

The Volatility and Correlation between the Exchange Rate of British Pound and Euro: Based on the Comparison before and after Brexit

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Abstract: After becoming the first country in history to leave the EU, the UK went through a transition period of 11 months, which ended on December 31, 2020. At this point, the process of the UK's exit from the EU comes to an end, and it is also the starting point of the future relationship between the UK and the EU. This paper focuses on the changes generated in the sterling exchange rate and the euro exchange rate before and after the UK's formal exit from the EU, so as to detect the changes in the volatility and correlation between the sterling exchange rate market and the euro exchange rate market. By selecting exchange rate data from the RESSET database, this paper uses the GARCH family model as well as the VAR model to compare the degree of volatility and correlation between the British and European exchange rate markets before and after Brexit, and analyze the changes in the return on the pound exchange rate and the return on the euro exchange rate before and after Brexit, as well as the correlation between the exchange rate fluctuations of the two exchange rate markets. Through theoretical and empirical analysis, the main findings and conclusions of this paper are that after the formal exit from the EU, the volatility of both the pound exchange rate and the euro exchange rate are strengthening, and the effectiveness of the exchange rate market is reduced. After the empirical study, the price volatility spillover effect of the sterling exchange rate market is obvious and it takes longer to recover from the shock of the UK's exit from the EU; while the euro market is subject to shorter shocks relative to the sterling market, and the correlation between the sterling exchange rate and the euro exchange rate also decreases with the UK's formal exit from the EU.

1 INTRODUCTION

There are many scholars who have conducted studies on exchange rate markets and Brexit. In the process of research on international exchange rate markets, Kim (Kim 2006) conducted an empirical analysis by selecting daily return data between the euro and major foreign currencies (Kim, et al, 2006), and the experimental results showed that the correlation between the euro and the US dollar increased and the correlation with the yen and the Australian dollar volatility decreased. Later some scholars continued to expand the research object, Bunda (Bunda 2009) studied 11 years of exchange rate market index data of 18 emerging markets and analyzed by GARCH family model (Bunda, et al, 2009), and the results showed that emerging markets are similar to developed countries, there is a linkage between exchange rate returns. After the financial crisis in

2008 and the European debt crisis in 2010, the study of the impact of major contingencies on the volatility between markets has gradually been included in the vision of scholars. Among the more common studies on yields, Kollias (Kollias 2011) uses yield pricing models, among others, to observe whether major events cause significant positive or negative fluctuations in market prices (Kollias et al, 2011), and Essaddam (Essaddam 2014) uses a GARCH model to portray the impact of major shocks on yield volatility (Essaddam, et al, 2014). In terms of targeting exchange rate movements, Christiansen (Christiansen 2010) provides an in-depth analysis of the volatility and time-variability between the euro and other currencies, and the study finds time-varying characteristics between the euro exchange rate and the exchange rates of other national currencies (Christiansen 2012). In studying the interaction between the sterling exchange rate and the euro exchange rate, Favero et al. (2012) developed a non-

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linear GVAR model and the results of the study showed that the market spread between the euro and sterling exchange rates are interdependent variables (Favero 2012). By comparing the volatility between the exchange rate of the British pound and the exchange rates of the UK's major trading partners before and after Brexit, Qiong Zhao (2019) shows that the UK's exit from the EU leads to weaker linkages between the UK market and the European exchange rate market (Zhao, et al, 2019). Wang Lu (2020) investigates the entire process of abnormal exchange rate fluctuations during the referendum period using a time series outlier diagnostic algorithm and finds that all major exchange rates are significantly affected (Wang, et al, 2019).

However, most of the current literature focuses on a comprehensive analysis of the exchange rates of several major world currencies, lacking a separate study between the euro and the pound, two types of European currencies, so there is still some room for research in the analysis of the impact of the UK's exit from the EU. This paper, on the basis of the earlier scholars' research, analyzes the impact of the UK's exit from the EU on the European monetary system, separately analyzes the changes in volatility and correlation between the exchange rates of the British pound and the euro, and explores the impact of the volatility caused by the UK's exit from the EU on the exchange rates of the British pound and the euro from the price spillover effect and the volatility spillover effect.

In the research process, this paper decided to adopt an empirical research method. By using the data of the British pound exchange rate and the euro exchange rate before and after the formal exit of the UK from the European Union, this paper builds a VAR model and a GARCH model to analyze the log returns of the exchange rate and investigate the price spillover effect and the volatility spillover effect on the British pound exchange rate and the euro exchange rate, respectively.

2 CHARACTERISTICS OF EXCHANGE RATE MARKET VOLATILITY

2.1 Pound Sterling Exchange Rate Market

The pound exchange rate fell continuously after the UK began preparations for a formal exit from the EU. Over the following three long years of Brexit negotiations, the pound exchange rate moved differently with each Brexit proposal. By January

2020, the UK was in the critical phase of its imminent formal exit from the EU and caught up in a sudden new crown epidemic. The dual pressures have had a significant impact on the sterling exchange rate market and indeed European currency markets. However, in late 2020, new economic stimulus policies were introduced in the Eurozone and the UK, combined with the successful development and application of several new crown vaccines, which mitigated the impact of the new crown epidemic and allowed the UK to avoid a disorderly exit from the EU to the greatest extent possible. In turn, at the end of 2020, after the UK and Europe in reaching a trade agreement, the pound against the dollar trend has entered the upward channel. And given that the pound is severely undervalued against the dollar, with Brexit officially in place, the pound will have far more upside against the dollar than the euro against the dollar in 2021.

2.2 Euro Exchange Rate Market

A look at the changes in the euro's movement over the last six years reveals a strong correlation between changes in the euro exchange rate and EU policy. Between mid and late 2014, the European Central Bank lowered its benchmark interest rate twice in line with the Fed's movements and the euro depreciated by 10% relative to the dollar. The European Central Bank announced another impending quantitative easing in January 2015, and the euro continued to dive against the dollar between the policy announcement and its implementation, with the shock in the euro exchange rate exacerbated by the events of the 2016 Brexit referendum in the period thereafter. Given the large impact of the epidemic on the eurozone economy, the ECB continued to implement a more accommodative monetary policy, with interest rates and asset returns remaining largely low. The euro exchange rate saw an appreciative move in April 2020 as we entered 2020, i.e. after the formal signing of the Brexit agreement between the UK and the EU.

3 CORRELATION ANALYSIS OF THE BRITISH POUND AND THE EURO

3.1 Price Spillover Effects

Price spillovers i.e. due to the existence of liquidity and transmission of funds and information and consumer information in the market itself, yields are affected not only by their own prior period yields but also by the current and prior period yields of other

assets. For example, the spread between the yield on 10-year gilts and the yields on other countries' bonds or US Treasury bills over the same period, 3-month European sterling deposits, i.e. sterling deposits placed with non-UK banks, and UK equities all have varying degrees of influence on the sterling exchange rate. Where the yield on the Euro exchange rate can also have a crossover effect on the Pound exchange rate. As the UK was also a member of the EU, there is a clear correlation between the fluctuations in exchange rate yields between the sterling exchange rate market and the euro exchange rate market.

3.2 Volatility Spillover Effects

Volatility spillover effects mainly measure the transmission of volatile information among exchange rate markets, and the causes of volatility in an exchange rate market may include not only its own volatility but also the volatility of other markets. For the euro and the pound, before Brexit, the pound as one of the European currencies, due to monetary policy, economic and trade relations, capital flows and other factors show a strong synergy with the euro. And the end of the referendum, the euro exchange rate of the pound exchange rate trend occurred in a clear sign of divergence. The reason for this is that the ongoing Brexit negotiations at the time had a significant impact on the pound exchange rate market and the euro exchange rate market.

4 EMPIRICAL ANALYSIS

4.1 Data Selection

In this paper, the pound to dollar exchange rate and the euro to dollar exchange rate are selected as variables for two different time periods and the exchange rates are indirectly marked up. The first time period before the formal exit from the EU, i.e. 1

January 2014 to 31 January 2020, and the second time period after the formal exit from the EU, i.e. 31 January 2020 to 31 March 2021, respectively. The daily returns on the sterling exchange rate and the daily returns on the euro exchange rate for the corresponding periods are then continued to be selected and processed, following which the corresponding four variables are obtained as shown in Table 1. All data were obtained from the RESSET database.

Table 1: Variables.

Variables	Variable Meaning
RGBP	GBP exchange rate yields from 1 January 2014 - 31 January 2020 (before official Brexit)
RGBPA	GBP exchange rate yields from 31 January 2020 - 31 March 2021 (after official Brexit)
RERUB	Euro exchange rate yields from 1 January 2014 - 31 January 2020 (prior to official Brexit)
RERUA	Euro exchange rate yields from 31 January 2020 - 31 March 2021 (after official Brexit)

4.2 Data Processing

After selecting the daily closing prices of the exchange rates in both phases, this paper uses logarithmic first order difference to obtain the daily returns. R_t is the daily return on day t , the P_t and P_{t-1} are the exchange rate daily closing prices on day t and $(t-1)$, respectively.

$$R_t = \ln P_t - \ln P_{t-1} \tag{1}$$

4.3 Correlation Test of Variables

4.3.1 Unit Root Test

In this paper, the ADF unit root test is selected in the form of a test that includes a trend term and an intercept term.

Table 2: ADF unit root test.

Variables	ADF value	1% threshold	probability (math.)	conclude
RERUB	-41.01785	-3.434265	0.0000	smoothly
RERUA	-14.35927	-3.99374	0.0000	smoothly
RGBP	-39.73734	-3.434265	0.0000	smoothly
RGBPA	-13.52014	-3.99374	0.0000	smoothly

Based on the results in Table 2, it can be seen that the results of the unit root test are smooth.

4.3.2 ARCH Effect Test

Before proceeding with the GARCH model modeling, the presence of autoregressive conditional heteroskedasticity in the error term needs to be tested, and in this paper, the ARCH-LM method is chosen to test for ARCH effects.

Table 3: ARCH effect test.

Variables	F-statistic	P-value
RERUB	39.86798	0.0000
RERUA	7.701291	0.0059
RGBPB	49.21345	0.0000
RGBPA	12.88510	0.0004

It can be seen from Table 3 that the p-values of the F-statistics are all less than 0.05, indicating that there is a significant ARCH effect in the series of GBP exchange rate and EUR exchange rate returns before and after Brexit, so the GARCH model can be used to study the volatility spillover effect between the two exchange rate markets.

4.3.3 Determination of the Lag Order

Before building a VAR model for the data before and after the Brexit, the lag order in the VAR model needs to be judged. By setting different lag lengths, the most appropriate lag order is selected under each criterion such as AIC, SC and LR.

Table 4: Lagged order test.

	lag	LogL	LR	FPE	AIC	SC	HQ
Post-Brexit	0	1943.619	NA	6.96e-10	-15.40967	-15.38166*	-15.39840*
	1	1948.894	10.42550	6.89e-10	-15.41980	-15.33576	-15.38598
	2	1952.144	6.371118	6.93e-10	-15.41384	-15.27379	-15.35749
	3	1957.452	10.31930	6.86e-10	-15.42422	-15.22814	-15.34532
	4	1962.027	8.825035	6.83e-10	-15.42879	-15.17669	-15.32735
	5	1966.552	8.653397	6.80e-10	-15.43295	-15.12482	-15.30897
	6	1973.847	13.83804	6.63e-10	-15.45910	-15.09496	-15.31258
	7	1982.848	16.93121*	6.37e-10*	-15.49880*	-15.07863	-15.32973
	8	1984.608	3.282021	6.48e-10	-15.48102	-15.00482	-15.28941
Pre-Brexit	0	12348.55	NA*	5.82e-10*	-15.58907*	-15.58230*	-15.58656*
	1	12351.33	5.557788	5.83e-10	-15.58754	-15.56721	-15.57999
	2	12353.64	4.609836	5.84e-10	-15.58541	-15.55152	-15.57282
	3	12355.71	4.122175	5.85e-10	-15.58297	-15.53553	-15.56535
	4	12356.27	1.106581	5.88e-10	-15.57862	-15.51763	-15.55596

As can be seen from the Table 4, the lag order in the post-Brexit phase should be 7 according to the optimal criterion, while in the pre-Brexit phase, the optimal lag order is 0 according to different criteria, and a lag order of 0 means that the variables do not meet the modeling conditions of the VAR model, so this paper finally decides to adopt a general linear model to conduct a simple regression analysis of the two variables in the pre-Brexit phase.

4.3.4 Stability Test

The stability of the model is tested again after

determining the lag order, and the AR root test results show that the characteristic roots fall within the unit circle, so the VAR model constructed in this paper is stable.

4.4 Modeling and Effects Analysis

4.4.1 VAR Model Results

VAR modeling is performed only for GBP exchange rate returns and EUR exchange rate returns after formal exit from the EU.

Table 5: VAR modeling results.

Variables	RERUA (-1)	ERERUA (-2)	RERUA (-3)	RERUA (-4)	RERUA (-5)	RERUA (-6)	RERUA (-7)
RERUA	0.031627*	0.075935*	-0.168947**	-0.017687*	0.085813**	-0.072016*	0.093485**
RGBPA	0.008421	0.218075*	-0.328837	0.130962	0.158315*	-0.058723*	-0.199245*
variable	RGBPA (-1)	RGBPA (-2)	RGBPA (-3)	RGBPA (-4)	RGBPA (-5)	RGBPA (-6)	RGBPA (-7)
RERUA	0.091273**	0.041363**	0.073354**	-0.053260**	0.008907**	-0.130022*	-0.040966**
RGBPA	0.168805*	0.257843*	0.257843*	-0.145745*	0.101457*	-0.109013*	-0.058465*

The output of the VAR model in Table 5 shows that the pound exchange rate is still influenced by its own pre-Brexit exchange rate as well as the euro exchange rate after the UK formally leaves the EU, but the coefficients are less significant. Based on the data from a simple general linear regression of the UK's pre-Brexit exchange rate in this paper, the regression coefficient between the pre-Brexit return on the pound exchange rate (RGPB) and the return on the euro exchange rate (RERUB) is 0.651240, which has a p-value of 0.0000, a significant result. This implies that the degree of explanation of the Euro exchange rate return on the Pound exchange rate

return is high, indicating that the two exchange rate returns are highly correlated and the Euro exchange rate has a significant impact on the Pound exchange rate before the UK leaves the EU. However, it can also be seen that after the UK has carried out a formal exit from the EU, the overall level of significance of the coefficient between the pound exchange rate and the euro exchange rate is significantly lower, indicating that the post-Brexit pound exchange rate market and the euro exchange rate market does still have a spillover effect, but the volatility of the return spillover effect is not very obvious, the degree of mutual influence between the two has been reduced.

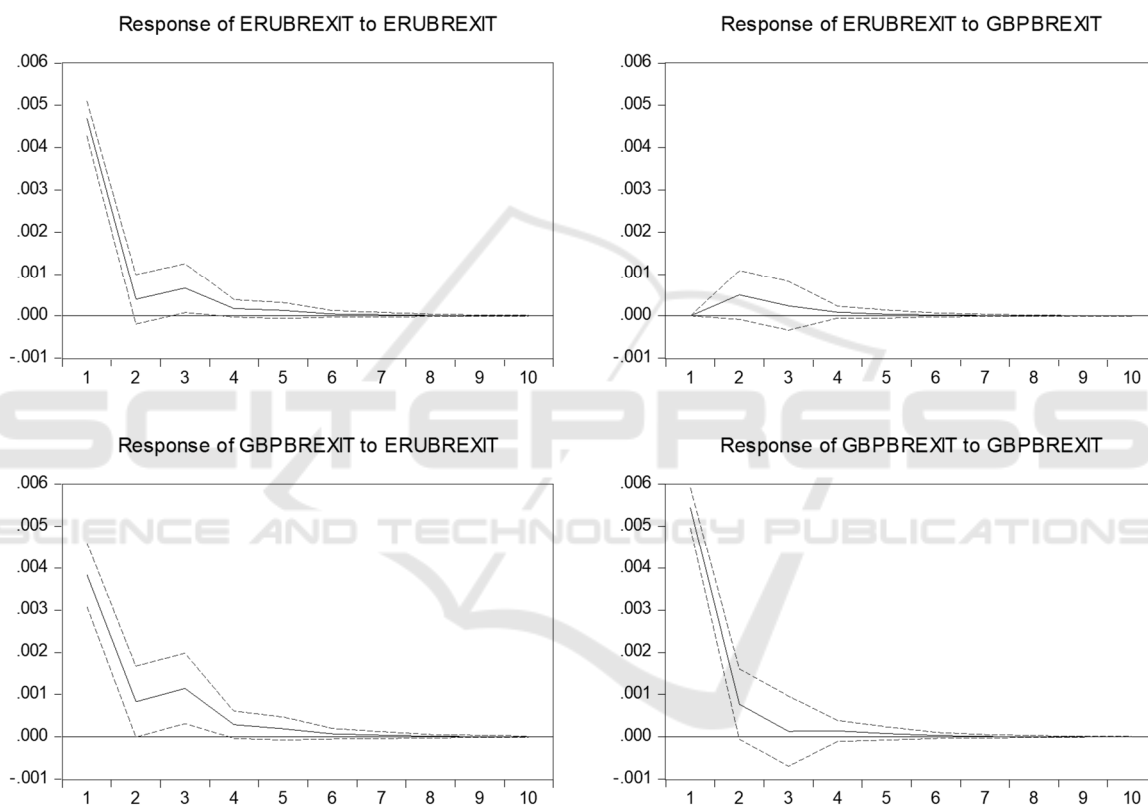


Figure 1: Impulse response function graph

As can be seen from the impulse response function results graph in Figure 1, after the UK's formal exit from the EU, the euro exchange rate returns and the pound exchange rate returns are subject to their own factors when the shock, in the first two periods are fast declining trend, indicating that the shock is strong at the beginning, the market produces significant volatility, the subsequent change amplitude slowed down, but the shock response time is longer. For the two markets between the impact of each other's yields when the shock, in the euro

exchange rate by the positive shock of the change in the exchange rate of the pound first showed an upward trend, and then gradually smooth, later there is a small decline, the overall volatility of the shock by the pound is not large. And when the pound by the euro shock in the early appear rapid downward trend, the response is stronger than the euro, and the overall view of the euro exchange rate on the impact of the pound exchange rate is negative, the response time of the pound market compared with the euro market is also longer.

4.4.2 GARCH Model

Table 6: Estimation results of the pre-Brexit GARCH model.

Variable Models	RERUB		RGBPB	
	GARCH		GARCH	
	modulus	P-value	modulus	P-value
α	0.035287	0.0000	0.036686	0.0000
β	0.963156	0.0000	0.955948	0.0000
Log likelihood	6137.996		6327.289	
AIC	-7.727783		-7.966338	
SC	-7.707482		-7.946037	

Table 7: Estimation results of Post-Brexit GARCH model.

Variable Models	RERUBA		RGBPA	
	GARCH		GARCH	
	modulus	P-value	modulus	P-value
α	0.112537	0.0481	0.154713	0.0079
β	0.801979	0.0000	0.738681	0.0000
Log likelihood	1045.497		960.8205	
AIC	-7.973155		-7.344773	
SC	-7.904869		-7.262604	

From the results in Table 6 and Table 7, it can be seen that after the formal exit from the EU, the euro and sterling market returns are still volatile, the sum of the ARCH term and GARCH term coefficients for euro exchange rate returns is 0.914516 and the sum of the ARCH term and GARCH term coefficients for sterling exchange rate returns is 0.893394, the sum of the coefficients in the post-Brexit GARCH model for both is less than 1. However, compared to the pre-Brexit become smaller than before Brexit, indicating that the conditional heteroskedasticity of the two exchange rate markets is less persistent in response to shocks after Brexit, the coefficients of the GARCH terms of both markets have decreased, and the coefficients of the ARCH terms have become larger, indicating that the volatility of the respective exchange rate markets has strengthened and market effectiveness has decreased.

5 CONCLUSIONS

The market shock from the Brexit event has been persistent. During the period from the Brexit referendum in 2016 until the formal exit from the EU in early 2020, the pound exchange rate and the euro exchange rate have been subject to persistent shocks, and the pound exchange rate yield has also suffered a new round of strong shocks after the formal exit from the EU, and the exchange rate is more volatile, while the euro exchange rate is subject to smaller shocks

than the pound. At the same time, through the image above response, the pound exchange rate market and the euro exchange rate market are affected by each other's prior yield shock and the effect is more obvious, indicating that the price volatility spillover effect in the two markets. This effect is with the implementation of the post-Brexit trade agreements gradually weakened, and will eventually gradually level off.

There is significant aggregation of exchange rate returns in the pound exchange rate market and the euro exchange rate market. Both before and after the UK's formal exit from the EU, there is a significant ARCH effect in both exchange rate markets, indicating that there is significant aggregation of exchange rate returns in both markets. The ARCH term coefficient increases after the formal exit of the UK from the EU compared to the pre-Brexit period, and the respective volatility of the GBP and EUR markets strengthens, but the effectiveness of the markets decreases. According to the current exchange rate market, the movements of the sterling exchange rate market and the euro exchange rate market are also gradually diverging, and the correlation between the two exchange rate markets has weakened.

The linkage between the pound exchange rate market and the euro exchange rate market has weakened. The results of the VAR model and the results of the GARCH model test show that, due to the re-establishment of the British-European political and economic trade relations, the close linkage between the sterling exchange rate market and the

euro exchange rate market has weakened compared with the period before the formal exit of the United Kingdom from the European Union, and the sterling exchange rate and the euro exchange rate have produced more obvious differences in response to each other's shocks, and the volatility spillover effect between the markets has decreased. With the formal exit of the United Kingdom from the European Union, the mutual impact between the two markets has also been reduced by the different measures taken by the United Kingdom and the European Union with regard to future developments.

- Wang Lu, Huang Denshi, Ma Feng and Liu Wenjia, 2019. Analysis of the impact of major unexpected events on the international foreign exchange market: based on the British EU referendum event [J] *Mathematical Statistics and Management*, vol. 39, no. 1, 2019, pp.174-190.
- Zhao Qiong and Guo Chengxiang, 2019. A study of volatility between the British pound and major currencies before and after Brexit and its spillover effects [J] *Economic Issues*, No. 11, 2019, pp.17-24.

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REFERENCES

- Bunda, Irina, Hamann, 2009. Correlations in emerging market bonds: The role of local and global factors [J] *Emerging Markets Review*, Vol. 10, 2009, pp.67-96.
- Christiansen, Charlotte, Volatility-spillover effects in European bond markets [J] *European Financial Management*, Vol. 13, 2012, pp. 923-948.
- Essaddam N, Karagianis J M., 2014. Terrorism, country attributes, and the volatility of shock returns [J] *Research in International Business and Finance*, Vol. 31, 2014, pp. 87-100.
- Favero, Carola. Modeling and forecasting yield differentials in the Euro Area-A Non-linear global VAR model [M] Milan: Innocenzo Gasparini Institute for Economic Research Working Paper Series, 2012.
- Kim, Suk-Joong, Lucey, 2006. Dynamics of bond market integration between established and accession European union countries [J] *Journal of International Financial Markets*, Vol. 16, 2006, pp. 41-56.
- Kollias C, Papadamous S, Stagiannis A., 2011. Terrorism and capital markets: The effects of Madrid and London Bomb attack [J] *The International Review of Economics and Finance*, Vol. 20, 2011, pp.154-167.