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### **Paper:**

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# **UK Imports, Third country effect and the Global financial crisis: Evidence from the Asymmetric ARDL Method**

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## **Abstract**

This paper examines the role of exchange rate volatility in determining real imports. As a robustness check, it further explores the impact of the recent global financial crisis which is a period characterized by heightened exchange rate volatility. More specifically, we investigate the impact of exchange rate volatility on UK real imports from Germany, Japan and the US during the period January 1991 – March 2013. In contrast to most studies which focus on bilateral trade, we additionally explore the third country exchange rate volatility effect on UK imports. To capture the non-linear features which often characterize macroeconomic data, we employ the asymmetric autoregressive distributed lag (ARDL) approach to cointegration. Our results suggest that exchange rate volatility plays an important role and reveal that there is a significant effect of the recent financial crisis on UK imports. This finding is consistent when we test for the third country volatility effect. Finally, we find that there is a significant causal relationship between exchange rate volatility and UK imports both in bilateral tests and in tests which account for the third country exchange rate volatility.

*JEL Classification:* F1, F10

*Keywords:* Real imports, Exchange Rate Volatility, GARCH, Asymmetric Cointegration, Financial Crisis

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## 1. Introduction

Exchange rate volatility has important implications for both exchange rate and trade policies. As a source of uncertainty, it is one of the main issues of concern for market participants, trade economists and policy makers who seek to determine whether an increase in exchange rate volatility affects international trade flow (see, Arize, 1998; Choudhry, 2005). A theoretical framework seems to indicate a negative relationship between international trade flow and exchange rate volatility. This is because higher exchange rate volatility leads to a higher cost for risk-averse traders and to lesser foreign trade (Arize et al., 2000). Several empirical studies indeed confirm the view that exchange rate volatility reduces international trade flow (see, *inter alia*, Chowdhury, 1993; Arize, 1995, 1998; and Arize et al., 2000). On the other hand, there are a number of papers which suggest that exchange rate volatility imposes a positive effect on international trade (see, Asseery and Peel, 1991; Franke, 1991; Giovannini, 1988; Sercu and Vanhulle, 1992; and Dellas and Zilberfarb, 1993). However, DeGrauwe (1988) argues that the relationship between exchange rate volatility and trade flow is analytically indeterminate.<sup>2</sup> Moreover, Sercu and Uppal (2003) show that the relationship between international trade and exchange rate volatility can be either negative or positive depending on the underlying source for the change in exchange rate volatility.

The conflicting results in the extant literature on international trade pose a very interesting empirical question which requires further empirical work on two dimensions: What is the effect of exchange rate volatility on international trade? Furthermore, what is the impact of the recent global financial crisis on international trade given that this period is associated with higher exchange rate volatility? Within this context, we make the following contributions to the literature.

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<sup>2</sup> Some previous studies have also documented little or no significant effect of the exchange rate variability on international trade (e.g., Koray and Lastrapes, 1989; Bahmani-Oskooee, 1991; and Gagnon, 1993).

First, we extend previous work and provide some new insights on the matter by investigating the impact of exchange rate volatility, together with real income and the relative import price, on UK imports from Germany, Japan and the US during the period January 1991-March 2013. The existing work on the relationship between UK imports and exchange rate volatility is rather limited and there is no consensus regarding whether it is positive or a negative one (see, Kroner and Lastrapes, 1993; Chowdhury, 1993; Qian and Varangis, 1994; Doyle, 2001; and Choudhry, 2005). We further study the potential reason for the direction of the relationship by investigating the price elasticity in the UK of the imports from these countries. Price elasticity of demand for UK imports has been estimated for all countries employing the Bahmani-Oskooee and Kara (2005) method. If imports are price elastic this implies that an increase in the import price relative to the domestic price is expected to depress import volume by a large amount, resulting in an inverse relationship between volatility and imports (Cushman, 1986 and Viaene and de Vries, 1992).

The aforementioned three countries are chosen because they are the major trading partners of the UK.<sup>3</sup> Figure 1 present the log of the UK imports from these three countries. In addition, the fact that they are geographically dispersed, adds value to the generality and significance of our main findings. Hence, it is of significance to investigate the effect of exchange rate volatility on UK trade.

Second, to our knowledge, this is the first study to explore the impact of the recent

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<sup>3</sup>Direction of trade data (IMF, 2012) reports that UK imports from these three countries represent 27% of its total imports and 34% of its imports from developed countries. Since 1993 Germany has been the top exporter to the UK based on annual imports data. The US was second until 2008 when China replaced it. Japan was the top exporter from Asian until 2003. Japan has remained the second top Asian exporter to the UK after China. UK imports from Germany, Japan and US mainly consist of capital goods. Major import sectors include: electrical/electronic equipment; machinery, nuclear reactors and boilers; optical/medical apparatus; precious metals and stones; aircraft/spacecraft and parts thereof; plastic and rubber articles, paper, paperboard, pulp and related articles; pharmaceuticals; vehicles; articles of iron and steel; mineral fuels, oils and distillation products (UN Comtrade, 2013). These sectors constitute more than 75% of UK import volume from these countries, respectively.

financial crisis on UK trade. This is of vital importance and provides new avenues for research especially due to the fact that during the crisis period volatility tends to increase (Fratzscher, 2009; Melvin and Taylor, 2009).<sup>4</sup> This part of the study also serves as a robustness check during a period characterized by heightened exchange rate volatility.

Third, unlike the majority of studies which generally focus on bilateral trade, we investigate the effect of the third country exchange rate volatility on UK imports. The third country effect is important from the point of view of competition as every exporting country is competing against other countries. Cushman (1986) argues that the effect of exchange risk on bilateral and aggregate trade flows should be analyzed by accounting for the impact of third-country exchange risk factors in addition to direct bilateral risk. Hence, this aspect of our analysis may have significant implications for understanding the relationship dynamics between exchange rate volatility and trade. Additionally, it allows us to offer some fresh evidence regarding the role of the third country effect and the channels (especially exchange rate volatility) through which the recent financial crisis has affected international trade flows (McKenzie, 1999; Bahmani-Oskooee and Hegerty, 2007; and Abiad et al., 2011).

Fourth, we extend the existing evidence by employing the asymmetric autoregressive distributed lag (ARDL) approach to cointegration advanced by Shin et al., (2013) as an extension of the linear cointegration technique proposed by Pesaran et al., (2001). Despite the well-known fact that macroeconomic variables possess asymmetric and non-linear features (Keynes, 1936; Kahneman and Tversky, 1979; Shiller 1993, 2005; Shin et al., 2013), research on the relationship between UK trade and exchange rate volatility has been tested only within

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<sup>4</sup> Along with global trade imbalances and credit crunch, other supply and demand side factors triggering massive decline in international trade that have been cited include: disruption of global value chains, rise in protectionism policies, disproportionate fall in the demand for tradable goods, inventory adjustments and postponement of durable goods purchases (Fratzscher, 2012; Evenett, 2009; Jacks et al., 2011; Alessandria et al., 2010; Yi, 2009; Behrens et al., 2013)

a linear framework so far.

Our key findings can be summarized as follows. Based on the asymmetric ARDL method, we find significant evidence of cointegration between UK real imports, exchange rate volatility, UK real income and relative import prices when Japan and the US are considered as UK's trading partners. This result holds in the pre-crisis period but it is also consistent when the crisis period is included in the sample suggesting the importance of the asymmetric long-run equilibrium relationship between UK real imports and its determinants. When the bilateral representation model is modified to account for the third country effect, we find strong evidence of cointegration confirming our prior belief that the third country exchange risk should be included in the model. This is especially true for Germany. The importance of exchange rate volatility and the third country effect is further confirmed by the estimated coefficients of the long-run asymmetric elasticities.

Finally, Granger causality tests suggest the importance of the determinant variables on UK imports in the long-run, a result that holds within the pre-crisis period and also when the crisis is included in the sample. Accounting for the third country effect, we find significant evidence of short-term causality from the relevant third country exchange rate volatility to UK imports (i.e. from the US dollar/British pound volatility when the US plays the role of the third country or from the Euro/British pound volatility in when UK imports from the US are considered).

The remainder of the paper is organized in the following manner. Section 2 provides a discussion which links exchange rate volatility and the recent financial crisis to international trade. Section 3 describes the data and the estimation of the exchange rate volatility while it also includes the unit root tests results. Section 4 offers the methodological approach and analyses the models employed in the paper. Section 4 also presents the results of the models

applied. Finally, the conclusion is presented in section 5.

## **2. Exchange Rate Volatility, Financial Crisis and the Effect on International Trade**

Financial crises have been a consistent element of the economic history. Reinhart and Rogoff (2009a, 2009b) have reported that since the 1970s debt and financial (banking) crises have been relatively more frequent. Periods of financial turmoil are generally followed by large and persistent declines in output and employment, deep and prolonged asset market downfalls and surge in government debt (see, Baldwin, 2009; and Abiad et al., 2011). However, the empirical evidence on the effects of the financial crisis on international trade is rather limited. Moreover, although periods of financial crises are characterised by heightened volatility which affects macroeconomic variables, very few papers have assessed the impact of such crises on trade flows through exchange rate volatility channels. For example, Abiad et al., (2011) employ data from 153 economies spanning the 1970-2009 period and report that exchange rate volatility is one of the most important intervening variables which can explain changes in imports and exports in pre/post financial crisis scenarios.

During the recent financial crisis highly volatile movements across all asset classes have occurred globally, including foreign exchange markets (Fratzscher, 2009; Melvin and Taylor, 2009). Fratzscher (2009) mentions three main factors which are responsible for the higher exchange rate volatility during this period. First, countries with large financial liabilities relative to the US experienced enormous currency depreciations. The second factor is the size of the foreign exchange (FX) reserves. As Fratzscher (2009) shows, the currencies of countries with FX reserves to GDP ratios below the cross-country average, declined by 23% on average, while the ones with higher than average reserves, depreciated only by 7% against the US dollar since the summer of 2008. Hence, countries with seemingly 'excessive' FX reserves were able to control the pressure on their respective currencies, while economies

where certain reserves were accumulated for precautionary motives could not absorb the shocks caused by the financial crisis. The third driving factor is the current account position; Countries with a higher than average current account position faced only a 10% depreciation against the US dollar whereas those with large current account deficits faced, on average, a depreciation of 22% between July 2008 and February 2009. The importance of the current account position in this context has also been stressed by Chor and Manova (2010). Given the above, our paper aims to fill the gap in the literature by analysing the relationship between UK trade and exchange rate volatility within the context of the recent financial crisis.

### **3. Data, Exchange Rate Volatility results and Unit Root tests**

The monthly data employed cover the period from January 1991 to March 2013.<sup>5</sup> The price indices are the import price indices for all four countries. The UK real income is represented by the real personal income. The nominal exchange rate applied is defined as the foreign currency per UK sterling. The corresponding real exchange rate is defined as the log of  $(ex-n)*(PUK/PF)$ , where  $ex$ -denotes the nominal exchange rate between the UK pound and the other currencies,  $PUK$  is the UK price index and  $PF$  is the price index of either Germany, Japan or the US. All data are obtained from the Thompson Financial DataStream.

The real exchange rate volatility is estimated by means of the univariate GARCH(1,1) model.<sup>6</sup> Table 1 present the univariate GARCH(1,1) estimations for all three real exchange rates.<sup>7</sup> In all three cases, the ARCH coefficient ( $\alpha_1$ ) is found to be significant implying

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<sup>5</sup> Trade data from Japan and Germany were only available until March 2013.

<sup>6</sup>Kroner and Lastrapes (1993), Caporate and Doroodian (1994), Lee (1999) and Choudhry (2005) also apply the volatility of exchange rate estimated from GARCH models in their study.

<sup>7</sup>In a GARCH(p,q) model, different combinations of p and q may be applied but, as indicated by Bollerslev et al. (1992, p. 10),  $p=q=1$  is sufficient for most financial and economic series. Tests in this paper were also conducted with different combinations of p and q with  $p=q=2$  being the maximum lag length. Results based on log-likelihood function and likelihood ratio tests indicate that the best combination is  $p=q=1$ . These results are



volatility clustering. Moreover, the Ljung-Box (1978) statistic fails to indicate any serial correlation in the standardized residuals and the standardized squared residuals at the 5% level using 6 lags. Absence of serial correlation in the standardized squared residuals implies the lack of need to encompass a higher order ARCH process (Giannopoulos, 1995).

[Inset Table 1 here]

Figure 1 shows the estimated volatility (conditional variance) with respect to all real exchange rates and log of real imports. The increase in volatility during the crisis period can be clearly observed for all exchange rates. Given this jump in the exchange rate volatilities, it is of interest to empirically examine to what extent UK imports have been affected by large exchange rate movements. It can be seen on all three graphs, the decline in imports as exchange rate volatility increased. These movements based on visual inspection advocates this empirical investigation. Based on the Jarque and Bera (1980) test, almost all series are found to follow a non-normal distribution. Most of the series have positive kurtosis and negative skewness. The basic statistics results are available on request.

As required by cointegration tests, first the order of integration of each series needs to be determined. This paper applies the augmented Dickey and Fuller (1979) test and the Kwiatkowski et al. (1992) (KPSS) test. The results indicate that most series are level non-stationary and that all first differenced series are stationary. The exchange rate volatilities are found to be stationary in levels and this is true also for the Japanese real income. These results are available on request.

## **4. Methodology**

### **4.1. Main Model Employed**

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available on request.

This paper employs a model similar to the one used in Arize et al. (2000) and Choudhry (2005). The following relationship is tested to check for the effects of exchange rate variability on the UK real imports:

$$\ln(m_t) = \delta_1 \ln(Y_t) + \delta_2 \ln(P_t) + \delta_3 \ln(V_t) + \varepsilon_t \quad (1)$$

where  $\ln(m_t)$  is the log of real UK imports from either Germany, Japan or the US,  $Y_t$  is the log of real UK income,  $P_t$  is a measure of relative imports prices from Germany or Japan or the US to the United Kingdom,  $V_t$  is the corresponding exchange rate volatility and  $\varepsilon$  is the error term. In this paper, the conditional variance of the first difference of the log of the exchange rate is applied as volatility. Equation (1) can be derived as a long-run solution of behavioural demand and supply functions for exports (Gotur, 1985). Based on the standard theory, the real income of the importing country should have a positive effect on the import level (Bailey et al. 1986, 1987). Thus, the coefficient on real income ( $\delta_1$ ) should be positive. The relative price is the ratio of the import prices of Germany or Japan or the US to the UK. Changes in the price ratio represents changes in the term of trade, reflecting the impact of changes in nominal exchange rates, differing rates of inflation among countries and changes in relative prices in each country between its non-traded goods and its exports (Bailey et al. 1986, 1987). According to Arize (1995) and Arize et al. (2000), the coefficient of the price ratio ( $\delta_2$ ) should be negative. As indicated by Bailey et al. (1986, 1987) and Arize (1995), the influence of the exchange rate variability ( $V_t$ ) on trade is uncertain. Investigation of the size and direction of the impact imposed by the exchange rate variability ( $V_t$ ) on the UK imports before and during the recent financial crisis is one of the main themes of our study. To empirically investigate further the effect of the recent financial crisis, we first estimate equation (1) by applying the asymmetric ARDL method during the 1991:01-2007:06 pre-crisis period. Subsequently, we add the crisis period to the sample (2007:07-2013:03) to

make the total period 1991:01 to 2013:03. If cointegration is confirmed, general-to-specific causality tests are conducted to study the direction of the effect between the variables during both in the long and in the short-run.

#### **4.2 Testing for the third country effect**

The literature on international trade predominantly assumes a two-country world (i.e. where the domestic market trades with only one foreign market). Therefore, almost all of models are based on the assumption that importers and exporters have to decide between doing business domestically or with the sole trading partner. However, this assumption is restrictive since in reality importers and exporters can select from many markets around the globe and they are not limited to just one trading partner. This modification in the traditional international trade theory warrants the inclusion of the third country effect as suggested by Bahmani-Oskooee and Hegerty (2007). According to Cushman (1986) this is a very important aspect in terms of global competition as changes caused in the trade pattern between two countries could be caused by exchange rate movements of another country's (not involved in the trade) currency against the home country. In other words, the exchange rate movement may divert importers in the domestic country from one trading partner to another. Similarly, exporters in the domestic country may decide to sell their products to another country due to better price prospects. Cushman (1986) and Li (2003) introduce another country (more generally rest of world) in order to understand the trade flows with relative volatilities of more than two currencies. Furthermore, they indicate the significance of controlling for comparative advantage of the third country.

To examine the impact of the third country exchange rate volatility on UK real imports, we modify Equation (1) in the following manner:

$$\ln(m_t) = \delta_1 \ln(Y_t) + \delta_2 \ln(P_t) + \delta_3 \ln(V_t) + \delta_4 \ln(TCV_t) + \varepsilon_t \quad (2)$$

where  $TCV$  is the third country exchange rate volatility. In tests between the UK and Germany or Japan, the third country exchange rate volatility is represented by the pound/dollar volatility. In tests between the UK and the US, the third country volatility is represented by the pound/euro variability. Similar to equation (1) and  $V_t$ , the conditional variance of the first difference of the log of the third country exchange rate is applied as volatility ( $TCV$ ). The third country exchange rate volatility should also increase during the global financial crisis. The sign on the coefficient  $\delta_4$  is also uncertain just as in the case of  $\delta_3$ . The other variables are defined as earlier. Equation (2) is also estimated by means of asymmetric ARDL method first for the pre-crisis period (1990-2007) and then the crisis period (2007-2013) is added for a re-estimation. Thus, we also investigate the effect of the crisis via the third country exchange rate volatility. The causality tests are further conducted to study the direction of the effect between the variables.

### **4.3. Asymmetric ARDL Approach and Results**

The long-run relationship between exchange rate volatility and UK's imports is explored using the nonlinear asymmetric ARDL method proposed by Shin et al., (2013).<sup>8</sup> Standard cointegration literature establishes the long and short-run relationship between different the variables. However, it implicitly assumes that this relationship is symmetric and the impact of positive and negative components within each independent variable is similar (Schorderet, 2001; Shin et al., 2013). This has led many researchers to explore asymmetries in the underlying relationship among various macroeconomic variables (Schorderet, 2001; Shin et al., 2013; Park and Phillips, 2001; Saikkonen and Choi, 2004; Escribano et al., 2006; and Bae and de Jong, 2007). Granger and Yoon (2002) introduced the "hidden cointegration" term which is attributed to long-run equilibrium relationship between positive and negative

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<sup>8</sup> This method has been applied in some of the recent studies such as Greenwood-Nimmo and Shin, 2011; Karantininis et al., 2011; Cho, Kim and Shin, 2012; Garz, 2012; Katrakilidis et al., 2012; Katrakilidis and Trachanas, 2012.

components of the underlying variables.

The first step of the Shin et al., (2013) method is to decompose all of the exogenous variables into partial sum processes. The partial sum processes are defined as follows:

$$x_t^+ = \sum_{j=1}^t \Delta x_t^+ = \sum_{j=1}^t \max(\Delta x_j, \bar{x}); \quad x_t^- = \sum_{j=1}^t \Delta x_t^- = \sum_{j=1}^t \min(\Delta x_j, \bar{x}) \quad (3)$$

Here  $\Delta x_t$  are the changes in independent variables ( $x_t$ ) whereas + and – superscripts indicate the positive and negative processes. In equation (3) above, threshold is set equal to mean of respective independent variables, which delineates the positive and negative shocks in the independent variables. Although ideally first differenced series should be normally distributed with zero mean, however financial time series often tend to have non-zero mean. In that case, setting zero threshold may bias the positive/negative partial sums, because the number of effective observations in the negative or positive regime may be insufficient for OLS estimator. Therefore, setting the threshold as the mean of the respective variables serves both types of series i.e. zero and non-zero mean series respectively (Shin et al., 2013).

Thus, the long-run relationship between UK imports and its determinants including the exchange rate volatility as described in equations (1) and (2) can be rewritten in terms of positive and negative partial sums in the following manner:

$$\ln(m_t) = \beta_0 + \beta_1^+ \ln Y_{F,t}^+ + \beta_2^- \ln Y_{F,t}^- + \beta_3^+ \ln P^+ + \beta_4^- \ln P_t^- + \beta_5^+ \ln V_t^+ + \beta_5^- \ln V_t^- + u_t \quad (4)$$

$$\ln(m_t) = \beta_0 + \beta_1^+ \ln Y_{F,t}^+ + \beta_2^- \ln Y_{F,t}^- + \beta_3^+ \ln P^+ + \beta_4^- \ln P_t^- + \beta_5^+ \ln V_t^+ + \beta_5^- \ln V_t^- + \beta_5^+ \ln TCV_t^+ + \beta_5^- \ln TCV_t^- + u_t \quad (5)$$

Here all the coefficients with “+” and “-” superscripts indicate the positive and negative partial sums for all the independent variables. These long run relationships can be further described in terms of the ARDL bounds testing approach to cointegration of Pesaran et al. (2001). Specifically, both level and first differenced variables are replaced by their respective

positive and negative partial sum representations. Hence, the error-correction version of equations (4) and (5) can be written as follows:

$$\begin{aligned} \Delta m_t = & \beta_0 + \beta_1 \sum_{j=1}^{n1} \Delta m_{t-j} + \beta_2^+ \sum_{j=0}^{n2} \Delta y_{F,t-j}^+ + \beta_3^- \sum_{j=0}^{n3} \Delta y_{F,t-j}^- + \beta_4^+ \sum_{j=0}^{n4} \Delta p_{t-j}^+ + \beta_5^- \sum_{j=0}^{n5} \Delta p_{t-j}^- \\ & + \beta_6^+ \sum_{j=0}^{n6} \Delta V_{t-j}^+ + \beta_7^- \sum_{j=0}^{n7} \Delta V_{t-j}^- \\ & + (\lambda_1 m_{t-1} + \lambda_2^+ y_{H,t-1}^+ + \lambda_3^- y_{F,t-1}^- + \lambda_4^+ p_{t-1}^+ + \lambda_5^- p_{t-1}^- + \lambda_6^+ V_{t-1}^+ + \lambda_7^- V_{t-1}^-) + u_t \end{aligned} \quad (6)$$

$$\begin{aligned} \Delta m_t = & \beta_0 + \beta_1 \sum_{j=1}^{n1} \Delta m_{t-j} + \beta_2^+ \sum_{j=0}^{n2} \Delta y_{F,t-j}^+ + \beta_3^- \sum_{j=0}^{n3} \Delta y_{F,t-j}^- + \beta_4^+ \sum_{j=0}^{n4} \Delta p_{t-j}^+ + \beta_5^- \sum_{j=0}^{n5} \Delta p_{t-j}^- \\ & + \beta_6^+ \sum_{j=0}^{n6} \Delta V_{t-j}^+ + \beta_7^- \sum_{j=0}^{n7} \Delta V_{t-j}^- + \beta_8^+ \sum_{j=0}^{n8} \Delta TCV_{t-j}^+ + \beta_9^- \sum_{j=0}^{n9} \Delta TCV_{t-j}^- \\ & + (\lambda_1 m_{t-1} + \lambda_2^+ y_{H,t-1}^+ + \lambda_3^- y_{F,t-1}^- + \lambda_4^+ p_{t-1}^+ + \lambda_5^- p_{t-1}^- + \lambda_6^+ V_{t-1}^+ + \lambda_7^- V_{t-1}^-) \\ & + \lambda_8^+ TCV_{t-1}^+ + \lambda_9^- TCV_{t-1}^- + u_t \end{aligned} \quad (7)$$

Similarly to earlier equations, all Greek letters with “+” and “-“ superscripts are positive and negative partial sum processes whereas “ $\Delta$ ” denotes the first difference of underlying variables. All other terms are defined as earlier. Long-run relationship coefficients are given by  $\lambda_i$ ,  $i=1, \dots, 7$  (equation 6) or  $i=1, \dots, 9$  (equation 7). Lags of  $I(1)$  or first differenced short run variables are determined using AIC/BC and number of lags used in the models are denoted by  $n_i$ ,  $i=1, \dots, 7$  (equation 6) or 9 (equation 7) above.

Following Schorderet (2001) and Shin et al., (2013) asymmetry hypotheses are tested for possible equality between positive and negative coefficients for each variable both in long and short-run scenarios respectively.<sup>9</sup> If the null hypothesis is rejected then these shocks are not equal in a statistical sense, which indicates the asymmetric nature of the relationship in

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<sup>9</sup>Shin et al., (2013) discuss two methods for computing critical p-values for hypotheses testing; i) non-parametric bootstrap method based on Monte Carlo simulations; and ii) pragmatic approach for selection of appropriate value of  $k$  (i.e. number of long-run regressors) which is the same as in the case of the (linear/symmetric) ARDL method by Pesaran et al. (2001). Shin et al., (2013) further show that both approaches lead to the same conclusions and that the pragmatic approach provides a more conservative test for long-run relationships in the context of the nonlinear ARDL approach.

the respective time horizon (long or short run). Specifically, this implies that both positive and negative components of the underlying independent variables have a different impact on the dependent variable and imposes long and short run equilibrium relationship between the positive and negative shocks with the dependent variable separately. The asymmetric effects may be associated both with the sign (direction) and the size (sensitivity) of the underlying coefficients. Hence this approach conveys much more information compared to standard (symmetric) long run equilibrium models where inference is limited to the average sensitivity among the variables and at times positive and negative changes could cancel out. However, the decomposition of each variable into positive and negative regimes inherits a lot more flexibility and captures the fluctuations simultaneously under both regimes.

The asymmetric ARDL cointegration results are shown in Tables 2 and 3. Tables 2A and 2B present the pre-crisis and the total period results respectively. Tables 3A and 3B show the corresponding results when we account for the third country effect in our model.

[Insert Tables 2 and 3 around here]

With the exception of Germany during the pre-crisis period, the results in Table 2 reveal long-run asymmetric cointegration or equilibrium relationship for all the countries across all periods. These results signify that all the variables including real exchange rate volatility have a significant impact in the long-run on the UK's demand for imported goods from Japan and the US across both samples and in case of Germany after inclusion of financial crisis period. More importantly, these relationships are asymmetric whereby the import demand responds differently to positive and the negative shocks to the independent variables. The cointegration results remain consistent for Japan and US during both the samples which show the consistency of the asymmetric long run equilibrium relationship between the underlying variables. However, the long-run relationship in case of Germany is only significant after

inclusion of the financial crisis period.<sup>10</sup>

Tables 3A and 3B include the third-country exchange rate risk as an additional determinant of UK's imports. The third country exchange rate risk is represented by the dollar-pound real exchange rate volatility when we consider UK imports from Germany and Japan whereas, in case the US is considered as the major trading partner, it is represented by the euro-pound real exchange rate volatility. Results indicate significant cointegration for three countries during both periods. This finding provides strong evidence in favor of the third-country exchange rate risk being an important determinant of UK imports. This is especially significant in the case of Germany where we fail to find cointegration without the third country risk before financial crisis.<sup>11</sup> The diagnostic test results reject the null hypotheses of serial correlation, heteroskedasticity and misspecification for these asymmetric ARDL estimates.

#### **4.4 The Normalized Equations and Long-Run Elasticities.**

Tables 4 and 5 present the normalized long run coefficients for the independent variables, under different hypotheses. Tables 4A and 4B tabulate the coefficients estimates from the pre-crisis period and the total period respectively without the third country risk. We only present the Japanese and the US results as no evidence of cointegration was found in the case of Germany. Asymmetric elasticities in the case of Japan and the US are mostly significant at the 1% or 5% conventional levels. We report more evidence of an inverse effect of the exchange rate volatility on the UK imports. We provide more evidence of the inverse relationship once the crisis period data are included. This result is in agreement with the

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<sup>10</sup> We also apply the symmetric ARDL method of Pesaran et al. (2001). Results indicate significant cointegration for Germany and the US during the pre-crisis period and for Japan and the US during the total period. These results are somewhat different from the asymmetric method involving Germany and Japan. They are available on request.

<sup>11</sup> The symmetric ADRL test indicates significant cointegration in all tests except for Japan during pre-crisis period. This result is similar to the asymmetric tests result. These results are available on request.



traditional theoretical inverse relationship between the exchange rate volatility and trade.

[Insert Tables 4 and 5 around here]

As stated earlier, to further strengthen the motivation for this research, we investigate the price elasticity of demand for UK imports from the three countries by employing the Bahmani-Oskooee and Kara (2005) method. If imports are price elastic this implies that an increase in the import price relative to the domestic price is expected to depress import volume by a large amount, resulting in an inverse relationship between volatility and imports. We find that prices are highly elastic in the cases of Germany and the US, which show that the demand for imports in UK is highly sensitive to the ratio between foreign and domestic goods prices. In the case of Japan, prices are less elastic but are not inelastic.<sup>12</sup>

Interestingly, after the inclusion of the third-country exchange rate risk, UK's imports respond differently to the two volatility variables (tables 5a and 5B). For example, in the case of Germany, real exchange rate (Euro-pound) volatility is significant and positive, whereas, the third country (dollar-pound) volatility coefficients are significant and negative. These findings imply that UK's imports from Germany increase with respect to euro-pound volatility while they decline in response to the dollar-pound volatility. The demand for Japanese exports in UK responds in a similar way. That is, positively to the yen-pound volatility and negatively to the dollar-pound volatility. In the case of the US, real exchange rate (dollar-pound) volatility has a significant negative impact while the third country exchange rate (euro-pound) volatility causes an increase in UK's imports from the US during the pre-crisis period and the one that includes the financial crisis. In terms of absolute value, the third country volatility imposes a larger effect for Germany and Japan. This clearly shows the importance of the dollar/pound exchange rate volatility. This result indicates the importance of taking into consideration the third country effect when investigating the

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<sup>12</sup> Price elasticity results are available on request.

relationship between exchange rate volatility and trade. The third country exchange rate volatilities become more positive when the crisis period data are included.

The above evidence provides an important insight as to how UK's imports from different countries respond to different exchange rate volatilities. In summary, the UK's imports respond negatively to the dollar-pound volatility whereas, the euro-pound and yen-pound volatilities cause an increase over both sample periods.

#### **4.5. Causality between Real UK Imports and its Determinants.**

Cointegration also implies that the transitory components of the series can be given a dynamic error correction representation, i.e. a constrained error correction model can be applied that captures the short-run dynamic adjustment of cointegrated variables.<sup>13</sup> The constrained error correction model allows for a causal linkage between two or more variables stemming from a common trend or equilibrium relationship. As long as two or more variables are cointegrated, causality must exist in at least one direction. The methodology applied in this paper follows the Hendry's (1987) "general-to-specific" paradigm.

To preserve space, we only provide a summary of the causality results. In all tests the coefficient on the error term is found to be negative and significant. This result implies that all the determinant variables affect the UK imports in the long run. The speed of adjustment as determined by the size of the coefficient on the error term ranges from 0.370 to 0.005 in absolute value. A coefficient of size 0.370 implies that 37% of the adjustment towards the long run equilibrium takes per month for UK imports from Japan during the pre-crisis period. The lowest speed of adjustment (0.005) is found in the case of UK imports from Japan in the presence of a third country effect during the pre-crisis period. The inclusion of the third country volatility reduces the speed of adjustment in the case of Japan. In most tests the speed

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<sup>13</sup> See Engle and Granger (1987) for a detailed discussion of the error correction modelling strategy based upon the information provided by cointegrated variables.

of adjustment increases from the pre-crisis to the total period (i.e. including the crisis period). There is a considerable decrease in the adjustment speed when the third country effect is included in the test. This is true for all countries during both periods. Our findings also provide ample evidence of short term causality from all the determinant variables to UK imports. The positive and negative change of real exchange volatility imposes short term causality on the UK imports for all three countries during both periods. This result provides further evidence which supports the importance of the exchange rate volatility in the estimation of the imports demand. Similar results are obtained when employing the third country exchange rate volatility for both periods. Including the third country exchange rate volatility does not diminish the importance of the real exchange rate volatility.

The Wald test is applied to test for the long and short run asymmetric effects and Tables 6 provides the results.

[Insert Table 6 around here]

The long and the short run asymmetry hypotheses are tested for possible equality between positive and negative coefficients for each variable and in both long and short run scenarios respectively. In case the null hypothesis is rejected and these shocks are not equal in a statistical sense, then this shows the asymmetric nature of the relationship in the respective time horizon (long or short run). The presence of long and short-run asymmetries imply that the positive and negative shocks to a single variable need to be modelled separately as both will affect the dependent variable differently. It means that the asymmetries may be in terms of both sign (direction) and size (sensitivity) of the coefficients.

Table 6A presents results without the third country exchange rate volatilities. The Wald-test statistics suggest that most of the positive and negative long run coefficients (elasticities) for each independent variable are significantly different from each other. This

means that positive and negative partial sums of each of these variables affect UK's imports differently. Hence, the long run equilibrium relationship between the underlying variables is asymmetric in most of the cases. More evidence of an asymmetric effect is found when the crisis period is added to the sample (Table 5B) and this is more pronounced in the case of the US. The real rate volatility is found to be asymmetric both in the long and in the short-run during both periods. The only exception is the US real exchange rate volatility which is symmetric with respect to the full sample but it exhibits long-run asymmetry within the pre-crisis period.

As shown in Table 7, including the third country effect enhances the evidence of the asymmetric effect. Nevertheless, the third country real volatility is found to be less asymmetric when the crisis period is added to the sample.

[Insert Table 7 around here]

The results derived above with respect to the asymmetric effect, offer a lot more information and a more in-depth examination compared to standard (symmetric) long-run equilibrium models where inference is limited to the average sensitivity among the variables. This is because in the latter case at times the positive and negative changes would cancel out, seriously limiting the inferential or forecasting capability of the underlying model.

## **5. Conclusion and Implication**

One of the major issues since the introduction of the flexible exchange rate is whether an increase in exchange rate volatility affects the international trade flow. This paper extends a relatively small body of work and investigates the effect of the exchange rate volatility on UK real imports from Germany, Japan and the US using monthly data from January 1991 to March 2013. As our sample includes the recent global financial crisis, it enables us to examine the issue within a period which is inherently associated with higher volatility.

Moreover, unlike most studies which focus on the bilateral trade between two countries, we additionally account for the third country effect (in terms of exchange rate volatility) in our analysis which is an important aspect from the point of view of competition. Moreover, we provide fresh evidence by employing the asymmetric autoregressive distributed lag (ARDL) approach to cointegration by Shin et al., (2013) which, to our knowledge, has not been applied in studies related to international trade. Causality tests are used to study the relationship between real imports and its determinants which are the real UK income, the import price ratio and the exchange rate volatility.

Our results from the ARDL method suggest that the long-run relationship between UK imports from the US and Japan and its determinants is significant and not affected by the financial crisis. This is also true when a third country exchange rate (between the euro and the pound) volatility is included in the relationship. The dollar-pound exchange rate volatility also shows the least volatility increase during the crisis. The demand for the German goods by UK consumers is influenced by the third country effect. A long run relationship between UK imports from Germany and its determinants is only confirmed when the dollar-pound exchange rate volatility is added as a determinant. Moreover, the normalized elasticity coefficients indicate a significant number of inverse relationships between exchange rate volatilities and the UK imports. The asymmetric elasticities in the case of Japan and the US are mostly significant while fewer are found to be significant with respect to Germany.

Finally, Granger causality tests show that the determinant variables are important factors for UK real imports across all cases. That is, UK real income, the import price ratio between the UK and its trading partner and the corresponding exchange rate volatility, are jointly important in determining UK imports. This result holds both during the pre-crisis period and during the full sample which includes the crisis period. Finally, the third country

volatility effect tests reveal a significant short-term effect of the USD/GBP exchange rate volatility on UK imports from Germany and Japan and of the Euro/GBP on UK imports from the US.

The results presented in our paper suggest that considering exchange rate volatility is important for modelling UK import behaviour especially during the recent crisis period. Any trade adjustment programmes by the UK that discourage import expansion could be unsuccessful if exchange rates and third country exchange rates are volatile. If policy makers ignore the variability of the nominal and real exchange rates between the British pound and German/Japanese/US currencies, policy actions aimed at stabilizing these import markets are likely to generate uncertain results. Our findings advocate further research in the field of the third country effect using data from other countries.

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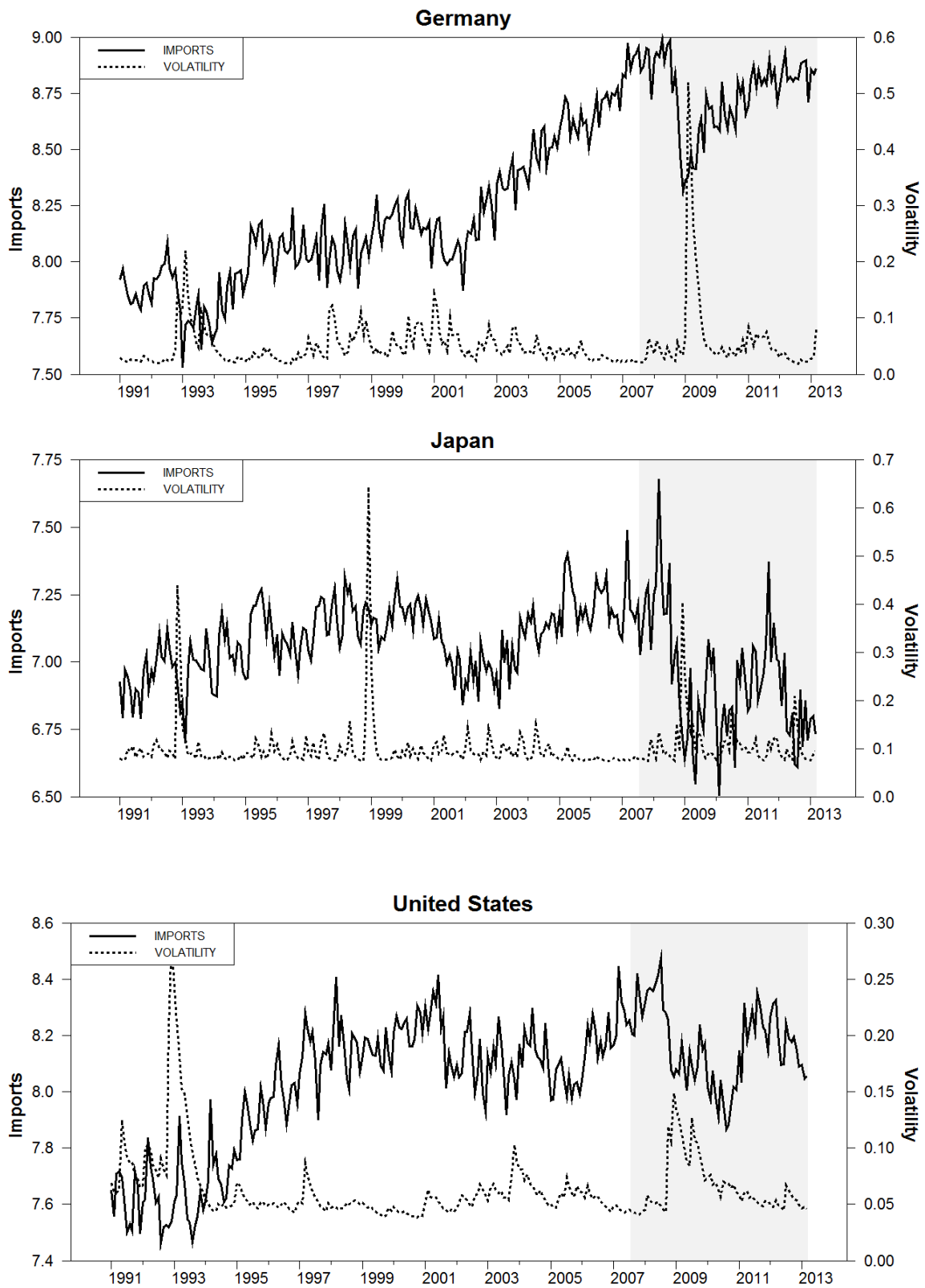
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**Figure 1: UK Imports and Real Exchange Rate Volatility (Jan-1991 to Mar-2013)**



This figure plots in the same space real exchange rates volatility and real UK imports with respect to the three trading partners. Shaded area represents financial crisis period.

**Table – 1: Univariate GARCH(p,q) Results for Real Exchange Rate Volatility**

Parameters	Germany	Japan	US
$\mu$	0.00117	0.0015	-0.00069
$\omega$	0.00008***	0.0005***	0.00007***
$\alpha\{1\}$	0.313***	0.1976***	0.0978***
$\beta\{1\}$	0.563***	0.2412***	0.7917***
<b>L</b>	684.34	573.02	634.86
<b>Std. Resids (Q-Stat,6)</b>	3.077	0.99	4.71
<b>Sq.Std.Resids (Q-Stat,6)</b>	4.827	1.92	1.79

1. \*\*\*,\*\* and \*: 1%, 5%, 10% imply significant levels respectively
2. L: Log Likelihood Function

This table presents the GARCH results with respect to real exchange rate volatility of all considered countries.

**Table – 2A: Asymmetric ARDL Results - Impact of Real Exchange Rate Volatility on UK Imports Before Financial Crisis (Jan-1991 to June-2007)**

Countries	F-stat	Diagnostics							
		R <sup>2</sup>	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
Germany	3.79	0.5932	0.00491	0.54489	5.45**	7.125	0.353	0.468	2.363
Japan	6.68***	0.437	0.0059	0.78134	2.78	14.62	1.745	2.26	3.22
US	4.65**	0.435	0.00587	0.41067	0.3722	8.591	0.78	0.216	3.71

**Table – 2B: Asymmetric ARDL Results - Impact of Real Exchange Rate Volatility on UK Imports during total period (Jan-1991 to March 2013)**

Countries	F-stat	Diagnostics							
		R <sup>2</sup>	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
Germany	4.14*	0.57	0.21	11.96	0.413	11.90	2.4	1.1	4.56
Japan	10.56***	0.568	0.126	1.69	1.28	10.47	1.52	0.922	1.35
US	4.63**	0.45	0.0783	0.098	1.27	4.67	2.152	0.162	1.27

Note:

\*\*\*, \*\*, and \* rejection of the null of no cointegration at the 1%, 5% and 10% level respectively.

SSE = Standard Error of Estimate, SSR= Sum of Squared Residuals, JB= Jarque-Bera Test, LB(12)= Ljung-Box test for autocorrelation upto 12 lags, RESET(3) = Ramsey's Specification Test, ARCH(1) and (3)= Autoregressive Conditional Heteroskedasticity for 1<sup>st</sup> and 3<sup>rd</sup> orders.

**Table – 3A: Asymmetric ARDL Results - Impact of Real Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk Before Financial Crisis (Jan-1991 to June-2007)**

Countries	F-stat	Diagnostics							
		R <sup>2</sup>	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
Germany	5.37**	0.58057	0.00506	0.43029	0.95701	10.20193	1.651	0.980803	4.245099
Japan	10.56**	0.56	0.083	1.69	1.28	10.47	1.52	0.92	1.35
US	3.79*	0.45	0.073	1.27	3.76	4.67	2.15	0.16	1.27

**Table – 3B: ARDL Results - Impact of Real Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk during the total period (Jan-1991 to March 2013)**

Countries	F-stat	Diagnostics							
		R <sup>2</sup>	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
Germany	4.15**	0.54	0.00519	0.855	0.702	13.54	1.27	0.118	1.56
Japan	4.55**	0.47	0.00848	1.17	1.07	4.79	0.239	3.33	4.71
US	5.44***	0.44	0.00543	0.755	1.06	11.89	0.969	0.093	5.43

See Note at the end of table 2

**Table – 4A Normalized Coefficients - Impact of Real Exchange Rate Volatility on UK Imports Before Financial Crisis (Jan 1991 – June 2007)**

Countries	Constant	Real Income		Relative Prices		Real Volatility	
		Positive	Negative	Positive	Negative	Positive	Negative
Japan	6.969***	5.977***	-0.635**	-0.1383	0.7812	-2.007***	0.878***
US	6.785***	2.616**	5.552***	11.723***	12.926***	-26.250	-27.921

**Table – 4B Normalized Coefficients - Impact of Real Exchange Rate Volatility on UK Imports during the total period (Jan 1991 – March 2013)**

Countries	Constant	Real Income		Relative Prices		Real Volatility	
		Positive	Negative	Positive	Negative	Positive	Negative
Germany	7.55***	6.03***	-1.85***	-2.026***	2.697***	-3.277***	-3.348***
Japan	6.98***	3.35***	0.913***	-215**	0.366***	-0.663***	-0.511***
US	7.62***	-0.438	5.49***	2.261***	-1.557***	-7.535***	-7.52***

Note:

\*\*\*, \*\*, and \* imply significance at the 1%, 5% and 10% level respectively.

Tables 4 (A-B) show normalized long run coefficients for “Positive” and “Negative” components (as discussed in section 4.4) of each independent variables, under Asymmetric ARDL approach suggested by Shin et al. (2013) approach.

**Table – 5A Normalized Coefficients - Impact of Real Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk Before Financial Crisis (Jan 1991 – June 2007)**

Countries	Constant	Real Income		Relative Prices		Real Volatility		Third Country Real Volatility	
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative
Germany	8.605***	-3.42***	2.311*	7.527***	-51.58***	5.403***	6.464***	-	-
Japan	7.76***	-2.17***	0.17	1.297***	5.909***	4.477***	1.787*	-15.4***	-14.9***
US	7.736***	2.787***	1.501*	4.379***	27.28***	-9.38***	-9.39***	3.987***	2.808**

**Table – 5B Normalized Coefficients - Impact of Real Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk during the total period (Jan 1991 – March 2013)**

Countries	Constant	Real Income		Relative Prices		Real Volatility		Third Country Real Volatility	
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative
Germany	7.72***	-9.9***	-4.15***	4.34***	1.40***	-4.96***	-4.88***	5.23***	3.45***
Japan	7.14***	0.47	-0.45	0.13	1.27***	3.29**	3.05**	1.43**	-0.43***
US	7.79***	1.44**	3.94***	1.60***	-1.74***	-5.67***	-5.03***	5.76***	6.51***

See note at the end of table 4

**Table 6A Impact of Real Exchange Rate Volatility on UK Imports before Financial Crisis (Jan 1991 to June 2007)**

Countries	Real Income		Relative Prices		Real Volatility	
	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm
Japan	93.77***	19.26***	-	19.4***	104.20***	16.58***
US	3.154*	0.028755	0.039	1.747	30.50***	0.067

**Table 6B Impact of Real Exchange Rate Volatility on UK Imports during total period (Jan 1991 to March 2013)**

Countries	Real Income		Relative Prices		Real Volatility	
	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm
Germany	8.83***	2.8*	12.6***	0.61	5.73***	18.02***
Japan	6.20***	3.042***	9.21***	4.276***	7.63***	10.27***
US	10.61***	11.88***	11.74***	0.074	0.055	52.107***

Notes:

Tables 6A and 6B show the Wald test results to test asymmetry hypotheses, where the null hypotheses posits that the positive and negative components of each independent variables have same effect on the dependent variable (UK Imports). \*\*\*, \*\* and \* imply rejection of the null of non-asymmetric at the 1%, 5% and 10% levels respectively.

**Table 7A**      **Impact of Real Exchange Rate Volatility on UK Imports in the Presence of Third-Country Exchange Rate Risk before Financial Crisis (Jan 1991 to June 2007)**

Countries	Real Income		Relative Prices		Real Volatility		Third Country Real Volatility	
	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm
Germany	22.13***	0.183	29.7***	10.4***	157.3***	--	15.2***	13.925***
Japan	53.69***	8.58***	3.327**	25.1***	17.52***	7.144***	36.2***	10.283***
US	0.568	1.302	16.7***	12.3***	89.96***	8.159***	61.1***	22.159***

**Table 7B**      **Impact of Real Exchange Rate Volatility on UK Imports in the Presence of Third-Country Exchange Rate Risk during the total period (Jan 1991 to March 2013)**

Countries	Real Income		Relative Prices		Real Volatility		Third Country Real Volatility	
	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm
Germany	4.56**	7.56***	5.47***	6.71**	5.58***	15.57***	7.76***	7.03***
Japan	6.31***	0.049	10.7***	8.39***	9.92***	0.57***	11.53** *	9.57***
US	9.07***	9.91***	8.92***	10.58***	7.56***	6.41**	11.7***	7.2***

See note at the end of table 6