Environment, Resource and Ecology Journal (2021) 5: 6-10
Clausius Scientific Press, Canada

DOI: 10.23977/erej.2021.050302
ISSN 2616-3756

Grey prediction model based on carbon emission optimization

Yihui Zhang, Jianxiang Li, Jingping Che

Shenyang Ligong University, Equipment Engineering College, Liaoning, Shenyang, 110159

Keywords: carbon neutralization, Entropy weight method, Grey prediction model.

Abstract: In the context of developing low-carbon economy to cope with climate change, China, as an economic power and energy consuming country, undertakes an important task of emission reduction. However, many factors, such as unreasonable industrial structure and energy consumption structure, have brought great challenges to the successful completion of China's carbon emission reduction task. In this paper, the entropy weight method is used to quantitatively analyze the relationship between the driving factors of carbon emission of energy structure and industrial structure and the result factors of carbon emission of energy consumption, and then the grey prediction model based on carbon emission optimization is established. According to the relationship between the driving factors and the result factors, the evolution law is summarized. At last, the advantages and disadvantages of the model are evaluated and summarized objectively. At the same time, the model can also provide reliable conclusions for the pollution of other polluting gases.

1. Introduction

According to statistics, China's energy structure is still in the process of industrialization, and carbon based energy is the main energy. During the fourteenth Five Year Plan period and for a long time in the future, emission reduction and low-carbon development will be an important theme of China's environmental governance, even national governance and social governance. In this paper, the driving factors of carbon emissions from energy structure and industrial structure and the results of carbon emissions from energy consumption are quantitatively analyzed, and the evolution law is obtained. Through prediction and analysis to optimize the driving factors, in order to solve the problem of carbon dioxide emissions and absorption.

2. Model Establishment

2.1 Quantitative Analysis Based on Entropy Weight Method

We can determined that the driving factors in the energy structure are coal, water, nuclear energy, oil, natural gas and hydrogen; The driving factors of industrial structure are heavy industry, light industry, agriculture, transportation and Commerce and service industry. The unit carbon emissions of oil, coal and natural gas are 3.37kg, 5.14kg and 2.26kg respectively; the combustion efficiency is 76%, 40% and 90% respectively. Insufficient combustion will produce more carbon emissions.

Therefore, we use TOPSIS method to analyze the unit carbon emissions and combustion efficiency. The steps of entropy weight method are as follows:

(1) The relevant data of each factor were processed forward;

(2) The information entropy of corresponding factors is obtained by using the formula:

$$e_j = -\sum_{i=1}^{n} p_{ij} \ln(p_{ij}) \ (j=1,2,...,m)$$

(3) The data were normalized;

(4) According to the following formula, the weights are 0.6325 and 0.3675 respectively:

$$W_j = d_j / \sum_{j=1}^{m} d_j \ (j=1,2,...,m)$$

(5) Get the forward matrix X, and use the formula to standardize it, get the matrix Z;

$$X = \begin{bmatrix} 3.37 & 0.76 \\ 5.14 & 0.40 \\ 2.26 & 0.90 \end{bmatrix} \qquad Z = \begin{bmatrix} 0.5146 & 0.6109 \\ 0.7849 & 0.3215 \\ 0.3451 & 0.7235 \end{bmatrix}$$

(6) Define maximum and minimum values:

$$Z^+ = (Z_1^+, Z_2^+, ..., Z_m^+) = (\max\{z_{11}, z_{21}, ..., z_{n1}\}, \max\{z_{12}, z_{22}, ..., z_{n2}\}, ..., \max\{z_{1m}, z_{2m}, ..., z_{nm}\})$$

$$Z^- = (Z_1^-, Z_2^-, ..., Z_m^-) = (\min\{z_{11}, z_{12}, ..., z_{n1}\}, \min\{z_{12}, z_{22}, ..., z_{n2}\}, ..., \min\{z_{1m}, z_{2m}, ..., z_{nm}\})$$

Then define the distance between each item and the maximum value, and the minimum value:

$$D_i^+ = \sqrt{\sum_{j=1}^{m} (Z_j^+ - z_{ij})^2} \quad D_i^- = \sqrt{\sum_{j=1}^{m} (Z_j^- - z_{ij})^2}$$

Then calculate the score by the following formula: $S_i = \frac{D_i^-}{D_i^+ + D_i^-}$

The scores of the three are 0.3942, 0.3312 and 0.2746 respectively, and the order of carbon emission is coal > Oil > natural gas.

Similarly, for the driving factors in the industrial structure, we first found that the proportions of each factor in carbon emissions are: Service Industry: 53.5%, heavy industry: 30.1%, light industry: 8.4%, transportation industry: 4.5%, agriculture: 1.9%. By using the entropy weight method to get the weight of each factor, and analyzing and calculating the carbon emissions and carbon use of the driving factors of industrial structure, the scores of the five factors are 0.3274, 0.2912, 0.1744, 0.1052 and 0.1018 respectively, and then the ranking of the five factors in the amount of carbon emissions from combustion is agriculture < commerce and service industry < light industry < transportation industry < heavy industry.

2.2 Establishment and solution of grey prediction model

This paper forecasts the carbon emissions from 2021 to 2065 without changing the industrial structure and energy structure. The data used by GM (1,1) is the national carbon emissions from 2005 to 2020, as shown in Figure 1.

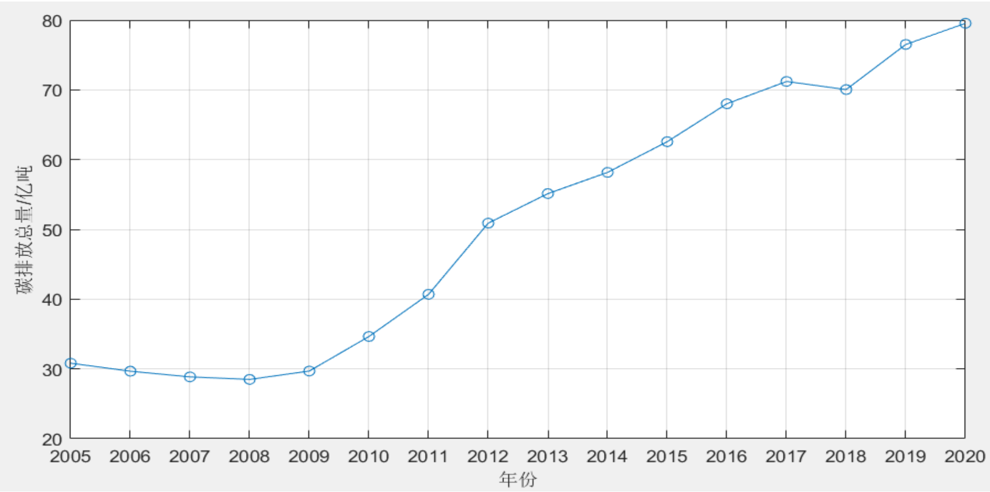

Figure 1: Trend of national carbon emissions

Because the sum of squared error of new information GM (1,1) model is the smallest, we should choose it to predict. The original data of GM (1,1) prediction are as follows:

[30.81745 29.67256 28.85722 28.4975 29.69576 34.64843 40.69239 50.8978 55.12703 58.17144 62.56704 68.00468 71.20158 70.04125 76.51024 79.54136]

The development coefficient is 0.07725, and the ash action is 25.5808. Then the fitting data is tested by residual.

Absolute residuals: $\varepsilon(k)=x^{(0)}(k)-\hat{x}^{(0)}(k), k=2,3,\ldots\ldots,n$

Relative residuals: $\varepsilon_r(k)=\frac{\left|x^{(0)}(k)-\hat{x}^{(0)}(k)\right|}{x^{(0)}(k)}\times 100\%, k=2,3,\ldots\ldots,n$

Then the average residual of fitting data can be calculated.

$\bar{\varepsilon}_r=\frac{1}{n-1}\sum_{k=2}^{n}|\varepsilon_r(k)|=0.089249<0.1$ can achieve a better degree of fitting.

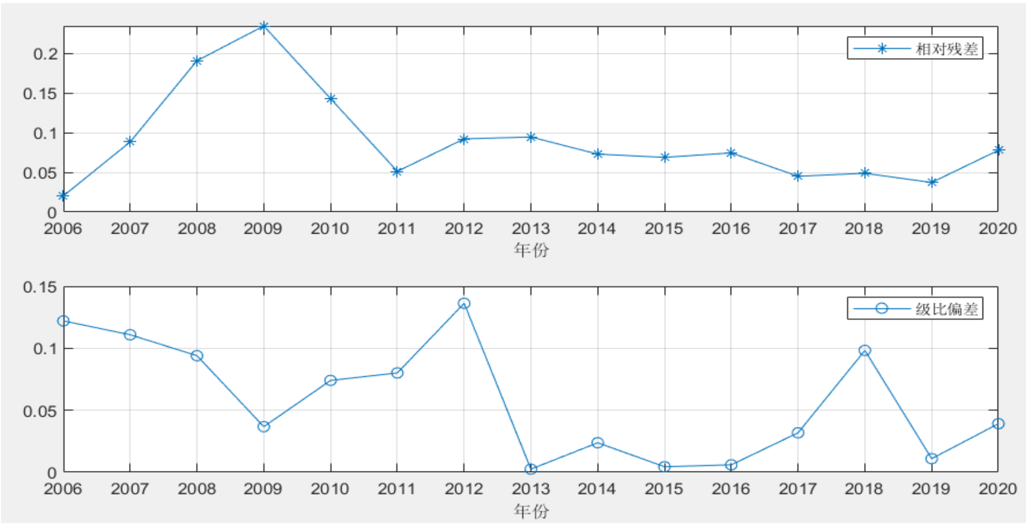

Figure 2: Relative residuals and rank ratio residuals

The results of 45 years backward prediction through grey prediction are shown in Figure 3.

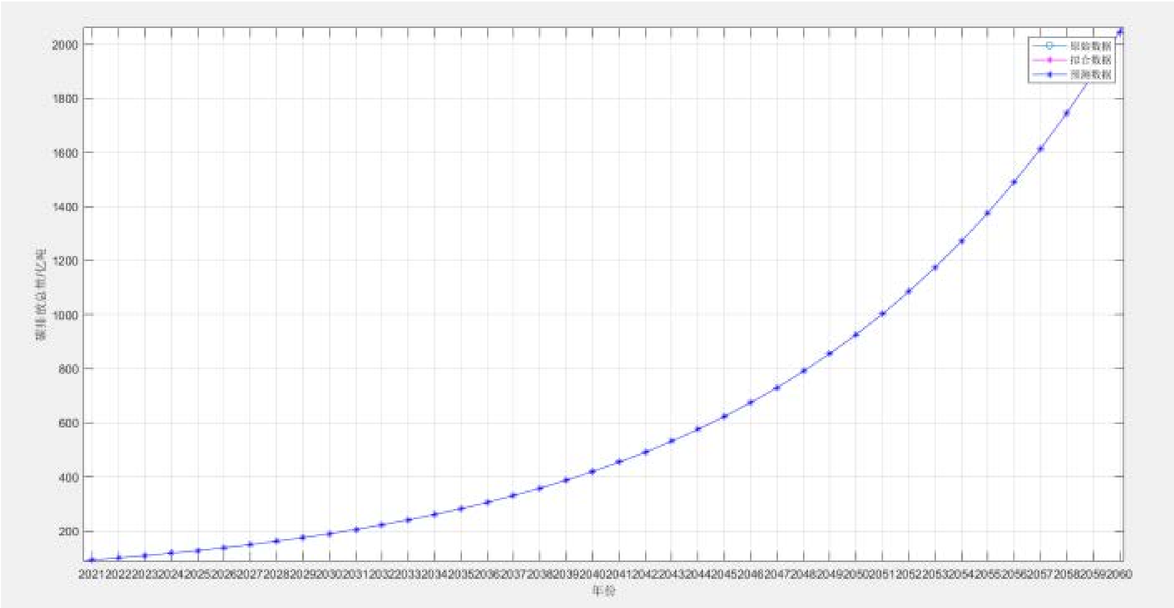

Figure 3: CO2 emissions over the next 45 years

Therefore, maintaining the original development trend, carbon dioxide emissions will reach 303977.3 billion tons after 45 years. If the proportion of industrial structure and energy structure is optimally adjusted, the carbon dioxide emission in 2060 is only about 20 billion tons, which is obviously not in line with the requirements of China's industrial development. Therefore, through the control variable method, we can ensure the stable development of economy and reduce the emission of carbon dioxide to the maximum.

2.3 Sensitivity Analysis

In the control of carbon emissions, there are a lot of driving factors of energy structure and industrial structure as variables of outcome factors, including energy structure variables such as water energy, nuclear energy, oil, natural gas, hydrogen energy, and industrial structure variables such as heavy industry, light industry, agriculture, transportation industry, commerce and service industry.

By observing the curve change, it can be seen that reducing the use of coal resources and improving the use of clean energy are more obvious in the graph, so the model is more sensitive, and the effect of changing nuclear energy is more significant than changing hydrogen energy when increasing the same proportion. In addition, reduce the proportion of heavy industry, and increase the proportion of low pollution industries, the curve change is more obvious, so the model is more sensitive, and increase the same proportion, change the agricultural ratio, change the business and service industry more significantly.

3. Model Evaluation

The advantage of grey prediction is that it doesn't need a lot of data, so it can solve the problems of less historical data, low integrity and reliability of sequence; It can make full use of the differential equation to excavate the essence of the system with high precision; It can generate the irregular original data to the regular generation sequence. It is easy to operate and test, and does not consider the distribution law and the change trend. However, compared with the time series model, the grey prediction has poor long-term prediction ability and large error.

The model can predict other harmful gases, such as sulfur dioxide, nitric oxide and so on. It is helpful for quantitative analysis of harmful gases and provides scientific basis for environmental protection and prevention of harmful gases.

4. Conclusion

To sum up, China's carbon dioxide emissions and absorption problems are not caused by any single factor. On the contrary, it is an interdisciplinary problem composed of a series of variables. Firstly, the prediction and optimization model of driving factors on carbon dioxide absorption and emission is established, and the influencing factors and degree of carbon dioxide content in the atmosphere are analyzed from multiple perspectives.

Although the algorithm model focuses on stochastic problems, it is based on the evaluation results, but the evaluation and optimization also consider social and environmental factors. Although this model can not explain all these factors, it uses a representative cross-section of the existing data to show the current situation of carbon dioxide problems in China, and clearly defines the original trend of carbon dioxide and the trend after intervention. The model shows that it is possible for China to achieve "zero emissions" around 2060 by improving the relationship between carbon dioxide emissions and absorption, and a slight change in anthropogenic emissions can significantly change the results.

References

[1] Li leiming, sun Liangping, Liu Bingquan. Evolution law and driving factors of carbon emission: a case study of Shandong Province [J]. Research on technology, economy and management, 2013 (06): 89-93

[2] Lu Sha. Digital transformation promotes high quality development of power energy enterprises [n]. China Information Weekly, December 23, 2019 (013)

[3] Fu Dongdong, Zhou Xinmiao. Analysis on Influencing Factors of China's carbon dioxide emissions from the perspective of regional differences [J]. Science and technology and management, 2016, 18 (02): 59-64 + 70