

Exchange Rate Volatility of US Dollar and British Pound during Different Phases of Financial Crisis

Daniel Stavárek

Silesian University
School of Business Administration
Univerzitní nám. 1934/3
Karviná, 733 40
Czech Republic
e-mail: stavarek@opf.slu.cz

Abstract

The aim of the paper is to model two types of asymmetric volatility of the exchange rate of the US dollar and British pound against the euro during the financial crisis. We apply a modified TARARCH model on daily data covering the period 1 March 2007 – 31 March 2011 divided into four phases of the financial crisis. The results suggest that the presence of asymmetric attributes of the exchange rate volatility were relatively common particularly in the US dollar exchange rate. We can conclude that appreciation changes of the exchange rate stimulate subsequent volatility to increase more than depreciation changes. Likewise, appreciation-side deviations from the target exchange rate increase the exchange rate volatility. We did not find any significant differences in asymmetry across the phases of the financial crisis.

Keywords: exchange rate, volatility, asymmetry, financial crisis, TGARCH

JEL codes: G01, G15, F31

1. Introduction

The current financial crisis is in many aspects specific. In contrast to previous financial crises in 1990s it has more global character and impact. It is safe to say that the crisis beginning in 2007 is unlike anything anyone working today has ever lived through before. As a result, it is important to chronicle the major events that have unfolded and their implications. In this paper, we focus our attention on foreign exchange market and particularly on two major currencies – US dollar (USD) and British pound (GBP) – and volatility of their exchange rate against the euro.

We aim to model two types of asymmetry in the exchange rate volatility. First, we test whether depreciation leads to higher volatility. Second, we resolve whether a larger deviation of the spot rate from the target rate increases volatility; and whether this is more significant on the depreciation side of the target zone.

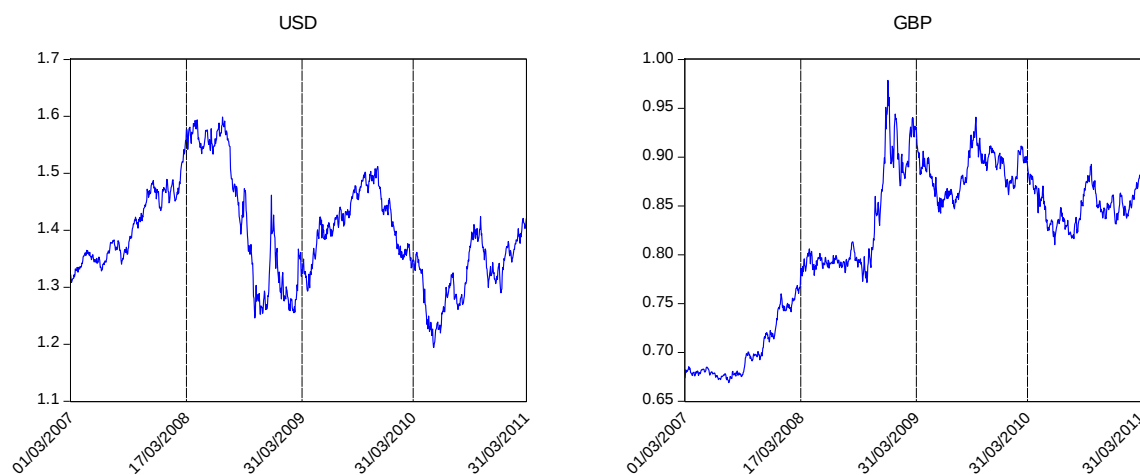
The entire period of the current financial crisis is divided into four phases that differ in intensity of the crisis and sentiment prevailing in the world financial markets. In particular, we distinguish (i) crisis initialization (1 March 2007 – 16 March 2008), (ii) crisis culmination (17 March 2008 – 31 March 2009), (iii) crisis stabilization (1 April 2009 – 31 March 2010), and (iv) crisis fade-out (1 April 2010 – 31 March 2011). Hence, we are able to compare level of the exchange rate volatility and its character under different market and economic circumstances. This structure of analyzed period reflects our aim to have the phases equally long and respecting the key milestones in the crisis timeline identified in literature.

2. Exchange Rate Development

Significant changes in exchange rates are typically one of the attributes of any financial crisis. The recent global financial crisis was no exception as it has caused sharp movements in global as well as local exchange rate configurations. According to Melvin and Taylor (2009) the crisis in the foreign exchange market came relatively late. On 16 August 2007, a major unwinding of the carry trades occurred and many currency investors suffered huge losses. This happened after the fixed income and

equity markets had already been under considerable stress for several months. Correspondingly, Melvin and Taylor (2009) date the very beginning of the crisis in the foreign exchange markets as August 2007. However, this date is applicable only on major currencies. Figure 1 depicts development of the analyzed exchange rates during the crisis period. We use exchange rates as the price of one euro in terms of each of the currencies. Hence, a positive change and upward movement of the exchange rate denotes depreciation of the respective currency (appreciation of the euro) and vice versa.

Figure 1: Development of USD/EUR and GBP/EUR Exchange Rate (01/03/2007 – 31/03/2011)



Source: Eurostat Economy and Finance Database

During the first phase, we can observe that USD and GBP began to depreciate in August 2007. It was caused by a contagion from other financial markets and the unwinding of carry trades in the foreign exchange markets. This was a market reaction to the fallout from the US subprime home loans debacle where the quality of bank loan portfolios became increasingly suspect primarily in the US and UK. When the bankruptcy of Bear Stearns was avoided through a takeover by JP Morgan Chase in March 2008, market conditions improved and financial markets returned to a more normal situation.

The failure of Lehman Brothers caused by huge losses from subprime business shocked financial markets in September 2008 after a summer of tranquility. Lehman's bankruptcy imposed losses on other firms across the industry. The risk aversion and deleveraging that occurred post-Lehman were incomparable to anything that had been seen before. One of the striking characteristics of the crisis in the foreign exchange market and particularly the phase of crisis culmination was substantial appreciation of the dollar, not only against the euro but almost all currencies of developed as well as emerging economies. Such a development was rather unexpected as the crisis originated in the US and many emerging countries had initially little direct financial exposure by holding relatively few US toxic assets (Fratzscher, 2009).

There are several factors that explain these global movements in the foreign exchange markets. First, at times of high uncertainty and risk aversion, some currencies, dubbed as 'safe haven currencies', appear more attractive than others. Kohler (2010) points out that the CHF, JPY and EUR tend to strengthen against USD during periods of high risk aversion and exchange rate volatility. On the other hand, USD tend to appreciate during those periods against a number of other currencies particularly from emerging markets. The fact that USD appreciated considerably even against other leading currencies can be related to the behaviour of US and foreign investors who have shifted out of equities and into fixed income instruments, principally into (presumably) safe US government bonds and bills. In addition, the USD appreciation was driven by USD funding shortages in the non-US banking sectors that reflected an increasing counterparty risk in the interbank market.

The British pound was perhaps one of the worst victims of the crisis in the foreign exchange markets. The enormous depreciation of GBP can be attributed to a devastated banking sector, the Bank of England's programme on monetary quantitative easing and general budget and current account

deficits. Although all these features of the UK economy closely mirrored the US economy, the pound depreciated as it did not benefit from the safe haven currency status.

In the second half of 2009, USD and GBP were depreciating against virtually every other currency. Investors grew more comfortable with risk, reverted the flow of funds and started to look outside the US for a better yield. Fundamental incentives for this behaviour can especially be found in a near-zero-interest-rate target, an aggressively expansionary policy aimed at boosting the economy and growing deficits. The pound joined the dollar on the list of ‘sick currencies’ because the UK economy still resembled the US economy. The dollar and pound developed together against the euro for the rest of the analyzed period. Their depreciation and appreciation period moved together as the market sentiment and economic fundamentals were changing.

3. Model Specification

The Threshold Autoregressive Conditional Heteroscedasticity (TARCH) model proposed by Zakoian (1994) and Glosten et al. (1993) is used in the paper. This model includes a leverage term that allows for the asymmetric impacts of good and bad news (positive and negative innovations) on volatility. Thus, the standard TARCH model is an ideal tool for testing the first hypothesis on asymmetry.

For modelling the second asymmetric component we have to augment the TARCH model by the parameters reflecting the deviation of the spot exchange rate from the target level. Since the target level was not explicitly set in any of the countries analyzed during the entire period we have to substitute for it with an implicit target exchange rate. In accordance with Chmelarova and Schnabl (2006), Fidrmuc and Horváth (2008) and Stavárek (2010) we approximated the target exchange rate to be the 180th moving average mode. This time varying target exchange rate is computed as the average of exchange rates from ± 90 trading days around the day of observation. For the computation of the moving average, we also used the exchange rates prior to 1 March 2007 and after 31 March 2011. Thus, the moving average time series is restricted neither at the beginning nor the end and fully captures the whole period of estimation.

Our estimation specification of the TARCH(1,1) model is as follows:

$$\Delta s_{jt}^D = \mu_j + \xi_{jt} \quad (1)$$

$$\sigma_{jt}^2 = \gamma_{j1} + \gamma_{j2}\xi_{jt-1}^2 + \gamma_{j3}\sigma_{jt-1}^2 + \gamma_{j4}D_{jt-1}^{arch}\xi_{jt-1}^2 + \delta_{j1}|s_{jt-1}^D - s_{jt-1}^F| + \delta_{j2}D_{jt-1}^S|s_{jt-1}^D - s_{jt-1}^F| + \omega_{jt} \quad (2)$$

where s_{jt}^D denotes the spot exchange rate of the national currency j against the euro in the time t . Next, s_{jt}^F is the time varying target exchange in the form of the above defined moving average. Besides the constant term, the mean equation (1) does not include any other explanatory variable. The constant term μ_t shows the average rate of depreciation or appreciation. The error term, ξ_{jt} , of the mean equation (1) is assumed to have a time varying conditional variance, σ^2 , specified by equation (2).

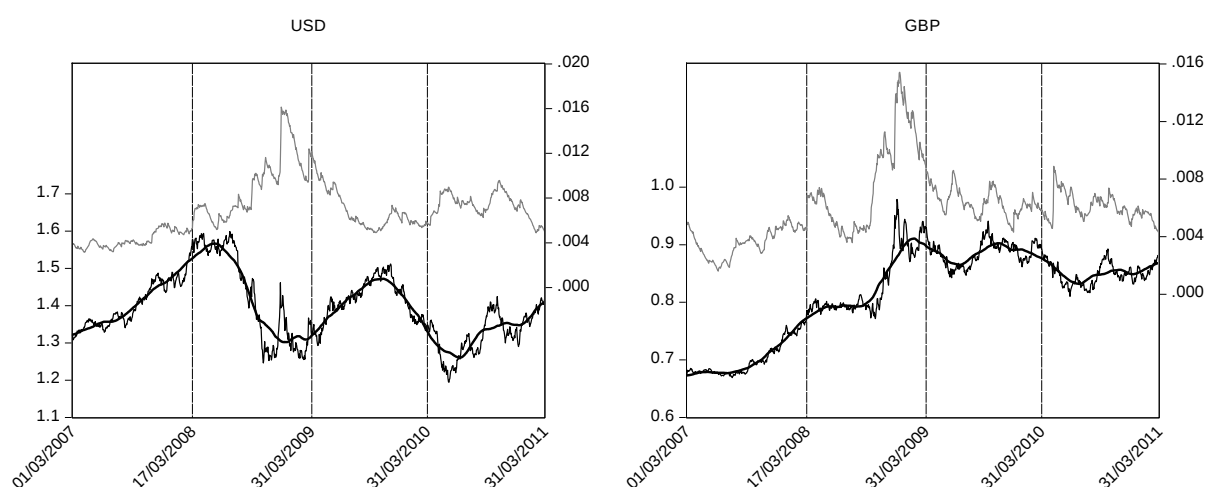
Furthermore, equation (2) comprises the ARCH term, ξ_{jt-1}^2 , that reflects the impact of news from previous periods that affect exchange rate volatility, and the GARCH term, σ_{jt-1}^2 , that measures the impact of the forecast variance from previous periods on volatility. The core of the TARCH term is the dummy variable, D_{jt-1}^{arch} , that equals 1 in the case of a negative shock or good news ($\xi_{jt} < 0$) and zero in the case of positive shock or bad news ($\xi_{jt} > 0$). In the case of the exchange rate, the leverage effect (positive value of the coefficient γ_{j4}) represents the fact that a decrease in the price of a foreign currency in terms of a domestic currency, or a domestic currency's appreciation, tends to increase the subsequent volatility of the domestic currency more than would a depreciation of equal magnitude. Likewise, the dummy variable, D_{jt-1}^S , is equal to 1 if the spot exchange rate is lower than the target exchange rate, that is, if the exchange rate is in the appreciation region of the target zone. Consequently, the positive value of coefficients δ_{j1} and δ_{j2} indicates that the exchange rate volatility increases as the spot exchange rate departs from the target value. More specifically, the positive value

of coefficient δ_2 implies that the volatility increase is associated primarily with the appreciation deviations from the target exchange rate.

4. Estimation Results

As the first step, an augmented Dickey-Fuller test was applied on log values of the exchange rates and target rates (180-day moving average). The results obtained suggest that all series tested are stationary in logs of first differences³ and, thus, this form of the time series is used in the model estimation. Before examination of the asymmetric attributes of exchange rate volatility we present the development of the exchange rate volatility as obtained from estimation of the TARCH models. Graphs in Figure 2 show the volatility in the form of conditional standard deviation along with development of the spot and target exchange rates.

Figure 2: Implied volatility, spot and target exchange rates (01/03/2007 – 31/03/2011)



Note: Exchange rates are on left axis and denoted by black lines, exchange rate volatility is on right axis and denoted by gray line.

Source: Author's calculations

Both graphs are divided into four parts representing the phases of the financial crisis as defined above. Generally, the estimated volatility of both currencies share very similar development. The exchange rate volatility was highest during the period of crisis culmination with the peak at the end of December 2008. Further, it is evident from the charts that the exchange rate volatility substantially decreased during the stabilization phase. The last phase of financial crisis labelled as the crisis fade-out could simultaneously be a beginning of future sovereign debt crisis in Europe. Hence, it brought more dynamics to the exchange rate volatility.

The visual analysis of the graphs suggests that the volatility often increases when the spot exchange rate departs from the target rate. Next, it is worth noting that the exchange rate and volatility develop very synchronically in some cases. It is apparent that mainly volatility of USD/EUR usually increases in periods of the dollar appreciation. This can be related to the position of safe haven currency that usually appreciates in turbulent times with higher and raising volatility. However, the visual analysis of graphs enables only examination of development trends for the mid-term and long-term horizon. Even though the findings can indicate some forms of asymmetry, they are very preliminary and have to be confirmed by the TARCH model estimations (Table 1)

Table 1: TARCH model estimation

	Initialization	Culmination	Stabilization	Fade-out
USD/EUR				
μ	0.0005 ^b	-0.0006	0.0003	0.0005
γ_1	0.0000 ^b	0.0000 ^c	0.0000 ^a	0.0000
γ_2	0.0051	0.1923 ^c	-0.1339	-0.0588
γ_3	1.0140 ^a	0.8025 ^a	0.6449 ^a	0.9494 ^a
γ_4	-0.0339	-0.1573	0.0227	0.0898 ^b
δ_1	0.0730 ^b	0.0735	0.8520 ^b	0.1188 ^a
δ_2	0.1150 ^c	0.2512	1.5875 ^b	0.1532 ^c
$\gamma_2 + \gamma_3 = 1$	1.0191	0.9948	0.5110 ^a	0.8906 ^b
$\gamma_2 + \gamma_3 + \gamma_4 = 1$	0.9852	0.8375 ^c	0.5337 ^a	0.9804 ^b
GBP/EUR				
μ	0.0002	0.0005	0.0001	0.0001
γ_1	0.0000	0.0000	0.0000	0.0000 ^b
γ_2	0.0471	0.0509	0.1395	-0.0299
γ_3	0.9280 ^a	0.9054 ^a	0.5156	0.3144
γ_4	-0.0582	-0.0982	-0.0749	0.3193
δ_1	0.0289	0.3366 ^a	0.2910	0.2152
δ_2	0.1366	0.6610 ^a	0.3375	-0.0406
$\gamma_2 + \gamma_3 = 1$	0.9751 ^b	0.9563 ^b	0.6551 ^a	0.2845 ^a
$\gamma_2 + \gamma_3 + \gamma_4 = 1$	0.9169 ^b	0.8581 ^a	0.5802 ^b	0.6038 ^b

Note: ^a, ^b and ^c denote significance for 1 percent, 5 percent, and 10 percent, respectively. For clarity of the estimates and discussion in the text, values of coefficients δ_1 and δ_2 are multiplied by 10^3 .

Source: Author's calculations

The values of the μ coefficients are rarely significant indicating a lack of any clear appreciation or depreciation trend in the exchange rate development. The only exception is the first phase (crisis initialization) during which USD depreciated significantly. The effect of unanticipated news or surprises about volatility is captured by the ARCH term γ_2 . Positive sign of the coefficient indicates that the news and surprises tend to increase the volatility and vice versa. Positive and significant coefficient was estimated only for USD in the second crisis phase.

The GARCH term is usually present and has strong significance. The values of coefficient γ_3 are in most cases positive and dimensionally large. The persistence of variance is measured by the sum $\gamma_2 + \gamma_3$. The more this sum approaches unity, the greater is the persistence of shocks to volatility and the slower is the convergence to a steady state that can be observed. The shocks to volatility have a permanent effect if the sum of the ARCH and GARCH coefficients equals or exceeds unity. In this case the conditional variance does not converge on a constant unconditional variance in the long run.

If we illustrate the situation on GBP/EUR estimates in the first phase, the sum $\gamma_2 + \gamma_3$ equals 0.9751 and is significantly different from unity. The sum is also an estimation of the rate at which the response function diminishes on daily basis. Since the rate is high, the response function to a shock is likely to diminish slowly. It means new shocks will have influence on returns for a longer period. The persistence of shocks to volatility seems to be high for both exchange rates particularly in the first half of the financial crisis.

The TARCH term capturing the first type of asymmetry in the exchange rate volatility is statistically significant only in the USD model of the last crisis phase. The value of the statistically significant coefficient γ_4 indicates the magnitude of the asymmetry (leverage effect), and the sign of its direction. Significantly positive coefficient implies that past appreciation (negative) shocks tend to increase subsequent volatility largely than depreciation (positive) shocks of the same magnitude. The sum $\gamma_2 + \gamma_3 + \gamma_4$ is more often than not lower than the sum of coefficients $\gamma_2 + \gamma_3$. This fact can be

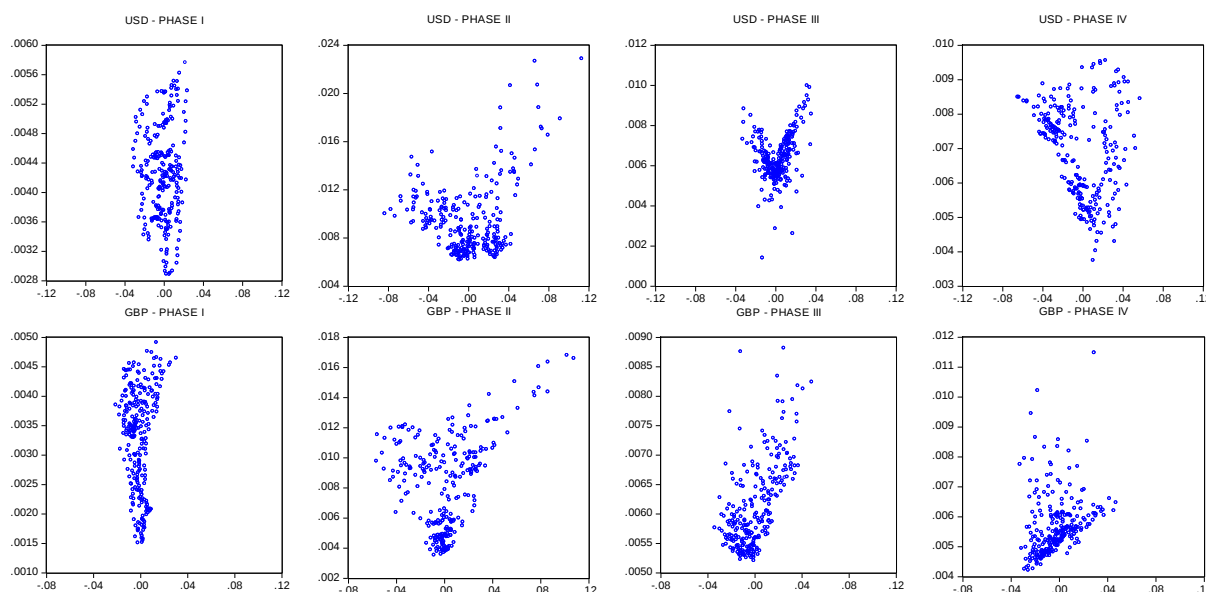
interpreted as the evidence of higher persistence of exchange rate shocks during the depreciation periods.

In both exchange rates, the deviation from the implicit target rate has a significant impact on volatility minimally in one crisis phase. The significant δ_1 coefficients are positive implying that the volatility increases as the distance from the target exchange rate expands. Thus, the implicit target is not credible and exchange rates do not act as shock absorbers.

The second type of asymmetry can be assessed by the values of the δ_2 coefficient. The coefficients are significant in the models that contain a significant δ_1 coefficient and both coefficients typically hold the same sign. Positive value of the δ_2 coefficient shows that the exchange rate volatility increases with the appreciation-side deviation from the target level. Apparently, the target zone is less credible in the appreciation part. By definition, the opposite is true for the depreciation region of the target zone.

The asymmetrical linkages between exchange rate volatility and deviation from the implicit target rate are graphically illustrated in Figure 3. The horizontal axes of the graphs represent the deviation as defined in (2) and the estimated conditional standard deviation is plotted on the vertical axes. We can see that the volatility usually increases as the spot exchange rate departs from the target level.

Figure 3: Conditional standard deviation and location of the exchange rate in the target zone



Note: Deviation of spot rate from the target rate on horizontal axis and estimated conditional standard deviation on vertical axis.

Source: Author's calculations

5. Conclusion

Estimations of the TARCH models revealed the presence of asymmetric attributes of the exchange rate volatility in exchange rates of USD and GBP. We discovered that the second form of asymmetry is more present than the first form. Whereas the asymmetry in the USD exchange rate was found in three phases of the financial crisis, the exchange rate volatility of GBP seems to be less asymmetrical as some evidence was found only in one phase. The results suggest that if the asymmetry is present the past appreciation increases subsequent volatility more than depreciation changes. Furthermore, the exchange rate volatility increases with the appreciation-side deviation from the target level. All of these conclusions confirm the specific role of USD in the foreign exchange market during the financial crisis when the dollar appreciated mostly during the most turbulent and risky periods.

References

- CHMELAROVA, V., SCHNABL, G. *Exchange rate stabilization in developed and underdeveloped capital markets*. Working Paper Series No. 636, Frankfurt am Main: European Central Bank, 2006.
- FIDRMUC, J., HORVÁTH, R. Volatility of exchange rates in selected new EU members: Evidence from daily data. *Economic Systems*. 2008, vol. 32, no. 1, pp. 103-118.
- FRATZSCHER, M. What explains global exchange rate movements during the financial crisis? *Journal of International Money and Finance*. 2009, vol. 28, no. 8, pp. 1390-1407.
- GLOSTEN, L., JAGANNATHAN, R., RUNKLE, D. E. On the Relation between the Expected Value and the Volatility of the Nominal Excess Return on Stocks. *Journal of Finance*. 1993, vol. 48, no. 5, pp. 1779-1801.
- KOHLER, M. Exchange rates during financial crises. *BIS Quarterly Review*. 2010, March, pp. 39-50.
- MELVIN, M., TAYLOR, M.P. The crisis in the foreign exchange market. *Journal of International Money and Finance*. 2009, vol. 28, no. 8, pp. 1317-1330.
- STAVÁREK, D. Exchange rate volatility and the asymmetric fluctuation band on the way to the Eurozone. *Applied Economics Letters*. 2010, vol. 17, no. 1, pp. 81-86.
- ZAKOIAN, J. M. Threshold heteroskedastic models. *Journal of Economic Dynamics & Control*. 1994, vol. 18, no. 5, pp. 931-955.