

A study of the dynamic relationship between the RMB exchange rate, foreign exchange reserves and monetary policy

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Abstract. In today's globalized economic environment, the relationship between China's RMB exchange rate, foreign exchange reserves and monetary policy has become more and more complex, and is crucial to the stability and sustainable development of the economy. The interactions among these three have a direct impact on China's macroeconomic situation, so it has become a very urgent task to study this relationship in depth. This study combines theoretical and empirical research to deeply analyze the dynamic relationship among these three, aiming to provide practical guidance for the formulation of China's monetary policy. This paper selects the time series data of RMB exchange rate, foreign exchange reserves and money supply from 2003 to 2023 to study the relationship between RMB exchange rate, foreign exchange reserves and monetary policy. This paper will deeply explore the impact of the government's market intervention on the RMB exchange rate under different exchange rate regimes, especially under the fixed exchange rate regime and the floating exchange rate regime. This paper will delve into the transmission mechanism of monetary policy, especially the flexibility and adaptability of monetary policy under the volatility of global financial markets and changes in economic cycles. In terms of empirical research, this paper will use the VAR model and the GARCH model for time series analysis to verify the applicability of the theoretical mechanism in practical situations and provide lessons for the formulation of future monetary policy.

Keywords: monetary policy; RMB exchange rate; dynamic relationship; foreign exchange reserves.

1. Introduction

RMB exchange rate, as an important indicator reflecting the value of the Chinese currency in the international market, its changes are not only affected by a variety of factors such as domestic and foreign economic situation, policy orientation, but also in turn affects all aspects of the domestic economy. And foreign exchange reserves, as an important embodiment of the country's economic strength, its size and structure of the changes also affect the market's nerves, and the RMB exchange rate formed a mutual influence, mutual constraints on the relationship.

Monetary policy, as an important means for the state to regulate the economy, its formulation and implementation also need to take into account the changes in the RMB exchange rate and foreign exchange reserves. Therefore, the study of the dynamic relationship between the RMB exchange rate, foreign exchange reserves and monetary policy not only helps us to understand the internal logic of economic operation, but also provides policy makers with strong theoretical support and practical guidance. This study is particularly important in the context of the current complex and volatile global economic situation and increased volatility in financial markets.

The purpose of this paper is to explore the dynamic relationship between RMB exchange rate, foreign exchange reserves and monetary policy and their impact on China's economy through in-depth analysis of the interaction mechanism between them. Through a combination of theoretical analysis and empirical research, this paper seeks to provide useful references and lessons for relevant policy making.

2. Literature review

In the current research in the field of finance, the dynamic relationship between the RMB exchange rate, foreign exchange reserves and monetary policy has been studied extensively and deeply, and

these studies provide useful theoretical and empirical support for a better understanding of this relationship.

The study by Jiang Lihong (2018) provides the first in-depth exploration of the interaction between China's money market, capital market and foreign exchange market, which provides a theoretical basis for subsequent related studies. The study focuses on the interactions between different markets, revealing the complex and close links between them. In Zhang Ruiqian's study (2018), the relationship between China's foreign exchange reserves and the RMB exchange rate is discussed in depth. The study emphasized the impact of foreign exchange reserves on the RMB exchange rate while studying the relationship between the two. This study provides empirical evidence for the study of China's foreign exchange policy, which is an important reference value for the formulation of China's monetary policy.

The empirical study by Guo Tianyong and Lan Ying (2019) goes further to delve into the dynamic relationship between RMB internationalization and foreign exchange market pressure. By observing the process of RMB internationalization, the study reveals the dynamic impact of internationalization on foreign exchange market pressure. This study not only provides important clues for a better understanding of the performance of the RMB in the international arena, but also provides empirical support for the evolution of the role of emerging currencies in the international financial market. The study by Wei Zhang and Xunan Jiang (2019) focuses on the nonlinear relationship between the RMB exchange rate, money supply and price level. Through nonlinear modeling, they reveal the mechanism of the complex association between these factors, which provides a new perspective for us to understand the dynamics behind the fluctuations of the RMB exchange rate. The discovery of this nonlinear relationship provides a richer reference for future monetary policy adjustments, making policymakers more capable of responding to various situations more precisely in practice. Tang et al. (2019) studied the dynamic correlation of exchange rates and spreads between the RMB and the currencies of the countries along the "Belt and Road" through the empirical study of the multivariate GARCH model. This study not only focuses on international relations, but also on the dynamic evolution of economic ties between China and the "Belt and Road" countries. This provides empirical support for our understanding of the development of economic cooperation between China and the countries along the Belt and Road.

Zheng Pengcheng's (2020) study provides an in-depth study of the dynamic relationship between the Chinese foreign exchange market and the stock market by employing a DCC-GARCH model. The study not only focuses on the short-term relationship between the markets, but also provides insights into the long-term relationship from the perspective of dynamic conditional correlation. The analysis by Yanlin Sun and Pei He (2020) focuses on the correlation between RMB foreign exchange market pressure and monetary policy. Through an in-depth analysis of market pressures, the impact of monetary policy adjustments on the foreign exchange market is examined. This study provides an empirical basis for understanding the subtle relationship between monetary policy and market reaction, and provides an important reference for future monetary policy formulation.

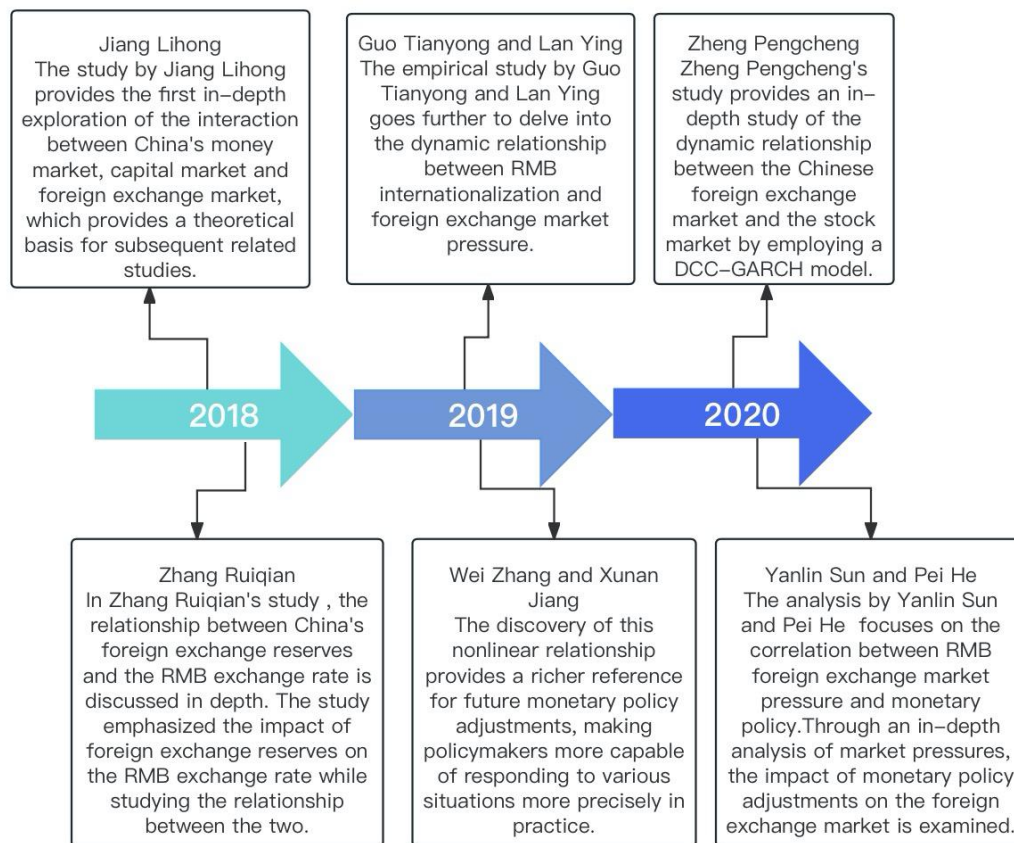


Figure. 1 Analysis of the time structure of the literature review

3. Data organization and analysis

3.1. Data sources and descriptive statistics

3.1.1 Data sources

The data in this paper mainly comes from the official website of the National Bureau of Statistics, adopting the RMB exchange rate from 2003-2022, foreign exchange reserves, and monetary policy is measured using money supply (M1).

3.1.2 Statistical description

Descriptive statistics of the main variables are shown in Table 1:

Figure. 2 Descriptive statistics of variables

variable name	observed value	average value	(statistics) standard deviation	minimum value	maximum values
exchange rates	20	695.9390	70.78977	614.28	827.70
Foreign exchange reserves (billions of dollars)	20	25516.0405	10852.7475	4032.51	38430.18
Monetary policy (money supply)	20	350387.700	200590.084	84118.57	671674.76

3.2. Modeling

In order to gain a deeper understanding of the dynamic relationship between the exchange rate and foreign exchange reserves, we will build a Vector Autoregression (VAR) model. The variables of the model include monetary policy, the RMB exchange rate and the level of foreign exchange reserves. We will use time-series data for estimation to examine the interactions between them, with a particular focus on the short- and long-term effects of foreign exchange reserves on the exchange rate.

Since the RMB exchange rate is a very important factor affecting monetary policy, and also combining the results of the related literature of many scholars in China, this paper constructs a vector autoregressive econometric model between the RMB exchange rate, foreign exchange reserves and monetary policy:

$$policy_t = a_0 + a_1 Rate_t + a_2 Reserve_t + \mu_t \quad (1)$$

Among them, policy indicates China's monetary policy variables, which are mainly represented by money supply M2, Rate indicates the independent variable of RMB exchange rate, and Reserve indicates the independent variable of foreign exchange reserves.

The specifics of the variables used in this paper are shown in the table below:

Figure. 3 Specifics of variables

Variable type	variable name	variable symbol	Variable Meaning and Description
explanatory variable	monetary policy	Policy	The main measure of monetary policy is the money supply, M2.
acrobatic display (esp. on horseback) (old) explain become different measure word	Renminbi exchange rate	Rate	Reflects changes in our RMB exchange rate
	foreign-exchange reserves	Reserve	Reflecting our foreign exchange reserves

Since the observation samples are time series variables, in order to avoid pseudo-regression phenomenon of time series, the steps of handling on the measurement are: firstly, unit root test is conducted, on the basis of which the possibility of cointegration analysis is confirmed, and finally Granger causality test is conducted between the variables.

4. Empirical analysis

4.1. Stability tests

Considering that in actual economic analysis, if non-stationary time series are directly treated as stationary time series for regression analysis, it may result in "pseudo-regression", i.e., there is no correlation between the variables, but the regression results lead to the erroneous conclusion that there is a correlation, and the resulting model does not have the ability to explain. In order to avoid the phenomenon of "pseudo-regression", it is necessary to determine the smoothness of the analyzed time series and test whether the variables are stable before conducting econometric analysis.

The purpose of unit root test for time series data is to determine whether the time series is smooth. If there is a unit root in the test result, it means that the time series data is non-stationary, and the regression result may have a "pseudo-regression" situation, which needs to carry out the first-order or second-order difference on the original series until it is stable. EVIEWS8.0 software is used to

carry out the extended dickey-fuller (ADF) test on the unit root of each variable, to screen out the willingness to trend, the presence or absence of a constant, and the optimal order of the lagged variable, so as to determine the basic form of (c,t,q), where c is the constant, t is the trend, and q is the order of the lag. The results of the ADF test for the original series of each variable are shown in Table 2.

The basic type of ADF test (c, t, q) is determined by performing the ADF test for unit root for each variable separately, choosing whether the trend want and constant term exist and the order of the optimal lagged variable. Where c denotes the constant term, t denotes the trend term and q denotes the lag order. The results of the test are shown in the table below:

Figure. 4 ADF test of the original series of each variable

variant	Type of test	The t-statistic of the ADF	threshold value	reach a verdict
Policy	(1, 1, 0)	-1.690	-3.887***	uneven
Rate	(1, 1, 0)	-1.997	-3.920***	uneven
Reserve	(1, 1, 0)	-0.181	-3.857***	uneven

The ADF test for each of the above consumer spending and financial variables found that the t-statistics of the original series are larger than the critical value of 10% significance level, so the original series has a unit root, i.e., it is non-stationary. Therefore, the original series of variables need to be single-integrated to the first or second order as shown in the table below:

Figure. 5 Results of ADF test for first order single integrality of the series of variables

variant	Type of test	The t-statistic of the ADF	threshold value	reach a verdict
Policy	(1, 1, 0)	-3.496	-3.887***	uneven
Rate	(1, 1, 0)	-3.416	-3.857***	uneven
Reserve	(1, 1, 0)	-2.178	-3.857***	uneven

From the results in Table 2, it can be seen that the variable LC1 is not smooth in the ADF test for first-order unitary and the ADF test for second-order unitary for the original series is shown in Table 3:

Figure. 6 Results of ADF test for second order single integrality of the series of variables

variant	Type of test	The t-statistic of the ADF	threshold value	reach a verdict
Policy	(1, 1, 0)	-4.586	-4.058***	smoothly
Rate	(1, 1, 0)	-5.729	-3.920***	smoothly
Reserve	(1, 1, 0)	-4.542	-3.920***	smoothly

Note: *** is the significance level at 1%.

4.2. Cointegration tests

In this paper, this paper uses ordinary least squares (OLS) to empirically investigate the relationship between the RMB exchange rate, foreign exchange reserves and monetary policy, and the Engel-Granger two-step test is used to derive the cointegration formula:

$$policy_t = 29.2Rate_t + 0.23Reserve_t + 110.88 \quad (2)$$

(2.62) (63.26) (8.66)

If the residual term μ is smooth, then there is a cointegration relationship between the level of rural financial development in Henan, the level of rural financial development in Henan and the level of rural economic development in Henan, and the results of the ADF test of the residual term μ are shown in Table 5.

Figure. 7 ADF test results for the residual term μ

variant	Type of test	ADF statistical values t	1% threshold	5% threshold	10% threshold	reach a verdict
Residuals μ	(1, 1, 0)	-4.361516	-2.699769	-1.961409	-1.606610	smoothly

By performing ADF test on the residual term μ , it was found that $P=0.0002$, which is less than 10%, rejects the original hypothesis that the series does not have a unit root and that the residual series of the regression equation is stable at the level of significance.

4.3. Empirical studies of monetary policy changes on exchange rates and reserves

(1) Event study of interest rate decisions

To gain a deeper understanding of the material impact of monetary policy changes on exchange rates and reserves, we will conduct event studies. We will select monetary policy interest rate change events as key observation points to reveal the short- and long-term effects of policy changes on the RMB exchange rate and foreign exchange reserves by analyzing the market reaction within the event window.

In the event study, we will construct a CAR (Cumulative Abnormal Returns) model to quantify the market's reaction to monetary policy changes by calculating the cumulative abnormal returns over the event window. Through this analysis, we are able to see more clearly the actual impact of monetary policy decisions on the FX market.

(2) Impact of changes in money supply on reserves

Through a panel data model, we will empirically investigate the impact of money supply changes on reserves. Examine the short-term and long-term effects of money supply changes on foreign exchange reserves in order to reveal the actual effects of monetary policy adjustments on foreign exchange reserves. In the model, we will include variables such as the money supply and the level of foreign exchange reserves, and we will deeply investigate the potential pathways of the impact of money supply changes on reserves through a fixed-effects or random-effects model.

Through the above empirical studies, we will be able to assess more accurately the actual relationship between exchange rates, foreign exchange reserves and monetary policy, and provide strong empirical support for the formulation of more effective policies.

5. Further studies

5.1. Data constraints and research limitations

(1) Challenges of data quality and reliability

Although we are committed to selecting high-quality time series and panel data in our current study, there may still be some limitations in data quality. In order to more accurately assess the relationship between the RMB exchange rate, foreign exchange reserves and monetary policy, we need to further address the data quality challenges. We will consider using more detailed and long-term data to enhance the credibility of the study.

(2) Simplicity and Complexity Balance in Research Modeling

In building models such as VAR and GARCH, we may have adopted certain assumptions in order to simplify the research process. These assumptions may have an impact on the complexity and realism of the models. In future research, we need to further explore the balance between model complexity and simplification to ensure that the findings are interpretable yet remain substantial.

5.2. Suggested directions for follow-up research

(1) Financial Market Deepening and Monetary Policy Effectiveness

Future research can further focus on the impact of the deepening of China's financial markets on the effectiveness of monetary policy. We can expand the scope of the study by introducing more financial market-related variables, such as stock market indices and the term structure of interest rates. In addition, more sophisticated models, such as the vector error correction (VEC) model, are used to capture more accurately the long-run relationship between variables.

(2) Coping Strategies for Global Economic Uncertainty and Policy Adjustments

Against the backdrop of the current intensified global economic uncertainty, focusing on the response strategies of the RMB exchange rate and foreign exchange reserves to global economic changes is an important direction for future research. This proposal aims to study in depth the performance of the RMB exchange rate in different economic contexts by introducing global macroeconomic indicators, and to dig deeper into the monetary policy adjustment strategies under global economic uncertainties with the help of more complex models such as the dynamic stochastic general equilibrium (DSGE) model.

Introduction of global macroeconomic indicators

Future research can expand the perspective on the RMB exchange rate and foreign exchange reserves by introducing global macroeconomic indicators. Considering globalized economic relations, indicators such as international trade data and global economic growth rates are important factors in understanding the performance of the RMB in the global economy. By analyzing the relationship between the RMB exchange rate and these global macroeconomic indicators, we can better understand the performance of the RMB in different economic environments and provide more targeted recommendations for the formulation of flexible monetary policies.

With the help of dynamic stochastic general equilibrium (DSGE) models

In order to dig deeper into the monetary policy adjustment strategy under global economic uncertainty, more complex models can be used, such as the dynamic stochastic general equilibrium (DSGE) model. The DSGE model can more accurately portray the impact of monetary policy on the RMB exchange rate and the foreign exchange reserves while taking into account the interactive effects of multiple economic factors. By building a DSGE model, we can simulate different economic scenarios and assess the long-term impact of different monetary policy choices on the RMB and foreign exchange reserves. This helps policymakers to more comprehensively recognize and respond to global economic uncertainties.

Addressing data constraints and research limitations

Addressing data constraints and research limitations is critical in future research. The accuracy and credibility of the study can be improved through richer and more comprehensive data collection. At the same time, researchers should also pay attention to introducing more factors that may affect the RMB exchange rate and foreign exchange reserves in the empirical analysis in order to construct a more complete research framework.

By addressing the above data constraints and research limitations, as well as expanding the direction of subsequent research, we will gain a more comprehensive understanding of the dynamic relationship between the RMB exchange rate, foreign exchange reserves, and monetary policy, and provide stronger support for future economic policymaking. This will help improve China's flexibility in responding to global economic fluctuations and promote the stable development of the domestic foreign exchange market.

6. Conclusions and recommendations

6.1. Conclusion

(1) The complex relationship between exchange rates, reserves and monetary policy

The empirical analysis of this study leads us to the following key findings:

There is a complex time-series dynamic relationship between the exchange rate and foreign exchange reserves. The results of the VAR model show that the exchange rate and foreign exchange reserves show a complex pattern of mutual influence in different time scales. Changes in foreign exchange reserves are not only affected by short-term shocks to the exchange rate, but also have a stabilizing and moderating effect on the exchange rate in the long run.

The impact of monetary policy changes on exchange rates and reserves shows diversity. The results of event studies and panel data models show that the impact of monetary policy changes on the RMB exchange rate and foreign exchange reserves varies significantly under different policy environments. This suggests that monetary policy adjustments need to take domestic and foreign factors into account in order to achieve economic goals more precisely.

(2) Urgency and Flexibility in Policy Adjustment

The urgency of adjusting monetary policy. Against the backdrop of heightened global economic uncertainty, we find that adjusting monetary policy to external shocks is crucial for maintaining economic stability. Policymakers need to closely monitor changes in the international economic environment and make swift and flexible monetary policy adjustments.

6.2. Recommendations

(1) Construction of a comprehensive research framework: In order to comprehensively and systematically study the dynamic relationship among the three, it is recommended that a comprehensive research framework be constructed. This framework should cover the exchange rate formation mechanism, foreign exchange reserve management strategy and monetary policy tools and other aspects, in order to reveal the mutual influence and constraints between them.

(2) Strengthening data collection and organization: in-depth study of the relationship between the three requires a large amount of high-quality data support. Therefore, it is recommended to strengthen the collection and organization of relevant data to ensure the accuracy and completeness of the data. At the same time, a unified data platform should be established to facilitate data analysis and mining by researchers.

(3) Focus on international comparison and reference: While there are differences in the exchange rate regimes, foreign exchange reserve management strategies and monetary policy tools of different countries, there may also be commonalities. Therefore, it is recommended that research focus on international comparison and reference, absorbing the successful experience of other countries and providing useful reference for national policymaking.

(4) Strengthening policy simulation and forecasting: In order to better guide policy formulation, it is recommended that econometrics and other methods be utilized for policy simulation and forecasting. Through the construction of simulation models, the impact of different policy combinations on the exchange rate, foreign exchange reserves and monetary policy will be analyzed to provide policymakers with a basis for decision-making.

(5) Strengthening interdisciplinary cooperation and exchanges: The study of the dynamic relationship between the RMB exchange rate, foreign exchange reserves and monetary policy involves a number of disciplines such as economics, finance and statistics. Therefore, it is recommended to strengthen interdisciplinary cooperation and exchange to jointly promote the research progress in this field.

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