

Exchange Rate Volatility Research of Pound Sterling

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Abstract:

This paper researched the volatility of foreign exchange rate through ARCH model and GARCH model, especially GARCH extensions. In order to research volatility in foreign exchange, the time series of GBPUSD would be as the main research target. Based on characterizes of exchange rate, this paper summarized the research progress and updated problems of volatility of exchange rate and global forecasting methods. Similarly, based on the econometric theory, this paper compared ARCH model with GARCH model and GARCH extensions (including EGARCH and TGARCH model). This paper adopted exchange rate data, which is daily data from 01/01/1990 to 20/06/2018. Sample data including 7428 observations, which is used to analyze the performance of exchange rate prediction of Great Britain Pounds. The ARCH model, GARCH model and its extension models apply to time series of GBPUSD from January 1990 to June 2018. The ARCH model and its extension models are usually used to describe the fluctuations of GBP exchange rate. Therefore, this paper explains methods and main criteria for selecting the optimal model. The results suggest time series of foreign exchange rate return of GBPUSD or GBPJPY does not have leverage effect. In the sum, the GARCH model could describe the exchange rate volatility of Pound Sterling.

Keywords:

Pound Sterling, ARCH Model, Serial Correlation, Volatility Clustering, Stationarity, GARCH Model, Extensions of GARCH Model

1. Introduction

1.1. Research topic and question review

Volatility in foreign exchanges among different countries are not only detrimental to the stability of one country's economic policies, but also affects the stability of a country's financial system [1]. Because the more stable exchange rate is, the more stable capital flows and the more secure financial system will be. Otherwise, if there is a volatility happens, the financial system will become vulnerable, such as the banking crisis in Argentina in 1980 and the financial crisis in Chile in 1981. Therefore,

it is of great importance to study currency fluctuations and to predict the exchange rate in both theoretical and practical aspects [2].

1.2. Research hypotheses and objectives

In this paper, the theoretical and empirical analysis method are used. In terms of models, ARCH model, unlike other standard deviation models, it does not use the sample standard deviation (whose assume is not the normal distribution of the return rate of financial assets) [3]. By using the maximum likelihood principle, the ARCH model constructs the conditional variance of an asset's yield as h^2 , this fitting the gathering of the financial asset volatility's features. This paper reviewed the research progress of both the domestic and the foreign currency fluctuations, as well as the forecast method. Moreover, we also carried out model selection and prediction ability comparison according to the characteristics of the cluster of exchange rate fluctuations. The objectives of this research are to help us understand the volatility of the exchange rate, and enable us to make forecasts of an effective exchange rate.

2. Literature Review

The traditional econometrics model assumed the variance of the sample is fixed and constant. However, it is not reasonable with the financial theory developing [4]. Empirical research suggests there are volatility clustering and fat-tail distribution characterizes. In order to describe the characterizes of asset return especially in the volatility accumulation and fat-tail distribution term better, Engle (1982) pointed out the ARCH model, which provided the framework to volatility model. Bollerslev (1986) presented the GARCH model can overcome the drawbacks of the ARCH model. GACRH Model, autoregressive conditional heteroscedasticity is appropriate to interpret and describe the characteristics of dependence in conditional variance and variance of error item. In the financial studies, volatility represented for the conditional variance of asset return [5]. It cannot be observed directly but there are some similar characteristics in the asset return rate. The first characteristic is fat tail and excess kurtosis. Compared it with the normal distribution, the distribution of the time series of the asset return has the fat tail and the sharp kurtosis. It suggests a large number of extreme values, which are different from the average return, occurs. The second is clustering [6]. The higher volatility is after the enormously volatile and the slightly volatile may happen after the week volatility [7]. In general, there is volatility clustering derived from the external impact and this factor has persistent affection. The third is leverage effect. It is also called the asymmetry, which points out that the affection of variation of the price is the asymmetric [8]. The bad news affects the volatility more than the good news. The fourth one is long-term memory. The time series of yield rate presents the periodic phenomenon characterizes. The last is overflow effect [9]. The financial asset price is not only affected by the historical volatility, but also it is restricted by other markets. This phenomenon is defined as the "Overflow effect" [10]. Bollerslev (1986) presented the extension of the ARCH model based on the previous model. It is the extension of the ARCH Model. This resolved the problem result from the fixed variance hypothesis. However, some issues ARCH and GARCH model did not resolve. The GARCH model cannot describe the asymmetry of the volatility of the conditional variance.

3. Data Description

In order to estimate the FX volatility, collect financial data in the foreign exchange market. The data mainly includes the FX daily price and the date, daily values of the currency pair GBPUSD to estimate the return from 01/01/1990 to present 06/20/2018. The daily data of GBPJPY is also collected and we analyze using EVIEWS 10. The period of data of GBPJPY is same as the GBPUSD. Price data is based on the daily closing price. After squared the time series of foreign exchange rate return of GBP against USD, time series has the mean return 0.00000858. The maximum or minimum means the peak value or lowest value of the time series. They are 0.014358 and 0.000000 while the value of skewness and Kurtosis is positive and high.

4. Empirical Analysis

The data of this empirical analysis part is GBPUSD daily closing price from 01/1990 to 06/2018. This paper used the indirect quotation approach in this part.

4.1. Statistical description of data

The standard deviation is 0.002574, which suggests the low volatility presents in the analysis. Skewness is negative, -0.593862, which suggests time series of foreign exchange rate return of GBPUSD has asymmetric distribution of skewness (negative skewness). The value of kurtosis is not low because it is extremely greater than three, 11.04291, which explains the time series does not have the low kurtosis. According to the test value of Jarque-Bera, p value is less than 0.001 so it is significant to reject the null hypothesis (normal distribution). This is one of the phenomena of volatility clustering. In the time series of exchange rate return of GBPJPY, the standard deviation is 0.003437, which is greater than GBPUSD. Skewness is also negative, -0.805915, which suggests time series of GBPJPY has negative skewness. However, the kurtosis is higher than GBPUSD because of its excess value, 15.38252, which explains the time series have the high kurtosis. Similarly, p value is zero according to the test value of Jarque-Bera. Therefore, the time series is not the normal distribution.

4.2. Stationarity test

Test the stability of exchange rate return time series of GBPUSD during the period of observations. Firstly, observe the correlogram of GBPUSD from the chart drew by Eviews. The statistics of ACF are around zero and the PACF has similar phenomenon. It suggests that the time series of exchange rate return of GBPUSD is stable. However, it is only the preliminary step to judge whether the financial time series is stable or not and sometimes, it is not accurate. Therefore, the Dickey-Fuller (ADF) test can overcome this drawback and judge the stationarity precisely. After check the correlogram of squared return time series, the result shows that the time series is stationary. By contrast, the value of ACF and PACF in correlogram of GBPJPY from the chart drew by Eviews are close to zero too. It suggests three time series (absolute return, squared return, absolute return in GBPJPY) are stationary. At next step, estimate ADF test through EVIEWS 10.

4.3. Dickey-Fuller(ADF) test

According to the result of Dickey-Fuller test, the critical values of ADF test of exchange rate return GBPUSD time series are greater than the statistic value of 1% level, which is -2.565273. It could reject the null hypothesis "time series of exchange

rate return during the period of observations is not stationary". The reason why this paper will run this test is to ensure the financial time series stable. The critical values of ADF test in GBPJPY exchange rate return time series are greater than the statistic value of 1% level, which is -3.431053. It means there is not unit root in the series.

4.4. LM test

The result of probability in GBPSUD is 0.2508, which means that it failed reject the null hypothesis. In other words, there is not autocorrelation. However, this paper still needs to test the squared return of GBPUUSD to check whether there is the serial correlation effect or not. According to the LM test of squared return time series and the test of GBPJPY daily return, there is not the serial correlation in the time series of absolute exchange rate return of GBPJPY.

4.5. ARCH model

It indicated there are heteroscedasticity in the residuals Table 1. At this stage, this paper built the ARCH model due to the heteroscedasticity in time series, which suggests there is a clustering in the fluctuation of the change rate of returns. Through many attempts of different lag terms, it suggests that when $p=5$, ARCH model can fit the time series best. For ARCH (5), the AIC value is -9.19008 with the probability less than 0.05. Therefore ARCH (5) model can appropriately describe the volatility in the time series of exchange rate return of GBPUUSD. Similarly, build the ARCH model of exchange rate return of GBPJPY Table 2.

Table 1. Heteroscedasticity test: ARCH.

	GBPUUSD	GBPJPY
F-statistic	57.4628	71.2989
Obs.R-squared	277.2089	340.4187
Prob. F(2,7424)	0.0000	0.0000
Chi-Square(5)	0.0000	0.0000

Table 2. ARCH result.

	Coefficient		Std. Error		Z-Statistic		prob.	
variable	GBPUUSD	GBPJPY	GBPUUSD	GBPJPY	GBPUUSD	GBPJPY	GBPUUSD	GBPJPY
	3.53E-06	5.39E-06	8.61E-08	1.22E-07	40.99162	44.25959	0.0000	0.0000
1	0.110778	0.144671	0.011075	0.007947	10.00260	18.20474	0.0000	0.0000
2	0.090916	0.103816	0.010041	0.010848	9.054660	9.569970	0.0000	0.0000
3	0.049182	0.068513	0.008144	0.010439	6.038843	6.562895	0.0000	0.0000
4	0.108570	0.107671	0.006294	0.010748	17.24875	10.01790	0.0000	0.0000
5	0.104186	0.119276	0.011954	0.008938	8.715771	13.34463	0.0000	0.0000

The results suggest the ARCH model removed the heteroscedasticity because the probability is 0.2532 and 0.6649 separately Table 3.

Table 3. ARCH LM test.

	GBPUUSD	GBPJPY
F-statistic	1.317683	0.187649
Obs.R-squared	6.587890	0.187694
Prob. F(2,7424)	0.2532	0.6649
Chi-Square(1)	0.2531	0.6648

4.6. GARCH model

The best GARCH model for each time series is the minimum value of AIC. In the chart below, the lowest value in GBPUSD is -9.247337, which indicates the best GARCH model in this case is GARCH (ARCH=2, GARCH=4). Similarly, this experiment found the best GARCH model (ARCH=4, GARCH=4) for GBPJPY time series because the lowest Akaike info criterion is - 8.717459 Table 4.

Table 4. AIC value of each GARCH.

GARCH (p, q) GBPUSD	1	2	3	4
1	-9.245263	-9.245312	-9.245069	-9.245891
2	-9.245165	-9.245050	-9.246967	-9.247004
3	-9.246772	-9.246712	-9.246450	-9.246404
4	-9.246700	-9.247337	-9.247073	-9.247086
GARCH (p, q) GBPJPY	1	2	3	4
1	-8.710566	-8.713088	-8.713669	-8.713486
2	-8.711461	-8.715082	-8.713613	-8.713353
3	-8.713062	-8.713209	-8.713388	-8.713634
4	-8.713013	-8.716068	-8.716232	-8.717459

The result of the GARCH model and GARCH showed below. In general, if the sum value of coefficients is less than one, the reduction of volatility will be slow and persistent when it is close to one. On the other hand, if the sum value is greater than one, it will suggest the system can amplify the previous volatility. Usually, their sum value suggests the external factors can affect the volatility and the value of ARCH coefficients are less than that of GARCH coefficients. In the case of GARCH (2, 4) model, their sum of value is equal to 0.975528, which is extremely close to one. Therefore, it suggests that the impact is persistent and it is significant to the prediction in the long-term period. In comparison, sum value of coefficients in GBPJPY exchange rate return time series is less than one. In this case, GARCH (4, 4) model, their sum of value is equal to 0.949, which is close to one. Therefore, it suggests that the impact is persistent. In order to make sure the GARCH model is appropriate to describe the volatility, carry out ARCH LM test. The results suggest the GARCH model removed the heteroscedasticity because the probability is 0.9503 and 0.3094 separately Table 5.

Table 5. GARCH result.

	Coefficient		Std. Error		Z-Statistic		prob.	
variable	GBPUSD	GBPJPY	GBPUSD	GBPJPY	GBPUSD	GBPJPY	GBPUSD	GBPJPY
	1.70E-07	9.01E-09	2.75E-08	2.06E-09	6.189993	3.458534	0.0000	0.0005
1	0.069129	0.093909	0.005988	0.004079	11.54427	23.02320	0.0000	0.0000
2	0.086705	6.27E-05	0.003354	0.004131	25.85008	0.015178	0.0000	0.9879
3	-	-0.019437	-	0.004106	-	-4.734095	-	0.0000
4	-	-0.068762	-	0.005743	-	-11.97374	-	0.0000
1	-0.537485	0.757376	0.063899	0.016472	-8.411514	45.98096	0.0000	0.0000
2	0.399324	0.185968	0.070114	0.009084	5.695336	20.47298	0.0000	0.0000
3	0.526586	0.869162	0.055475	0.008645	9.492291	100.5396	0.0000	0.0000
4	0.431269	-0.818977	0.077318	0.012955	5.577844	-63.21727	0.0000	0.0000
+	0.975528	0.9491167	-	-	-	-	-	-

The results suggest the GARCH model removed the heteroscedasticity because the probability is 0.9503 and 0.3094 separately Table 6.

Table 6. ARCH LM test.

	GBPUSD	GBPJPY
F-statistic	0.003888	1.033207
Obs.R-squared	0.003889	1.033342
Prob. F(2,7424)	0.9503	0.3094
Chi-Square (1)	0.9503	0.3094

4.7. TGARCH model

In order to check whether the time series have asymmetric property, build the TGARCH model. The best TGARCH model is minimum value of AIC. Therefore, according to the statistics, TGARCH (4, 4) is the best model in GBPUSD and GBPJPY time series. In the time series of GBPUSD, the result shows leverage effect variable is positive: 0.013271 but the probability is greater than 0.05 so that there is not leverage effect. Compared with GBPJPY, variable is positive and the probability is less than 0.05 so the leverage effect exists in this time series. The results suggest the TGARCH model removed the heteroscedasticity because the probability is 0.6299 and 0.8924 separately.

4.8. EGARCH Model

After many attempts, the best model is EGARCH (ARCH 4, GARCH 1) in GBPSUD time series because of minimum value of AIC -9.242867. Similarly, the best model for GBPJPY time series is EGARCH (ARCH 3, GARCH 1) and the minimum value of AIC is equal to - 8.716164. In the EGARCH model, the asymmetric coefficient is -0.002668 which is less than zero but the possibility is greater than 0.05. It means it is not significant so that there is not leverage effect in the time series of GBPUSD. In this paper, owing to the indirect quotation of GBP, the good news is appreciation of GBP and the depreciation of GBP is bad news. The asymmetric coefficient of GBPJPY is -0.030172, which is less than zero but the possibility is less than 0.05. It means it is significant so that there is leverage effect in the time series of GBPJPY. The impact of good news and bad news on the market is asymmetric. Similarly, the results of ARCH LM test suggest the EGARCH model removed the heteroscedasticity because the probability is 0.2806 and 0.4950 respectively.

4.9. Prediction

After forecast these models, although RMSE of four models are same which are 0.002575, the GARCH model is the best model among these models because the value of AIC is minimum in the GBPUSD time series. RMSE values in GBPJPY of four types of models presents they all have same values 0.003438. Therefore, there is not asymmetric effect in the time series of GBPJPY exchange rate return.

4.10. Conclusion

After check the value of AIC in the ARCH, GARCH, TGARCH, EGARCH, the optimal model of time series of exchange rate return of GBPUSD is GARCH (2, 4) model. GARCH model is the best model to describe the volatility of GBPJPY because AIC value of GARCH (4, 4) model is -8.717459 which is minimum among these models Table 7.

Table 7. Value of AIC and MSE.

Model	AIC	RMSE
GBPUSD		
ARCH(5)	-9.190080	0.002575
GARCH(2,4)	-9.247337	0.002575
TGARCH(4,4)	-9.246947	0.002575
EGARCH(4,1)	-9.242867	0.002575
GBPJPY		
ARCH(5)	-8.666484	0.003438
GARCH(4,4)	-8.717459	0.003438
TGARCH(4,4)	-8.716870	0.003438
EGARCH(3,1)	-8.716164	0.003438

5. Conclusions

This paper is based on the daily data, compared GBPUSD with GBPJPY to present the empirical analysis. Through the stationary test, time series of exchange rate return of GBPUSD is stable. According to the test of GBPJPY, the same result suggests that the time series of exchange rate return GBPJPY is stationary. In addition, this is the precondition to estimate ARCH model. Time series of exchange rate return of GBPUSD does not have the leverage effect. The EGARCH model and TGARCH model is not significant from the statistics. Therefore, the GRCH (2, 4) is best to describe the volatility. Due to same reason, there is not leverage effect in time series of foreign exchange rate return of GBPJPY, the GARCH (4, 4) is best to describe the volatility. This also suggests that there is not asymmetric effect in the time series of GBPJPY exchange rate return. Exchange rate return of Great Britain Pounds suggests the characteristics of volatility persistence. In the result of GARCH model, the sum value of ARCH coefficients and GARCH coefficients is close to one, which means the time series of GBP has strong persistence impact. Therefore, the impact is difficult to vanish in the short-term when the strong fluctuate happen.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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