ISSN:2790-1661 Volume-10-(2024)

Analysis and Forecasting of Shenzhen GDP Application and Comparison of Time Series Models

Yao Zhang [1, a]

[1] Department of Mathematics and Applied Mathematics, Southern University of Science and Technology, ShenZhen, China.

[a] zhy15829279772@gmail.com

Abstract. Gross Domestic Product (GDP) serves as a core indicator in the national economic accounting system and plays a crucial role in assessing the economic development of a country or region. In order to explore the future development trend of GDP in Shenzhen in the coming years, this paper uses GDP data from the past 42 years (1979-2021) in Shenzhen as samples and fits an Autoregressive Integrated Moving Average (ARIMA) model to the second-order differenced GDP series. After testing the fitted model, the ARIMA model is used to forecast the GDP values of Shenzhen for the next six years (2022-2027). By utilizing the model to predict the GDP values of Shenzhen for the next six years, it is concluded that Shenzhen's GDP will increase year by year over the next six years, and the upward trend is relatively stable.

Keywords: GDP; Forecasting; ARIMA; Shenzhen; Time Series; Data Analysis.

1. Introduction

Gross Domestic Product (GDP), typically abbreviated as GDP, refers to the final output of all resident units' production activities in a country or region during a certain period, calculated at market prices. GDP is not only a core indicator in the national economic accounting system but also one of the most important indicators for measuring the macroeconomic situation of a country. It plays a crucial role in assessing the economic development status of a country or region, as well as the level of national income.

The text selects Shenzhen City as the research subject for several reasons:

1、High Economic Growth Rate: As a pioneer of China's reform and opening-up policy and an economic special zone, Shenzhen City has long maintained a high level of economic growth. The GDP growth rate of Shenzhen City often represents one of the development trends of the Chinese economy. Therefore, the GDP of Shenzhen City has significant macroeconomic indicator significance.

2、Innovation and Technological Development: Shenzhen City is one of China's important centers for science, technology, and innovation, with numerous high-tech enterprises and research institutions. The GDP of Shenzhen City reflects the performance of the region in terms of technological innovation, research and development investment, etc., which is of great significance for evaluating China's competitiveness in the field of science and technology.

Foreign Trade and Industrial Upgrading: Shenzhen City is an important center for China's

foreign trade and a manufacturing base, and its GDP reflects China's trade relations with international markets, as well as the development level of China's manufacturing industry and the situation of industrial structure adjustment.

4、Urban Development and Urban Governance: The GDP of Shenzhen City also reflects the level of urban development and the effectiveness of urban governance. With economic development, improvements in urban infrastructure construction, environmental protection, social welfare, etc., will also be reflected. These aspects collectively make Shenzhen City a compelling choice for academic research and analysis.

The text discusses the concept of time series analysis and its application to studying and predicting the GDP (Gross Domestic Product) trends in Shenzhen City. Time series analysis involves examining the properties, patterns, and trends of data points arranged in chronological order, as well as forecasting future values. There are two main types of time series: stationary and non-stationary.

Stationary Time Series: A stationary time series is characterized by constant mean and variance over time, unaffected by factors such as trends, seasonality, or cycles. Its statistical properties remain constant over different time periods, making analysis and prediction more reliable. Non-stationary Time Series: A non-stationary time series exhibits changing mean, variance, or other statistical characteristics over time. It may be influenced by trends, seasonality, cycles, or unexpected events, posing challenges for analysis and prediction. Time series analysis techniques include descriptive statistics, smoothing methods, decomposition, auto-regressive models, moving average models, ARIMA models (Auto-regressive Integrated Moving Average), seasonal adjustments, and time series forecasting. These techniques help identify patterns, cycles, and trends in time series data and provide estimates and forecasts for future values.

To investigate the GDP trends in Shenzhen City and predict future developments, the text utilizes GDP data from 1979 to 2021, covering a period of 42 years. Time series analysis methods are applied to model the data, and MATLAB, a mathematical tool, is used for data fitting. Conclusions are drawn based on the analysis, and future GDP trends in Shenzhen City for the next six years are forecasted.

2. Data collection and processing

In this modeling exercise, the data used consists of GDP figures for Shenzhen City from 1979 to 2021, sourced from the Shenzhen Statistical Yearbook 2022, available on the website of the Shenzhen Municipal Bureau of Statistics.

Using MATLAB's plot function, a time series plot of the changes in Shenzhen City's GDP is generated. A time series plot is a two-dimensional coordinate plane graph, typically with time represented on the horizontal axis and the values of the sequence on the vertical axis. In this document, the horizontal axis represents the years, while the vertical axis represents the total GDP of Shenzhen City for each year. Time series plots help to understand the basic distribution characteristics of the time series. By observing the time series plot, it is evident that from 1979 to 2021, over the span of 42 years, the GDP of Shenzhen City shows a clear upward trend, indicating it is not a stationary sequence. Further analysis using the Augmented Dickey-Fuller (ADF) test confirms that the original sequence is a non-stationary time series. Therefore, it is necessary to apply logarithmic transformation or differencing to the data and then assess the stationary of the resulting sequence.

Analysis of the time series plot of the original sequence reveals a long-term increasing trend in Shenzhen City's GDP from 1979 to 2021. First-order differencing and second-order differencing are performed on the sequence: $\nabla Xt = Xt - Xt\text{-}1$ and $\nabla Xt2 = \nabla Xt - \nabla Xt\text{-}1$. Examination of the time series plots after first-order and second-order differencing indicates that first-order differencing still does not achieve stationary, whereas second-order differencing results in a stationary sequence. The differencing results are illustrated in Fig. 1.

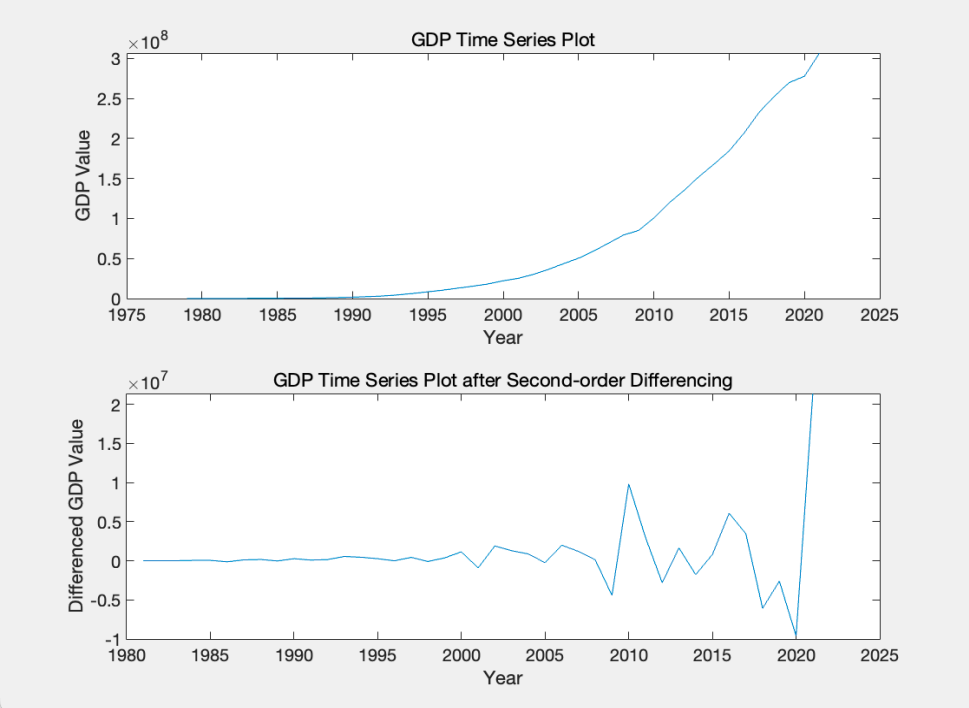

Figure 1 The original GDP time series plot and the plot after second-order differencing

The ACF (Auto-correlation Function) and PACF (Partial Auto-correlation Function) analysis of the differenced GDP time series reveals that while the auto-correlation gradually decays, all values remain within two times the standard deviation, indicating truncation of auto-correlation. The PACF exhibits a sharp drop-off. Refer to Figure 2.

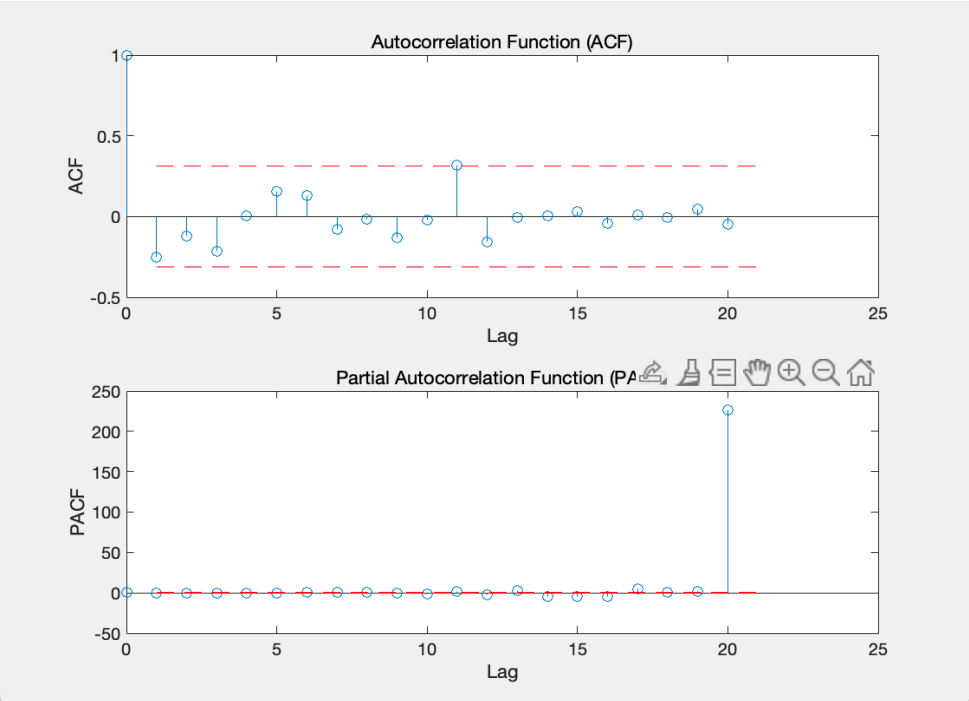

Figure 2 ACF and PACF

3. Modeling and results of time series data

3.1 Model Definition and Testing

Using the ARIMA function in MATLAB to model with different parameters resulted in eight scenarios as depicted in Figures 3 and 4.

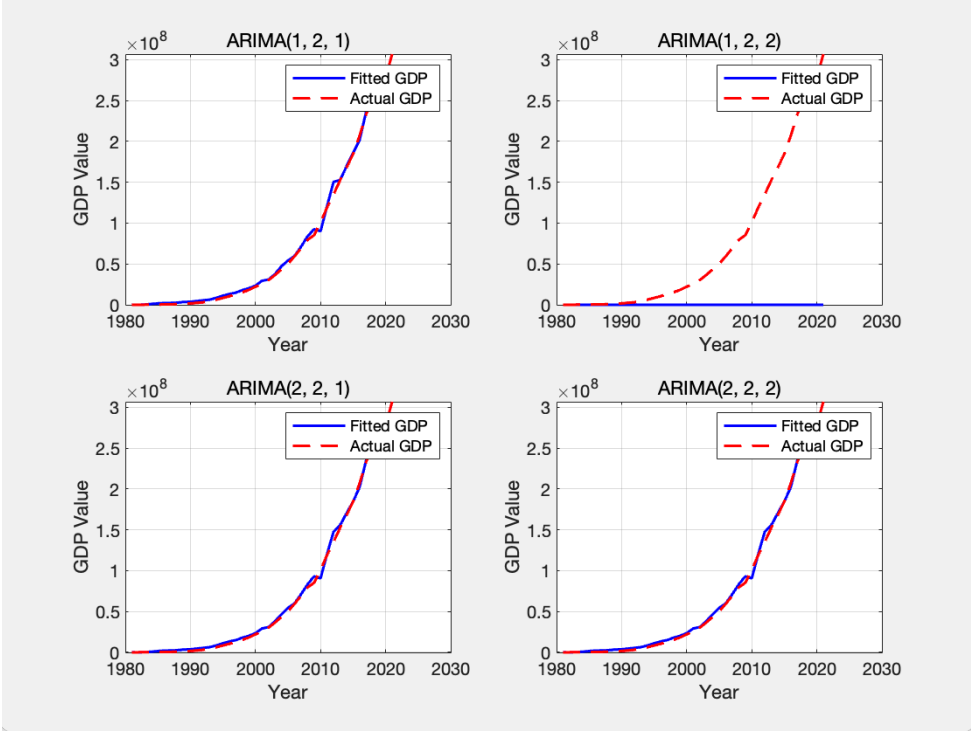

Figure 3 Comparison 1

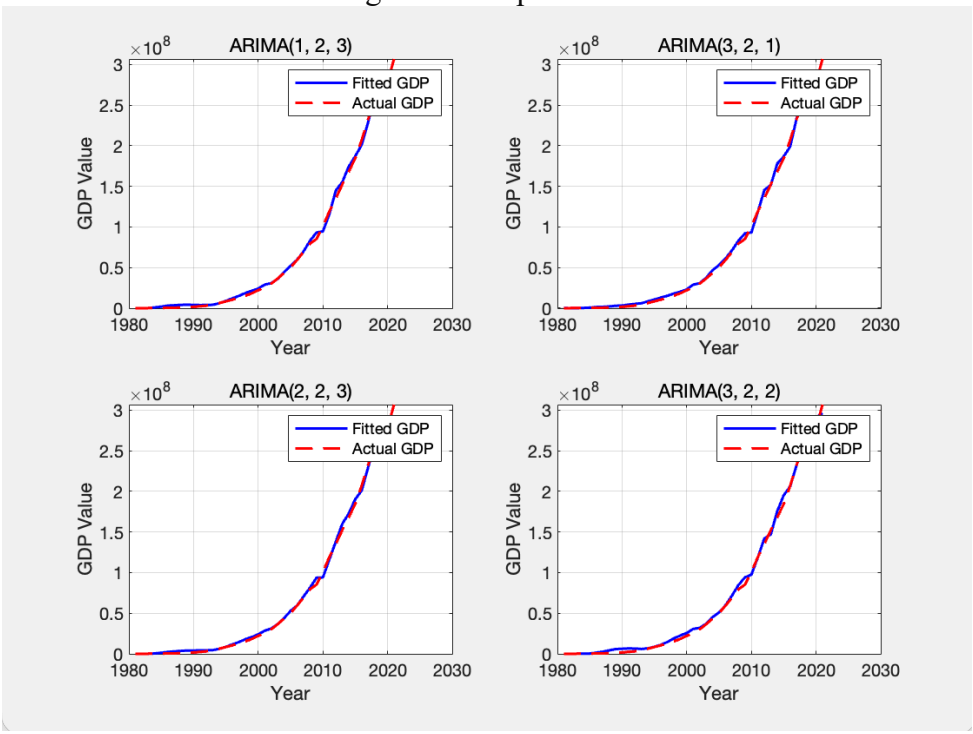

Figure 4 Comparison 2

Among these scenarios, the model ARIMA(1,2,1) yields the following results as shown in Table 1:

	Value	Standard Error	T Statistic	P value
Constant	7.4704e + 05	1.1194e + 06	0.66734	0.50455
AR{1}	-0.69702	0.39117	-1.7819	0.074767
MA{1}	-0.67402	0.23763	-2.8364	0.0045621
Variance	5.2917e + 13	0.039538	1.3384e + 15	0

The intercept term of the model is not statistically significant, as its p-value of 0.50455 exceeds the significance level of 0.05. The coefficient of the AR(1) term is also not statistically significant, as its p-value of 0.074767 is slightly greater than the significance level of 0.05. The coefficient of the MA(1) term is statistically significant and not equal to zero, as its p-value of 0.0045621 is less than the significance level of 0.05. This indicates that the influence of previous white noise errors on the current value is significant. The residual variance is relatively large, suggesting the presence of a considerable amount of unexplained random fluctuations in the model.

3.2 Fitting results

As shown in Figure 3, Figure 4, and Table 1, the closer the coefficient of determination R2 is approaching to 1, the better the model fit. Since R2=0.998, the fit is very good. The coefficients of AR and MA are -0.69702 and -0.67402, respectively, with both having small p-values. The AR coefficient is significant at the 0.1 level. Therefore, it can be concluded that the model fits very well. Additionally, through the trend line plot of the time series after second differencing, ACF, and PACF analysis, it is observed that the series is stationary. Hence, selecting ARIMA(1,2,1) is reasonable. The fitted results of this model are shown in Figure 5.

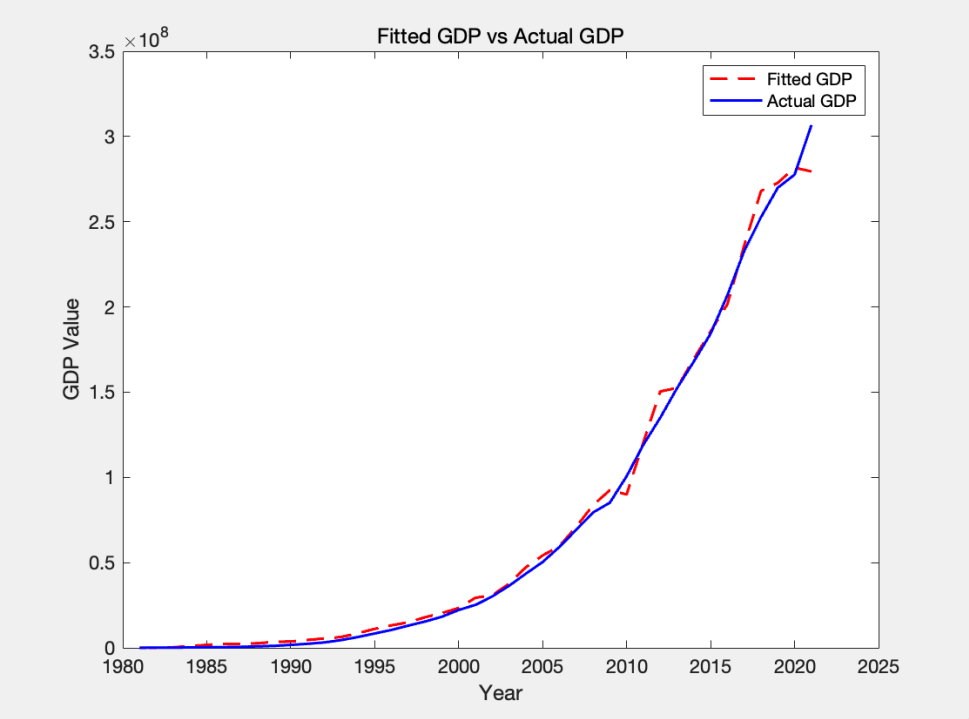

Figure 5 Fitting result

4. Model prediction

Using MATLAB's forecast function, GDP predictions for the next six years from 2022 to 2027 were made. The predicted results are presented in Figure 6 and Table 2. It is observed that over the next 6 years, there will be a stable growth trend.

Year	2022	2023	2024	2025	2026	2027
Prediction GDP	326732147	347283256	367810013	388338038	408865998	429393961

Upper bound	319005383	333978820	348368978	362175541	375417378	388124476
Lower bound	334458911	360587692	387251049	414500536	442314618	470663445

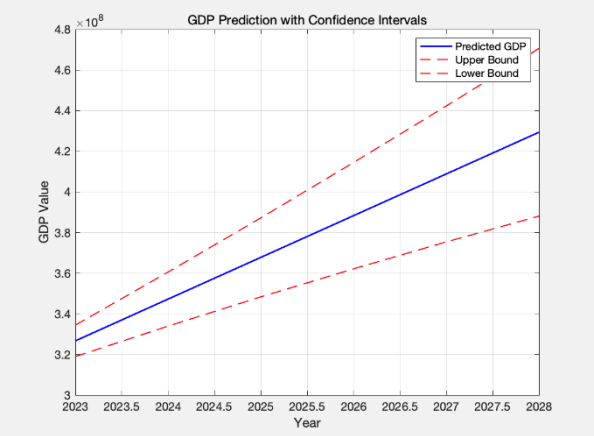

Figure 6 Prediction Result

Among them, the data for the year 2022 has been released, and the deviation from the actual results is within one standard deviation, indicating that the model prediction is relatively accurate.

5. Conclusion

By performing second-order differencing on the historical GDP data of Shenzhen over the past 42 years and fitting the corresponding model, we have successfully predicted the GDP of Shenzhen. The forecast results using the ARIMA model for the next six years indicate a high degree of fitting and good prediction accuracy. Over the next six years, the GDP of Shenzhen will exhibit a stable growth trend. Shenzhen has demonstrated strong and effective responses when facing multiple challenges, with key economic indicators consistently improving, demonstrating robust economic development. However, the external environment remains complex and severe, and economic development faces numerous risks and challenges. In the future, we will continue to adhere to the guidance of Xi Jinping Thought on Socialism with Chinese Characteristics for a New Era, fully implement the spirit of the 19th National Congress of the Communist Party of China, the spirit of the Central Economic Work Conference, and earnestly implement the deployment requirements of the Second Plenary Session of the Thirteenth Provincial Party Committee and the Sixth Plenary Session of the Seventh Municipal Party Committee. We will adhere to the underlying principle of seeking progress while maintaining stability, focus on promoting high-quality development, better coordinate epidemic prevention and control with economic and social development, better balance development and security, promote overall improvement in the city's economic operation, achieve qualitative and effective improvements, and reasonable growth in quantity. We will accelerate the building of a more globally influential economic center city and modern international metropolis, set a good start for the comprehensive construction of a socialist modernized country, and make a greater contribution to the overall economic development of the country and the province.

References

[1] Nini Xie. Application of time series modeling in economic analysis - GDP analysis and forecasting in Shaanxi Province[J]. Sino-Arab Science and Technology Forum (in Chinese and English),2024,(02):42-46.

[2] Nie Shuyuan. Comparison of GDP forecasting effects based on four types of time series models[J]. Statistics and Decision Making, 2024,4040(02):63-67.DOI:10.13546/j.cnki.tjyjc.2024.02.011.

[3] Bonnie Wu. Hangzhou GDP forecasting based on time series model[J]. Enterprise Reform and Management 2019,(23):212-213.DOI:10.13768/j.cnki.cn11-3793/f.2019.3192.