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Analysis and prediction of GDP of three major industries based on grey prediction model

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Abstract: *Based on the panel data of China's three major industries' GDP from 2000 to 2020, this paper studies the development trend and trend of China's GDP in the past 20 years from the perspective of data analysis, finds that China's GDP industrial structure has changed from "one, two and three" pattern to "three, two and one" pattern, and gives the personal prediction value of the three major industries' GDP in the next few years by using the grey GM (1,1) model, Through the test of the model, the reliability of the result is high. In addition, it gives its own outlook and views on the impact of relevant policies.*

Keywords: *Panel Data, GDP, GM (1,1)*

1. Introduction and Literature review

Since the reform and opening up, China's three major industries have developed rapidly. From the data source, after 42 years of bloody struggle, the GDP of China's three major industries has increased from 102.753 billion yuan, 174.520 billion yuan and 87.248 billion yuan to 7775.410 billion yuan, 38425.530 billion yuan and 55397.68 billion yuan respectively. The transformation of industrial structure is closely related to the level of economic development. From the "two, one and three" pattern to the "three, two and one" pattern, the international competitiveness and industrial structure have been continuously optimized. Peng Wenzhu [1] pointed out that some economic laws have also been shown in the process of industrial structure optimization. By using the guiding role of economic laws and relevant policies, we can understand the specific development trend of China's economy. However, Guo Xiaobei [2] pointed out that compared with developed economies, there are still some problems in China's industrial development level, such as poor ecological environment, low labor productivity and low capacity utilization.Therefore, it is of great significance to study the GDP development process of China's three major industries and predict the next few years.

With regard to the structural changes and development of the three major industries since China's reform and opening up, Hu Qiuwu [3] concluded that China's tertiary industry is relatively backward by comparing the proportion of the added value of the tertiary industry in GDP between China and other developed and developing countries. Pei Changhong and Yu Yan [4] pointed out that since the reform and opening up, the proportion of China's primary industry has continued to decline and the industry has been optimized. It can be seen that in the past 40 years of development, different industries have shown different development trends. Therefore, it is necessary for us to put forward the development direction of GDP of different industries. So far, there is no special research on the quantitative analysis and prediction of China's GDP, so this paper uses the grey prediction method to predict the specific value of GDP of the three industries, and puts forward its own suggestions combined with the background of the times.

2. Research design

(1) Sample selection and data source

Considering the timeliness of the data, China's international status and changes in the international situation, the old values are excluded, the GDP values of the three major industries in recent 20 years are screened, and the GDP values of the three major industries in recent 20 years are obtained from the collection data as samples for statistical analysis.

(2) Variable selection

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The independent variable of this paper is time, and the dependent variable is the GDP of the primary industry, the secondary industry and the tertiary industry. Among them, the GDP of the primary industry represents the GDP of agriculture, the GDP of the secondary industry represents the GDP of industry, and the GDP of the tertiary industry represents the GDP of service industry.

(3) Model selection

The grey prediction model is suitable for the situation with less data. It does not need a lot of data. Generally, it only needs four data. It can solve the problems of less historical data, incomplete sequence and low reliability. The purpose of this paper is to explore the trend of GDP in the short term, so the grey prediction model is suitable for this research object. At the same time, the univariate regression model was used as the control.

(4) Univariate regression model and grey prediction model

We first establish a univariate regression model:

$$y = kt + b \tag{1}$$

Where y is the value of GDP (unit: trillion), k is the slope and b is the intercept.

Establishment of grey prediction model:

Select the 5-year GDP data as the original data:

$$X^{(0)} = \{x_1^0, x_2^0, x_3^0, x_4^0, x_5^0\} \tag{2}$$

Where, $x_i^0 (i = 1,2,3,4,5)$represents the GDP value from the first I year of the forecast year.

Accumulate and normalize the original data:

$$X^{(1)} = \{x_1^1, x_2^1, x_3^1, x_4^1, x_5^1\} \tag{3}$$

Calculate the nearest mean sequence:

$$Z_k = \frac{1}{2}(x_{k-1}^1 + x_k^1), k = 1,2,\ldots,5 \tag{4}$$

The first-order differential equation GM (1,1) model is established as follows:

$$\frac{dx^{(1)}}{dt} + ax^{(1)} = \mu \tag{5}$$

Where, a is the development coefficient and μ is the grey action quantity.

$Y = \begin{pmatrix} x_2^0 \\ x_3^0 \\ x_4^0 \\ x_5^0 \end{pmatrix}$, $B = \begin{pmatrix} -z_1 & 1 \\ -z_2 & 1 \\ -z_3 & 1 \\ -z_4 & 1 \\ -z_5 & 1 \end{pmatrix}$, Using the principle of least square method, the solution a and μ.

The final prediction model is obtained:

$$X_{k+1}^{(1)} = (X_1^0 - \frac{\mu}{a})e^{-ak} + \frac{\mu}{a}, k = 1,2,\ldots,5 \tag{6}$$

Then the predicted value is reduced to obtain the original predicted value:

$$X_{k+1}^{(0)} = X_{k+1}^{(1)} - X_k^{(1)}, k = 1,2,\ldots,5 \tag{7}$$

The algorithm flow chart of grey prediction model is as follows:

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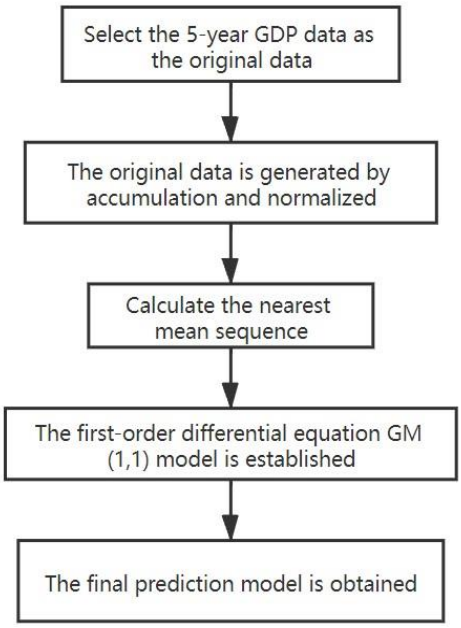

Figure 1: The algorithm flow chart of grey prediction model

3. Experimental results and analysis

(1) Visualization of GDP data of three major industries:

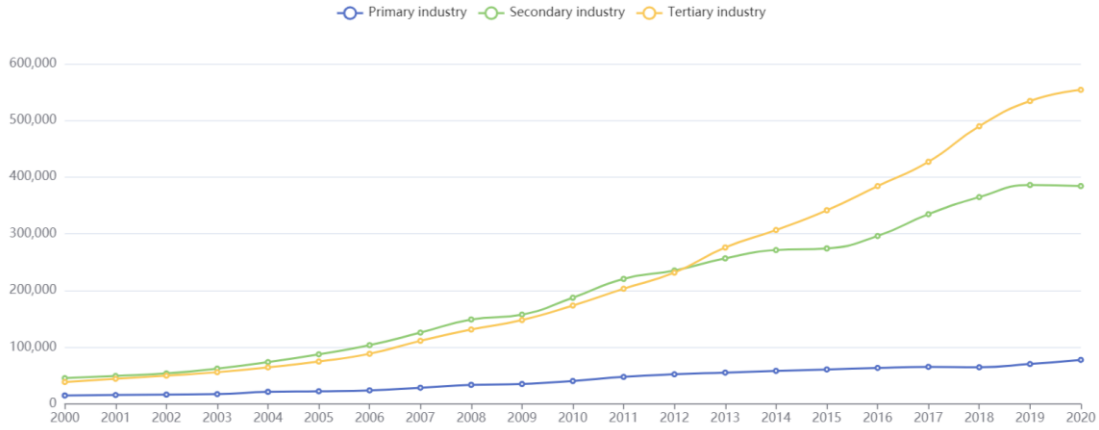

Figure 2: Visualization of GDP data of three major industries

Through the visualization of the data, we can find that the GDP of the tertiary industry in China in recent 20 years exceeded that of the secondary industry for the first time in 2013. At the same time, it is found that the growth momentum of the tertiary industry this year is significantly higher than that of the secondary industry and the primary industry.

(2) Model inspection:

Define error rate:

$$\text{error rate} = \frac{\text{true value} - \text{estimate value}}{\text{true value}} \times 100\% \tag{8}$$

For the established grey prediction model, the error rate is calculated by using the data from 2010 to 2020.The calculation results using Python are as follows:

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Table 1: Error rate of each industry under grey prediction model

Year	2011	2012	2013	2014	2015
Error rate of Primary industry (%)	5.1	0.2	5.9	4.3	1.1
Error rate of secondary industry (%)	4.9	6	4.6	1.7	5.1
Error rate of tertiary industry (%)	2.3	2.5	3	4.1	3.6
Year	2016	2017	2018	2019	2020
Error rate of Primary industry (%)	0.3	1.5	5.1	6.2	4.8
Secondary industry error rate (%)	3.7	4.6	3.4	1.3	4.5
Error rate of tertiary industry (%)	1.2	0.5	2.5	3.0	6.1

The negative growth of the primary industry in 2018 led to a slight error in the later forecast. However, the overall error range is acceptable and the prediction accuracy is excellent. Therefore, it can be used to predict GDP in the short term.

(3) Error rate of regression model (primary industry as an example)

Table 2: Error rate of each industry under regression model

Year	2016	2017	2018	2019	2020
Error rate of Primary industry (%)	10.1	12.2	6.5	4.5	8.7

It can be found that for the primary industry, the prediction accuracy of the regression model is inferior to that of the grey prediction model.

(4)GDP forecast of three major industries in the next four years

Substitute the data into the established grey GM (1,1) model to obtain the following table:

Table 3: GDP forecast of three major industries in the next four years

Years	2021	2022	2023	2024
Forecast value of primary industry	81152	86390	91966	97902
Forecast value of secondary industry	411154	430295	450327	471291
Forecast value of tertiary industry	614333	667703	725710	788757

The forecast results show that the GDP of the three major industries will grow rapidly in the next four years, and the ratio of the tertiary industry to the total GDP in the growth process is 0.555, 0.564, 0.572 and 0.580, showing an upward trend year by year. The continuous increase of the proportion of the tertiary industry shows that China's economic structure is undergoing major changes, and the transformation and upgrading has reached a key stage, which is worthy of attention. It is worth noting that the growth rate of the secondary industry is relatively slow,

4. Conclusion and suggestions

(1) Seize the opportunity of the times and build a tertiary characteristic industry

The tertiary industry plays an important role in the development of GDP. As an emerging industry, it can provide convenient services for the society, enrich and improve people's lives. The domestic consumption market is huge. With the improvement of various policies and measures, the GDP of the tertiary industry is bound to become the main artery of China's GDP and drive the economy to develop better and better.

(2) Pay attention to the development of secondary and primary industries

Through the observation of data visualization charts and prediction results, it can be found that the economic growth of the secondary industry and the primary industry is more gentle than that of the tertiary industry. Only when the three industries promote and cooperate with each other will China enter the developed countries as soon as possible.

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