Persistence And Asymmetry In Exchange Rate Volatility

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ABSTRACT

Recent economic downturn in the United States and Europe has affected major currencies around the world. This paper focuses on the behavior of exchange rates over the past decade to study how volatility pattern of these exchange rates responds to any exogenous shocks. The paper focuses on persistence and asymmetry in volatility of major exchange rates due to exogenous shocks. The paper employs a univariate GARCH and an EGRACH model to test the persistence and asymmetry of exchange rate volatility using data from the past decade plus. The results show high persistence and asymmetric behavior in volatility implying that the effect of good news on exchange rates is different from the effect of bad news. The results of this paper have important implications for foreign exchange investors and will provide a better understanding of the foreign exchange market to interested observers.

Keywords: Volatility Persistence; Time Series; GARCH

INTRODUCTION

The randomness of time series has enticed many researchers over the past several years. Researchers have been actively studying the behavior of stock indexes, oil prices, and foreign exchange rates. The global recession recently has affected major economies around the world. This is especially true for Europe's largest economies like the United Kingdom, Germany, and France. The paper studies the behavior of exchange rates for these economies over the past decade or so. The paper attempts to examine the persistence of shocks to volatility of the return series along with any asymmetric response to different types of shocks, either good or bad. The U.S. dollar exchange rate, with reference to other currencies, has been the focus of researchers over the past several years. This paper focuses on the behavior of U.S. dollar exchange rate with reference to two major European currencies; i.e., the Euro and the British Pound, to measure the persistence of shocks to volatility and any asymmetric behavior over time. Just like other time series, exchange rate returns also show significant evidence of volatility clustering. Volatility clustering means that time periods of high volatility are followed by time periods of high volatility and time periods of low volatility are followed by time periods of low volatility. The paper makes a significant contribution to the literature since not much research has been done to study the asymmetric behavior of these two major exchange rates. Some related research is discussed in the next section followed by methodology and data sections. The findings of the tests are discussed in the empirical results section and the paper concludes with some final remarks.

LITERATURE REVIEW

There is a plethora of research available on time series modeling and the behavior of return series in response to any exogenous shocks. Some of the relevant research is discussed in this section. McKenzie and Mitchell (2002) have studied the behavior of exchange rate volatility using several different exchange rate series for the time period between 1986 and 1997 and found that return series did not show signs of asymmetric response to any shocks to exchange rate volatility. Laopodis (1997) studied the effect of U.S. Dollar appreciation and depreciation before and after 1985 on six different currencies and found that the Dollar depreciations had a more significant effect on the volatility of other currencies than the Dollar appreciation. Most of the research done has utilized the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model given by Bollerslev (1986), which is a variant of the Autoregressive Conditional Heteroscedasticity (ARCH) model introduced by Engle

(1982). Engle (2002) and Harris and Sollis (2003) discuss the usefulness of different ARCH and GARCH models in their research and explain that GARCH models are better suited for modeling time series volatility. Other noteworthy mentions regarding the use of ARCH and HARCH models for time series modeling include Engle et al. (1990), Bollerslev, Chou, and Kroner (1992), Engle and Susmel (1993), Brooks and Persand (2003), Malik, Ewing, and Payne (2005), Hassan and Malik (2007), Rahman and Serletis (2009), and McMillan and Speight (2010).

METHODOLOGY

Earlier research shows that selection of an appropriate model is the key to finding the right answers. ARCH and its variant models are still considered the best methods for modeling volatility of time series. One of the popular explanations for the use of ARCH and GARCH models is that volatility in high-frequency time-series data is time-varying; i.e., time periods of high volatility have a tendency to cluster and ARCH and GARCH models and their variants seem to work better for these types of data. As discussed earlier, many researchers have used the ARCH and GARCH models to study high-frequency time series as they usually provide a better fit compared to other constant variance models. The paper uses a univariate GARCH model to study the persistence of volatility in exchange rate return volatility and an Exponential GARCH (EGARCH) model to study the asymmetric behavior of the return series as a response to any exogenous shocks. The two models are described as follows:

The Univariate GARCH Model

The equations for the univariate GARCH(1,1) model can be given as:

$$Y_t = \mu + \varepsilon_t, \quad \varepsilon_t \mid I_{t-1} \sim N(0,h_t) \tag{1}$$

$$h_t = \omega + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1} \tag{2}$$

The term (1,1) in GARCH (1,1) is a reference to the presence of a first-order autoregressive GARCH term and a first-order moving ARCH term. Here, Equation 1 is the mean equation and Equation 2 is the conditional variance equation in the univariate GARCH model. The term Y_t gives the volatility of the time series and the forecast variance in time period t, based upon time period t-1, is given by h_t. N is the conditional normal density with a zero mean and h_t variance and ε_t is the residual term. The term I_{t-1} describes the information set available at time t-1. In Equation 2, h_{t-1} is conditional variance from the previous period, ω is the mean, and ε_{t-1}^2 is news from the previous time period. The ARCH term in the variance equation is given by α which gives information about volatility in the last period, whereas the GARCH term is given by β which describes the past period forecasted variance. According to Engle and Bollerslev (1986), the sum of the coefficients α and β in Equation 2 describes the persistence of a shock to volatility. A value of α plus β close to 1 means that shocks to volatility will be more persistent; i.e., the conditional variance will take a long time to converge to its steady state. When this sum equals 1, it becomes an *integrated* GARCH (IGARCH) process meaning that any news (good or bad) will have a permanent effect on the volatility for future periods. It would be reasonable to expect the sum of α and β for this study to be close to 1; i.e., shocks to volatility are expected to be highly persistent. Therefore, the study of asymmetric effects of news on exchange rate volatility becomes even more important. The Ljung-Box Q-statistic shows significant autocorrelation in the series; therefore an AR (1) (autoregressive process of order one) specification for mean equation is used.

The Exponential GARCH; EGARCH (1,1) Model

To capture the asymmetry in a return series, a popular variant of the GARCH model is the exponential GARCH (EGARCH) model which was proposed by Nelson (1991). Engle and Ng (1993) suggest that the EGARCH model allows positive return shocks to have a different impact on volatility than negative return shocks. A plus about this model is that it guarantees the forecasts of the conditional variance to be non-negative. The equation for conditional can be given:

$$\text{Log}(\sigma_t^2) = \omega + \beta\log(\sigma_{t-1}^2) + \alpha(\varepsilon_{t-1}/\sigma_{t-1}) + \gamma(\varepsilon_{t-1}/\sigma_{t-1}) \qquad (3)$$

In this model, γ is the parameter that measures the asymmetry in the return series. When γ has a zero value, it means that positive and negative shocks have the same effect on volatility of the return series. However, a non-zero value for γ suggests that the effect of positive shocks is different from the effect of negative shocks. A negative value of γ means that the effect of negative shocks exceeds the effect of positive shocks, whereas a positive value of γ means the opposite. The sum of α and γ shows the impact of positive shocks on the return series, so this sum will have a smaller value than α when the value of γ is negative and vice versa, showing that the impact of positive shocks is less than the impact of negative shocks.

DATA

This paper employs daily data for the past 12 years from January 2000 to March 2012. The data was obtained from the Federal Reserve Bank of St Louis. The total number of usable observations in the study was 3,079. The selection of the data is based upon the time period immediately after the introduction of the Euro by the European Union until the current time period to capture all possible changes in the volatility of the time series. The other series used in the study is the British Pound which would be useful for the major purpose of comparison of currencies from the same region. The study of this data is important for U.S. and European investors, as well as other economies, since their balance of payments also depend upon the behavior of the foreign exchange market.

Table 1 shows the descriptive statistics of both exchange rate returns, showing evidence of skewness and kurtosis. A normally distributed random variable has zero skewness and kurtosis of three. The British Pound is negatively skewed whereas the Euro shows positive skewness. The probability values of the Jarque-Bera (1980) test statistic confirm that the two variables are non-normally distributed. Table 1 also shows the significant p-values for the Ljung-Box Q-statistic which means that autocorrelation exists in the residuals.

Table 1: Descriptive Statistics for Return Series

	British Pound	**Euro**
Mean	-5.74E-06	8.85E-05
Median	0.000101	7.02E-05
Maximum	0.044349	0.046208
Minimum	-0.049662	-0.030031
Std. Dev.	0.006229	0.006645
Skewness	-0.299258	0.077164
Kurtosis	8.158729	5.050479
Jarque-Bera	3460.117 (0.00)	542.4530 (0.00)
Sum	-0.017672	0.272351
Sum Sq. Dev.	0.119416	0.135894
Q(16)	52.67 (0.00)	26.02 (0.05)
Observations	3079	3079

Notes: The above statistics are for daily exchange rate returns. Q(16) is the Ljung-Box statistic for serial correlation. Jarque-Bera statistic is used to test whether or not the series resembles normal distribution. Actual probability values are in parentheses.

Table 2 comprises results of the unit root tests. These results are based upon the Augmented Dickey-Fuller (1979) and the Phillips-Perron (1988) tests and the significant p-values mean that the null hypothesis of no unit root in the return series is rejected.

Table 2: Unit Root Tests

	British Pound	Euro
ADF	0.0000	0.0000
Lags	18	17
PP	0.0001	0.0001
Bandwidth	178	252

Notes: The lag length of the Augmented Dickey-Fuller (ADF) test was automatically selected through the Schwarz information criterion and the bandwidth for the Phillips-Perron (PP) was set using the Bartlett Kernel.

EMPIRICAL RESULTS

The results for the GARCH and EGARCH models are given in Table 3. The outcomes of the first model are given by α and β, where these are the ARCH and GARCH terms, respectfully, and the sum of these terms gives the information regarding the persistence of shocks to volatility. As the sum gets closer to 1, it can be concluded that shocks to volatility are highly persistent. When this sum is exactly equal to 1, it means that shocks to volatility of the return series will have permanent effects for all future time periods. In the present case, the value of this sum is pretty close to 1, being at 0.98 for the British Pound and 0.99 for the Euro, meaning that any shocks to volatility will be highly persistent. The p-values are given in parentheses which describe the statistical significance of a derived value. For the GARCH model, the p-values are significant for both α and β, so the results are statistically significant for this model.

Table 3: Results of GARCH and EGARCH Models

	British Pound	Euro
α	0.04 (0.00)	0.03 (0.00)
β	0.94 (0.00)	0.96 (0.00)
γ	-0.02 (0.01)*	-0.01 (0.06)**
$\alpha + \beta$	0.98	0.99
$\alpha + \gamma$	0.02	0.02
TR^2	-0.01 (0.82)	-0.01 (0.65)
Q(16)	24.51 (0.08)	20.97 (0.18)

Notes: The sum of α and β is close to 1, showing that shocks to volatility of exchange rates is highly persistent. TR^2 refers to the ARCH LM test for a null of no ARCH in the residuals. The Ljung-Box Q-statistics are given in the last column with 16 lags and tested for a null hypothesis of no autocorrelation.
*: Significant at 5% level
**: Significant at 10% level

The results of the Exponential GARCH model are given by the values of γ in this table. As we can see, the value of γ is negative for both the British Pound and the Euro return series; however, the p-value is smaller than 0.05 in the case of the British Pound (0.01), but not in the case of the Euro (0.06.) It can still, however, be concluded that the results for asymmetry in the volatility of return series are statistically significant for both series. The results clearly show that negative shocks have a greater effect on volatility of both exchange rate series than positive shocks since the value of γ is negative and significant in both cases.

CONCLUSION

From the results of the two models, it can be concluded that any shocks to volatility of both exchange rate return series are highly persistent with the persistence being slightly higher for the Euro compared to the British Pound. This means that when an exogenous shock has an impact on any of these time series, it will show it effects for a long time in the future. The second conclusion is that the volatility of both exchange rate returns shows asymmetric behavior toward positive and negative shocks where the impact of negative shocks seems to be relatively greater than the impact of any positive shocks. These results have important implications for investors and provide a critical perspective to keen observers. The paper would suggest that the foreign exchange investors should use extra care when handling these currencies, especially after a negative macroeconomic shock. The paper opens new doors toward more research on asymmetric behavior of different exchange rates around the globe.

AUTHOR INFORMATION

Dr. S. Aun Hassan earned a Ph.D. in Financial Economics from Texas Tech University in Lubbock, TX in 2005. He is currently working as an assistant professor at Colorado State University Pueblo and joined this institution in Fall 2009. He has taught courses in Economics and Finance both at the graduate and undergraduate level. His main areas of interest for research are Financial Economics and Time Series Econometrics. Dr. Hassan has published research papers in the Journal of Economics and Finance and the Quarterly Review of Economics and Finance. E-mail: aun.hassan@colostate-pueblo.edu

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