Prediction of GDP in Time Series Data Based on Exponential Smoothing Model and Neural Network Model

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Abstract. Gross Domestic Product (GDP) is the main indicator for measuring the economic size of a country or region, which represents the market value of all final goods and services over a certain period of time. This article compares the performance of exponential smoothing(ES) model and neural network(NN) model in GDP forecasting. The ES model is a classic time series forecasting method widely used in economic data analysis due to its simplicity and ease of use. This study uses single index smoothing and double index smoothing methods to predict GDP, with a focus on analyzing its performance in short-term economic forecasting. To compensate for this deficiency, this study introduced a neural network model to leverage its powerful nonlinear modeling ability and long-term memory capability for time series data. It demonstrates significant advantages in GDP forecasting, better adapting to the complexity of economic data and providing more accurate predictive support for economic decision-making.

Keywords: GDP; Forecast; Exponential smoothing; Neural network.

1. Introduction

The necessity of predicting China's GDP, is reflected in multiple aspects, including economic policy formulation, investment decision-making, financial market stability, international relations, social development, and economic risk management. Accurate GDP forecasts are not only crucial for governments and businesses, but also have profound implications for the international community and public stakeholders [1].

Firstly, predicting China's GDP provides an important basis for the government to formulate macroeconomic policies. The government needs to understand the trends and potential risks of economic growth in order to implement effective fiscal and monetary policies. For example, a slowdown in economic growth may require stimulating the economy through tax cuts or increased public spending, while an overheated economy may require raising interest rates or reducing spending to control inflation. Accurate predictions help the government make timely policy adjustments in different economic situations, promoting economic stability and sustainable development [2].

Secondly, for businesses and investors, GDP forecasting is a key reference for making strategic decisions and investment plans [3]. Investors rely on GDP forecasts to assess changes in the economic environment and make more informed investment decisions [4].

At the international level, as the world's second-largest economy, China's economic trend has a significant impact on the global market. Accurate GDP forecasts can help other countries and international organizations assess the potential impact of China’s economy on global trade and investment, and adjust their economic policies and strategies accordingly. This is not only beneficial for international economic cooperation, but also contributes to the balanced development of the global economy [5].

In short, accurate prediction of China's GDP is essential not only for policy-making, investment decisions, financial market stability, and international relations, but it also has a profound impact on social development planning and economic risk management [6]. Through accurate GDP forecasts, stakeholders can better respond to economic challenges, seize development opportunities, and achieve sustainable economic growth.

This article analyzes the GDP values of Zhejiang Province in the past 30 years using exponential smoothing models and neural network models, and predicts the situation for the next five years. Then, the results obtained from the two methods were compared, and the advantages and disadvantages of each method were analyzed separately

Through the use of two models, this article concludes that the economy of Zhejiang will show a stable upward trend in the next five years. At the same time, it is concluded that the exponential smoothing model can handle linear functions well and obtain more accurate results for short-term predictions, while the neural network model relies on large-scale data. The more data analyzed, the more accurate the results can be obtained.

2. Methods

2.1. Exponential Smoothing Model (ES)

ES was proposed by Robert Brown. He believes that because time series are very stable and also have patterns, they can be reasonably predicted.

Therefore, more attention need to be paid to the newest data. ES is an analysis and prediction method developed from the moving average method. ES is a widely used production forecasting method that can also be used to predict trends, but the prediction effect will be better in a short period of time [7]. ES is the most common prediction method among all methods. Use all data series from the uniform usage period to average the entire time period. ES has the advantages of the two methods mentioned above. It won't ignore past data, but it will give it some weight. The closer the data is to the present, the greater the weight it will occupy in the data [8].

Firstly, in order to obtain the results, the simple smoothing index method is used, its formula is:

$$R_t+1=\alpha R_t+(1-\alpha)R_t \quad (1)$$

Where α is a smoothing factor with a value between 0 and 1, it determines prediction errors by minimizing the sum of squares.

Table 1. Zhejiang's GDP values in the past 27 years

year	value	year	value	year	value
1992	1375.7	2001	6927.7	2010	27399
1993	1925.9	2002	8040.7	2011	34382
1994	2689.3	2003	9753.4	2012	37334.6
1995	3563.9	2004	11482.1	2013	40023.5
1996	4195.8	2005	13028.3	2014	43507.7
1997	4695.9	2006	15302.7	2015	47254
1998	5065.5	2007	18640	2016	52403.1
1999	5461.3	2008	21284.6	2017	58002.8
2000	6164.8	2009	22833	2018	62462

The data in Table 1 is Zhejiang's GDP values over the past 27 years used for prediction which comes from a user named Chen Han on Kaggle who uploaded it on the website two years ago.

The GDP index of Zhejiang in the Table1 over the past 30 years in data analysis is in a stable upward stage. In order to predict the future economy of Zhejiang, smoothing index need to be calculate. The value range of alpha is periodically determined by empirical judgment methods. When the temporal changes fluctuate greatly, the trend of data changes will have a significant impact, and when the trend rises rapidly, a larger alpha value should be chose, for example, when the time-series data shows a clear upward or downward trend, a larger alpha value should be chose, typically between 0.6 and 1.0.

2.2. Artificial Neural Network

An artificial neural network model is a computer operation model that imitate the thought of humanity. It is a nonlinear system problem [9]. In this experiment, an artificial neural network model was also used to predict the value of GDP, and the results of the two methods were compared.

This article uses an algorithm called error back propagation(BP), which is a supervised learning algorithm.

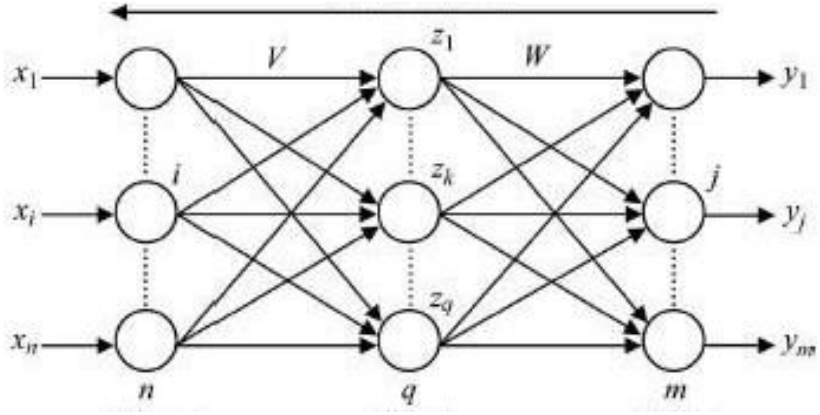

Fig. 1. BP diagram

The operation method of neural network method can be found in Fig. 1. BP diagram for withdrawal. The BP trains the model through two computational processes, one of which is the forward propagation process where the input data undergoes regular processing in the input layer, and then passes on to the next layer, which is the output layer.

If the required output cannot be obtained during the input process, that is, if there is a deviation in the data, an error signal will be output, and the erroneous data will be backpropagated and returned to the input layer along the original calculation path. The weight of each neuron in the following way need to be adjusted to minimize the error.

2.2.1 Node output model

The hidden layer nodes and output layer nodes both have their own output models, as shown in formulas (1) and (2) respectively:

$$Z_j=g(\sum w_{ij} * X_i - \theta_j) \quad (2)$$

$$Y_j=g(\sum T_{jk} * Z_j - \theta_k) \quad (3)$$

In formulas (2) and (3), g is the nonlinear function, θ is the threshold of the neural unit, W_{ij} connects the strength between the input value and the hidden layer value, and T_{jk} connects the strength between the hidden layer value and the output value.

2.2.2 Functional method

The action function is a function that reflects the strength of input from the upper node to the lower node. It usually takes the Sigmoid function within (0,1):

$$f(x)=1/(1+e^{-x}) \quad (4)$$

3. Experimental Result

3.1. ES

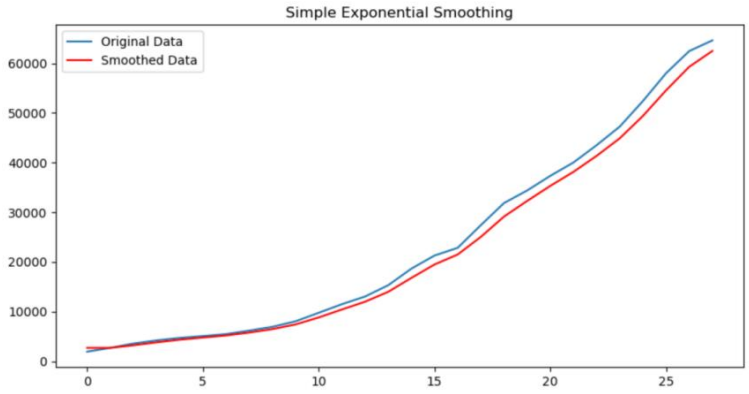

Fig. 2. The original and smoothed data

In Fig. 2, The original and smoothed data is a smoothing index operation performed on the GDP data of Zhejiang Province in the past 20 years. The smoothing coefficient used is 0.6, which makes the model more closely follow the data, but may introduce more noise.

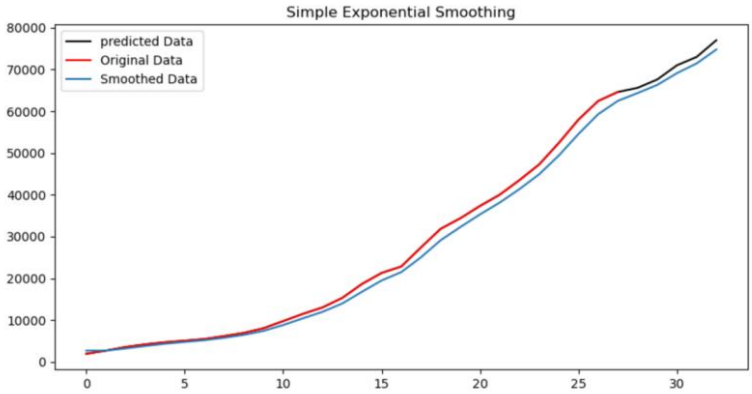

Fig. 3. The original and smoothed data with its prediction

Next, the same method is used to calculate the smoothing index, aiming to make the single index smoothing value as close to the predicted value as possible while maintaining the same end of the original data, in order to obtain the predicted GDP value, the result is shown in Fig. 3.

3.2. Artificial neural network

Through the table, the GDP of Zhejiang forecast can be obtained, as shown in **Fig. 4.**

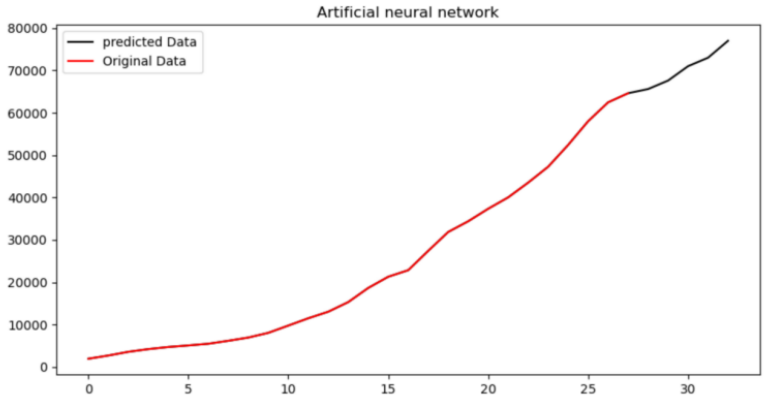

Fig. 4. The original with its prediction

Compared to neural network methods, exponential smoothing models can still provide effective predictions even with small amounts of data. This allows it to be applied even in situations where data is insufficient. The exponential smoothing model has relatively low requirements for data preprocessing and does not require complex feature extraction or transformation of the data [10]. Due to the fact that the exponential smoothing model is based on weighted averaging, its prediction results and model behavior are relatively easy to explain. The model structure is simple and intuitive, which can clearly display the relationship between predicted results and historical data.

The exponential smoothing model mainly relies on the linear trends and seasonal characteristics of the data. They assume that data changes are relatively simple linear functions, typically suitable for short-term forecasting and stable time series data. The model can handle complex patterns such as non-linear relationships, seasonal variations, and unexpected events. Neural network models perform particularly well in processing time series data with long-term dependencies. Neural network models can handle large-scale datasets, and by increasing the network size (number of layers and neurons), more data can be utilized to improve prediction performance. For large-scale datasets, the computational and storage efficiency of exponential smoothing models may be limited, and the performance improvement space of the model is relatively small.

4. Conclusion

GDP is a great tool to assess economic strength and effectively measuring its economic indicators. Therefore, it is necessary to predict GDP. There are many methods for forecasting GDP, like exponential smoothing, regression, etc. This article chooses ES model and NN model and compares the two methods. Through these two methods, the GDP data of Zhejiang for the next five years has been obtained. From the data, it can be seen that China's GDP is in a steady upward stage and is in a good trend of continuous development.

References

[1] Youssef J, Ishker N, Fakhreddine N. GDP Forecast of the Biggest GCC Economies Using ARIMA. 2021.

[2] Kumar S, Muhuri P K. A novel GDP prediction technique based on transfer learning using CO2 emission dataset. Applied Energy, 2019, 253: 113476.

[3] Abonazel M R, Abd-Elftah A I. Forecasting Egyptian GDP using ARIMA models. Reports on Economics and Finance, 2019, 5(1): 35-47.

[4] Wu J, He Y. Prediction of GDP in time series data based on neural network model//2021 IEEE International Conference on Artificial Intelligence and Industrial Design (AIID). IEEE, 2021: 20-23.

[5] Li Q, Yan G, Yu C. A novel multi-factor three-step feature selection and deep learning framework for regional GDP prediction: evidence from China. Sustainability, 2022, 14(8): 4408.

[6] Obeng-Amponsah W, Zehou S, Dey E A. Using exponential smoothing method in forecasting domestic credit to private sector of Ghana. Journal on Innovation and Sustainability RISUS, 2019, 10(3).

[7] Parvez S M. ANALYSIS OF THE PATTERN OF RICE PRODUCTION AND FORECASTING IN BANGLADESH BY SIMPLE EXPONENTIAL SMOOTHING MODEL.

[8] Hossain A, Hossen M, Hasan M M, et al. GDP growth prediction of bangladesh using machine learning algorithm//2021 Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks (ICICV). IEEE, 2021: 812-817.

[9] Li Q, Yu C, Yan G. A new multipredictor ensemble decision framework based on deep reinforcement learning for regional gdp prediction. IEEE Access, 2022, 10: 45266-45279.

[10] Barsoum F, Stankiewicz S. Forecasting GDP growth using mixed-frequency models with switching regimes. International Journal of Forecasting, 2015, 31(1): 33-50.