Federal Reserve Interest Rate Policy and US-RMB Exchange Rate: Evidence from ARIMA Model

Tengjie Ji[1†], Minglu Yu[2†], Ao Zhang[3*, †]
* Corresponding author: s1210209@stu.cpu.edu.cn

[1]Commercial College, South China Agricultural University, Zhujiang College Guangzhou, China

[2]Music Academy, Soochow University, SCU Soochow, China

[3]College of Science, Northeast Forestry University, NEFU Harbin, China

† These authors contribute equally.

Abstract—Since 2022, the Federal Reserve has raised its benchmark interest rate several times, profoundly affecting the volatility of exchange rates across countries This paper assumes that if the Fed does not raise interest rates, the USD-RMB exchange rate can be estimated and pre-stored by the ARMA model. Accordingly. This paper first tests the biased autocorrelation and autocorrelation of exchange rate returns through PACF and ACF, respectively. After determining the AR and MA orders, the ARMA model is constructed and overstated for multiple periods. By using an autoregressive moving average model (ARIMA) to predict the exchange rate movements without the rate raise and comparing it with the actual exchange rate movements after the rate rise, this paper finds that the Fed's rate rise has led to a depreciation of the RMB, which has had an impact on our economy. In light of this unusual volatility, China needs to analyze and adjust to problems such as asset devaluation promptly.

Keywords-interest rate policy; exchange rate; time series model.

1 INTRODUCTION

China officially joined the WTO on December 11, 2001, which further integrated the Chinese economy into the global market economy. After a series of adjustments and reforms, the RMB began to slowly appreciate against the US dollar interest rate after 2004. The RMB also joined the International Monetary Fund's Special Drawing Rights (SDR) basket of currencies on October 1, 2016, officially taking to the stage of the international monetary system. The two-way volatility of the foreign exchange market increased after the RMB joined the SDR, and the exchange rate was passively generated by external shocks [1]. On March 17, 2022, the United States Federal Reserve raised the federal funds rate interval by 25 basis points, from 0.25% to 0.5%, signaling the start of a new cycle of the interest rate rise. In the United States, as the inflation rate was at a persistently high level, the Federal Reserve's decision to raise interest rates

could be predicted. When the dollar enters the interest rate hike cycle, it will increase capital outflows and liquidity crunch pressure in emerging economies, causing a certain capital siphon effect. Over the past four decades, the Fed has had six interest rate hike cycles. This Fed raises rates and balance sheet reduction are accompanied by epidemic shocks and the outbreak of geopolitical wars, and if the macro policies of major global countries fail to effectively synergize the exogenous shocks from both the supply and demand sides, the world may face a certain degree of recession [2].

According to the International Monetary Fund (IMF) in World Economic Outlook Report on April 21, the global economy increased by only 3.6% in 2022. Compared with the January forecast, it has a sharp downward revision of 0.8 percentage points. The outbreak of the Russia-Ukraine conflict has led to a continued rise in global inflation [3]. LongXiao analyzed the RMB exchange rate during the US-China trade war, which is based on the fluctuation of exchange rate data from January 2018 to December 2019. He found the model ARIMA (3, 0, 4) was a better predictor of RMB exchange rate changes. The forecast indicated that as the trade relationship between China and the US enters into a de-escalation phase, the RMB exchange rate convert the US dollar will also show a fallback, in other words, the RMB's currency value is expected to appreciate in a short term [4]; Shaoyan Sun et al., in order to analyze the characteristics of the exchange rates sequential, they selected the mid-price of the US dollar to the RMB exchange rate from October 2016 to March 2018 when was the RMB joined into the SDR as data for analysis, and they found ARIMA(3, 1, 3) - GARCH(1, 2) is an idealized model which can obtain the more accurate results. These results indicated that the USD/CNY exchange rate can exhibit a volatile callback trend, however, the RMB exchange rate is in a stable and controllable situation, with little possibility of substantial fluctuations [5]; Tingting Shi, by choosing the RMB-USD exchange rate from January to October 2020 in China Currency Network, constructed ARIMA(2, 1, 2) to make a forecast about the RMB exchange rate for the next three months, the study found that the RMB-USD exchange rate is stable and has an appreciating trend in the short term during the epidemic period [6].

Looking through the relevant papers in recent years, we find that most researchers used ARIMA models to make forecasts, which have good scientific validity in the short term.

Some researchers found that the deterioration of the Fed's rate rises will cause corresponding fluctuations in the exchange rate. However, there is a lack of the corresponding perception about the exchange rate forecasting structure. Therefore, this paper collects data related to the China exchange rate for the last 3 years and uses the ARIMA model to investigate the fluctuation pattern of the exchange rate between China and Europe under the Fed raises rates. By processing some of the details, we will obtain a more suitable model, combine current events and theoretical analysis to briefly predict the trajectory of exchange rate fluctuations, and analyze and utilize the results.

The rest of the paper is organized as follows: the second part is the research design, which includes the data sources and model specification; the third part is the procedure and results of the experiment, and the fourth part is the discussion related to the experiment, and the last part is the conclusion of the paper.

2 RESEARCH DESIGN

2.1 Data sources

The RMB exchange rate data from a total sample of 735 from March 15, 2019, to March 14, 2022, in the International Monetary Fund database. The data for this period was chosen because, since the 2018 Fed rate hike, no rate raise was adopted from 2019 to 2021 until a new rate raise meeting on 15-16 March 2022, the data for this period can be used to forecast the value of the currency assuming no rate raise and to compare it with the actual value of the currency.

2.2 AR model specification

Autoregressive models are statistically a method of working with time series. The autocorrelation function (ACF) image of the stationary AR(p) model exhibits a mixture of amplitude-reducing sine, cosine, and exponential attenuation, depending on the nature of its feature root [7]. It is expressed as

$$x_t = \phi_0 + \phi_1 x_{t-1} + ... + \phi_p x_{t-p} + a_t \qquad (1)$$

2.3 MA model specification

The moving average model is one of the model-parametric methods of spectral analysis and is a commonly used model in modern spectral estimation. Past perturbations can be used to predict the future. It is expressed as

$$x_t = c_0 + a_t - \theta_1 a_{t-1} - ... - \theta_q x_{t-q} \qquad (2)$$

2.4 ARIMA model specification

ARMA models are a common class of stochastic time series models that describe the evolution of things by means of the stochastic nature of the time series. If a smooth stochastic process has the properties of both an autoregressive process and a moving average process, it is not appropriate to use the AR(p) or MA(q) model alone, but rather a mixture of the two models. Since this model contains both autoregressive and moving average components, it is denoted as ARMA (p, q) and is called an autoregressive moving average model. The ARMA model was first systematically elaborated by Jenkins and Box [8] and is known as a differential autoregressive moving average model. If the series is a smooth time series, the model is a hybrid model with an autoregressive of order p and a moving average of order q, denoted by ARMA (p, q), and if it is a non-stationary time series, it is to be differenced, with d being the number of differences. By ARIMA model, it means a model built by transforming a non-stationary time series into a stationary time series and then regressing the dependent variable on its lagged values only and the present and lagged values of the random error term. It is expressed as

$$(1 - \sum_{i=1}^{p} \phi_i L^i)(1 - L)^d X_t = (1 + \sum_{i=1}^{q} \theta_i L^i) \grave{o}_t \qquad (3)$$

3 EMPIRICAL RESULTS

3.1 Unit root test

In the unit root test, the purpose of the test is to check whether the series has a unit root, namely whether it is stationary.

In general, the exchange rate related data is not smooth and is subject to many exogenous factors. In order to effectively use the ARIMA model for forecasting, it is requisite to perform a unit root test on the data and process the data by means of differential analysis to restore stability to the data.

In the ADF test form, T-tests, and unit root tests on the original data, first-order difference data, and second-order difference data can be used to determine whether the original hypothesis of unstable data is significantly rejected. Once the data is transformed into smooth data, the new data derived by differencing can replace the original data, yielding the type of data that the ARIMA model can handle. Selecting daily exchange rate data (in RMB) for a total of three years from March 2019 to March 2022 and subjected it to differential analysis and unit root tests to obtain data that would fit the ARIMA model effectively. The expression for the unit root test is

$$x_t = c_t + \beta x_{t-1} + \sum_{i=1}^{p-1} \phi_i \Delta x_{t-i} + e_t \tag{4}$$

Original hypothesis H0: $\beta=1$ and alternative hypothesis H1: $\beta<1$ Decision rule: It can choose to look directly at the p-value.

Table 1 ADF-test

Order	t	p	AIC	Critical value		
				1%	5%	10%
0	-0.257	0.931	-3926.026	-3.439	-2.865	-2.569
1	-17.194	0.000***	-3922.065	-3.439	-2.865	-2.569
2	-11.22	0.000***	-3883.875	-3.44	-2.866	-2.569

Without differencing, p=0.931>0.01, which is not significant at the level of the original hypothesis, therefore it cannot be rejected and is an unstable series.

By further processing, the data under first-order differencing, p=0.000***, satisfies the p<0.01, level of significance and rejects the original hypothesis, the data obtained after differencing is a smooth series. Therefore, the first-order differenced data can be used in the ARIMA model. As shown in the figure below, the first-order differenced data of the RMB exchange rate can be seen to be significantly smooth. A more specific analysis of the ARIMA model is required next.

3.2 AR and MA identification

Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as "3.5-inch disk drive".

With the ADF unit root test described above, it can be concluded that the 3-year RMB exchange rate data through processing is already stationary. The next step is to determine the value of (p, d, q) for the ARIMA model. First, we need to initially estimate the value of the ARIMA model by observing the autocorrelation plot (ACF) and the partial autocorrelation plot (PACF) for the first-order difference data. Following the general guideline and with the data being first-order difference data, we, therefore, construct ARIMA (p, 1, q). The ACF is truncated at order 2 and the biased autocorrelation plot is trailed according to the figure below, so we can simplify the model to MA (2). The data are not autocorrelated, p = 0, q = 2.
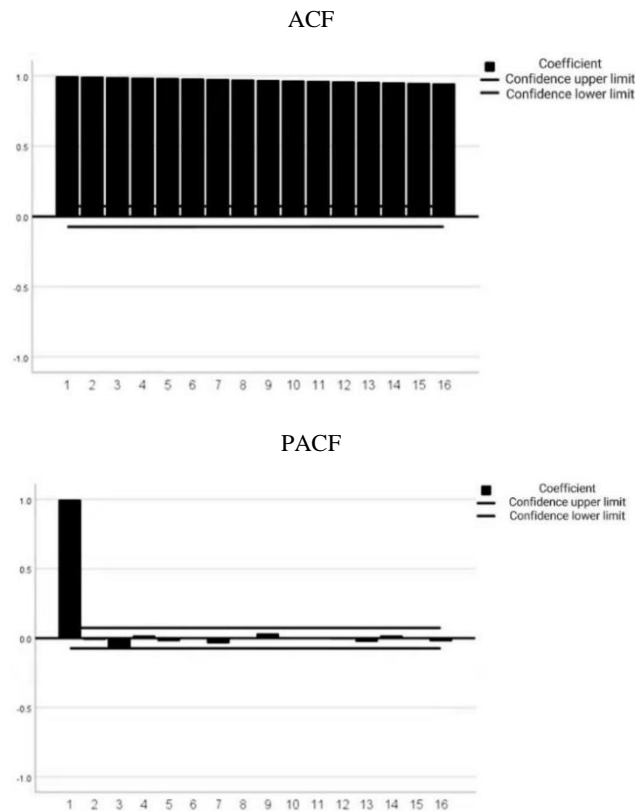
ACF

PACF

Figure 1 PACF and ACF for order identification

3.3 Model results

For the model ARIMA (0, 1, 2), we use the software to obtain detailed outputs for our model parameters. The expression for the model is

$$y(t) = 0.0 - 0.055 * \varepsilon_{t-1} + 0.125 * \varepsilon_{t-2} \qquad (5)$$

Table 2 ARIMA model estimation results

		Estimate	Standard error	t	Significance
Constant		0.001	0.001	0.911	0.363
Difference			1		
MA	Delay 1	0.055	0.037	1.503	0.133
	Delay 2	-0.125	0.037	-3.383	<0.001
Molecule	Delay 0	-4.293E-6	2.847E-6	-1.508	0.132

Then, it is necessary to test the White noise. Using the software to analyze the sample size, degrees of freedom, Q statistic, and goodness of fit of the model. The ARIMA model requires that the residuals of the model are not autocorrelated, in the other words, the residuals are white noise, and the square of R represents the goodness of fit, with the closer to 1 the more reliable it is.

This leads to the following diagram. The model white noise was tested according to the figure above. Under Q18, p=0.211>0.1. The original hypothesis cannot be rejected and does not present significance at the level. The residuals of the data are white noise series. At the same time the goodness of fit of the model reaches 0.996, and the model performs well and meets the demand.

The ACF and PACF plots of the residuals, both fall within the confidence range. This indicates that the data show a weak correlation and that the information affecting the model has been removed.
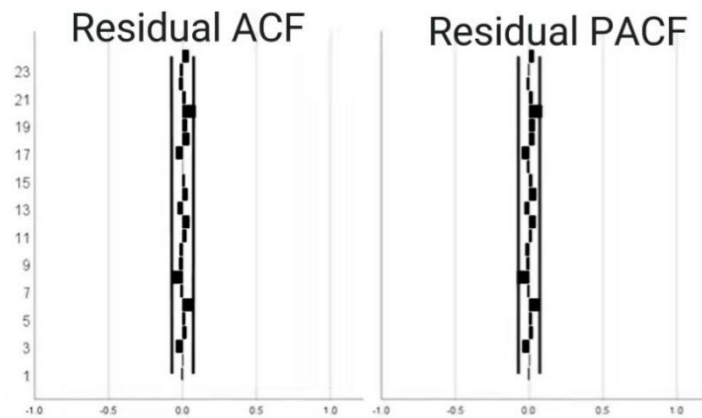

Figure 2 Residual autocorrelation test

4 DISCUSSION

As the interest rate hike took hold, the RMB exchange rate changed in response, moving up and down around 6.35 compared to forecasts, but accelerated in depreciation after the 21st period. China is both a major exporter and importer, importing large amounts of energy and basic raw

materials from around the world every year. Therefore, while the devaluation of the RMB is beneficial to exports, it should also take into account the rising cost of imports and the resulting imported inflation [9].
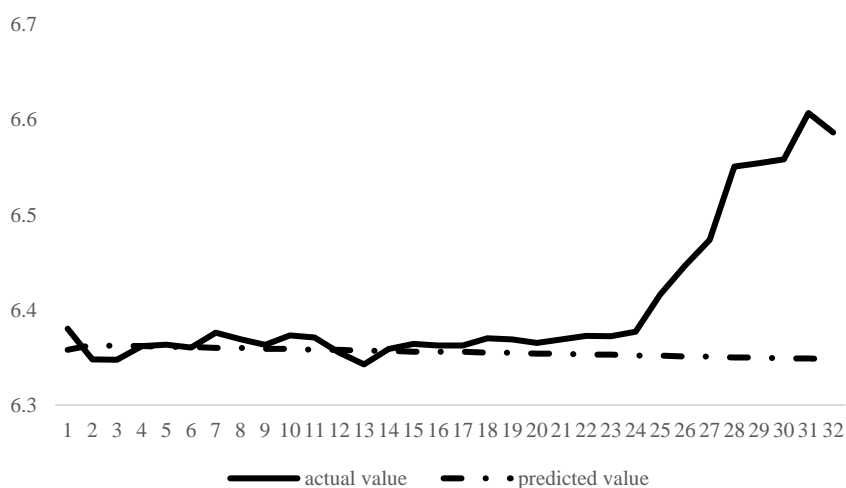

Figure 3 Comparison of actual and predictive value

At the end of 2019, coronavirus suddenly appeared and spread rapidly around the world. This has resulted in many countries, including the United States, China, and the European Union, having to adopt policies, in order to deal with the expanded unemployment, the setbacks in foreign trade, and the decreasing tax revenues. In the torrent of the era of Economic Globalization, the United States, as a major economic power, has implemented a $900 billion bailout for the population in December 2020, and the President signed another $1.9 trillion bailouts in 2021.3, which by giving money directly to the people to enhance economic vitality and stimulate economic development. Under the circumstance of U.S. dollar hegemony, although the US has the money printing machines, this measure has increased the economic bubble while bailing out the population. It caused economic growth to stagnant, inflation, and other problems. And in order to keep the country's economic structure balanced, avoid a crisis in social credit and maintain the stability of the stock market, the Federal Reserve released news about interest rate rises. In response to high inflation, on 15 June local time, the Federal Reserve Open Market Committee (FOMC) voted to raise the target range for the policy rate federal funds rate by 75 basis points. the FOMC's statement concluded that a sustained increase in interest rates may be appropriate at the current level of inflation [10].

The rise in the Federal Reserve interest rate, the increase in deposits, and the decrease in market capitalization, greatly contributed to the appreciation of the US dollar. The US dollar index has risen by eight percent so far this year, while the RMB has weakened relatively. In a poor macro-environment, exchange rate shocks are a huge test for the country at the moment. By comparing the forecasted value of the exchange rate with the actual value, it is possible to see more visually the impact of the Fed's interest rate hike on our economy. The two sessions set a growth target of

5 percent, but inflation was only 0.9 percent. In response, China's central bank, Ministry of Finance, and other ministries have stated that they will maintain stable economic development. Therefore, stimulating the economy, encouraging consumption, and promoting employment are the primary objectives of China's policy.

With the "dollar tidal" effect, countries inevitably face the risk of being harvested. Therefore, following the Fed and raising benchmark interest rates could restrict capital outflows. Throughout history, there have been three massive "dollar tides" in which dollar capital has been successfully harvested from developing countries, not only because of the speculation of dollar bankers but also because of a single industrial structure, a weak financial firewall system, and insufficient foreign exchange reserves. China, as the second-largest economy in the world, has a complex industrial structure, abundant foreign exchange reserves which rank first in the world, and a well-developed financial firewall. It has an extremely anti-risk ability. On the other hand, As a result of the coronavirus, the manufacturing industry in all countries has been affected to some extent. China has taken the lead in restoring the industrial chain, taking into account both domestic and international aspects. It should not only supply itself but also continued to export its products abroad. As a result, the bargaining power has increased while export volumes have increased, the competitiveness of foreign trade enterprises has continued to rise and exports have not been inhibited by changes in the exchange rate. The RMB may fluctuate in the short term, but China's economic growth has been showing great potential, with high market confidence and investment interest from foreign investors is strong. While the government should respond to the currency war activity, enterprises should catch the opportunity to develop themselves.

The increase in lending rates forced capitalists to choose to repay early or reduce their loans to have less cost of capital. Meanwhile, the continued escalation of the Russia-Ukraine war has increased demand for safe-haven currencies, and the US dollar is the currency with the most global reserve, both situations have intensified capitalists to cash out and return their funds to the market. Thus after the Fed's rate rise, US stocks bucked the trend, while the three major A-share indices fell for two days in a row. Comparing the timing of the Fed's rate rise with the change in A-shares, it is also clear that China was greatly affected by the rate rise. The subsequent changes in A-shares can also reflect some extent the impact of the Fed on domestic Chinese flows.

5 CONCLUSION

In the face of the US interest rate raise policy, there has been some change in the entry and exit of capital in each country. In this paper, the ARIMA model was found to be more accurate in forecasting the exchange rate after the practical operation. The ARIMA model was therefore used to forecast the RMB and a comparison of the predicted values obtained with the actual values revealed that the RMB has depreciated and is likely to continue to depreciate.

As China's financial markets continue to open up and the exchange rate system continues to develop and improve, the exchange rate, as the link between the currencies of different countries, is bound to be influenced by every move made by the Federal Reserve. Not only the domestic price level and economic growth rate, but also the exchange rate, as an important economic indicator, has a huge impact on the domestic foreign trade market and the asset market. The findings of this paper, as well as the study of the fluctuations in the value of the Renminbi, provide

an initial macro impression of the currency situation at home and abroad. As a result, based on the abnormal changes in the value of the RMB currency, further analysis of the current rate of depreciation of our assets and net asset value can be carried out; pricing issues for foreign trade transactions can also be more proactive.

REFERENCES

[1] S.J. Yang Exploring the law of exchange rate fluctuation and RMB internationalization after RMB's accession to SDR. Times Economic & Trade, vol. 18, pp. 23-26, September 2021.

[2] R.J. Fan. The global economy faces a severe test of inverted US bond yields. China Bancassurance News, April 2022

[3] Y. Xu, M.L. Xiong. World economic growth faces multiple risks. Xinhua Daily Telegraph, April 2022.

[4] L. Xiao. Patterns of RMB exchange rate movements and trend forecasting under the US-China trade war: An empirical study based on ARIMA model. Jilin Financial Studies, pp. 12-15, June 2020.

[5] S.Y. Sun, W.X. Sun. A study on the volatility pattern of RMB exchange rate after joining SDR--an empirical analysis based on ARIMA-GARCH model. Economic Issues, pp. 42-47, February 2019.

[6] T.J. Shi. Research on the prediction of RMB exchange rate fluctuation trend under the new crown epidemic based on ARIMA model. Modern Business, vol. 14, pp. 108-110, 2021.

[7] Y. Tang, P.F. Zhu. Financial econometrics (2nd ed.). Beijing: Tsinghua University Press, pp. 79-87, 2019

[8] Box, George E P, Jenkins, et al. Time Series Analysis. North-Holland Publishing Co. Amsterdam-New York, vol. 61, pp. 285-293, March 2011.

[9] X.C. Chen. Fed rate hikes pick up pace as major central banks brace for inflation. Securities Times, June 2022.

[10] H. Ni. Chinese companies tell impact of yuan devaluation. Global Times, May 2022.