

Forecasting of US GDP using Two Different Methods

Chuan Xu *

School of Science and Engineering, University College London, London, N1C 4BE, UK

* Corresponding Author Email: xuchuanuk@outlook.com

Abstract. In the rapid development of society and economy today, Gross Domestic Product (GDP) is regarded as a significant indicator to measure a country's economic development and residents' income. In this study, the author introduced several methods used by many scholars in the history, included BP neural network and ARIMA model. Then the author gave two different methods (Series and non-linear regression), next the author used past US GDP data predicted the US GDP tendency in next 2 years. By using first method author figured out the GDP value in 2024 and 2025 is 29.112226k and 30.931449k. And the GDP value in 2024 and 2025 which are predicted by regression is 29.57k and 31.598k. These different results illustrate the difference in prediction between the two different methods. The author explained the different results, and mentioned the advantages and disadvantages of these two methods. At the end future research direction and application were discussed.

Keywords: GDP growth forecasting, series, non-linear regression.

1. Introduction

Gross Domestic Product (GDP) is an important indicator to measure social economic development. To measure the economic status and development level of a country or region, the most important indicator is GDP, which is also the core indicator of economic accounting. GDP (Gross Domestic Product) is the final result of the production activities of all resident units in a country (or region) over a certain period of time. GDP is the index which can best reflect the macro economy. It reflects the price of labor for all final goods produced in the national economy of a country or region at a given time and can help to make judgement of the extent of the total economic activity of a country or region [1]. So far, 23 provincial capitals in China published the economic data for the first half of the year in 2024. In 11 of these cities include Guangzhou, Chengdu, Hangzhou, Nanjing, Changsha and Xi'an, which have a GDP of one trillion RMB, GDP growth was slower than the national average [2]. In 2020, when the epidemic broke out, China's GDP still broke through the mark, reaching 100 trillion yuan for the first time. On April 16, 2021, the National Bureau of Statistics released the latest data, according to preliminary calculations, China's GDP in the first quarter reached 24,931 billion yuan, up 18.3% year-on-year, 0.6% month-on-month, compared with 2019, up 10.3%, and an average growth of 5.0% in two years. Therefore, having a high gross economic value need to adopt some measures in order to maintain this advantage, and it's necessary to take reasonable measures to stabilize the economy when the crisis occurs. Economic forecast is an efficient approach to help government fully aware of the economic situation of region. So accurate economic forecast information is urgently needed to assist policy making [3]. Therefore, timely and precisely forecasting of GDP growth will not only help the decision-making and supervision departments to find the risks in the economic operation in time, but also make accurate policy responses in advance, so as to effectively prevent and resolve macroeconomic systemic risks and strengthen the forward-looking macroeconomic governance of the country. It is also conducive to make strategic responses in a timely manner and avoid macro risk [3].

At present, the world economic recovery is slowing down, the relationship between major countries is complicated, and China's economic growth is also slowing down. To increase China's GDP, government cultivated and strengthened emerging industry, promoted the transformation and upgrading of traditional industries, accelerated the development of high-end, intelligent and green manufacturing, promoted the combination of modern service industries with advanced manufacturing and modern agriculture [4]. As the world's largest economy, the United States has both competition

and cooperation with China, which has a significant impact on China's economic development, and it is necessary to forecast the GDP of the United States. Scientific forecasting of macroeconomic trend has always been an important research subject in economics. However, economic forecasts always illustrate less accuracy compared to other kinds of prediction. Main reason is that the object is the economic society, which made up of countless people. This object is much more complicated than natural science and engineering science. This special object brings difficulty to prediction [5]. In order to get accurate predicted result, many economic scholars adopt different methods.

2. Methods

So far, economics researchers have made many attempts and exploration in the field of GDP forecasting, lot of methods were used in the prediction project. For instance, a team from the Inner Mongolia University predicted the GDP of Inner Mongolia Autonomous Region by using the publicly released annual GDP data of Inner Mongolia Autonomous Region from 1992-2022 released by the National Bureau of Statistics, and set up two-steps model and three-steps model based on Long Short-Term Memory (LSTM), and also add the Dropout mode into LSTM in order to avoiding overfitting, and increase the predictive ability of model. According to the results of predicted value and the real value, Mean Absolute Error (MAE), Root Mean Square Error (RMSE) indexes are used to evaluate the advantages and disadvantages of the two models [6]. Lu innovatively used web search data (WSD) with timeliness and optimization algorithm to construct a prediction model, which improves the timeliness and accuracy of prediction and provides a scientific basis for government decision-making [7].

Among these methods, neural network is the most widely used method. Jahn used artificial neural network regression models as suitable tools for the analysis of economic panel data. He combined the regression and neural network, made the prediction more accurate [8]. A team from Department of Mathematics, Yanbian University used stepwise regression analysis method to do the preprocessing of the raw data, the data are easier to analyze. Using the methods of simulation fitting, neural network prediction and so on based on the statistical data of Yanji's GDP from 2001 to 2009 after pretreatment, relevant factors which significantly affect economic development situation of Yanji city are worked out [9]. A team from Department of Statistics, North China University of Technology used the sample data of the country from 1978 to 2019 to test empirically, selects four important variables to measure the growth of GDP, they are investment in fixed assets, total social consumer goods, government expenditure and net exports. By constructing a multiple linear regression model, using the Eviews software to revise it, and eliminating Multicollinearity, they determined that the GDP is significantly affected by both total social consumption goods and net exports [10].

It's worth noting that some researchers make predictions in many areas by using dozens of mathematic models, these can inspire economic scholars to adopt same approach in GDP forecasting. For instance, In the context of the "dual carbon" goal, it is difficult to change the high-carbon economic development model in Hebei Province and the previous prediction model is difficult to meet the actual needs. According to the statistical yearbook data, A team from North China Electric Power University studies the energy consumption trend and carbon emission characteristics of different industries in Hebei Province, explores the dynamic change trend of carbon emissions in Hebei Province with the help of the decoupling index, selects the calculation method of carbon dioxide emissions, and establishes the carbon emission model of Hebei Province optimized by genetic algorithm (GA) optimized BP neural network based on six influencing factors of carbon emissions, and simulates and predicts the carbon emissions of Hebei Province from 2021 to 2030. This method (BP neural network) can also be used in GDP prediction [8]. However, some large enterprise units or government departments often have professional forecasting teams, but for some individuals, it's difficult to use such complicated method. In this article, the author used two totally different methods to forecast the US GDP value in 2024 and 2025. And compared the two methods, the author will give a simpler and more accurate one.

3. Results and Discussion

3.1. Series Forecasting

This method assumes that the rate of GDP growth changes in the same proportion (k) every year. It is restricted by the tendency of graph because it only uses a rough model.

Equations below illustrate the US GDP tendency in the last 5 years. Using this simple function prediction method, this paper set up a model (1):

$$x_{2023} = (1 + m\%)^2 \cdot x_{2021} \quad (1)$$

Where x_n means the GDP value in n year. By using the data this paper got, the author can easily know the value of m. Then the author uses:

$$x_{2024} = (1 + m\%)x_{2023} \quad (2)$$

Then the author can get the predicted value of GDP in 2024. And the author also can get a recurrence sequence like:

$$x_n = x_{n-1}(1 + m\%) \Leftrightarrow \frac{x_n}{x_{n-1}} = (1 + m\%), n > 1 \quad (3)$$

According to this formula, the author knows that it's a geometric progression.

$$x_n = (1 + m\%)^{n-1}x_1 \quad (4)$$

As you see, the premise of this method is that the author hypothesizes the GDP growth function is an exponential function. That in itself has a big margin of error. It's worth noting that in this model, the author assumed that GDP will grow m percent each year. In fact, m is changing all the time.

3.2. Non-Linear Regression Analysis

As you see, in the last method, the author assumes that GDP growth follows the rule of exponential function. In other words, the author uses an exponential function to fit the image of GDP growth but failed. If the author can do this by changing another function which is highly similar to the image, the author can reduce the error significantly. This is the main part of the non-linear regression analysis model. The author tries to find a function which can fit the image best, and figure out the formula, use this function to get the prediction value. So, finding the formula is important. In the linear regression model,

$$\hat{b} = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^n (x_i - \bar{x})^2} \quad (5)$$

$$\hat{a} = \bar{y} - \hat{b}\bar{x} \quad (6)$$

Observing the image (3-1-1), the author made a decision to use logarithmic function to fit it. There is (3)

$$\bar{y} = \hat{b} \ln \bar{z} + \hat{a} \quad (7)$$

For unify the form, $x = \ln z$,

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i = \frac{1}{n} \sum_{i=1}^n \ln z_i = \frac{1}{n} \ln \prod_{i=1}^n z_i \quad (8)$$

To find the regression equation.

3.3. Real Data Example

All data are from trading economics in Table 1.

Table 1. Data source

time	2019	2020	2021	2022	2023
The value of time by taking the logarithm	7.6103	7.6108	7.6113	7.6118	7.6123
GDP (USD BILLION)	21.5k	21.3k	23.6k	25.7k	27.4k

By using the real data, the calculation process and results of the two methods are compared. For the first method,

$$\frac{x_{2023}}{x_{2019}} = (1 + m\%)^4 \Leftrightarrow 1 + m\% = \sqrt[4]{\frac{x_{2023}}{x_{2019}}} \quad (9)$$

Using the past data, $m \approx 6.249$. Then,

$$\frac{x_{2024}}{x_{2023}} = (1 + m\%) = 1.06249 \quad (10)$$

$$x_{2024} = 29.112226k \quad (11)$$

By parity of reasoning, $x_{2025} = 30.931449$.

For the second method, according to author's calculation, the regression equation is,

$$\hat{y}(k) = 4056 \ln x - 30847.9468 \quad (12)$$

Put $x = 2024, x = 2025$ in the equation, $x_{2024} = 29.57k$, $x_{2025} = 31.598k$.

Looking at the first method, set n year GDP is x_n , and consider that $\frac{x_{n+1}}{x_n} = k$, it could be written as $x_n = x_1 \cdot k^{n-1}$. If the author expresses this by using function, the author can get,

$$f(n) = f(1) \cdot k^{n-1} \quad (13)$$

This can be seen as a kind of quantity in the exponent (exponential function). This method can be seen as using an exponential function to fit the graph of the GDP. This is similar to non-linear regression. But only use one constant k , and ignored the process of regression. This method only calculated k by using two random data. So, if researcher choose different data, the predicted result will be different. This definitely caused some error. For further optimization, the function used to predict should be written as,

$$f(n) = ak^n + b \quad (14)$$

And the author uses non-linear regression to calculate the value of k and b (same as the second method). As you see, non-linear regression can be finished by using different function, it's important to figure out which one is more accurate.

4. Conclusion

Difference in the predicted values of the two methods reveal differences in accuracy. The two predictions were not far apart. This means that there is some value in using both methods in some particularly filed.

Through the predictions and research in this article, some suggestions can be provided. Observing the results, the rate of US GDP rise is slowing down, this may have some relations with the turmoil. From individual perspective, this data illustrated that this is not an entrepreneur-friendly time. This may be due to international tensions, bad people welfare, inappropriate government's tactics, etc. From a researcher's perspective, choosing reasonable model is very significant for research. From an individual perspective, according to either model, US GDP is on an upward trend, it means USA has a good market prospect and increasing people welfare. Looking to the future research, for space reasons, this paper only using non-linear regression to predict the GDP tendency, but ignored some important factor of influence, such as warfare, tense international situation, climate, etc. If the author

uses particle filter analysis framework, or neural network fitting technique, the result will be more accurate, this is the direction that the author will tackle next.

References

- [1] Wu Yang, Luo Jikang, Zhao Zhen, Xie Xiaobo, Pang Jing. GDP Forecast of Inner Mongolia Autonomous Region Based on LSTM Neural Network. *Journal of Inner Mongolia University of Technology (Natural Sciences Edition)*, 2024, 43 (04): 296 - 301.
- [2] LI Xiuzhong. What are the reasons for the "stalling" of GDP growth in the first half of the year in the 11 provincial capitals that are not as fast as the whole country. *CBN Daily*, 2024.
- [3] LU Zihan. Research on GDP forecasting in China based on network search data. *North China University of Technology*, 2024.
- [4] XU Gao. Why are economists' forecasts always inaccurate. *Finance Expo*, 2024, (07): 37 - 38.
- [5] Wu Yang, Luo Jikang, Zhao Zhen, Xie Xiaobo, Pang Jing. GDP Forecast of Inner Mongolia Autonomous Region Based on LSTM Neural Network. *Journal of Inner Mongolia University of Technology (Natural Sciences Edition)*, 2024, 43 (04): 296 - 301.
- [6] LU Zihan. Research on GDP forecasting in China based on network search data. *North China University of Technology*, 2024.
- [7] Jahn M. Artificial neural network regression models in a panel setting: Predicting economic growth. *Economic Modelling*, 2020: 148 - 154.
- [8] SUN Wenyuan, YIN Zhe, SHEN Jinghu. GDP Prediction of Yanji City Based on BP_ Neural Network Model. *Journal of Business Globalization*, 2015, 3 (3): 65 - 73.
- [9] LI Wenyue, LI Jungang. An Empirical Analysis of China's GDP Growth Based on Linear Regression Model. *Statistics and Applications*, 2022, 11(6): 1492 - 1499.
- [10] Wang Yongli, Li Yiwen, Wang Huan, Dong Pengxu, Teng Yue, Lin Yuan, Liu Lin. Carbon emission prediction in Hebei Province based on improved BP neural network. *Ecological Economy*, 2024, 40 (06): 30 - 37.