Paper:
Choudhry, T. & Hassan, S. (2015). Exchange rate volatility and UK imports from developing countries: The effect of the global financial crisis. *Journal of International Financial Markets, Institutions and Money, 39*, 89-101.
http://dx.doi.org/10.1016/j.intfin.2015.07.004

Exchange Rate Volatility and UK Imports from Developing Countries: Effect of the Global Financial Crisis

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Abstract
This paper studies the role of exchange rate volatility in determining the UK's real imports from three major developing countries - Brazil, China, and South Africa. The paper contributes to the literature by investigating the third country effect and also by analyzing the impact of the current financial crisis on the relationship between exchange rate volatility and UK imports. This paper further expands the empirical literature on the subject by offering evidence based on the Asymmetric ARDL method by applying monthly data from January 1991 to December 2011. Results suggest that exchange rate volatility plays an important role in determination of trade and also reveal a significant effect of the recent financial crisis on UK imports. This finding remains consistent when we test for the third country volatility effect. We also find that there is a significant causal relationship between exchange rate volatility and UK imports. The third country effect is significant for all the countries. These results have significant implications for the trade policy and international trade in minimizing the underlying risk factors and ensuring stable trade flows in different economic scenarios.

JEL Classification: F1, F10

Keywords:
Real imports
Exchange Rate Volatility
Asymmetric Cointegration
Financial Crisis

Date: 31 March 2015

1. Introduction

After the collapse of the fixed exchange rate system under the Bretton Wood agreement in 1973, exchange rates for many currencies started to fluctuate, exposing traders to enormous uncertainty regarding their trade volumes and profitability (McKenzie, 1999;

Bahmani-Oskooee and Hegerty, 2007). The risk of unexpected movements in the exchange rates deters the risk-averse exporters, resulting in a decline in the output level on their part (McKenzie, 1999; Bahmani-Oskooee and Hegerty, 2007); therefore, an increase in the exchange rate uncertainty translates into a profit risk for the exporter. Assuming the exporters are risk averse, and considering the non-diversifiable nature of exchange rate risk, increase in the profit risk reduces the benefits and therefore the volume of trade (Ethier, 1973; Blanchard et al., 2005; Obstfeld and Rogoff, 2005). This paper contributes to the literature by investigating the effect of exchange rate volatility (uncertainty) on the UK imports from three major developing trade partners - Brazil, China, and South Africa.

Theorists have presented various models to explain the basis and dynamics of the relationship between exchange rate volatility and international trade. The basic hypothesis found in early literature is that exchange rate volatility reduces international trade (Ethier, 1973; McKenzie, 1999; Krugman, 2007). This hypothesis assumes that the international traders are risk averse and that, in the wake of increased volatility, these traders will reduce their level of output leading to a reduction in international trade. A positive impact of volatility on international trade has also been hypothesized by a number of studies (McKenzie, 1999; Bahmani-Oskooee and Hegerty, 2007). However, DeGrauwe (1988) argues that the relationship between exchange rate volatility and trade flow is analytically indeterminate.[1] 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 of the change in exchange rate volatility.

According to Bahmani-Oskooee and Hegerty (2007), much of the existing evidence on the subject is limited to just two economies, which does not reflect the real-world scenario where every economy is competing against many other economies in its respective region as

[1]Some previous studies have also documented little or no significant effect of the exchange rate variability on international trade (see Koray and Lastrapes, 1989; Bahmani-Oskooee, 1991;and Gagnon, 1993).

well as globally. Similar arguments have also been documented by Cushman (1986) and McKenzie (1999); according to these studies, third country effect[2] is important from the point of view of competition in the global business as every exporting country is competing against many other countries. According to Cushman (1986) this is a very important aspect in terms of global competition as changes in the trade pattern between two countries could be due to the exchange rate movements of another country's currency (not involved in the trade) against that of the home country. In other words, the third country 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. Against this background this paper further contributes to the UK trade literature by including the third country effect for the UK imports from developing countries.

Another important limitation identified in the literature by McKenzie (1999), Bahmani-Oskooee and Goswami (2004), Bahmani-Oskooee and Ardalani (2006), and Bahmani-Oskooee and Hegerty (2007) and is the application of the methodological. Many studies to date have relied on the standard cointegration methods which require all variables to be I(1) or nonstationary at level. However, exchange rate volatility is usually stationary at level. Given the mixed scenario of I(0) and I(1) series, Bahmani-Oskooee and Hegerty (2007) have suggested the use of the ARDL (Bounds Testing Approach) proposed by Peseran et al. (2001). This paper further contributes to this work by applying the asymmetric ARDL method (Shin et al., 2013).

The recent financial crisis has caused highly volatile shocks across all asset classes globally, including foreign exchange markets (Fratzscher, 2009; Melvin and Taylor, 2009). Many researchers have classed this crisis as more severe than the Great Depression of the 1930s, both in terms of its longevity and the extent of severity in economic and social costs

[2] Third country effect is the change in the trade between two countries due to the exchange rate movement of a third country not involved in the trade (Cushman, 1986).

and in policy interventions by governments around the globe (Fratzscher, 2009, 2012). This provides sufficient motivation for analyzing the impact of the financial crisis on the relationship between exchange rate volatility and the UK's imports. As the existing literature in this area provides very little evidence in this context, this research aims to make a significant contribution in this field.

Thus, this paper makes four key contributions to the literature. First, we study the effect of the exchange rate volatility on the UK imports from developing countries. To the best of our knowledge this is the first empirical study involving UK trade with developing countries. Second, we also study the third country effect on the volatility and import relationship. Thirdly, we investigate the effect of the financial crisis on the relationship between volatility and UK imports with and without the third country effect. Finally, we also make a contribution based on the econometrical model we apply, the Asymmetric ARDL model.

Results, based on Asymmetric ARDL, confirm the long-term relationship between UK imports and exchange rate volatility along with other determinant variables such as the UK's real income and the relative import price ratio. These relationships hold irrespective of the exchange rate volatility (nominal or real) and the time period selected, i.e. before or after the inclusion of the financial crisis period. Normalized coefficients for the nominal and real exchange rate volatilities show a large number of inverse relationships. With respect to third country exchange rate volatility, which for developing countries is represented by the USD/GBP volatility, this has a negative impact on imports from Brazil, China and South Africa in almost all the tests. Other determinant variables such as real income and relative price ratio are also significant in most of the tests. Import demand elasticity towards all regressors, particularly real income and exchange rate volatility, significantly changes across both data samples, i.e. before and after the financial crisis. More importantly, the results show strong evidence of asymmetric behavior in the underlying independent variable for all countries; to our knowledge no evidence is available in the existing literature to this effect. Furthermore, the incidences of long-term asymmetry increase after the inclusion of the financial crisis which shows that the structural shift in the long run relationship between these variables was caused by this crisis. These findings also hold in the presence of third country exchange rate risk.

The remainder of the paper is organized in the following manner. Discussion in section 2 links the exchange rate volatility and the recent financial crisis to international trade. Section 3 describes the data and the estimation of the exchange rate volatility as well as the unit root tests results. Section 4 offers the methodological approach and discusses the results obtained. Finally, the conclusion is presented in section 5.

2. Exchange Rate Volatility, UK Imports and the Recent Financial Crisis

According to Fratzscher (2009), three main factors were responsible for the exchange rate volatility during the current financial crisis. The first is the enormous currency depreciations against the US dollar borne by various countries that had large financial liabilities relative to the US, particularly those countries where US investors had heavily invested both in equity and fixed income securities markets. The second factor is the size of the foreign exchange reserves. The currencies with FX reserves to GDP ratios below cross-country averages declined by 23%, while those above the threshold only depreciated by 7% against the US dollar during the period July 2008 to January 2009 (Fratzscher, 2009). A similar increase in the FX reserve was also observed during the past two decades, particularly with central banks in the emerging markets. Countries with seemingly ‘excessive’ FX reserves benefitted by controlling the pressure on their respective currencies, while countries where certain reserves were accumulated for precautionary motives were not able to successfully absorb the shocks of the financial crisis. Lastly, the third driving factor is the current account position, as countries with higher cross countries averages faced only 10% depreciation against the US dollar whereas those with below average current account balances, on average, were faced currency depreciated of 22% (Fratzscher, 2009). The importance of current account position in this context has also been stressed by Chor and Manova (2012).

Few studies, however, have analyzed the impact of the financial crisis on international trade. Moreover, papers assessing the effect of the financial crisis on trade flows through exchange rate volatility channels are even more rare (Abiad et al., 2011). This paper takes steps to fill this gap in the literature.[3]

3. Models, Data and Methodology

3.1 Models

Demand for imports is generally modeled as any other demand model, that is, import demand is inversely related to price and positively affected by the income of the importing country. Hence the basic models for import demand cited in many of the research studies are as follows:

$$ln\ (M_t) = \beta_0 + \beta_1 \ln(Y_{H,t}) + \beta_2 \ln(P_t) + \beta_3 \ln(V_t) + \eta_t \quad (1)$$

$$ln\ (M_t) = \beta_0 + \beta_1 \ln(Y_{H,t}) + \beta_2 \ln(P_t) + \beta_3 ln(V_t) + \beta_4 ln(TCV_t) + u_t \quad (2)$$

[3] Abiad et al. (2011), using data from the last 40 years, have attempted to explain various channels through which the financial crises may have affected the imports/exports around the globe. They have reported that, alongside other variables, exchange rate volatility is one of the more important intervening variables explaining the changes in the trade flows in the pre-/post-financial crisis scenarios. Other channels include a reduction in output, global/regional demand and protectionism, etc.

where $\ln(M_t)$ is the natural log of the UK imports and $\ln(Y_{H,t})$ is the natural log of income of the home (H) country (which is UK throughout this research). P_t and V_t denote the relative prices and exchange rate volatility between the UK and its trading partners, respectively. Lastly, β_i and α_i represent model parameters. Equation (1) can be extended in the form of equation (2), to include the third country exchange rate volatility (TCV) as an additional determinant of imports. The third country exchange rate volatility is represented by the volatility of the exchange rate between the US dollar and the UK pound. In this paper, the conditional variance of the first difference of the log of the exchange rate is applied as volatility. The conditional variance is estimated by means of the GARCH(1,1) model. Equation (1) can be derived as a long-run solution of behavioral supply and demand functions for exports (Gotur, 1985) and 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 (β_1) is expected to be positive. Changes in the price ratio represent changes in the terms 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). The coefficient on the price ratio (β_2) should be negative (Arize, 1995; Arize et al., 2000). As indicated by Bailey et al. (1986, 1987) and Arize (1995), the influence of the exchange rate volatility (β_3) on trade is uncertain. Similarly, the sign on the coefficient $\beta_4$on the third country exchange rate volatility is also uncertain.

To empirically investigate the effect of the recent financial crisis, we first estimate equations (1) and (2) by applying the Asymmetric ARDL method during the pre-crisis period (January 1991-June 2007). Subsequently, we add the crisis period to the sample (July 2007 – December 2011) to construct the total period January 1991-December 2011. In this manner, we are able to investigate the impact of the global financial crisis on the relationships. This approach serves as a useful robustness check in our study given that the crisis period is characterized by heightened volatility. If cointegration is confirmed, general-to-specific causality tests are conducted to study the direction of the effect between the variables over both the long term and the short term.

3.2 Data

This paper uses seasonally adjusted monthly data from January 1991 to December 2011, obtained from the DataStream. The UK is considered to be the home country and three of its trade partners from developing countries - Brazil, China, and South Africa – make up the research sample.[4] The sample countries are geographically dispersed in order to cover different regions around the globe. To the best of our knowledge this is the first study of the dynamics of UK trade with developing countries. Figure 1 present the log level of real UK imports from these countries. This figure clearly shows the high growth of imports from these countries over the year; this is particularly true in the case of China. The shaded region represent the crisis period. The decrease in the growth of imports is visible during the crisis period; this is particularly true in the case of South Africa. Given the change in the imports during the crisis period, it is of empirical interest to study the effect of the crisis on UK imports.

Research variables comprise bilateral monthly imports, relative import price ratios, the UK's real income, and exchange rates both in nominal and real terms. These variables represent the standard import demand function widely cited in the literature (Gotur, 1985; McKenzie, 1999; Choudhry, 2005; Bahmani-Oskooee and Hegerty, 2007; Choudhry, 2008).

[4] Major imports from Brazil, China and South Africa to the UK include precious metals and stones; aircraft/spacecraft and parts thereof; pulp and related articles; machinery and nuclear boilers; ores, slag and ashes; edible nuts, oil, food grains and meat; and toys and games, etc (China only). These sectors represent more than 60% of UK imports from these developing countries (UN Comtrade, 2013).

Thus, the log of monthly UK imports from Brazil, China and South Africa are the dependent variables in all the hypotheses tested and the empirical estimations.

Among the independent variables, real income is represented by the UK's index of industrial production. Similarly, relative prices are calculated as ratio between the log of import price indices of the UK and each of the sample countries. Exchange rates, in terms of both nominal and real for each country, represent a ratio of their respective currency exchange rates in terms of the British Pound (£). The third country exchange rate volatility is represented by the US dollar and UK pound rate volatility; the nominal exchange rate applied is defined as the unit of foreign currency per UK pound; and the corresponding real exchange rate is defined as the log of (ex-n)*(PUK/PF), where ex-n 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 the respective foreign country in the sample.[5]

Basic statistical analysis of the variables shows that the means of the log-level variables are positive for all the countries. In terms of normality of the underlying variables, the null hypothesis of normality under the Jarque-Berra test is rejected in most of the cases, implying that a large number of the variables exhibit non-normal distribution. These basic statistics are available on request.

Unit root tests results show the log-level variables contain a unit root as indicated by various forms of the Augmented Dickey-Fuller (ADF) test at 1% or 5% significance levels. Similarly the null hypothesis of stationarity under the KPSS test is rejected up to the 10% level for the majority of log-level variables. In case of the first-difference variables, the null hypothesis of the unit root is rejected under the ADF test at the 1% significance levels. These results have been confirmed in the majority of cases using the KPSS test where most of the first-difference variables are found to be stationary. However, some conflicting results have

[5]We only present the results using the real rates in order to save space. Results using the nominal rates are similar and are available from the authors on request.

been reported for the log-level Brazilian imports, both nominal and real exchange rates, where applying the ADF tests, variables are found to be I(0) whereas under KPSS they are reported to be nonstationary, or vice versa. As the ARDL framework does not warrant distinguishing between I(0) stationary and I(1) unit root variables, we are not concerned regarding the stochastic structure of the variables. These results are not presented here in order to save space but are available from the authors on request.

As stated above, the real exchange rate volatility is estimated by means of the univariate GARCH(1,1) model.[6] Table 1 presents the univariate GARCH(1,1) estimations for all three real exchange rates.[7] In all cases, the ARCH coefficient (α_1) is found to be significant, implying volatility clustering. The GARCH coefficient (β_1) is also significant in all tests, indicating persistent volatility. 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 six lags. Absence of serial correlation in the standardized squared residuals implies the lack of need to encompass a higher order ARCH process (Giannopoulos, 1995). Unit root tests results of the real exchange rate volatilities indicate that all three volatilities are found to be stationary at level and first difference, which is confirmed by both the ADF and KPSS tests. These results are available on request.

3.3 Asymmetric ARDL Method

The long-term relationship between exchange rate volatility and the UK's trade flows is explored using the nonlinear asymmetric ARDL method proposed by Shin et al. (2013)[8].

[6]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 studies.

[7]We considered different combinations of *p* and *q* lags with 2 being set as the maximum lag length. However, the results based on the log-likelihood function and the likelihood ratio tests indicate that the best (p,q) combination is when p=q=1, except for the UDS/GBP exchange rate. These results are available on request.

[8]This method has been cited in some of the recent studies such as Greenwood-Nimmo and Shin (2011), Karantininis, Katrakylidis and Persson (2011), Cho, Kim and Shin (2012), Garz (2012), Katrakilidis, Lake and Trachanas (2012) and Katrakilidis and Trachanas (2012).

This model provides a flexible and efficient framework for analyzing both long- and short-run asymmetries between the independent and dependent variables.

According to Keynes (1936), macroeconomic variables can shift suddenly from an expansionary state to a recessionary form. However, there may be hardly any sharp turning points in the opposite scenario - i.e. when downward movement in these variables is replaced by an upward trend. This dissimilarity in the variables shifting between different states over a period of time has given rise to the need to model asymmetry and nonlinearity in order to improve our understanding of long-term relationships between various macroeconomic variables (Kahneman and Tversky, 1979; Shiller, 1993, 2005; Shin et al., 2013).

Another important issue identified in a similar context has been the time-varying stochastic distribution of time series, whereby these variables demonstrate non-ergodic behaviour, put more simply, these variables are mostly found to be nonstationary (Brooks, 2008; Taylor, 2011). The nonstationary and integration order problem has been discussed in the cointegration literature whereas nonlinearity and asymmetry have been addressed mainly in regime-switching models.

According to Schorderet (2001) and Shin et al. (2013), standard cointegration implicitly assumes a symmetric relationship between the underlying variables; that is, both positive and negative components within each exogenous variable affect the dependent variable in a similar fashion. Many researchers consider this assumption incorrect and have provided evidence of asymmetric relationship among major macroeconomic variables (Park and Phillips, 2001; Schorderet, 2001; Saikkonen and Choi, 2004; Escribano et al., 2006; Bae and De Jong, 2007; Shin et al., 2013). Granger and Yoon (2002) coined the term "hidden cointegration" which describes the long-term equilibrium relationship between the positive and negative components of the underlying variables.

Regime-switching models, on the other hand, are based on the view that linear models are inadequate to provide a strong inference, or to yield consistent and reliable forecasts, because the linearity assumption may be restrictive in most of the macroeconomic scenarios, hence leading to incorrect forecasts and inferences (Shin et al., 2013). Although over the years various studies have attempted to address these problems of asymmetry, nonlinearity and non-stationarity, the focus of these studies has been limited to only one or some of these problems.

It is shown that the Asymmetric nonlinear ARDL method proposed by Shin and colleagues (2013) can deal with/can be applied to the above three areas. This model uses the ARDL bound-testing approach (Pesaran et al., 2001) for testing long-term equilibrium relationships between the underling variables irrespective of the order of integration of the regressors, that is, I(0) or I(1) or a mix of both, and nonlinearity and asymmetry are modeled using the partial sum processes approach (Schorderet, 2001).

The first step under this method is to decompose all of the exogenous variables into partial sum processes. This decomposition may be illustrated using the following asymmetric regression (equation 3) (Schorderet, 2001),

$$y_t = \alpha_0 + \beta^+ x_t^+ + \beta^- x_t^- + u_t \qquad (3)$$

where the independent variable x_t is decomposed into partial sum processes x^+ and x^- for positive and negative changes in x_t respectively. This decomposition applies to the variables irrespective of their order of integration and can be used in the cases of both I(0) and I(1) variables. The following defines both processes:

$$x_t^+ = \sum_{j=1}^{t} \Delta x_t^+ = \sum_{j=1}^{t} \max(\Delta x_j, 0); \; x_t^- = \sum_{j=1}^{t} \Delta x_t^- = \sum_{j=1}^{t} \min(\Delta x_j, 0) \qquad (4)$$

Here, $\triangle x_t$ are the changes in x_t whereas + and – superscripts indicate the positive and negative processes. In equation (4) above, the threshold is set to zero, which delineates the positive and negative shocks in the independent variables. Although, ideally, first-difference series should be normally distributed with a zero mean, financial time series often tend to have non-normal distribution, which implies a non-zero mean for the underlying variables. In that case, depending upon the sign and size of the mean, setting zero as the threshold may bias the positive/negative partial sums, because the number of effective observations in the negative or positive regimes may be insufficient for the OLS estimator. Therefore, setting the threshold as the mean of the respective variables may resolve this issue as it will serve in both types of series, i.e. zero and non-zero mean series (Shin et al., 2013). Thus, equation (4) above may be rewritten in the following manner to set the mean as the threshold level:

$$x_t^+ = \sum_{j=1}^{t} \Delta x_t^+ = \sum_{j=1}^{t} \max\left(\Delta x_j, \bar{x}\right);\ x_t^- = \sum_{j=1}^{t} \Delta x_t^- = \sum_{j=1}^{t} \min\left(\Delta x_j, \bar{x}\right) \qquad (5)$$

Thus, the long-term relationship described above in equations (1) and (2) can be rewritten in terms of positive and negative partial sums in the following manner:

$$ln(M_t) = \beta_0 + \beta_1^+ lnY^+{}_{H,t} + \beta_2^- lnY^-{}_{H,t} + \beta_3^+ ln\mathrm{P}^+ + \beta_4^- ln\mathrm{P}_t^- + \beta_5^+ V_t{}^+ + \beta_5^- V_t{}^- + u_t \qquad ($$

$$\begin{aligned} ln(M_t) = {} & \beta_0 + \beta_1^+ lnY^+{}_{H,t} + \beta_2^- lnY^-{}_{H,t} + \beta_3^+ ln\mathrm{P}^+ + \beta_4^- ln\mathrm{P}_t^- + \beta_5^+ V_t{}^+ + \beta_5^- V_t{}^- \\ & + \beta_5^+ TCV_t{}^+ + \beta_5^- TCV_t{}^- + u_t \end{aligned} \qquad ($$

Here all the coefficients with “+” and “-”superscripts indicate the positive and negative partial sums for all the independent variables. These long-term relationships can be further described in terms of the error correction method, where all the level and first-difference variables are replaced by their respective positive and negative partial sums in levels as well as in first-difference form. Hence, the error-correction versions of equations (6) and (7) are as follows:

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

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

Similar to the earlier equations, all Greek letters with "+" and "-" superscripts are positive and negative partial sum processes whereas "△" denotes the first difference of the underlying variables. All other terms are as already defined above. Long-term relationship coefficients are given by $\lambda_{1 \ldots 7 \text{ or } 9}$. Lags of I(1) or first-difference short-term variables are determined using AIC/BC and the number of lags used in the models are denoted by $n_{1 \ldots 7}$ or $_{9}$ above.[9]

Following Schorderet (2001) and Shin et al. (2013), the long- and short-term asymmetry hypotheses are tested for possible equality between the positive and negative coefficients for each variable and in both the long- and short-term scenarios. If the null hypothesis is rejected and these shocks are not equal statistically, then this shows the asymmetric nature of the relationship in the respective time horizon (long or short term). It

[9]The number of terms in equation (8) is seven whereas in equation (9) the number of terms is nine for both the long- and short-term variables.

implies that both positive and negative components of the underlying independent variables have different impacts on the dependent variable hence imposing long- and short-term equilibrium relationships between the positive and negative shocks with the dependent variable separately.

The presence of long- and short-term asymmetries implies that the positive and negative shocks to a single variable should be modeled separately as both will have a different effect on the dependent variable. This means that variability may be found in terms of both the sign (direction) and size (sensitivity) of the coefficients. This information enables more inference to be made compared to the standard (symmetric) long-term equilibrium models where inference is limited to average sensitivity among the variables (which at times would average-out the positive and negative changes, thereby seriously limiting the inferential or forecasting capability of the underlying model). However, decomposition of the variables into positive and negative regimes creates a great deal more flexibility and captures the fluctuations simultaneously under both regimes.

4. Results

4.1 Asymmetric ARDL Cointegration Results

Tables 2 to 5 present the hypotheses test results based on equations (8) and (9) tested by the asymmetric ARDL tests. Tables 2 and 3 show the F-test results for the basic hypothesis (equation (8)) analyzing the impact of bilateral real exchange rate volatility on UK imports from Brazil, China and South Africa. Tables 4 and 5 provide the F-test results for the second major hypothesis (equation (9)) evaluating the role of third country exchange rate volatility on the basic relationship identified in the first hypothesis. Each of these hypothesis is then applied to the analysis of the impact of recent financial crisis on the underlying relationship by discussing the results for both before the financial crisis and then after the inclusion of the crisis period.[10] We only present the results using the real exchange rate volatilities; results using the nominal rate volatilities are available on request. Third country exchange rate volatility (risk) is proxied by the dollar-pound volatility. Tables 2 and 3 provide strong evidence at the 1% level of long-term asymmetric relationships among the underlying variables across all three developing countries. Moreover, these relationships hold both before and after the inclusion of financial crisis data, implying stochastic stability of the underlying relationships. This evidence contributes to the literature by identifying the asymmetric dimension of the exchange rate volatility and trade-flow relationship whereby the import demand responds differently to positive and negative shocks to the independent variables.

Tables 4 and 5 provide results when the third-country exchange rate risk is included as an additional determinant of the UK's imports. The null hypothesis of no asymmetric cointegration is rejected across all countries for both the pre-crisis and total periods at the 1% level. This finding provides strong evidence in support of the third-country exchange rate risk being an important determinant of UK imports. The diagnostic test results reject the null hypotheses of serial correlation, heteroskedasticity and misspecification for these asymmetric ARDL estimates (Tables 2 to 5).

4.2 Normalized Equations and Long-run Elasticities

The estimated normalized equations help to infer the long-term relationship between the underlying regressors (UK real income, relative price ratio and exchange rate volatility) and the dependent variable (UK imports). In this case, independent variables are represented

[10] As suggested by the referee, we conducted the Chow test to determine if the coefficients in equations (8) and (9) are equal during the pre-crisis (1991-2007) and the crisis periods (2007-2011). This method involves regressions from both sample periods along with an additional regression for the total period (1991-2011). Results indicate that the coefficients from the two samples are not equal. This is probably due to the increase in volatilities during the financial crisis period. This justifies investigating the effect of the crisis on international trade.

by positive and negative partials of underlying variables and these have been normalized on the UK imports. These estimates reveal the long-term elasticities of the respective independent variables and represent percentage changes in UK imports due to a unit change in these independent variables.

Tables 6 and 7 show the normalized equations estimated from the Asymmetric ARDL method for Brazil, China and South Africa before and including the financial crisis period. Long-run coefficients for the UK's real income show varying impact on the UK imports from Brazil, China and South Africa both under positive changes and negative changes. For instance, a 1% fall in the UK's real income in the long run causes, approximately, a 3% decline in demand for Brazilian imports in the UK before the financial crisis period (Table 6). Similarly Chinese imports show a reduction of 1.76%. UK imports from China demonstrate a negative reaction and decrease by 2.5% due to a 1% increase in the real exchange rate volatility. Moreover, in case of decline in real exchange rate volatility, import volume increases in the long run by 3.23%. In the case of South Africa, long-run coefficients show a negative reaction to exchange rate volatility of approximately 0.2% under both positive scenarios (Table 6). Table 7 shows estimates of the long-run parameters after inclusion of the financial crisis period. Long-run real-income elasticities increase significantly for both positive and negative components in comparison to the pre-crisis period results shown in Table 6.

Tables 8 and 9 provide normalized long-run coefficients for the underlying independent variables, where the impact of third-country exchange rate risk is included in the relationship. The overall results show an increase in the significant elasticities in the presence of third-country exchange rate risk. Long-run coefficients are mostly significant for both positive and negative components ranging from the 1% to 5% significance levels, with the exception of a few cases. In the case of the UK's real income, coefficients for the positive partial sum are 2.92 and 3.18 for Brazil and South Africa, respectively. These estimates are income elasticities for a 1% increase in the UK's real income, whereas for negative variations, these estimates are -2.84 and -0.09 respectively. This shows the asymmetric effect of the changes in the UK's real income over its imports and further strengthens the evidence regarding asymmetry in economic/financial time series. The above findings hold even after extending the sample to include the recent financial crisis (Table 9). Moreover, an increase in the income elasticities has also been reported. For instance, in the case of Brazil, income elasticity increases from 2.92 to 4.747 and for South Africa these figures jump from 3.18 to 7.612. This shows higher elasticities due to the global financial crisis and in line with the findings of Leibovici and Waugh (2012).

The real exchange rate volatilities - both bilateral and third country - are the main independent variable of interest in this research. Here, the positive (negative) component coefficients demonstrate the sensitivity of UK imports against a positive (negative) change in the volatility. The sign of each coefficient shows the direction of exchange rate volatility changes on the UK imports from the respective countries. For instance, an increase of 1% in REAL/GBP volatility depresses the UK imports from Brazil by 0.01% whereas, in the case of RAND/GBP (South Africa), UK imports decrease by 0.22%. In the case of third country (USD/GBP) volatility, UK imports from Brazil, China and South Africa are negatively affected by an increase in exchange rate volatility. For instance, a 1% increase in USD/GBP volatility is followed by 1.23%, 2.44% and 0.76% decline in UK imports, respectively, from Brazil, China and South Africa. This highlights the importance of third country exchange rate risk while modeling UK imports from the developing countries. As these countries mostly invoice their exports in US dollars or other major currencies, third country exchange rate risk is a major determinant while modeling UK imports from the developing countries. Exchange rate volatility for USD/GBP adversely affects UK imports during both sample periods. The above evidence provides an important insight as to how the UK's imports from different countries respond to different exchange rate volatilities.

In summary, the results presented provide more evidence of an inverse effect of the exchange rate volatility on the UK imports. This result is in agreement with the traditional theoretical inverse relationship between the exchange rate volatility and trade. Third country volatility is found to be significant and negative in the majority of cases during both periods. These results show that the UK imports from these countries decrease (increase) as the real exchange rate between the pound and the dollar increase (decrease). This finding clearly shows the importance of the dollar/pound exchange rate volatility on the UK imports from these three countries. It also indicates the importance of taking into consideration the third country effect when investigating the relationship between exchange rate volatility and trade.

4.3 Causality test between UK imports and Determinants Variables

Cointegration implies that the transitory components of the series can be given a dynamic error correction representation; that is, a constrained error correction model can be applied that captures the short-run dynamic adjustment of cointegrated variables.[11] The constrained error correction model allows for a causal linkage between two or more variables stemming from a common trend or equilibrium relationship. The causality tests are conducted using Hendry's (1987) 'General-to-Specific' causality method. In order to save space we only provide a summary of the results here, but full results are available on request. Results, excluding the third country volatility, show significant and negative error correction terms from the cointegration tests for all the three countries (Brazil, China and South Africa) during both periods. This indicates a long-term equilibrium relationship between the UK imports and the underlying determinant variables. The speed of adjustment, as indicated by the

[11]See Engle and Granger (1987) for a detailed discussion of the error correction modeling strategy based on the information provided by cointegrated variables.

coefficient on the error term, shows a reduction in the speed of adjustment when the crisis period is included. Results also show ample short-term causality between the variables and UK imports. Including the third country exchange rate volatility, the results are similar. The error terms are always significant and negative. A reduction in the speed of adjustment when the crisis period is included clearly indicates the impact of the crisis on UK imports. The speed of adjustment again decreases when the crisis period is included. Third country exchange rate volatility at different lags, in addition to its long-term significance, also affects UK imports in the short term. This is true for all three countries during both periods. The diagnostic test statistics are satisfactory for all causality tests.

4.4 Long- and Short-term Asymmetric Effects

The Wald test is applied to test for the long- and short-term asymmetric effect, and Tables 10 to 13 provide these results. The long- and the short-term asymmetry hypotheses are tested for possible equality between the positive and negative coefficients for each variable and in both long- and short-term scenarios. As stated earlier, in cases where the null hypothesis is rejected, and these shocks are not equal statistically, statistically, the asymmetric nature of the relationship is shown in the respective time horizon (long or short term). The presence of long- and short-term asymmetries implies that the positive and negative shocks to a single variable should be modeled separately as both will affect the dependent variable differently. This means that the variability may be in terms of both the sign (direction) and size (sensitivity) of the coefficients.

Tables 10 and 11 present the results without the third country exchange rate volatilities. The Wald test statistics show that most of the positive and negative long-term coefficients (elasticities) for each independent variable differ significantly from each other. This means that the positive and negative partial sums of each of these variables affect the

UK's imports differently. Hence, the long-term equilibrium relationship between the underlying variables is asymmetric in most of the cases. More evidence of the asymmetric effect is found when the crisis period is added to the sample size; this is particularly true in the case of Brazil. Although the Brazilian real exchange rate volatility is found to be to be symmetric in both the long- and short-runs during both periods, the South African real exchange rate volatility becomes asymmetric in the long run when the crisis period is included. The incidences of long-term asymmetry increase after inclusion of the financial crisis which shows the structural shift in the long-term relationship between these variables caused by this crisis.

Including the third country effect (Tables 12 and 13) enhances the asymmetric effect. Comparison between results presented in Tables 10 and 12 shows Brazil and South Africa providing more evidence of asymmetric effects when the third country exchange rate volatility is included. Once again, more evidence of the asymmetric effect is found when the crisis period is added to the sample; this is particularly evident in the cases of Brazil and China. There is also more evidence of the real exchange rate volatility and the third country real exchange rate volatility asymmetric effect; once again Brazil and China provide the most evidence. These results also enhance the importance of the effects of the crisis.

The results derived above, with respect to the asymmetric effect, offer a great deal more information and inference compared to the standard (symmetric) long-term 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 average out, thus seriously limiting the inferential or forecasting capability of the underlying model.

5. Conclusion and Implications

This paper investigates the effect of exchange rate volatility on the UK imports from three major developing trade partners - Brazil, China, and South Africa. This research uses monthly data from January 1991 to December 2011. The UK is considered to be the home country.

This paper makes four main contributions to the literature. First, we study the effect of the exchange rate volatility on the UK imports from developing countries. Second, we also study the influence of the third country effect on the volatility and import relationship. Third, we investigate the effect of the financial crisis on the relationship between volatility and UK imports with and without the third country effect. Finally, we also make a contribution based on the econometrical method we apply, the asymmetric ARDL model. These contributions render this paper unique in the UK trade literature.

Results, based on the Asymmetric ARDL, confirm the long-term relationship between UK imports and exchange rate volatility along with other determinant variables such as the UK's real income and relative import price ratio. These relationships hold irrespective of the exchange rate volatility (nominal or real) and the time period selected, i.e. before or after the inclusion of the financial crisis period. Normalized coefficients for the nominal and real exchange rate volatilities from the Asymmetric ARDL method show a large number of inverse relationships. With respect to third country exchange rate volatilities, which are represented by the USD/GBP volatility, this has a negative impact on imports in almost all the cases. Other determinant variables, such as real income and relative price ratio, are also significant in most of the cases. Import demand elasticity towards all the regressors, particularly real income and exchange rate volatility, significantly changes across both data samples, i.e. before and after the financial crisis. More importantly, these results show strong evidence of the asymmetric behavior of the underlying independent variable for all countries;

no prior evidence is available in the existing literature to this effect so this is a significant contribution of this study. Further, the incidences of long-term asymmetry increase after inclusion of the financial crisis, which shows the structural shift in the long-term relationship between these variables caused by this crisis. These findings also hold in the presence of third country exchange rate risk.

The results presented above suggest that the consideration of exchange rate volatility is important for modeling UK import behavior, particularly during the current crisis period. Any trade adjustment programs initiated by the UK that discourage import expansion could prove unsuccessful if exchange rates and third country exchange rates are volatile. If policy makers ignore the variability of the nominal and real exchange rates of the underlying bilateral and third country effect (USD/GBP), policy actions aimed at stabilizing these import markets are likely to generate uncertain results. Lastly, this paper shows strong evidence for the asymmetric behavior of exchange rate volatility along with other macroeconomic variables such as UK real income and import price ratio, which indicates that using the same policies for both expansionary and recessionary periods may not be very effective as these variables behave differently under different economic situations. This holds practical implications for policy makers as well as international traders (imports), investors in global foreign exchange markets, academics, and exchange rate risk management, among other stakeholders.

Future research extensions based on this paper may be derived from two perspectives - theoretical and empirical. Theoretical modeling of the financial crisis separately as a control variable can contribute to the literature. Further empirical tests employing the asymmetric ARDL method may be conducted by applying the trade data of other countries. Analysis of UK exports could be another useful extension of this research in the near future.

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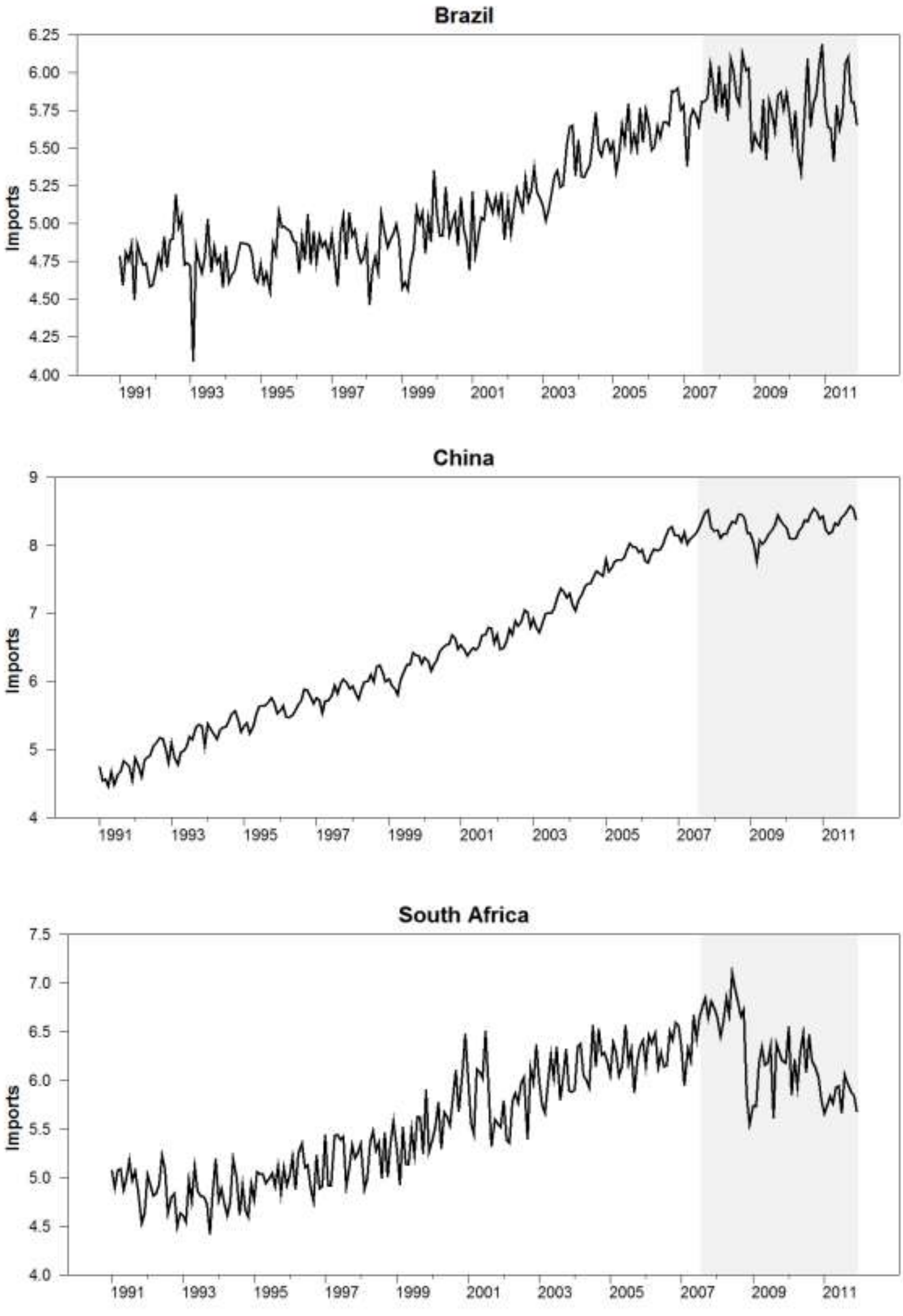

Fig. 1. Log of Real Imports of the United Kingdom (January 1991-December 2011).

Table 1

Univariate GARCH(p,q) Results for Real Exchange Rate Volatility.

Parameters	Brazil	China	South Africa	US
M	0.0001	0.0004	0.0022	-0.00004
ϖ	0.0001^{***}	0.00005^{***}	0.0007^{***}	0.002^{***}
$\alpha_{(1)}$	0.41^{***}	0.0082^{***}	0.223^{***}	0.196^{***}
$\beta_{(1)}$	0.42^{***}	1.019^{***}	0.46^{***}	0.227^{***}
$\beta_{(2)}$	--	--	--	0.323^{***}
L	614.13	525.77	426.12	580.87
Std. Residuals (Q-Stat,12)	3.991	5.386	5.73	6.028
Sq.Std.Residuals (Q-Stat,12)	1.623	0.471	3.84	2.436

Note:

1. ***,**,* denote significance levels at 1%, 5%, and 10% respectively.

2. L= Log Likelihood; Std, Resids: Standardised Residuals; Sq.Std.Resids: Squared Standardised Residuals; (Q-Stat, 12): Ljung-Box Autocorrelation Test up to 12 lags.

Table 2

Asymmetric ARDL Results - Impact of Exchange Rate Volatility on UK Imports before Financial Crisis (Jan 1991 to June 2007).

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB (12)	RESET (3)	ARCH (1)	ARCH (3)
Brazil	10.3^{***}	0.585	0.015	2.57	1.54	17.69	0.072	0.271	2.528
China	5.33^{***}	0.663	0.0043	0.678	1.79	6.463	1.213	0.173	3.82
South Africa	21.8^{***}	0.522	0.044	7.45	1.96	1.85	0.270	1.024	1.253

Table 3

Asymmetric ARDL Results - Impact of Exchange Rate Volatility on UK Imports during Financial Crisis (July 2007 to Dec 2013).

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB (12)	RESET (3)	ARCH (1)	ARCH (3)
Brazil	12.5^{***}	0.536	0.019	4.22	2.37	17.17	0.67	0.717	4.035
China	7.06^{***}	0.622	0.004	1.012	0.22	3.042	1.11	0.936	3.396
South Africa	22.8^{***}	0.46	0.049	10.68	1.28	5.76	0.736	0.0178	1.395

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. $R^{2:}$ Adjusted R-Squre; SSE: Standard Error of Estimate; SSR: Sum of Squared Residuals; JB: Jarque-Bera Test for Residual Normality; LB (12): Serial correlation Ljung-Box Test up to 12 lags; RESET(3): Ramsey's specification Test; ARCH(1) and ARCH(3): Autoregressive Conditional Heteroskedasticity Test for Volatility Clustering for Levels 1 and 3.

Table 4
Asymmetric ARDL Results - Impact of 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^2	SSE	SSR	JB	LB (12)	RESET (3)	ARCH (1)	ARCH (3)
Brazil	8.5^{***}	0.61	0.014	2.36	0.91	14.08	1.89	0.357	0.60
China	5.3^{***}	0.647	0.0045	0.724	3.11	6.10	0.73	0.0018	3.273
South Africa	23.8^{***}	0.592	0.037	6.05	2.37	14.51	1.436	1.36	4.117

Table 5
Asymmetric ARDL Results - Impact of Exchange Rate Volatility on UK Imports in the presence of Third Country Exchange Rate Risk (Jan 1991 to Dec 2011).

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB (12)	RESET (3)	ARCH (1)	ARCH (3)
Brazil	10.4^{***}	0.555	0.0186	3.999	1.48	8.636	0.518	0.2185	2.322
China	5.97^{***}	0.619	0.0048	1.0198	0.16	7.297	1.743	0.848	2.246
South Africa	22.6^{***}	0.531	0.043	9.045	2.00	4.47	0.639	0.136	0.6199

Note:
1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. $R^{2:}$ Adjusted R-Squre; SSE: Standard Error of Estimate; SSR: Sum of Squared Residuals; JB: Jarque-Bera Test for Residual Normality; LB (12): Serial correlation Ljung-Box Test up to 12 lags; RESET(3): Ramsey's specification Test; ARCH(1) and ARCH(3): Autoregressive Conditional Heteroskedasticity Test for Volatility Clustering for Levels 1 and 3.

Table 6

Normalized Coefficients - Impact of Exchange Rate Volatility on UK Imports before Financial Crisis (Jan 1991 to June 2007).

Countries	Constant	Real Income		Relative Prices		Real Volatility	
		Positive	Negative	Positive	Negative	Positive	Negative
Brazil	4.89***	-0.1396	-3.03***	0.6521	3.69***	-0.0006	-0.0081
China	5.03***	5.31***	-1.76***	4.94**	4.14***	-2.5***	3.23***
South Africa	4.15***	-2.09	-1.02	17.04***	-30.56**	-0.24**	-0.22**

Table 7

Normalized Coefficients - Impact of Exchange Rate Volatility on UK Imports including Financial Crisis (Jan 1991 to Dec 2011).

Countries	Constant	Real Income		Relative Prices		Real Volatility	
		Positive	Negative	Positive	Negative	Positive	Negative
Brazil	5.0***	5.525***	-0.907*	-2.453**	7.23**	0.0059	0.0010
China	4.917***	11.95***	0.29**	-15.94***	13.87*	157.24	159.95
South Africa	4.43***	1.99	6.62***	6.74	-51.56***	-0.25*	-0.50***

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. $R^{2:}$ Adjusted R-Squre; SSE: Standard Error of Estimate; SSR: Sum of Squared Residuals; JB: Jarque-Bera Test for Residual Normality; LB (12): Serial correlation Ljung-Box Test up to 12 lags; RESET(3): Ramsey's specification Test; ARCH(1) and ARCH(3): Autoregressive Conditional Heteroskedasticity Test for Volatility Clustering for Levels 1 and 3.

Table 8
Normalized Coefficients - Impact of Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk before Financial Crisis (Jan 1991 to June 2007).

Countries	Constant	Real Income		Relative Prices		Real Volatility		Third Country Real Volatility	
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative
Brazil	4.99***	2.92**	-2.84***	-1.71	5.64***	-0.01**	-0.02***	-1.23***	-0.93**
China	4.69***	-0.52	-5.91***	2.45	-1.58	2.68	4.45**	-2.44***	-2.7***
South Africa	4.62***	3.18*	-0.09	11.05*	-12.71	-0.22**	-0.16	-0.76	1.35**

Table 9
Normalized Coefficients - Impact of Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk including Financial Crisis (Jan 1991 to Dec 2011).

Countries	Constant	Real Income		Relative Prices		Real Volatility		Third Country Real Volatility	
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative
Brazil	5.115***	4.747***	-1.32***	-1.574*	6.193***	0.007	0.002	1.473***	-0.858**
China	5.387***	10.82***	0.039	-12.3***	11.62***	1.88***	5.82***	-3.89***	-3.60***
South Africa	4.849***	7.612***	2.020***	1.497	2.921	-0.3***	-0.3***	-5.03***	-1.83***

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. $R^{2:}$ Adjusted R-Squre; SSE: Standard Error of Estimate; SSR: Sum of Squared Residuals; JB: Jarque-Bera Test for Residual Normality; LB (12): Serial correlation Ljung-Box Test up to 12 lags; RESET(3): Ramsey's specification Test; ARCH(1) and ARCH(3): Autoregressive Conditional Heteroskedasticity Test for Volatility Clustering for Levels 1 and 3.

Table 10
Impact of 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
Brazil	1.61	4.85***	0.98	2.70***	1.684	0.482
China	5.16**	1.98**	0.002	4.416***	4.25**	2.138**
South Africa	0.25	3.78***	3.50*	3.136***	0.13	-

Table 11
Impact of Exchange Rate Volatility on UK Imports including Financial Crisis (Jan 1991 to Dec 2011).

Countries	Real Income		Relative Prices		Real Volatility	
	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm
Brazil	35.26***	19.96***	34.04***	2.81*	1.572	2.41
China	18.27***	20.44***	44.4***	3.1*	0.124	50.32***
South Africa	5.68**	31.19	5.84**	45.34	11.02***	-

Note:
1. ***, **, and * denote rejection of the null of symmetric at 1%, 5% and 10% respectively.

Table 12
Impact of 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 Volatility	
	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm
Brazil	3.48***	48.37***	2.35**	20.76***	1.543	0.14	0.807	2.78*
China	3.42***	3.142*	0.41	0.069	1.23	3.60*	0.581	--
South Africa	1.48	24.4***	1.0055	28.75***	0.92	56.55***	3.96***	29.15***

Table 13
Impact of Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk including Financial Crisis (Jan 1991 to Dec 2011).

Countries	Real Income		Relative Prices		Real Volatility		Third Country Volatility	
	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm
Brazil	5.24^{***}	19.79^{***}	3.60^{***}	3.12^{*}	1.20	2.82^{*}	4.87^{***}	19.71^{***}
China	4.44^{***}	1.36	1.73^{*}	0.24	1.81^{*}	7.16^{***}	0.453	33.42^{***}
South Africa	1.78^{*}	15.01^{***}	0.044	10.23^{***}	0.122	56.07^{***}	4.42^{***}	78.38^{***}

1. ***,**, and * denote rejection of the null of symmetric at 1%, 5% and 10% respectively.