Dynamic Relationship between RMB Exchange Rate and Interest Rate Based on VAR-DCC-GARCH Model

Xuhang Zhao[1]
[1]School of Economics, Wuhan University Wuhan, China

Abstract: Based on the daily data of Shibor and nominal exchange rate from 2006 to 2019, this paper constructs VAR model and uses Granger causality test and impulse response model to analyze the dynamic relationship between exchange rate and interest rate. Based on the DCC-GARCH model, this paper analyzes the correlation between exchange rate volatility and interest rate volatility, and concludes that there is a weak negative correlation between exchange rate and interest rate. Both exchange rate and monetary policy will have an important impact on China's economic environment, so it is of great practical significance to study the joint impact of exchange rate and monetary policy.

1 INTRODUCTION

As two important reference indexes of financial market, interest rate and exchange rate have been widely concerned, especially after the financial crisis in Southeast Asia in the late 1990s, people began to realize that the financial crisis can be quickly transferred from one domestic financial market to another, or from one country to another. In China, interest rate and exchange rate are important policy tools to maintain national economic security and financial stability in an open economy environment. Effective adjustment of exchange rate and application of interest rate policies can reduce the impact of external shocks on the economic environment, and thus achieve the role of maintaining financial stability. In recent years, with the continuous development of currency swap agreements, offshore RMB financial centers and the "one belt and one way" strategy, RMB is widely used in the international market. Accompanied by the stable trend of RMB exchange rate reform, there have been large fluctuations, especially in 2015, the "August 11" exchange rate reform makes RMB exchange rate more flexible in both directions, and the trend of exchange rate is more complex. According to the "triangle paradox" theory, in an open economic system, it is impossible for a country to realize the free flow of capital, the independence of monetary policy and the stability of exchange rate at the same time (kurgman, 1999). In order to realize the internationalization of RMB and maintain the independence of monetary policy, it is necessary to implement a managed floating exchange rate system. In addition, we can see that both exchange rate and monetary policy will have an important impact on the internationalization of RMB, so it is of great practical significance to study the joint impact of exchange rate and monetary policy.

With the development of interest rate and exchange rate theory, the research on the relationship between exchange rate and interest rate has been developing in the deepening process of interest rate parity theory, Mundell Fleming Model and asset market theory determined by exchange rate. In the 1990s, in addition to the impact model of interest rate changes on the exchange rate, the impact model of exchange rate changes on the interest rate also came into being. With the rapid development and wide application of co integration theory and panel data technology, many economists empirically test the relationship between interest rate and exchange rate of representative countries and regions based on classical models. This paper selects the daily data of Shibor and nominal exchange rate from 2006 to 2019, uses VAR-DCC-GARCH model to analyze the dynamic relationship between exchange rate and interest rate, including the long-term and short-term impact of exchange rate fluctuation on interest rate, and uses the relevant theoretical model of time series to make further analysis on the interaction mechanism between interest rate and exchange rate.

2 LITERATURE REVIEW

The empirical results of the relationship between exchange rate and interest rate are complex and uncertain. Dekle et al. (2001) studied the relationship between Korean interest rate and exchange rate based on weekly data, and found that there was a leading lag relationship between exchange rate and interest rate, and raising interest rate would lead to the appreciation of Korean dollar nominal exchange rate; Tanner et al.

2017301120016@whu.edu.cn

(1999) found that tight monetary policy could help reduce the pressure of exchange rate appreciation. However, Baig and Goldfajn (2002) studied the relationship between exchange rate and interest rate in six emerging markets based on VAR method and impulse response function. They found that the large fluctuation of exchange rate could not be explained by the change of interest rate. Ohno et al. (1999) studied seven Asian countries with daily data and reached the same conclusion. In order to describe the dynamic relationship between exchange rate and interest rate, so (2001) studied the short-term dynamic relationship between exchange rate and interest rate in Meiyuan based on the multivariable EGARCH model. The results showed that the price change of interest rate had a significant impact on the exchange rate change, while the exchange rate change could not explain the change of interest rate, but there was a volatility spillover effect between the foreign exchange market and the money market, the second of exchange rate and interest rate The order moments are closely related, and they are nonlinear. Mundell (1960) constructed a dynamic adjustment analysis framework of interest rate and relative price through internal and external equilibrium lines, and pointed out that different dynamic assumptions lead to different stability conditions and equilibrium paths, resulting in different dynamic adjustment mechanisms under the fixed exchange rate and floating exchange rate systems. Flankel (2005) explained the necessity and regulation way of using two independent policy tools of real exchange rate and interest rate to achieve internal and external equilibrium in China by expanding the Swan model. Lin et al. (1994) studied the volatility spillovers between different countries' markets; TSE and booth (1996) studied the volatility spillovers between different assets.

Many domestic scholars have also carried out empirical research on the relationship between RMB exchange rate and interest rate. There are two opposite views on the dynamic relationship between exchange rate and interest rate: one view is that there is a negative correlation between exchange rate change and interest rate fluctuation, i.e. "fluctuation coordination hypothesis". Another view is that the exchange rate changes and interest rate fluctuations are positively related, that is, "risk strengthening hypothesis". Yi Gang and fan min (1997) think that the theory of interest rate parity is not established in China. JinZhongxia (2000) applied the monthly model of vector autoregression to analyze the interaction among exchange rate, interest rate and balance of payments in China from 1981 to 1999. Shen guobing (2002) proposed the exchange rate and interest rate expansion M-F model based on the traditional M-F model.

3 DATA DESCRIPTION

The variables selected in this paper are as follows:

1. Exchange rate index: in this paper, the average of the middle price of the exchange rate between RMB and US dollar is used as the index of exchange rate. Although the exchange rate of RMB changed from reference bilateral exchange rate to multilateral exchange rate after the "August 11" exchange rate reform, the exchange rate of RMB to us dollar is more representative due to the international monetary status of US dollar. The higher the exchange rate is, the lower the value of RMB against the US dollar, and vice versa.

2. Shanghai interbank offered rate (Shibor): in this paper, the interest rate is Shanghai interbank offered rate (Shibor) which is the arithmetic average interest rate calculated by the RMB interbank offered rate independently quoted by the bank with higher credit rating. It is a simple, unsecured and wholesale interest rate. At present, there are many kinds of Shibor released by the society. In this paper, we choose the 1-month lending rate as the representative interest rate index.

4 RESEARCH METHOD

VAR model, or Vector Auto - Regressive model is not based on the economic theory, which directly consider the relationship between variables in time sequence. VAR model generalizes the univariate autoregressive model (AR model) by allowing for more than one evolving variable. All variables in a VAR enter the model in the same way: each variable has an equation explaining its evolution based on its own lagged values, the lagged values of the other model variables, and an error term.

$$Y_t = \alpha + \sum_1^p \beta_i Y_{t-i} + \varepsilon_t \quad (1)$$

Where $E(\varepsilon_t) = 0,\ E(\varepsilon_t, Y_{t-i}) = 0,\ i = 1,2,\dots,p.$

DCC-GARCHmodelassumes that the correlation coefficient between multiple variables is constantly changing with time, and the model can finally obtain the dynamic correlation coefficient, so as to describe the dynamic linkage and dependence degree between multiple variables.

$$r_t|\varphi_{t-1} \sim N(0, D_t R_t D_t) \quad (2)$$

$$D_t^2 = diag\{\omega_i\} + diag\{k_i\} o r_t r_{t-1}' + diag\{\lambda_i\} o D_{t-1}^2 (3)$$

$$\epsilon_{t-1} = D_t^{-1} r_t \quad (4)$$

$$Q_t = So(11' - A - B) + Ao\epsilon_{t-1}\epsilon_{t-1}' + BoQ_{t-1} (5)$$

$$R_t = diag\{Q_t^*\}^{-1} Q_t diag\{Q_t^*\}^{-1} \quad (6)$$

Where, r_t is the return sequence whose mean value is 0, φ_{t-1} is the set of all possible information at time $t-1$, D_t^2 is the diagonal elements of the diagonal matrix, D_t is the condition of single variable variance, S is the unconditional covariance matrix of standardized residual error ϵ, 1 is a column vector, R_t is the conditional correlation coefficient matrix, o represents the matrix of the same order corresponding to the product of elements, Q_t is the conditional covariance matrix of the standardized residual sequence, Q_t^* is the diagonal matrix, and the diagonal element is the square root of the diagonal element of Q_t.

5 EMPIRICAL RESULTS

A. Unit Root Testing

VAR model and DCC-GARCH model both require the sequence to be stable. Therefore, the unit root test is carried out for exchange rate and Shibor series. After testing, unit roots exist in both sequences. In order to meet the requirement of stability, the logarithm of the two series is taken, and then a differential treatment is carried out for the exchange rate series, which is recorded as de, and a differential treatment is carried out for the Shanghai interbank offered rate (Shibor), which is recorded as ds. After the test, the two sequences are stable.

B. Construction and Testing of VAR Model

Based on the $\Delta\ln(\text{exchange})$ and $\Delta\ln(\text{shibor})$ sequences obtained after the logarithmic difference, a 2D vector autoregressive model is constructed, and the lag order of VAR model is determined by the lag length standard in the lag structure. The results are shown in Table 1. There are two indexes (FPE, HQ) to determine the lag order of 3 as the optimal lag order, so the lag order is chosen as 3. There is no autocorrelation in the residual autocorrelation graph. The VaR (3) model is stable. The subsequent Johansen co integration test, Granger causality test and impulse response are all based on the stable var (3) model.

TABLE I. OPTIMAL LAG ORDER OF VAR MODEL

Lags	AIC(n)	HQ(n)	SC(n)	FPE(n)
Lag-1	-19.56415173	-19.56139826	-19.55647688	3.19E-09
Lag-2	-19.56934455	-19.56383761	-19.55399484	3.17E-09
Lag-3	-19.56960454	-19.56134413	-19.54657998	3.17E-09
Lag-4	-19.56787144	-19.55685756	-19.53717203	3.18E-09

C. Granger Causality Test

Granger causality test gives the statistics of Granger causality test for each endogenous variable relative to other endogenous variables of the model, and the p value corresponding to the test statistics is shown in Table 2. Through Granger causality test, it is concluded that the change of exchange rate is not Granger cause of interest rate change, nor is the change of interest rate Granger cause of exchange rate.

TABLE II. GRANGER CAUSALITY TEST RESULTS

Null Hypothesis	Statistics	Freedom	P	Result
$\Delta\ln(\text{exchange})$ isn′t the Granger Reason for $\Delta\ln(\text{shibor})$	0.08924	3	0.966	Not Reject
$\Delta\ln(\text{shibor})$ isn′t the Granger Reason for $\Delta\ln(\text{exchange})$	0.71823	3	0.541	Not Reject

D. Impulse Response Analysis

The impulse response function is used to analyze the impact of a standard deviation of random disturbance on the endogenous variables, that is, how to consider the influence of disturbance to each variable. As can be seen from the figure, Shibor will drop sharply in the short term after a shock to the exchange rate, but it will return to the previous level in the long term. After a shock to Shibor, the exchange rate will decline in the short term, that is, the appreciation of RMB, but in the long term, the exchange rate will gradually return to the previous level. This shows that the depreciation of RMB against the US dollar will lead to a negative expectation for the RMB investment, which will cause the investors' willingness to hold the RMB and the demand for the RMB to decline. But in the long run, the adverse effects will gradually disappear. When the interest rate increases, investors expect the government to adopt a tight monetary policy. In the short term, the capital inflow will cause the appreciation of RMB. In the long term, the influence will disappear due to the existence of arbitrage opportunities.

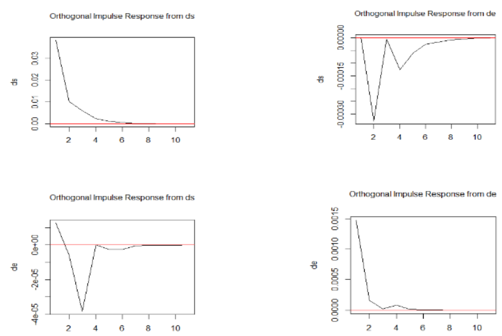

Figure 1. Impulse Response

E. Construct DCC-GARCH Model

The test of ARCH effect shows that there is obvious ARCH effect in the $\Delta\ln(\text{exchange})$ and $\Delta\ln(\text{shibor})$ sequences at the significant level of 1%. GARCH model can be used to measure the exchange rate and Shibor time series data used in this paper. The results are shown in Table 3.

TABLE III. ARCH TEST RESULTS

Null Hypothesis	Statistics	Freedom	P	Result
There is no ARCH effect for $\Delta\ln(\text{exchange})$	38.074	6	1.087e-06	Reject
There is no ARCH effect for $\Delta\ln(\text{shibor})$	760.11	6	2.2e-16	Reject

First, GARCH (1,1) model is used to estimate the two sequences of $\Delta\ln(\text{exchange})$ and $\Delta\ln(\text{shibor})$.Then, the standardized residual is obtained by removing the residual with the conditional variance obtained in the previous step. Finally, the dynamic parameters can be obtained by using the standardized residual. It can be seen that the two GARCH (1,1) models that there is no autocorrelation between the residual and residual square series, so it is reasonable to adopt GARCH (1,1) model. The value of $\alpha + \beta$ is close to 1, which indicates that the fluctuation of exchange rate and interest rate has significant persistence. The estimated results of dcc-garch model are shown in Table 4.

TABLE IV. ESTIMATION RESULTS OF DCC-GARCH MODEL

	Coefficient	Std.error	t-value	Prob.
[ds].mu	0.000516	0.000441	1.170691	0.241723
[ds].omega	0.000003	0.000004	0.885285	0.376003
[ds].alpha1	0.129662	0.034216	3.789507	0.000151
[ds].beta1	0.869338	0.039994	21.736579	0.000000
[de].mu	-0.000024	0.000013	-1.896757	0.057860
[de].omega	0.000000	0.000001	0.013592	0.989156
[de].alpha1	0.081983	0.040622	2.018161	0.043575
[de].beta1	0.909664	0.039085	23.273783	0.000000
[Joint]dcca1	0.000000	0.000004	0.003369	0.997312
[Joint]dccb1	0.900963	0.057758	15.598927	0.000000

The dynamic correlation coefficients between Shibor and exchange series are all negative, indicating that there is a negative impact between RMB exchange rate and Shibor, but the average correlation coefficient is only about - 0.027, indicating that the correlation between RMB exchange rate fluctuation and interest rate fluctuation is at a low level.

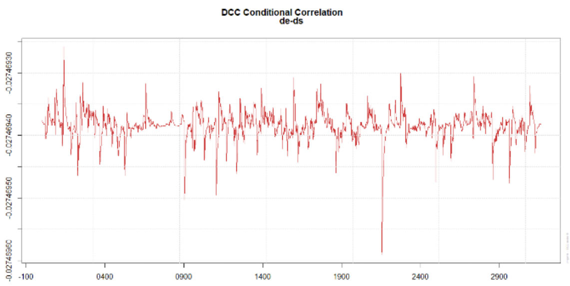

Figure 2. Dynamic Correlation

6 Conclusion

In this paper, VAR-DCC-GARCH model is used to analyze the dynamic relationship between RMB exchange rate and interest rate. Based on the theory of interest rate evaluation, the transmission mechanism and theoretical relationship between interest rate and exchange rate are deduced. In this paper, the daily data of Shibor and nominal exchange rate of Shanghai interbank offered rate from 2006 to 2019 are selected. After processing, the VAR model is established on the basis of stable time series data, and Granger causality test and impulse response analysis are carried out. Through empirical analysis, we can get the following conclusions from the VAR model. First, there is no Granger causality between exchange rate and interest rate. Second, changes in the exchange rate will affect the trend of interest rates in the short term, but in the long term, interest rates will return to a stable state. Similarly, the change of interest rate will also affect the exchange rate in the short term, and in the long term, the exchange rate will return to a stable state.

Through the establishment of DCC-GARCH model, there is a negative correlation between exchange rate volatility and interest rate volatility, but the correlation is low. Considering that China's current exchange rate system is still a fixed exchange rate system in essence, and there are non-market factors in the determination of exchange rate, the fitting results better explain this economic phenomenon. However, with the continuous promotion of exchange rate marketization, the correlation between exchange rate and interest rate is gradually strengthened. With the increasing flexibility of exchange rate, the volatility of interest rate is gradually weakened.

REFERENCES

[1] Frankel, Jeffrey A. On the Renminbi: The Choice Between Adjustment under a Fixed Exchange Rate and Adjustment under a Flexible Rate[J]. SSRN Electronic Journal, 2004.

[2] Mundell R A. The Monetary Dynamics of International Adjustment under Fixed and Flexible Exchange Rates[J]. The Quarterly Journal of Economics, 1960, 74(2):227-257.

[3] Nagayasu M D. The Long-Run Relationship between Real Exchange Rates and Real Interest Rate Differentials: A Panel Study[J]. IMF Economic Review, 2000, 47(1):116-128.

[4] So R W. Price and volatility spillovers between interest rate and exchange value of the US dollar[J]. Global Finance Journal, 2001, 12(1):95-107.

[5] Jyh-lin Wu, Show-Lin Chen. Mean Reversion of Interest Rates in the Eurocurrency Market[J]. Oxford Bulletin of Economics & Statistics, 2001, 63(4):459-473.

[6] Yi Gang, fan min. determinants and trend analysis of RMB exchange rate [J]. Economic research, 1997 (10): 26-35

[7] Jiang Zhiping. Dynamic correlation between RMB interest rate and exchange rate: a study based on DCC model [J]. Soft science, 2008 (07): 11-14 + 29

[8] Zhao Hua. Study on price and volatility spillover effect between RMB exchange rate and interest rate [J]. Financial research, 2007 (03)

[9] Shen guobing. On the relationship between exchange rate and interest rate: a case study of Thailand from 1993 to 2000 [J]. World economy, 2002 (5)