement on the impact of domestic carbon emissions, the agreement will not be effective, the United States participates in the agreement. When the United States withdraws from the agreement, the results of the US carbon emissions are compared, as shown in Figure 5.

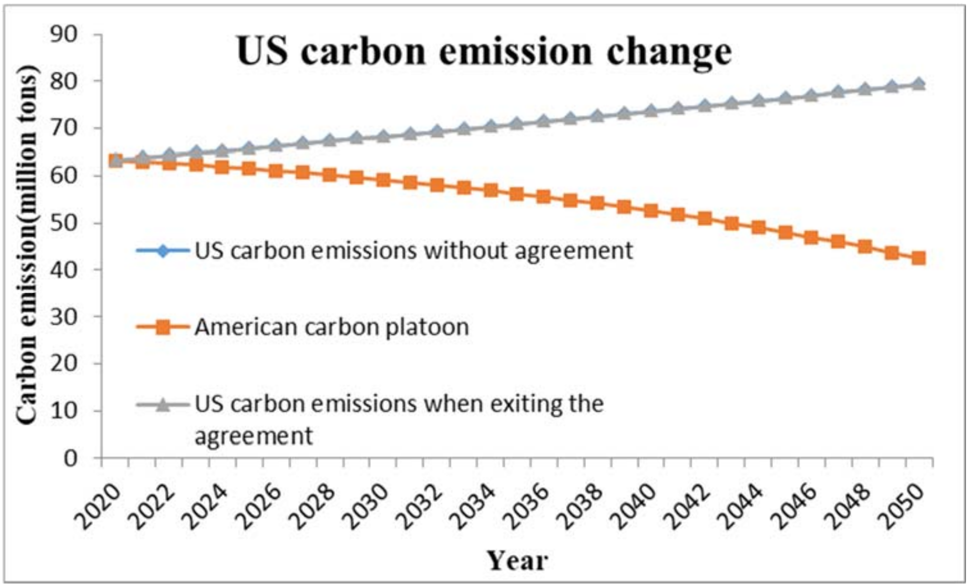

Figure 5. Impact of US participation in the agreement on US carbon emissions

As can be seen from Figure 5, if the United States does not participate in the free emissions of the agreement, the annual carbon emissions are increasing. If the participation agreement bears the responsibility for emission reduction, the annual carbon emissions will show a downward trend. Therefore, the withdrawal of the United States from the agreement has had a certain impact on the US carbon emissions.

4. Impact of the US Exit on the Agreement on the Global Economy

4.1. Global GDP When the Agreement Is Not in Force

When the agreement is not in force, the prediction of global GDP data is based on the historical data from 1980 to 2015. When considering the factors affecting GDP, when the single item prediction method is adopted, the prediction error is larger due to the instability of the single item. . Therefore, a combined prediction model is used to improve the accuracy of the overall system prediction.

Combined prediction model [8,9]: Starting from the one-way prediction model, the single prediction model is weighted according to historical data, and the combined prediction model is obtained to improve the prediction accuracy by using the partial information provided by the single prediction method. The regression prediction model and the grey prediction model are selected as two single prediction models in the combined model, and different weights are used to utilize information from different angles, thereby improving the accuracy and reliability of the prediction.

Step 1: Determining combined forecasting model

The predicted values $\hat{x}_1^{(0)}(k)$ and $\hat{x}_{2(0)}(k)$ are obtained by the regression prediction model and the $GM(1,1)$ gray prediction model, respectively.

In this paper, the arithmetic weighted average combined prediction mode is used to predict the value, which makes the algorithm simple and easy to understand, and at the same time obtain better prediction accuracy, that is, the combined model is: $\hat{x}^{(0)}(k) = w_1\hat{x}_1^{(0)}(k) + w_2\hat{x}_{2(0)}(k)$

For easy calculation, choose $\omega_1 = \omega_2 = 0.5$ for calculation.

Step2: Determining the regression prediction model

For the global GDP, with time as the independent variable x, the global GDP from 1980 to 2013 is the independent variable y. Using SPSS software to analyze historical data, it is found that for the world GDP, when the quadratic regression model is established, the error is small. Therefore, it is necessary to return to the prediction model: $y = a_1 + b_1 x + c_1 x^2$

Using the least squares method, calculate with matlab $a_1 = 11.68$、$b_1 = 0.1738$、$c_1 = 0.04926$

Therefore, the regression prediction model of global GDP is $y = 11.68 + 0.1738x + 0.04926x^2$

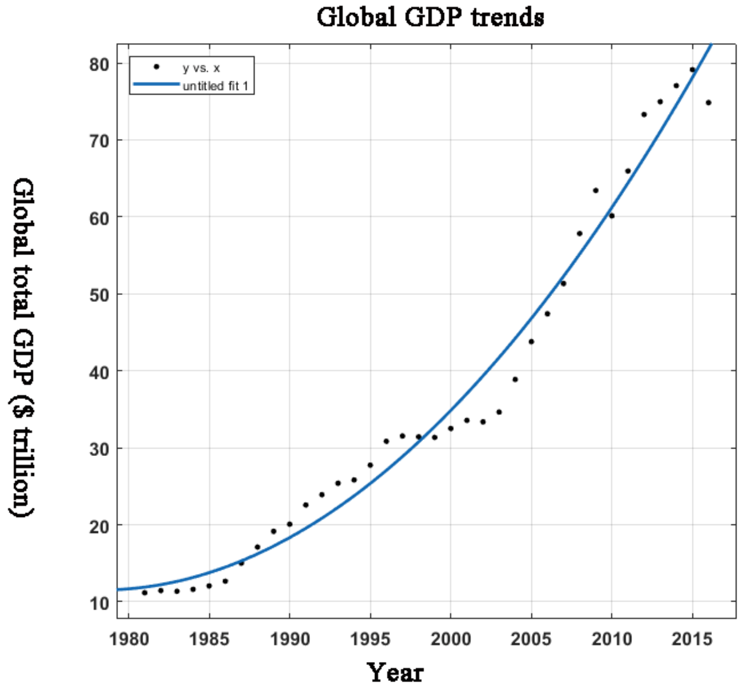

Figure 6. Regression analysis fit graph

Using the matlab software to perform quadratic curve fitting on the regression prediction model based on historical global carbon emission data, it can be seen in the fitting graph (Fig. 10). The predicted value is close to the actual value, and the fitting is good, so it can be used twice. The regression function establishes a predictive model.

Step 3: Determining the grey prediction model $GM(1,1)$

Based on the forecasting steps of the US and global carbon emissions when the agreement is not in force, the global GDP is predicted and solved:

$$x^{(1)}(k+1) = \left(x^{(0)}(1) - \frac{b}{a} \right) e^{-ak} + \frac{b}{a} = \left(x^{(0)}(1) - \frac{11.5107}{-0.0566} \right) e^{0.0566k} + \frac{11.5107}{-0.0566}$$

Step 4: Use three methods to predict data

Using the established combined forecasting model to predict the global GDP, and to solve the forecast results of the single forecasting model, the total GDP of the United States after the withdrawal of the agreement, that is, from 2020 to 2030, the results are shown in Table 7.

Table 7. Forecast of Global GDP

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Regression prediction	105.87	110.24	114.69	119.25	123.91	128.66	133.52	138.47	143.52	148.67
Grey prediction	120.25	127.26	134.67	142.51	150.81	159.59	168.89	178.73	189.14	200.15
Combined forecast	113.06	118.75	124.68	130.88	137.36	144.13	151.20	158.60	166.33	174.41

The result obtained by the combined prediction model is between the regression prediction result and the gray prediction model. The combined prediction is more realistic.

4.2. US to Global GDP

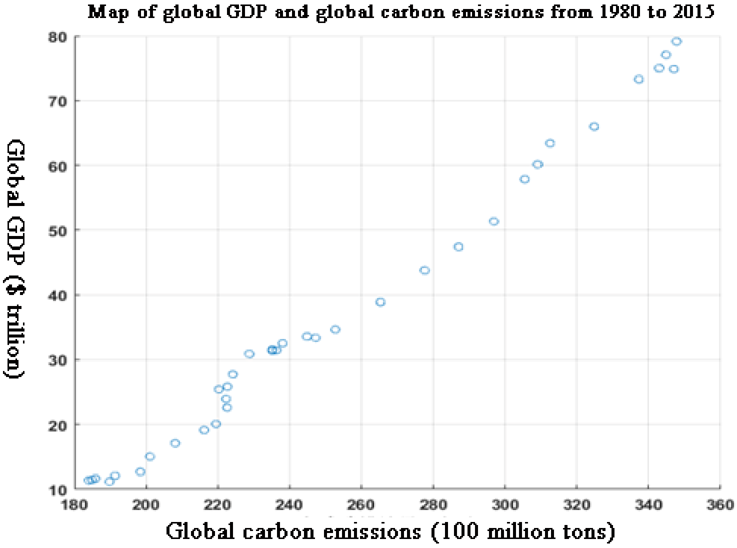

Figure 7. Global carbon emissions and global GDP

According to the scatter plots drawn from the global carbon emissions and global GDP data, it can be seen that GDP increases with the increase of carbon emissions, in order to eliminate the possible errors in the time series, making the time series. The trend is linear, while also making the data more stable. So logarithmize each indicator.

2) Model establishment

Establish a nonlinear regression equation for carbon emissions and GDP

$$\ln y = a + b\ln x + c(\ln x)^2 + d(\ln x)^3$$

Where y is GDP, x is carbon emissions, a is constant, and b, c, and d are coefficients.

Determine the regression coefficient: regression analysis by MATLAB, the following results

$$a = -659.8 \quad b = 340.2 \quad c = -58.48 \quad d = 3.373$$

The corresponding model is $y = -659.8 + 340.2Inx - 58.48(Inx)^2 + 3.373(Inx)^3$

Make a significant test on the coefficients in the model, that is, use the stepwise culling method to find the partial regression squared sum of the coefficients, namely:

$$P_i = S_{Eibefore} - S_{Eiafter}$$

Where P_i is the partial regression squared sum of the coefficients, $S_{Eibefore}$ is the regression square sum before the variable x_i is removed, and $S_{Eiafter}$ is the regression square sum after the variable x_i is removed. After calculation, the partial regression square sum of each coefficient can be obtained. It is found that the coefficient of the primary term has little influence, so the item can be eliminated, and the final equation can be obtained as follows:

$$\ln y = -34.14 + 3.138(\ln x)^2 - 0.3443(\ln x)^3$$

By substituting the global carbon emissions of the United States from the agreement and the global carbon emissions that the United States does not withdraw, the corresponding GDP can be derived.

3) Model solution and result analysis

Through the above model, the data results in question 2 are cited, and the MATLAB software is used to solve the GDP when the US does not exit and the GDP when the US exits. The specific results are shown in Table 8.

Table 8. Global GDP in all cases

Year	Not active	US participation	US exit	GDP change
2020	107.62	84.465	84.188	0.277
2021	113.06	85.045	84.466	0.579
2022	118.75	85.576	84.468	1.108
2023	124.68	86.057	84.470	1.587
2024	130.89	86.487	84.472	2.015
2025	137.36	86.864	84.473	2.391
2026	144.13	87.188	84.475	2.713
2027	151.20	87.458	84.476	2.982
2028	158.60	87.673	87.478	3.195
2029	166.33	87.833	87.982	0.149
2030	174.41	87.938	87.976	0.038
2031	182.86	87.986	87.886	0.100

From Table 8, it is found that the increase in carbon emissions in the United States due to the withdrawal of the United States from the Paris Agreement has led to an increase in US GDP, which has led to an increase in global GDP. Through the global GDP of the United States when participating in the agreement, it can be seen that due to the limitations of the Paris Agreement, the global economic growth is relatively slow, with an increase of only $352.1 billion from 2020 to 2031.

5. Conclusion

In this paper, by collecting data, using grey prediction model, regression prediction model, combined prediction model, etc., respectively, the global development under the three conditions of the agreement is not effective, the United States does not participate in the agreement, and the United States withdraws from the agreement. At the same time, with the two factors of global carbon emissions and global GDP, the impact of the United States' withdrawal from the agreement on the implementation of the global Paris Agreement was analyzed. It was concluded that the US exit agreement has a certain effect on the realization of the global carbon reduction target.

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