

Empirical Study on Volatility of RMB against US Dollar Based on ARCH Family Model

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Abstract: Based on the daily data of the central parity of the RMB against the US dollar from August 2015 to March 2017, this paper uses the ARCH model as the main research tool and through corresponding tests to establish the ARCH model of the yield rate of the exchange rate of RMB against the US dollar, thereby studying its volatility. The empirical analysis shows that the fluctuation of the RMB exchange rate does not obey the normal distribution, and the RMB exchange rate bears the significant characteristics of a sharp peak and a thick tail. In addition, through the establishment of the EGARCH model, this paper concludes that there is a certain leverage effect on the yield rate of the exchange rate of RMB against the US dollar, that is, the impact of bull news on the RMB exchange rate will be greater than the bear news. At the same time, this paper also finds that the relationship between the yield rate of the exchange rate of RMB against the US dollar and its lagging terms is not significant, which shows that the exchange rate of RMB against the US dollar is not only effective for the market, but also has a certain degree for the effectiveness of China's exchange rate reform.

1. Introduction

In recent years, China's economy has developed rapidly and received increasing attention from the international community. It's well known that foreign exchange is a link connecting the economies of various countries. Therefore, the RMB exchange rate has also received increasing attention from people of all countries. The exchange rate, as an important part of the price system, will affect the relative price of the country's import and export commodities, which in turn will exert important impact on the country's foreign trade. Therefore, studying the volatility of the RMB exchange rate is of great significance to the economic development of various countries.

2. The Establishment of the Volatility Mean Model of RMB Against the US Dollar

This paper makes an analysis of 405 data from the daily data of the central parity of the RMB against the US dollar from August 3, 2015 to March 31, 2017 and the daily exchange rate of the central parity of the RMB against the US dollar is expressed by XX. In order to improve the accuracy of the calculation, the logarithmic yield rate is multiplied by 100 so as to obtain the logarithmic yield rate of RMB against the US dollar. The specific formula can be expressed as:

$$\ln L = 100 \cdot (\ln p_t - \ln p_{t-1})$$

Fluctuations of the yield rate will change over time and demonstrate heteroscedasticity with "fluctuating clusters". In addition, there may be an ARCH effect, which can be shown in Figure 1^[1].

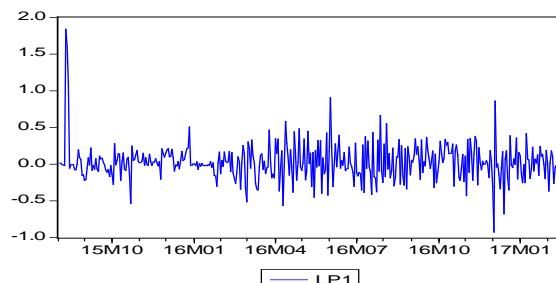


Fig 1 The time series of the yield rate of the exchange rate of RMB against the US dollar

Using the unit root method to test the stability of the logarithmic yield rate of the exchange rate of the US dollar against RMB, it's found that the yield rate series of the exchange rate all show stationary characteristics. In addition, the autocorrelation and partial autocorrelation of the sequence were inspected with the results showing in Figure 2.

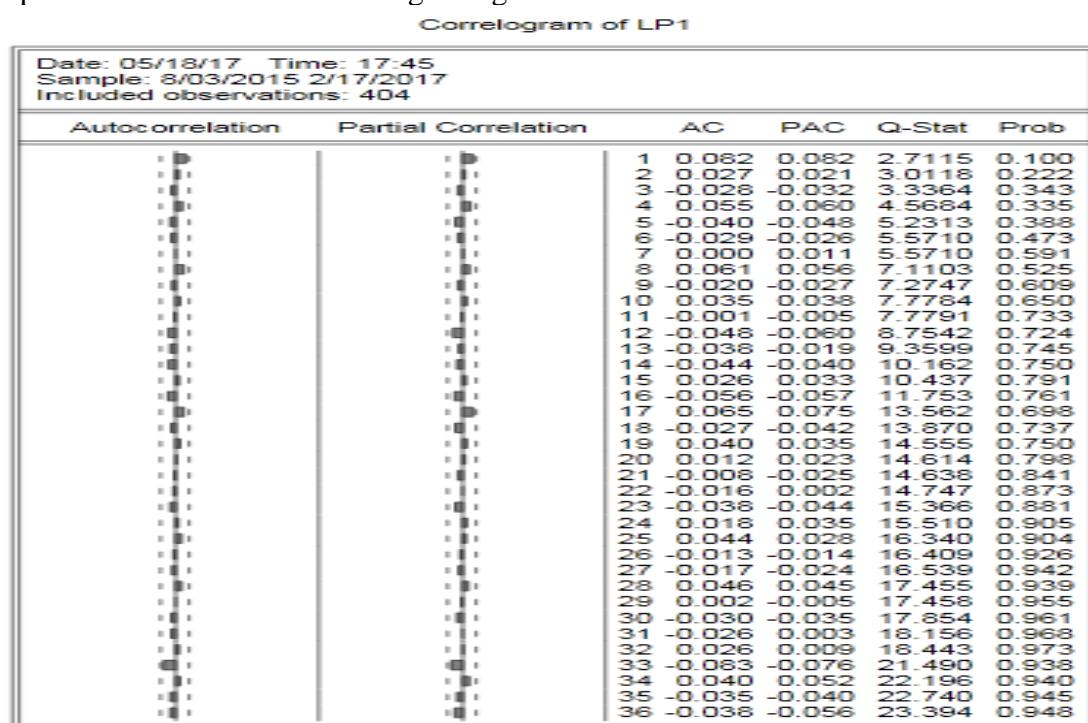


Fig 2 Autocorrelation and partial autocorrelation of RMB against US dollar

By comparing the data like AIC and BIC, maximum likelihood value and the goodness of fit, the mean model of ARMA (1, 1) was finally selected, as shown in Table 1.

Table 1 Parameter estimation and test results of ARMA(1,1) model of sequence

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(1)	0.406591	0.436779	0.930885	0.3525
MA(1)	-0.316001	0.453550	-0.696727	0.4864
R-squared	-0.004265	Mean dependent var	0.029835	
Adjusted R-squared	-0.006770	S.D. dependent var	0.251154	
S.E. of regression	0.252003	Akaike info criterion	0.086195	
Sum squared resid	25.46562	Schwarz criterion	0.106041	
Log likelihood	-15.36836	Durbin-Watson stat	1.998213	
Inverted AR Roots	.41			
Inverted MA Roots	.32			

$$r_t = 0.406591 r_{t-1} + \varepsilon_t - 0.316001 \varepsilon_{t-1}$$

In the following step, an ARCH-LM test is performed on the residual term of the mean model to investigate whether there is an ARCH effect^[2].

Table 2 The mean model of the exchange rate of RMB against the US dollar ARCH-LM test

ARCH Test:

F-statistic	54.94136	Probability	0.000000
Obs*R-squared	86.75817	Probability	0.000000

The test results in Table 2 show that there is a significant correlation between the residual sequence in the model of the yield rate series of the exchange rate of RMB against the US dollar, that is, the ARCH effect exists. In order to eliminate the ARCH effect, it is necessary to establish the ARCH model to study the volatility of the yield rate of the exchange rate of RMB against the US dollar.

3. The Establishment of ARCH Family Model of Volatility of RMB Against US Dollar Exchange Rate

In order to eliminate heteroscedasticity, the ARCH model was introduced. After comparing various test indicators, it's found that the second-order ARCH model can be used to eliminate the ARCH effect^[3]. Therefore, as for the selection of the logarithmic yield rate series, the ARCH(2) model is adopted. Based on the above mentioned analysis, the estimated results of the ARMA(1,1)-ARCH(2) model are:

Table 3 ARCH(2) model parameter estimation and test results

	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	0.860341	0.046950	18.32469	0.0000
MA(1)	-0.890276	0.032366	-27.50615	0.0000
Variance Equation				
C	0.025760	0.003223	7.992742	0.0000
RESID(-1)^2	0.430137	0.095980	4.481534	0.0000
RESID(-2)^2	0.224590	0.065527	3.427430	0.0006
R-squared	0.031482	Mean dependent var	0.029835	
Adjusted R-squared	0.021748	S.D. dependent var	0.251154	
S.E. of regression	0.248408	Akaike info criterion	-0.138772	
Sum squared resid	24.55917	Schwarz criterion	-0.089158	
Log likelihood	32.96262	Durbin-Watson stat	1.843232	
Inverted AR Roots	.86			
Inverted MA Roots	.89			

The resulting equation is:

$$r_t = 0.860341r_{t-1} - 0.890276\epsilon_{t-1} + \epsilon_t$$

$$\epsilon_t^2 = 0.025760 + 0.430137\epsilon_{t-1}^2 + 0.224590\epsilon_{t-2}^2$$

Next, the ARCH-LM test is to test the ARCH effect on the residual difference and the square sequence of the residual difference using the ARCH-LM test method, as shown in Table 4. The results show that there is no ARCH effect in the sequence, and the ARCH effect of the square sequence of the residual difference has also been eliminated. Therefore, the results prove that the established ARCH model is suitable^[4].

Table 4 The results of ARCH-LM effect test of ARCH (2) model

ARCH Test:

F-statistic	0.410177	Probability	0.522247
Obs*R-squared	0.411805	Probability	0.521055

Taking consideration of the fact there does have information asymmetry and leverage effect in the fact of the exchange rate of the RMB against the US dollar. Moreover, in view of the impact of the RMB against the US dollar, the bear news will be greater than the bull news and investors will be more sensitive to bull news, which is consistent with the leverage effect usually found in the

exchange rate market^[5]. Therefore, the EGARCH model of the yield rate series of the exchange rate of the US dollar against RMB was carried out. After making analysis and comparison, the EGARCH (1,1) model was finally established, as shown in Table 5.

Table 5 Parameter estimation and test results of EGARCH (1,1) model

	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	0.832002	0.051964	16.01127	0.0000
MA(1)	-0.852280	0.039067	-21.81612	0.0000
Variance Equation				
C(3)	-0.690229	0.097952	-7.046591	0.0000
C(4)	0.511037	0.059977	8.520576	0.0000
C(5)	-0.197545	0.038029	-5.194537	0.0000
C(6)	0.901431	0.024513	36.77379	0.0000
R-squared	0.024849	Mean dependent var	0.029835	
Adjusted R-squared	0.012568	S.D. dependent var	0.251154	
S.E. of regression	0.249571	Akaike info criterion	-0.267259	
Sum squared resid	24.72735	Schwarz criterion	-0.207721	
Log likelihood	59.85267	Durbin-Watson stat	1.848923	
Inverted AR Roots	.83			
Inverted MA Roots	.85			

That is, the model of the rate of return sequence of the RMB exchange rate against the US dollar is as follows:

$$r_t = 0.832002r_{t-1} + \varepsilon_t - 0.852280\varepsilon_{t-1}$$

$$\ln \sigma_t^2 = -0.690229 + 0.511037 \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} - E\left(\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right) \right| - 0.197545 \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + 0.901431 \ln \sigma_{t-1}^2$$

The sum of the coefficients obtained through the model is 0.524894, which is less than 1, indicating that the exchange rate market has continuous fluctuations. In addition, the results of the ARCH effect test on the residual (see Table 6) show that the p value is 0.382627, which is more than 0.05, so the residual does not have the ARCH effect. Since the coefficient of the asymmetric term is 0.511037, which is greater than 0, indicating that the message of the current market "bull news" is more influential than the "bear news", and illustrating that the role of the information is asymmetrical. Therefore, the "leverage effect" of the yield rate of the exchange rate of RMB against the US dollar in the current financial market is not significant.

Table 6 The ARCH effect test of EGARCH (1,1) model residual error

ARCH Test:

F-statistic	0.958098	Probability	0.384505
Obs*R-squared	1.921389	Probability	0.382627

4. Conclusion

This paper analyzes the volatility of the yield rate of the exchange rate of RMB against the US dollar and draws the following conclusions:

First, it can be seen from the description of the sample data of the yield rate of the exchange rate that the yield rate series of RMB against the US dollar shows the significant phenomenon of a sharp peak and a thick tail. The yield rate sequence of the exchange rate of RMB against the US dollar shows the significant characteristics of a sharp peak and a thick tail and the residual sequence of the yield rate has heteroscedasticity.

Second, in the EGARCH (1,1) conditional variance equation estimation of the yield rate series of the exchange rate of RMB against the US dollar, each parameter is significantly less than 0, which also indicates that the RMB exchange rate does have information asymmetry, that is, leverage effect. The bear news of the impact of the RMB exchange rate is greater than the bull news, and investors are

more sensitive to bear news than bull news.

Third, in the autocorrelation test of the yield rate series of the exchange rate of RMB against the US dollar, it is found that the relationship between the exchange rate of RMB against the US dollar and its lagging terms is not significant, which indicates that the exchange rate market of RMB against the US dollar is not only effective for the market, but also has a certain degree for the effectiveness of China's exchange rate reform.

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