Application of Seasonal ARIMA Model in Forecasting the Exchange Rate：Taking RMB to USD as an Example

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Abstract. Forecasting exchange rate is very profitable and crucial. Realizing the forecasting of the exchange rate means that personal investors can do arbitrage; For the policy makers, it means that they can optimize their fiscal policy and monetary policy. The article has used seasonal ARIMA model in terms of forecasting the RMB to USD exchange rate, and captures the seasonal factors of the RMB to USD exchange rate which is a time series better. First, the author deals with the data by using first-order seasonal difference； then,the author applies the auto ARIMA model in Rstudio to fit the model with the data, receiving the ARIMA(4,2,1)(0,1,0)(365). After that, the author forecasts the RMB to USD exchange rate in the next 90 days. Finally, the author does the residual test, and discusses the autocorrelation,fitting degree, and whether or not it is overfitted of the model. The conclusion of the writer is that the RMB to USD exchange rate will fall in the next 90 days.

1 Introduction

Predicting exchange rates is very important for different kinds of people because knowing exchange rate helps the people to minimize their risk of finance and maximize their returns in a market which is full of the worry towards volatility [1]. In addition, the exchange rate also has some certain impacts on the price of a country, and the change of the exchange rate will not be fully reflected in the domestic price [2]. In view of this, forecasting the exchange rate is of great significance to the people's daily life and the country's macro-control system. In the many means of exchange rate forecasting, the ARIMA model has been tested over time, since the ARIMA model is created for the prediction of time series data, and has proved its effectiveness in the prediction of many time series data. Seasonal ARIMA model is a variant of ARIMA model, which focuses on the presentation of seasonal factors in ARIMA models. For example, the climate parameters of Kashmir Valley can be predicted by ARIMA model and seasonal ARIMA model [3]. Because there is a seasonal effect in the factors affecting the exchange rate, the author of this paper will use the seasonal ARIMA model to predict the exchange rate of RMB to the US dollar, hoping to help investors to do invest and help the government judge the future exchange rate [4].

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2 Literature Review

Much achievements have been done by researchers to predict exchange rates using the ARIMA model and its variants. For example, there was a study that has used ARIMA model to predict prospective exchange rate of the Nigerian naira to Saudi riyal, taking the ARIMA (0,1,1) model as a tool [5]. The Indonesian rupiah soared against the US dollar during the COVID-19 period, the bad time of the history, so some researchers tried to predict whether exchange rate of ASEAN countries against the Indonesian rupiah would rise using ARIMA model, and the results showed that the exchange rate of ASEAN countries against the Indonesia monetary did not rise [6]. Another study which focused on the monthly rainfall and the temperature patterns in Van province of Turkey has also used ARIMA and SARIMA models, which proves that ARIMA and SARIMA are very popular in time-series analysis again [7]. In addition, there was a study in which the researchers used the ARIMA model to study the changes in the exchange rate of the Australian dollar to the US dollar, and had also obtained results that meet the requirements of researchers [8]. Therefore, it can be judged that it is safe to use ARIMA. And ARIMA has advantages, some studies show that it is more accurate than LSTM method, and it is better than LSTM method in many indicators [9].As for the distinction between the use of seasonal ARIMA and the use of ARIMA, some researchers used ARIMA and seasonal ARIMA to predict the exchange rate of Jordanian dinar against the US dollar, using ARIMA(1,0,1) and seasonal ARIMA(1,0,1) (1,0,0) (12), and the MAPE, MAE and MASE of the seasonal ARIMA model were found to be smaller than those of the ARIMA model.The smaller these parameters are, the more accurate the model is, so the study shows that the seasonal ARIMA model is better than the ARIMA model. Finally, statisticians also conclude that seasonal ARIMA has good statistical properties [10].

3 Research Method

The research method of this paper is to use Rstudio software and seasonal ARIMA model to predict the exchange rate of RMB to the US dollar. The data source comes from Federal Reserve which published spot exchange rate of Renminbi of China against dollar of United States. The selected time is from May 16, 2020 to May 16, 2025, and the unit is RMB to 1 US dollar. Operationally, an automated ARIMA model with manually defined first order seasonal differentials is used for forecasting. The forecast set is the exchange rate movement over the next 90 days, or three months.

4 Research Result

After the first order seasonal difference is defined manually, the ARIMA model parameters obtained automatically by the computer are ARIMA (4,2,1) (0,1,0) (365).Other parameters are listed below. The parameters of the model which will be used to test the fitting degree are AIC=-3744.23, AICc=-3744.13, BIC=-3745.54, ME=0.0003735124, RMSE=0.02384209, MAE=0.01500139, MPE=0.006055528, MAPE=0.2141412, MASE=0.03767283, ACF1=0.001418254.

The data for the past five years and the forecast for the next 90 days are as follows in Figure 1 and 2 (the start date is May 18, 2020, and the end date is August 18, 2025):

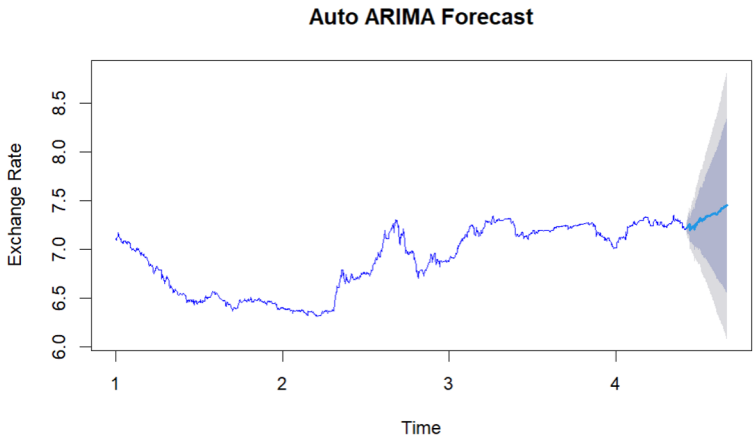

Fig.1. The Forecasting Plot of the Next 90 Days.

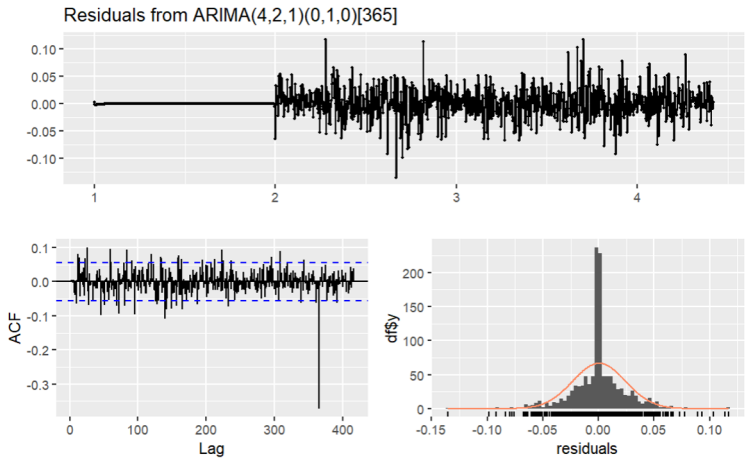

Fig.2. The Residuals, ACF and Residuals in Normal Distribution.

5 Discussion

The parameters of the ARIMA (4,2,1) (0,1,0) (365) model expresses the following meaning:

In the non-seasonal part of the model, the autoregressive order (AR) is 4, indicating that the current value is predicted by the observed values of the past four time points, which is used to capture the short-term autocorrelation of the series; the difference order (I) is 2, indicating that the original data is non-seasonally differenced by order 2 to smooth the series to eliminate the trend. The moving average order (MA) is 1, which means that the current value is corrected by the prediction error of the past time point, that is, the short-term noise influence of the sequence is captured. However, the sum of AR and MA of the model is greater than 5, indicating that there is a risk of overfitting. When the model is overfitted, the practical value of the model will decline. The main disadvantages of

overfitting are as follows: it will lead to poor generalization ability, which means that the prediction performance of new data is significantly reduced; it is highly sensitive to noise and fluctuation, because the model overfits the details such as random noise and outliers in the training set, which leads to drastic and unreasonable prediction results, which changes too much, when new data containing tiny noise is input; the model is unstable, which means that small changes in the training data make the parameters of the model change dramatically, and it is difficult to maintain and trust; the model is highly complex and poorly interpreted, which means that the model is too complex to calculate quickly, and it is difficult to understand and interpret the results of the model; it is possible for the model to learn spurious correlations, which means that it understands coincidence as correlation or even causality.

In the seasonal part of the model, the seasonal autoregressive order (SAR) is 0, indicating that observations from past seasonal periods are not used to predict the current value to capture seasonal autocorrelation. The seasonal difference order (SI) is 1, which means that the series is seasonally differenced by order 1 to smooth the seasonal portion to eliminate the seasonal trend. The Seasonal Moving Average Order (SMA) is 0, which means that the current value is not corrected by the forecast error of the past seasonal period and the seasonal noise effect is not captured. The seasonal cycle length is 365, reflecting my use of date data, and the cycle is 365 days in a year.

The AIC and BIC of the model are very small, the AIC is only -3774.23, and the BIC is only -3745.54, which reflects the degree which describes the fitting level of the model is very high, because AIC and BIC are the parameters indicating the degree which describes the fitting level of the model, and the lower the parameters, the higher the degree which describes the fitting level of the model. The high degree which describes the fitting level of the model of the model indicates that prediction is accurate.

The ACF of the training set is also very small, only 0. 001418254.The ACF is a parameter representing the autocorrelation of the model, and the larger the ACF, the greater the autocorrelation of the model. Therefore, the ACF is small, indicating that the autocorrelation of the model is very small, then indicating that the prediction of the model is reliable.

The graphic representation of the ACF (see Figure2) indicates that it is acceptable for the ACF to breach the threshold, except for one case where the ACF clearly breached the threshold, indicating that abnormal data may have occurred.

The RMSE, MSE and MAPE of the model are very small, indicating that the error of the model is small. These three parameters represent the error, and the smaller the RMSE, MSE, and MAPE, the smaller the error. The small RMSE, MSE and MAPE of the model represent the small error of the model.

In this paper, the first order difference is used for the data. The operation is to calculate the difference between the current value and the previous value, and then use the difference as a new data set. This operation is conducive to making the data more stable, reducing the volatility of the data, and thus facilitating the processing of the data. The reason for using the first order difference rather than the second or higher order difference in this paper is that the second order difference will make the model more difficult to explain, while the third or higher order difference will make the model lack of practical significance and only pure mathematical calculation.

In a word, using seasonal ARIMA model to try to figure out the result of exchange rate that is about two currencies of their countries: China and America may meets small error and a good degree of fitting, which is consistent with previous studies. I think the next research should be to compare the ACF, RMSE, autoregressive order and other data of ARIMA and seasonal ARIMA models in predicting the exchange rate of RMB against the US dollar, and to explore whether seasonality should be added.

6 Conclusion

This paper uses seasonal ARIMA model to forecast the exchange rate of RMB against the US dollar in the next 90 days. The results show that, in general, the RMB will continue to depreciate to the US dollar (see Figure1). This shows that for individual investors, they should do arbitrage by borrowing RMB to buy US dollars at the beginning of the period and selling US dollars to exchange RMB at the end of the period. This will increase demand for the renminbi, which in turn will allow it to appreciate in the future. For the Chinese government, the devaluation of the RMB means that China's prices will fall and deflation will occur. The country should increase the supply of RMB to stimulate its economy. But on the other hand, the devaluation of the RMB shows that China's exports will be increased and the process of economic recovery will be accelerated. The contribution of this paper is mainly to illustrate the effectiveness of seasonal ARIMA model in exchange rate forecasting, since the fitting degree of data processed by seasonal ARIMA model is very high; in addition, this paper also shows that in some cases, the difference of data plays an important role in making the data stable and enhancing the fitting degree between data and model. The data of the exchange rate after being dealt with the first order difference by the author of this paper is easier to be captured by the seasonal ARIMA model and thus predicted.

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