Forecasting Exchange Rates and Trade Balances: An ARIMA Analysis of USD/RMB and China's Trade Dynamics

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Abstract: This paper utilizes an ARIMA model to predict the future exchange rate and trade balance of China. The primary data is the monthly average exchange rate of USD/RMB, while China's monthly trade balance serves as auxiliary data. The findings indicate a projected downward trend in the USD/RMB exchange rate, continuing from 2023 to 2024 and stabilizing around 6.7 from 2024 to 2025. This implies a depreciation of the Chinese currency against the US dollar. Additionally, China's trade balance is expected to experience modest growth over the next two years, albeit at a significantly reduced rate compared to previous years. These projections highlight the challenges faced by Chinese exporters and suggest evolving global trade dynamics. The paper discusses policy implications for managing exchange rate fluctuations and sustaining balanced trade relations. It emphasizes the usefulness of the ARIMA model for forecasting exchange rates and trade balances while acknowledging the limitations and potential impact of unforeseen events or policy changes on the outcomes. The study concludes by suggesting avenues for future research to improve the accuracy and robustness of such forecasts, encouraging continued exploration in this dynamic field of study.

Keywords: time series analysis, exchange rates, China's trade balances

1. Introduction

The exchange rate is a crucial variable in economic activities, affecting a country's balance of payments, inter-country debt status, and domestic price levels. It also has a significant impact on cross-border trade. As such, forecasting future exchange rate movements is essential in international economic activities. From 1994 to 2005, China adopted a fixed exchange rate system, maintaining a rate of 1 US dollar to 8.3 RMB. Subsequently, from 2005 to 2015, China shifted to a managed floating exchange rate system. In mid-2015, China implemented exchange rate reforms, which relaxed the restrictions on daily exchange rate fluctuations, essentially meeting the needs of intraday fluctuations in the RMB exchange rate. Prior to 2015, the exchange rate of the RMB could be inferred more accurately based on China's exchange rate system. However, since 2015, the exchange rate between the US dollar and the RMB has exhibited continuous fluctuations, making intuitive prediction of exchange rate changes unrealistic. Nonetheless, given the significant impact of exchange rates on a country's economic activities, predicting exchange rates using known information and suitable models remains essential.

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This article focuses on forecasting the USD/RMB exchange rate for several reasons. Firstly, the U.S. dollar is a leading reserve currency globally. Secondly, the USD dominates international trade, with most international trade being settled in U.S. dollars, making it a dominant trade currency. Thirdly, the United States is one of the largest economies in the world, with the size and strength of its economy providing the USD with a powerful influence in global financial markets. The fluctuations in the exchange rate of the USD can have a significant impact on the global economy. Lastly, the United States possesses a strong financial system and financial markets, with its financial institutions enjoying a relatively high reputation and influence worldwide. These factors contribute to the USD being highly liquid and widely accepted internationally, further consolidating its international standing. In summary, this article focuses on forecasting the exchange rate of USD/RMB due to the USD's prominent position in the global economy and financial markets.

Time series analysis and linear regression analysis are the leading methods for analyzing and modeling exchange rate movements. Wu & Wen utilized the closing price of a 250-period stock from "Huatai Securities" as the empirical data for time series analysis, establishing an ARIMA model to predict the law and trend of stock price changes in China's GEM market [1]. This approach provides useful insights for this article. The exchange rate of USD/RMB can be viewed as the price at which RMB purchases USD, while the closing price represents the cost of stocks. The similarities between the two make it appropriate to use historical exchange rate data as the empirical data for time series analysis and to employ an ARIMA model to predict exchange rate fluctuations.

In previous research, exchange rate analysis has often been accompanied by trade balance analysis, as changes in the exchange rate can impact imports and exports [2, 3]. This relationship between the exchange rate and trade balance provides valuable insights for this article. Given this relationship, it is appropriate to use the trade balance as an auxiliary indicator to reflect exchange rate changes directly. With respect to the impact of exchange rates on trade, different enterprises respond differently to exchange rate changes. For instance, there is heterogeneity in exchange rate elasticity between general trade and processing trade enterprises [4]. Moreover, the real exchange rate of RMB has varying impacts on the export commodity structure of labor-intensive and capital-intensive products [5]. Additionally, exchange rate changes can affect the price and quality of export enterprises [6]. Thus, this paper aims to provide trading companies with development decisions based on exchange rate forecasts to manage future interest rate changes.

2. Methodology

2.1. Data Pre-Processing

The primary dataset employed in this study is the exchange rate of the US dollar against the RMB. The data comprises monthly observations spanning from 2006 to April 2023 and was obtained from the China Foreign Exchange Trade System. The unit of measurement for this dataset is "100 million RMB". Prior to data analysis, all observations before August 11, 2015 were excluded as China's exchange rate began to exhibit normal fluctuations after the exchange rate reform on this date, rendering the data appropriate for predictive modeling. The ts() function in R was then utilized to transform the dataset into time series format, and the resulting time series plot is presented in Figure 1. Additionally, the study utilizes China's trade import and export balance as an auxiliary dataset, obtained from the General Administration of Customs of China. To ensure the appropriate correspondence between the trade balance and exchange rate data, observations after August 2015 were also extracted for forecasting purposes. Notably, due to the outbreak of COVID-19 in 2020, China's trade balance shifted from a surplus to a significant deficit in February of that year. To avoid any forecast bias, the February data was replaced with March data, which more closely reflects the prevailing situation. The subsequent data processing procedures for the auxiliary dataset are similar

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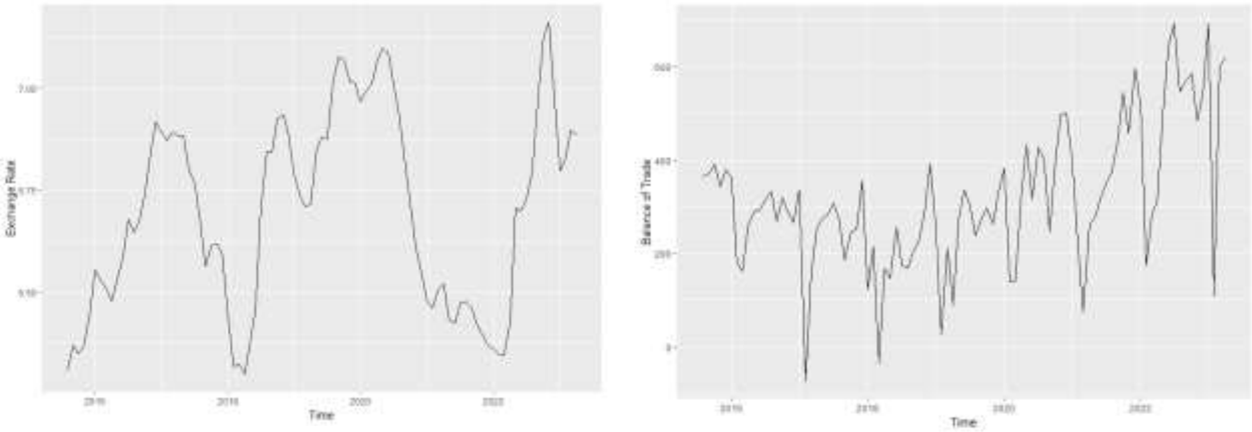
to those employed for the primary dataset. Following conversion to time series format using the ts() function, the resulting time series plot is presented.



(a) Main dataset (b) Secondary dataset

Figure 1: Time series plot of dataset.

2.2. Dataset Model Modeling

2.2.1. Model Introducing

The autoregressive summation moving average model was originally proposed by Box and Jenkins. The model is designed to stabilize non-stationary time series by implementing a d-order difference, followed by autoregressive and moving average processes. The established model is then identified using data such as sample autocorrelation coefficient and partial autocorrelation coefficient [1]. The presence of non-stationarity and seasonality in the data, as depicted in Figure 1, requires the use of the Seasonal ARIMA model as the forecasting model in this study. When no differencing is applied, the expression for the Seasonal ARMA model is:

$$\Phi(B^S)\phi(B)(x_t - \mu) = \Theta(B^S)\theta(B)\omega_t \tag{1}$$

The seasonal components are specified as follows.

$$\text{Seasonal AR: } \Phi(B^S) = 1 - \Phi_1 B^S - \Phi_2 B^S - \cdots - \Phi_P B^{PS} \tag{2}$$

$$\text{Seasonal MA: } \Theta(B^S) = 1 + \Theta_1 B^S + \Theta_2 B^S + \cdots + \Theta_Q B^{QS} \tag{3}$$

2.2.2. Main Dataset Model

To analyze the exchange rate time series, this paper employed the auto.arima function. This function utilizes a grid search algorithm to identify the optimal ARIMA model. Specifically, the function fits multiple ARIMA models to the available time series data and uses information criteria such as AIC and BIC to evaluate the goodness of fit of each model. The model with the smallest information criterion value is then selected as the optimal model. In this study, after comparing the goodness of fit of multiple models, the best model was identified as ARIMA(2,0,0) with zero mean. Following

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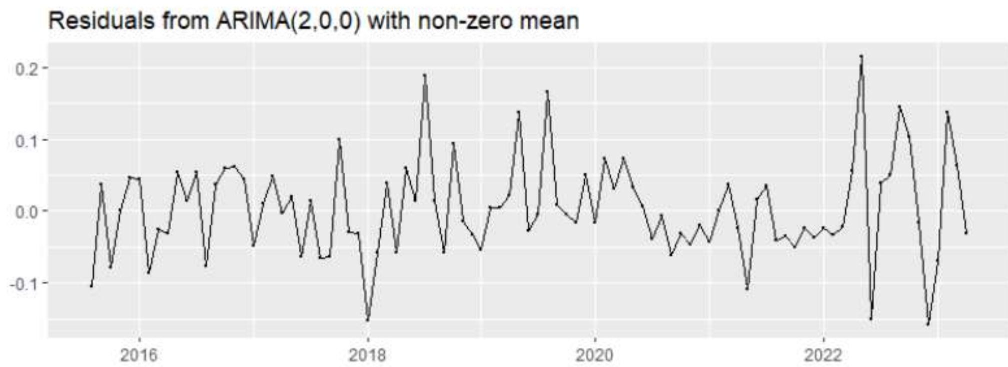
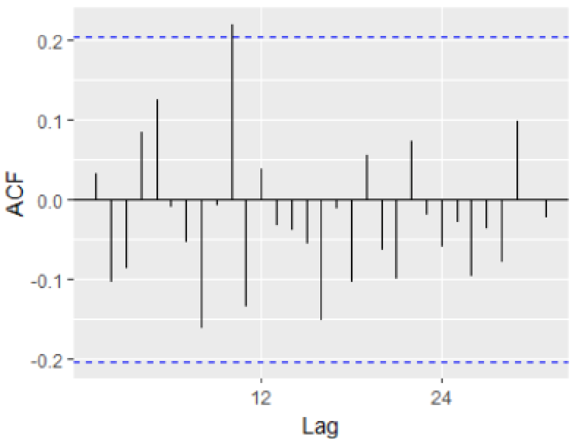
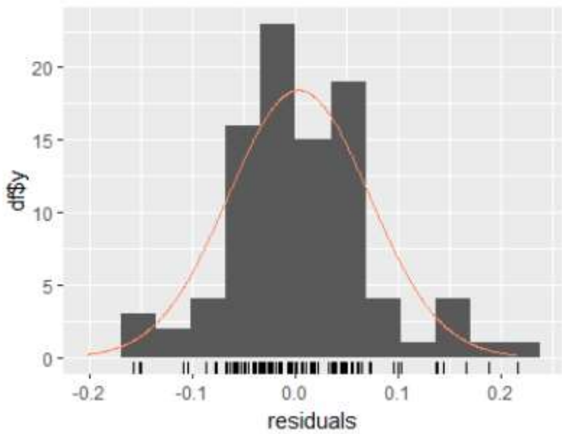
model construction, this paper utilized the checkresiduals() function to test the p-value of the model. The final p-value=0.3107, which is significantly greater than 5%. Thus, the null hypothesis that the residual is white noise can be accepted. Moreover, the residual plot shows that the autocorrelation coefficient of the residuals is close to zero, and the residuals follow a normal distribution (see Figure 2). These findings further support the conclusion that the residuals of the model are white noise, indicating that the model's predictive performance is satisfactory.



(a) Residuals plot





(b) Lag (c) Residuals

Figure 2: Residual testing result of main dataset model.

2.2.3. Secondary Dataset Model

Following the exchange rate forecast, the next step involves modeling and forecasting China's trade balance. Upon preprocessing the data, as illustrated in Figure 1(b), it became evident that the time series for this variable is non-stationary and seasonal. Hence, utilizing the Seasonal ARIMA model is a reasonable approach. Similar to the exchange rate model selection process, this paper utilized the auto.arima function to analyze the trade balance time series. After comparing the results, it identified the best model as ARIMA(0,1,1)(2,0,0) [7]. Once the model was constructed, it employed the checkresiduals() function to evaluate the p-value of the model, which was found to be 0.02919. The residual plot indicates that most of the autocorrelation coefficients are close to zero and follow a normal distribution, further corroborating the white noise nature of the residuals and the model's good predictive performance (see Figure 3). It is worth noting that although the p-value is less than 5%, indicating a potential deviation from white noise, this result may be attributed to external factors such

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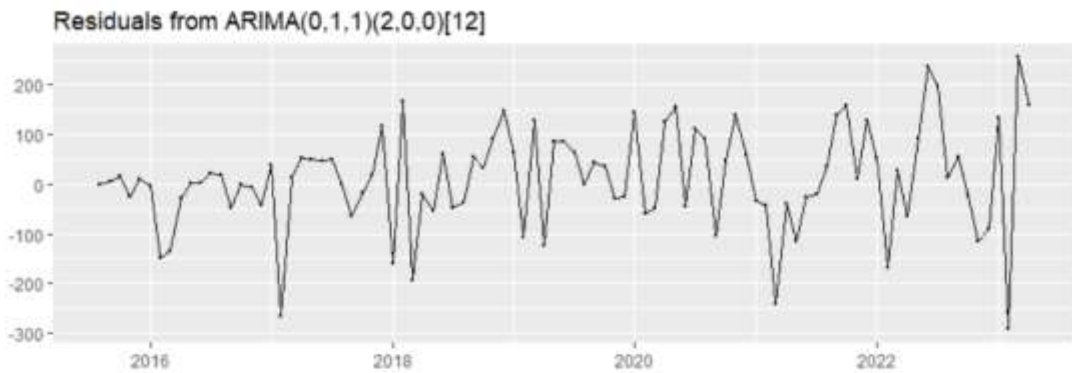
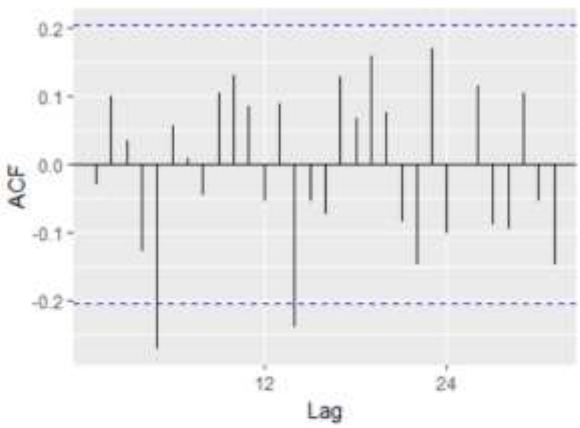
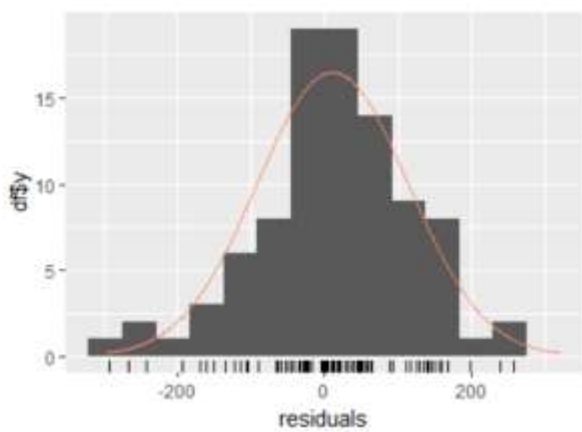
as the trade war between China and the United States in 2019, which may have exogenous impacts on China's trade balance. Additionally, modified error values may also contribute to the uncertainty in the p-value assessment. Nonetheless, based on the available evidence, we conclude that the residuals can be considered white noise.



(a) Residuals plot





(b) Lag

(c) Residuals

Figure 3: Residual testing result of secondary dataset model.

3. Results

After completing the model training through the experiments in the methodology section, the forecast() function was used to predict the two models, resulting in the following observations: (1) The exchange rate is expected to continue declining in the future; (2) The trade surplus is expected to continue rising in the next two years, albeit at a relatively slow pace.

Figure 4 depicts the forecast map of the USD/RMB exchange rate. It can be observed from the figure that the exchange rate will continue declining between 2023 and 2024, indicating the continued appreciation of the RMB, eventually stabilizing around USD/CNY=6.7. This prediction aligns with realistic expectations. After 2022, the Fed is expected to continue raising interest rates, leading to the continued appreciation of the dollar, which is reflected in the rise in the exchange rate in the figure. However, in Q2 2023, the Fed's interest rate hike is expected to slow down and almost stop, which could prompt capital to flow out of the United States and cause the dollar to depreciate, reducing the exchange rate of the dollar against the RMB.

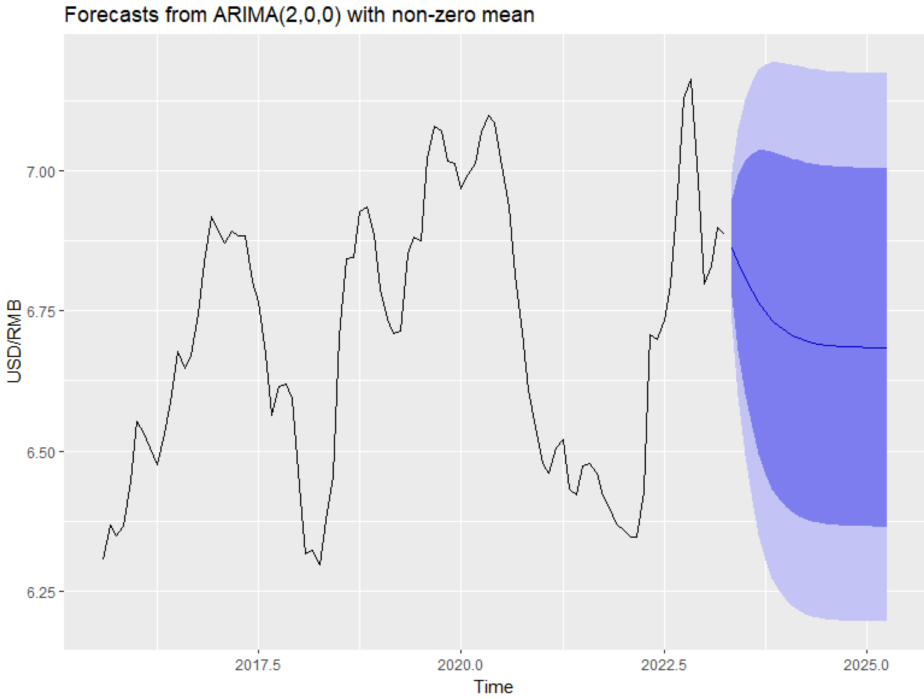


Figure 4: Forecast plot of main dataset model.

Figure 5 displays the forecast results of China's trade balance. The figure indicates that the overall trade surplus is expected to continue rising in the next two years, with small fluctuations due to different quarters within a year. However, from the perspective of the overall growth trend, the growth of the trade balance has significantly slowed down, and the peak value during the year is similar to that of 2022. This observation is consistent with expectations.

The appreciation of the renminbi and the decline in the exchange rate have increased the export price of Chinese goods, reducing their competitiveness abroad and resulting in a decrease in exports. Conversely, the appreciation of the renminbi has led to lower prices of foreign products relative to Chinese products, increasing their competitiveness in China and leading to an increase in imports. Consequently, China's trade surplus has declined overall. Furthermore, figure 6 indicates that the lowest point of China's trade balance has slightly increased compared with previous years, which is seemingly opposite to conventional understanding. Under normal circumstances, in the event of RMB appreciation, imports should increase while exports decrease, which should lead to a lower trade balance. However, this phenomenon can be explained by the "linkage effect" proposed by Liu et al. [2]. Processing trade constitutes a significant portion of China's foreign trade, and a considerable portion of imports are utilized as raw materials or intermediate products for export. Consequently, a high correlation exists between exports and imports, resulting in the "linkage effect." Thus, the decline in exports causes a decrease in imports, leading to a slight increase in the trade balance's lowest point compared to before, despite the decrease in exports due to the RMB's appreciation.

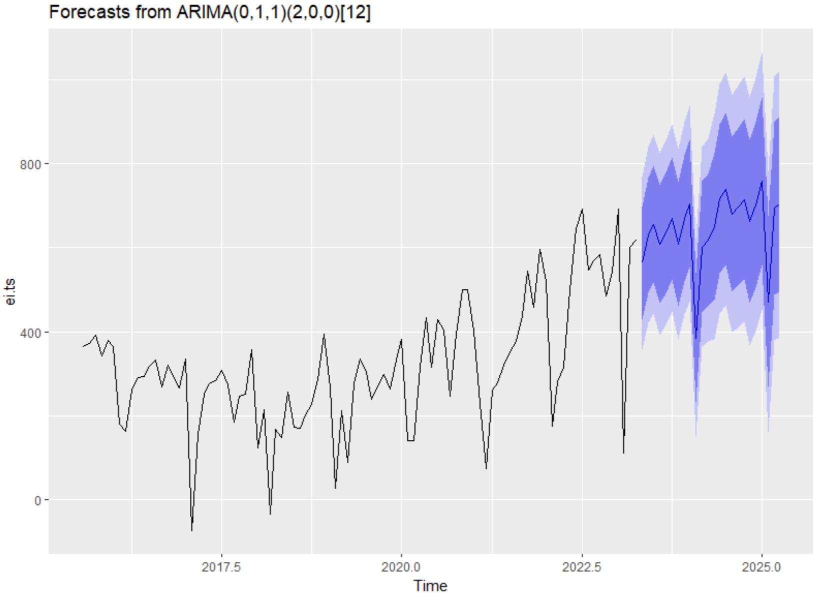


Figure 5: Forecast plot of secondary dataset model.

In summary, the experimental results are outstanding, and the prediction results are significant. The successful prediction of future exchange rate changes and the forecast of trade balance confirm the accuracy and reliability of our predictions. This provides strong evidence to support the recommendations for trading companies presented in the subsequent text.

4. Discussion

As noted earlier, this study provides valuable insights for the future development of trading enterprises. While exchange rate fluctuations have a significant impact on enterprise development, the optimal development strategies vary across different types of enterprises. For processing enterprises, Huang et al. found that RMB appreciation would reduce the export price of enterprises engaged in processing imported materials and general trade enterprises, but processing enterprises with imported materials would be less affected by exchange rate changes [8]. The appreciation of the renminbi has led to an increase in the price of Chinese goods in foreign markets, resulting in a decline in the competitiveness of Chinese goods, which is detrimental to the interests of enterprises. However, the appreciation of the renminbi also reduces the cost of material imports, enabling imported material processing enterprises and general trade enterprises to reduce the export price of their commodities, thereby maintaining relatively stable commodity prices in foreign markets and avoiding self-harm. Thus, our findings suggest that, in the event of a fall in the USD/RMB exchange rate and an appreciation of the RMB, the first two types of enterprises should formulate import and export plans and be prepared to adjust product prices. Timely responses to exchange rate changes can enable enterprises to gain more market share while avoiding the need to cut prices.

In addition to processing industries, domestic production-oriented enterprises are also significantly impacted by exchange rate changes. Zeng & Zhang have highlighted that RMB appreciation is beneficial to the development of capital-intensive industries, but not conducive to the development of labor-intensive industries [9]. As previously mentioned, the appreciation of the renminbi leads to an increase in the price of Chinese goods in foreign markets. In response, firms may choose to reduce costs and improve production efficiency to reduce prices and enhance product competitiveness. Due to the appreciation of the renminbi, capital-intensive enterprises are able to import additional equipment and raw materials at relatively lower prices, thereby improving production efficiency, enhancing product quality, and reducing product prices. However, for labor-intensive enterprises, while the prices of imported raw materials have fallen, it is difficult for this type of enterprise to increase production efficiency. Improving production efficiency requires a greater amount of labor, but the appreciation of the renminbi leads to an increase in the purchasing power of the domestic currency, thereby elevating wage levels and labor costs. These factors tend to increase the production cost of domestic labor-intensive industries and reduce their competitiveness in the international market. Therefore, under the assumption of an anticipated future decline in the exchange rate, Chinese labor-intensive enterprises may consider industrial transformation and gradually transition into capital-intensive enterprises. For capital-intensive enterprises, it is advisable to formulate equipment purchase plans and plant construction strategies to enhance production efficiency.

For foreign companies that import products to China, it is important to prepare for the anticipated appreciation of the renminbi in the future. According to Chen et al., exporting firms tend to increase export prices and upgrade product quality when the foreign currency appreciates [10]. In the face of RMB appreciation, exporting a large number of products to China can yield significant profits for foreign export companies. Therefore, foreign export companies may choose to raise prices and improve product quality simultaneously, ensuring that they maintain a competitive edge in the Chinese market while achieving high profits. In addition to enhancing product quality, another option is to reduce or maintain commodity prices, which would also improve competitiveness in terms of commodity prices. Given the expected appreciation of the RMB in the future, it is recommended that enterprises exporting products to China plan to improve product quality and reduce production costs to maintain selling prices.

5. Conclusions

Based on the findings presented in the results section of this study, it can be concluded that the research objectives outlined in the introduction section have been achieved. However, the study has some limitations, primarily related to the modeling of non-stationary datasets. It is challenging to obtain accurate trends solely from predicted graphs when dealing with non-stationary datasets. As discussed in the methodology section, the p-value of the LB test of China's trade balance is less than 5%, indicating the limitations of this method. To overcome these limitations and obtain more precise analyses of non-stationary time series data, machine learning algorithms can be employed to incorporate additional auxiliary data and obtain more robust results. Moreover, predicting exchange rates based solely on past data is insufficient, as exchange rates are also influenced by a range of other factors, such as various policies and unforeseen events, including black swan events. These effects are often not reflected in the past data. For instance, despite the high USD/CNY exchange rate in 2020, China's trade balance was small due to the COVID-19 outbreak. Additionally, in terms of politics, the Sino-US trade war has resulted in significant fluctuations in China's trade balance. Therefore, these external factors, which cannot be captured by time series data alone, play a critical role in determining exchange rate levels.

In future research, empirical analysis can be employed to examine the effects of different factors on exchange rates. Based on these findings, a machine learning model that incorporates various external shocks can be developed to obtain a more accurate prediction model.

References

[1] *Wu, Y., & Wen, X. (2016). Short-term stock price prediction based on ARIMA model. Statistics and Decision, 467(23), 83-86.*

[2] *Liu, Y., Feng, M., & Tang, Y. (2015). The impact of exchange rate fluctuations on China's trade surplus: Direct and spillover effects. Investment Research, 34(11), 91-107.*

DOI: 10.54254/2754-1169/46/20230310

[3] Fracasso, A., Secchi, A., & Tomasi, C. (2022). Export pricing and exchange rate expectations under uncertainty. Journal of Comparative Economics, 50(1), 135-152.

[4] Song, C., & Xie, Y. (2017). The impact of RMB exchange rate on China's export: Processing trade versus general trade. World Economy, 40(8), 78-102.

[5] Héricourt, J., & Poncet, S. (2013). Exchange Rate Volatility, Financial Constraints, and Trade: Empirical Evidence from Chinese Firms. The World Bank Economic Review, 29(3), 550–578.

[6] Fan, H., Li, Y. A., & Zhao, C. C. (2018). Margins of imports, forward-looking firms, and exchange rate movements. Journal of International Money and Finance, 81, 185-202.

[7] Liu, L. (2002). The impact of exchange rate fluctuations on a country's import and export trade: An empirical analysis of the J-curve effect. Journal of Yunnan College of Finance and Trade, (03), 67-69.

[8] Huang, Q., Song, P., & Li, Y. (2020). RMB exchange rate, intermediate input in imports, and the transmission effect on export prices of enterprises. Journal of International Economic Exploration, 36(12), 33-51.

[9] Zeng, Z., & Zhang, Y. (2007). RMB real exchange rate appreciation and adjustment of China's export commodity structure. World Economy, (345), 16-24.

[10] Chen, M. W., Lu, C., & Tian, Y. (2021). Export price and quality adjustment: The role of financial stress and exchange rate. Economic Modelling, 96, 336-345.