

The Application of Exponential Smoothing in GDP Forecasting

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Abstract: GDP forecasting is the estimation of gross domestic product (GDP) over a period of time in the future, which is important for national governments, businesses, and investors respectively. The exponential smoothing method, also known as an exponentially weighted average method, is a forecasting method with the advantages of a clear process and convenient calculation. In this paper, the literature method is used, and "gross domestic product", "GDP", and "exponential smoothing method" are used in various databases and literature review websites, "Macroeconomics" and "forecasting" as the keywords to search, comb the literature, categorize and summarize the application of exponential smoothing method in GDP forecasting, and at the same time, the experimental method is used to design an experiment to forecast the future growth of GDP in the next three years by using the data published by the National Bureau of Statistics of China (NBSC). The results of the experiment are that the value-added of the primary industry is expected to continue to grow from about 9227.246 billion Yuan in 2023 to about 100139.20 billion Yuan in 2025. The value added of the secondary industry is projected to continue to grow from about 510,795,800,000,000 Yuan in 2023 to about 563,968,676,000,000 Yuan in 2025. The value added to the tertiary sector is projected to continue to grow from about 679,630.84 billion yuan in 2023 to about 753,204.88 billion yuan in 2025. Correspondingly, the Gross Domestic Product (GDP) will continue to grow, from about 1,281,982,888 million yuan in 2023 to about 1,417,312,284 million yuan in 2025. By analyzing the forecast results, it can be seen that all three major industries in China will maintain growth in the next three years. Depending on the different attributes of the three major industries, the government or enterprises will take appropriate measures to ensure the growth of the industries as well as to cope with various risks. This forecast is based on past data, but the actual economic situation may be affected by many external factors such as the international trade environment and the global economic situation. Governments and businesses will therefore need to pay close attention to these factors in order to adjust their strategies in a timely manner.

Keywords: Gross domestic product, GDP forecasting, Exponential smoothing method, Macroeconomics.

1. Introduction and Explanation of Concepts

1.1. GDP and the importance of its forecasting

GDP (Gross Domestic Product) is the main indicator of a country's economic activity, reflecting the total value of all goods and services produced in a country over a specific time period. The importance of GDP is mainly in measuring the size and growth of a country's economy, reflecting the gap between countries, helping in the formulation and evaluation of national policies, reflecting the standard of living of the people, and helping investors in their investment decisions. In short, GDP is an important indicator of a country's economic activity, which is important for measuring the size of the economy, formulating policies, and evaluating the investment environment.

GDP forecast is an estimate of the gross domestic product in the future period, which is important for the national government, enterprises, and investors respectively. The GDP forecast can be used by government departments to formulate appropriate fiscal and monetary policies and social development programs. Accurate GDP forecasts help the government to take appropriate policy measures to cope with possible future economic fluctuations and to identify potential economic risks, such as inflation and deflation, at an early stage. The government and enterprises can take measures in advance to minimize the impact of these risks on the economy and ensure stable economic growth. For enterprises and

investors, GDP forecast is an important basis for measuring the investment environment. By forecasting the future GDP, enterprises and investors can better judge the future economic development trend and thus make more informed investment decisions.

1.2. Exponential smoothing method:

Jingwen Ma et al.[1] proposed that, at the present stage, the forecasting of GDP is mainly through two methods respectively, the transformation of modeling method from linear model to nonlinear model, and the conversion of simple parameter optimization to composite model research. The exponential smoothing method, also known as the exponentially weighted average method, is a linear forecasting method, which was first proposed by American scholar R.G. Brown in 1959. This method analyzes the pattern of change of time series data to forecast, making up for the moving average method cannot make full use of all the data information and will participate in the operation of the N data equal weighted view of the shortcomings. The exponential smoothing method has the advantages of a clear process and convenient calculation, so it is highly praised in theory and widely used in forecasting in engineering, economy, and management. The common exponential smoothing methods are primary exponential smoothing, secondary exponential smoothing, and tertiary exponential smoothing. In practical forecasting, which smoothing method to use is determined based on the trend analysis of the time series^[2]. The primary exponential smoothing method is usually used for the series

without trend and seasonality, and its model is suitable for forecasting smooth data with the formula: α is the smoothing coefficient ($0 < \alpha < 1$). The secondary exponential smoothing method is based on the primary exponential smoothing and then does another smoothing, usually used for the trend but no seasonality of the series, and its forecasting model is suitable for the time series data is a linear trend of the situation, the formula is: $S_t^{(2)} = \alpha S_t^{(1)} + (1 - \alpha) S_t^{(2)}$. The cubic exponential smoothing method is based on the secondary exponential smoothing method to continue to do a smoothing, usually used for the series with a trend and seasonality, the formula is: $S_t^{(3)} = \alpha S_t^{(2)} + (1 - \alpha) S_t^{(3)}$. Because the test is to obtain annual data, the data obtained have trends but not seasonality, so this paper will choose the quadratic exponential smoothing method to make predictions.

1.3. Value added of the three main industries:

The value added of the primary industry refers to the final results of the production activities of the primary industry of all resident units of a country (or a region) during a certain period of time, calculated according to market prices. The primary industry refers to agriculture, forestry, animal husbandry, and fishery (excluding agriculture, forestry, animal husbandry, and fishery services). Value-added of the secondary industry refers to the final results of production activities of the secondary industry engaged in by all resident units of a country (or region) within a certain period of time, calculated at market prices. The secondary industry refers to the mining industry (excluding mining auxiliary activities), manufacturing industry (excluding metal products, machinery, and equipment repair industry), electricity, heat, gas, and water production and supply industry, and construction industry. Value-added tertiary industry refers to the final results of all resident units in a country (or region) engaged in tertiary industry production activities in a certain period of time, calculated at market prices. The tertiary industry refers to industries other than primary and secondary industries.

2. Data Sources and Experimental Steps

Since the forecasting country is China, the dataset will be selected from the value added of the primary, secondary, and tertiary industries published by the National Bureau of Statistics of China for the past 20 years, and then the values of the three years after the forecasting will be summed up to get the total GDP forecasting value.

The steps of the experiment are as follows:

(1) The value added of China's primary, secondary, and tertiary industries from 2003 to 2022 was collected from the National Bureau of Statistics of China as a forecast dataset, and the downloadable file format is Excel.

(2) Handling outliers: handles outliers in the data by calling the `handle_outliers` function, which first calculates the moving average of the data and determines which data points are outliers by calculating the z-score, a normalized measure of the deviation of a data point from its mean value. This function calculates the moving average and z-score using a window size of 3. If the absolute value of the z-score for a data point is greater than 3, then it is considered an outlier and is replaced with its corresponding moving average.

(3) Fitting a quadratic exponential smoothing model: since the acquired data set is annual and the acquired data is trending, but not seasonal, quadratic exponential smoothing is chosen for forecasting. The `holt_forecast` function is called to fit a Holt quadratic exponential smoothing model using the processed data and predict the values for the next few periods (3 by default).

(4) Data preprocessing: the data is set to be indexed by 'indicator' (the 'indicator' rows in the acquired dataset are the years) and the data rows are inverted so that the years are sorted in ascending order.

(5) Forecasting the value added of each industry: Quadratic exponential smoothing of the value added of primary, secondary, and tertiary industries is forecasted.

(6) Visualization of predicted results: each industry's data is plotted as a chart in which the actual data from 2018 to 2022 is shown along with the predicted data for 2023, 2024, and 2025. The actual data is represented by a solid line and the forecasted data is represented by a dashed line, and the forecasted values are marked with red numbers on the chart.

(7) Forecast of GDP: The value added of the primary, secondary, and tertiary sectors in 2023, 2023, and 2023 were added up to get the forecast of GDP in 2023, 2023 and 2023 respectively, and plotted as line graphs.

(8) Analysis

3. Experimental Results and Summary Analysis

3.1. The table of projections for the three industries:

Figure 1 shows the forecast of value added of the primary sector: (in billions of dollars)

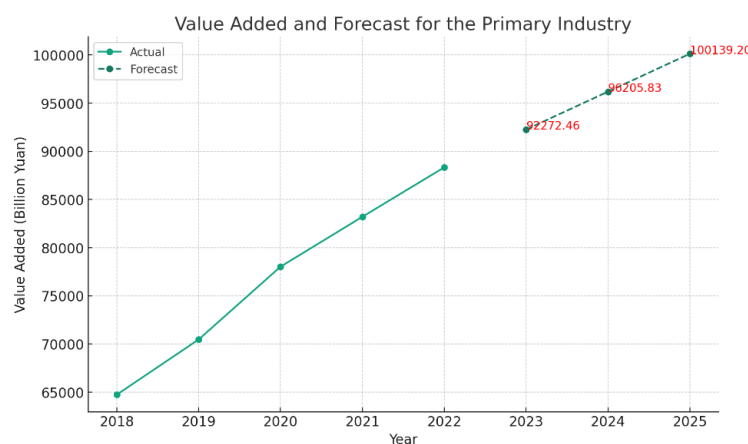


Figure 1. The forecast of value added of the primary sector.

Figure 2 shows the forecast of value added in the secondary sector: (in billions of dollars)

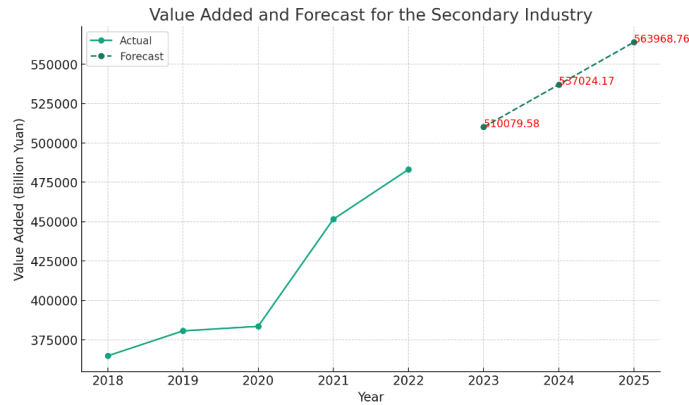


Figure 2. The forecast of value added in the secondary sector.

Figure 3 shows forecast of the added value of the tertiary sector: (in billions of dollars)

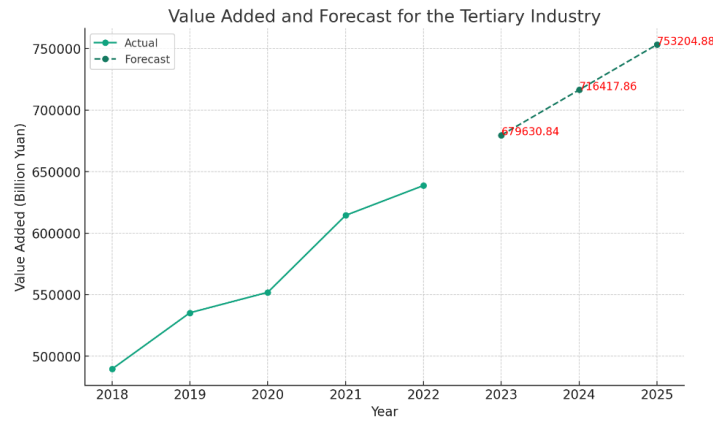


Figure 3. The forecast of value added in the tertiary sector.

Table 1 shows the projections for 2023, 2023, and 2023 and 2023, respectively: were summed to obtain the projected GDP for 2023, 2023,

Table 1. Forecast of Gross Domestic Product (GDP)

particular year	Value added of primary industry (billion yuan)	Value added of secondary industry (billion yuan)	Value added of tertiary industry (billion yuan)	Gross domestic product (billions of yuan)
2023	92272.46	510079.58	679630.84	1281982.88
2024	96205.83	537024.17	716417.86	1349647.86
2025	100139.20	563968.76	753204.88	1417312.84

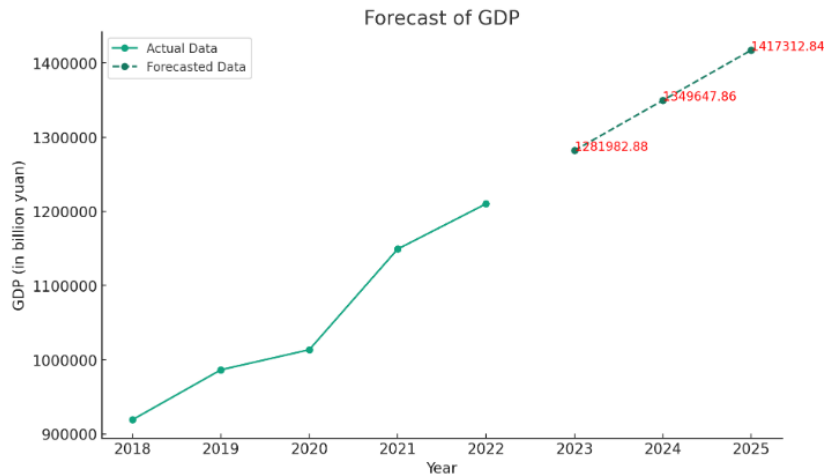


Figure 4. The forecast of the value of GDP (In billions of yuan)

3.2. Summary and Analysis:

From the results of the forecast, it can be seen that all three major industries in China, namely the primary, secondary, and tertiary sectors, will continue to grow in the next three years, thus driving the growth of the Gross Domestic Product (GDP).

The analysis can be made according to Figure 1, the primary sector, or agriculture, is projected to grow from approximately 922,7246 million yuan in 2023 to approximately 100,139.20 billion yuan in 2025. Although the growth is modest, its stability and continuity are critical to national food security and the stability of the rural economy. It can therefore be inferred that government support for agriculture and advances in agricultural technology are likely to be the key factors driving this sustained growth. In addition, agriculture is important for environmental protection and climate change adaptation.

The analysis can be made according to Figure 2, The secondary industry, which mainly consists of manufacturing and construction, is projected to grow from approximately 510,795,800,000,000 Yuan in 2023 to approximately 563,968,676,000,000 Yuan in 2025. The results of this forecast indicate that manufacturing and construction remain important drivers of China's economy. In the coming years, more innovation and technological advancements are likely to be seen to drive the growth of this industry. Meanwhile, environmental protection and green building may become new growth areas.

The analysis can be made according to Figure 1, the tertiary sector, or other industries such as services, is projected to grow from about 67,963,084 million yuan in 2023 to about 75,320,488 million yuan in 2025. This projection indicates that other industries such as services will likely grow significantly in the coming years. As the economy grows, so does the demand for high-quality services. For example, information technology, financial services, education, and healthcare are likely to see major growth. The Government and enterprises may need to consider further investment in these areas.

From Table 1 and Figure 4, the Gross Domestic Product (GDP) is projected to continue to grow, from about 1,281,982,888 million yuan in 2023 to about 1,417,312,284 million yuan in 2025. The results of this forecast reflect the strong growth momentum of the Chinese economy, showing that the country's economic policies are likely to be effective, business activity is booming, and consumer confidence is increasing.

It should be noted, however, that the results of these forecasts are based on past data, and the actual economic situation may be affected by many external factors, such as the international trade environment, the global economic situation, and domestic policy changes. Therefore, the forecast results should be used as a reference for possible trends rather than an exact expected value.

In economic terms, the forecasts suggest that China's economy is likely to continue to grow. This could mean that China's economic policies are effective, business activity is booming, and consumer confidence is increasing. This growth may also stimulate more foreign investment, further boosting economic growth. In addition, as GDP grows, employment is likely to increase as well, leading to growth in personal income and consumption levels.

From a social point of view, economic growth is usually

associated with social development and improvement in people's living standards. This could mean that China's social development is likely to continue in the coming years and that people's lives are likely to improve. This may be reflected in improvements in education, healthcare, and other social welfare services. As the economy grows, the government may have more resources to invest in these areas, thus improving the quality of life of the population.

From a policy perspective, government economic policies may affect GDP growth. Forecast results may imply that current policies may support future economic growth. The government may need to continue to implement and adjust policies to sustain such growth. For example, the government may need to further promote technological innovation, optimize the business environment, and provide more support and incentives to promote business growth.

Overall, while the forecasts indicate that China's economy is likely to continue to grow in the coming years, this should not be seen as a certainty. The actual economic performance may be affected by many unknown factors, so the government, businesses, and investors need to pay close attention to the economic situation in order to make timely adjustments to their strategies and plans.

4. Conclusion

To summarize, this study uses exponential smoothing to forecast China's primary, secondary, and tertiary industries as well as total GDP for the next three years. The forecast results show that all three industries and the GDP in China are likely to continue to grow in the next three years. Of these, growth in the service sector is likely to be the most significant, which may push the government and businesses to further invest in service sectors, such as information technology, finance, education, and healthcare. Meanwhile, the continued development of industry and infrastructure remains critical to China's economic growth, and more investment in technological advances, energy efficiency improvements, and environmental protection should be considered. As for the primary sector, although it is expected to grow relatively slowly, given its importance for food security and the rural economy, continued investment of resources is still needed to enhance its productivity and sustainability.

It is important to note, however, that the results of these forecasts are based on past data only and that the actual economic situation may be affected by many external factors, such as the international trade environment, the global economic situation, and so on. Therefore, the results of these forecasts should be used as a reference for possible trends and should not be regarded as an exact expected value. Future economic development requires the Government, enterprises, and investors to pay close attention to various factors that may affect the economy in order to adjust their strategies in a timely manner.

In addition, although the exponential smoothing method has the advantage of being a clear process and easy to compute, it also has some limitations. For example, it assumes that future trends will continue past trends, which may not be the case in reality. Therefore, future research may need to explore additional forecasting methods or combine multiple methods to improve the accuracy of forecasting.

Overall, GDP forecasting is important for national governments, enterprises, and investors to help them formulate policies and make decisions. This paper hopes that

this research can provide them with useful references and also a possible forecasting method for future research. It also looks forward to more studies in the future to further improve the accuracy and usefulness of GDP forecasting.

References

- [1] Ma, J. W., Li, S. Q., & Xia, M. Y. (2022). A review of the application of machine learning in GDP forecasting. *Journal of Science and Technology Information Research*, 03, 73-94.
- [2] Xu, J. X., Yan, Y., & Yan, F. H. (2008). Application of exponential smoothing method in GDP forecasting of typical cities. *Water Resources Science and Technology and Economics*, 07, 551-554.