UNIVERSITY OF SOUTHAMPTON

FACULTY OF BUSINESS AND LAW

SOUTHAMPTON MANAGEMENT SCHOOL

Volume 1 of 1

Exchange Rate Volatility, UK Imports and The Recent Financial Crisis: Evidence from Symmetric ARDL and Asymmetric ARDL Methods

by

Syed Shabi Ul Hassan

Thesis for the degree of Doctor of Philosophy

September, 2014

UNIVERSITY OF SOUTHAMPTON

ABSTRACT

FACULTY OF BUSINESS AND LAW

FINANCE

Thesis for the degree of Doctor of Philosophy

EXCHANGE RATE VOLATILITY, UK IMPORTS AND THE RECENT FINANCIAL CRISIS: EVIDENCE FROM SYMMETRIC ARDL AND ASYMMETRIC ARDL METHODS

Syed Shabi Ul Hassan

Uncertainty in the amount and direction of changes in exchange rates is described as the exchange rate volatility. This research examines the role of exchange rate volatility in determining the UK's real imports in a broader perspective by including: i) the third country exchange rate volatility; and ii) the impact of the current financial crisis on the relationship between exchange rate volatility and UK imports. In the context of international trade, exchange rates are often more important than the prices of the traded goods and services because the prices are observed to be more stable and predictable in comparison to the exchange rate movements. Thus, a rise in exchange rate volatility causes an increase in the degree of risk aversion of the traders, which results in the reduction of trade volume. This research contributes to the empirical literature on the subject by offering evidence based on the Symmetric ARDL bounds testing approach (Pesaran, Shin and Smith, 2001) and the Asymmetric ARDL method (Shin et al., 2013). These models are capable of addressing important issues related to the non-stationary and nonlinear characteristics of the underlying macroeconomic data. The analysis sample includes the UK's major trading partners, i.e. the US, Germany and Japan representing the developed countries and Brazil, China and South Africa representing the developing economies. Results suggest that exchange rate volatility plays an important role, and also reveal that there is a significant effect from the recent financial crisis on UK imports. This finding is 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, both in bilateral tests and in tests that account for the third country exchange rate volatility. Comparative analysis of developed and developing countries shows that the third country effect is significant for all the countries. The UK imports' demand elasticity to different determinant variables, including exchange rate volatility, changes significantly after the inclusion of the financial crisis. These changes are more pronounced under the Asymmetric ARDL method, where positive and negative changes in determinant variables, especially exchange rate volatilities, affect UK imports differently before and after inclusion of the financial crisis. These findings contribute to the existing literature as no evidence of the third country effect and asymmetric behaviour of exchange rate volatility on UK trade flows currently exists in the literature. This has significant implications for trade policy and international trade to minimise the underlying risk factors and ensure stable trade flows in different economic scenarios.

Table of Contents

List of Tables

List of Figures

DECLARATION OF AUTHORSHIP

I, SYED SHABI UL HASSAN declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

[title of thesis] **EXCHANGE RATE VOLATILITY, UK IMPORTS AND THE RECENT FINANCIAL CRISIS: EVIDENCE FROM SYMMETRIC ARDL AND ASYMMETRIC ARDL METHODS**

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
5. I have acknowledged all main sources of help;
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. Parts of this work have been presented/published as: [please list references below]:
   i. Choudhry, T.; Hassan, SSU; Papadimitriou, I.F (2013) "UK Imports from Germany, Japan and the US: Evidence from Asymmetric Nonlinear ARDL", *International Review of Financial Analysis*, (In Press).
   ii. Choudhry, T.; Hassan, SSU; Papadimitriou, I.F (2013) "Exchange Rate Volatility, UK Trade and Financial Crisis", 22nd International Business Research Conference, Madrid, Spain September 2013
   iii. Choudhry, T.; Hassan, SSU; Papadimitriou, I.F (2013) "UK Imports from Germany, Japan and the US: Application of Asymmetric Nonlinear ARDL", World Finance Conference, Cyprus, July 2013
   iv. Choudhry, T.; Hassan, SSU; Papadimitriou, I.F (2013) "UK Imports from Germany, Japan and the US: Evidence of the Third Country affect and the Global Financial Crisis", International Conference on Global Financial Crisis, Southampton UK, April 2013

Signed:.....

Date: .....

Acknowledgements

One person I can't thank enough for my PhD experience is Professor Taufiq Choudhry, my supervisor. He has been there for me at every step of the way through all these years. I consider myself fortunate to have benefitted from Professor Choudhry's immense knowledge and research experience. I am highly grateful for his exceptional support, guidance and encouragement. I am also thankful to Dr. Fotios Papadimitriou for his help and insight.

I am appreciative of Southampton Management School and the University for all the opportunities of learning and growth; for the resources and facilities; and for the sound research environment. I am obliged to all the people that have supported me as a research student in various capacities, especially the administrative staff for being there ready to help, whenever I needed. I am gratified to Southampton Management School and University of Southampton for funding my studies towards the end of PhD.

Chapter 1: Introduction

1.1 Background

Exchange rates are an important monetary tool and mechanism for international trade. Against the backdrop of globalization and integration of world economies, exchange rates have an important role and variations in these rates are significant for countries across the globe. Thus, in the international trade arena, the exchange rates of respective currencies are sometimes more significant than the domestic prices of products and services. from a firm's stand point these exchange rates are part of the external economic environment, hence they can do little to control them. Uncertainty in the direction and extent of changes in exchange rates is described as the exchange rate volatility.

Since the collapse of the Bretton Woods agreement in 1973, exchange rates for many currencies have started to fluctuate, exposing traders to enormous uncertainty regarding their trade volumes and profitability, which has already affected international trade (Bahmani-Oskooee and Hegerty, 2007; McKenzie, 1999). This thesis investigates the effect of exchange rate volatility on UK imports from major developed and developing trade partners.

According to Bahmani-Oskooee and Hegerty (2007), much of the existing evidence on the subject is limited to only two economies at a time. This does not reflect the real world scenario where every economy is competing against many other economies in their respective regions, as well as globally. Hence the inclusion of the third country effect in this research. Similar arguments have also been documented by Cushman (1986) and McKenzie (1999). Another important limitation identified in the literature by Bahmani-Oskooee and Goswami (2004), Bahmani-Oskooee and Ardalani (2006), Bahmani-Oskooee and Hegerty (2007) and McKenzie (1999), is methodological in nature. Most of the literature to date has relied on standard cointegration methods, which require all variables to be I(1) or nonstationary at level. But in cases such as we will look at in this thesis, the underlying variables are a mix of both stationary and nonstationary variables, as exchange rate volatility is usually stationary at level. Given this 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, Shin and Smith (2001). This thesis applies both the Symmetric and Asymmetric ARDL methods.

The recent financial crisis has caused highly volatile shocks across all asset classes globally, including foreign exchange markets (Fratzscher, 2009, Melvin and Taylor, 2009). This crisis is considered to be very severe by many researchers, even compared to the great depression of 1930s, both in terms of its time span, the extent of the severity in both economic and social costs, and policy interventions by governments around the globe (Fratzscher, 2009; Fratzscher, 2012).

This provides sufficient motivation for analysing 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 does not provide any evidence in this context, this research aims to contribute to the literature by bridging this gap.

1.2 Objectives

This research will look at both the theoretical and empirical aspects of the relationship between exchange rate volatility and international trade. On the theoretical side, it builds upon the existing evidence on the subject and extends it further by including the third-country effect, as suggested by some of the earlier studies (Cushman, 1986; McKenzie, 1999; Bahmani-Oskooee and Hegerty, 2007). This research also studies the impact of the global financial crisis on the underlying variables.

This research then empirically analyses the relationship between exchange rate volatility and international trade, in the absence/presence of third country exchange rate risk and the global financial crisis, by employing the Symmetric ARDL Bounds Testing approach (Pesaran *et al.*, 2001) and the nonlinear Asymmetric ARDL approach (Shin *et al.*, 2013). To the best of my knowledge, there is no previous study in this area based on the later framework proposed by Shin *et al.* (2013).

1.3 Research Questions

This research aims to answer the following research questions:

i. Does Exchange Rate Volatility affect UK Trade flows?
ii. How is the relationship between exchange rate volatility and UK trade flows affected by third-country exchange rate volatility (risk)?
iii. What is the impact of the financial crisis on the relationship between exchange rate volatility and UK trade flows (with and without the presence of third-country volatility/risk?
iv. Do the underlying independent variables in the above questions, especially exchange rate volatility, affect UK trade flows asymmetrically?

1.4 Data and Econometric Methodology

1.4.1 Data

This thesis employs monthly data for the period from January 1991 to December 2011. UK imports from three trading partners among the developed countries, i.e. Germany, Japan and the US, and three countries from emerging markets, i.e. Brazil, China and South Africa, are selected for this research. The dependent variable throughout this research is UK real imports. Among the independent variables, the relative import price ratio is the ratio between import price indices of the foreign countries against the UK import price index, and UK real income is represented by the index of industrial production. The nominal exchange rate applied is defined as the unit of 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 the respective foreign country in the sample. All data are obtained from the Thompson Financial DataStream.

The 'Direction of trade' data (IMF, 2012) reports that UK imports from Germany, Japan and the US 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 Asia until 2003.

Introduction

Japan has remained the second top Asian exporter to the UK after China. UK imports from Germany, Japan and the 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. Similarly, major imports from Brazil, China and South Africa 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 (China only) etc. These sectors represent more than 60% of UK imports from these developing countries (UN Comtrade, 2013).

1.4.2 Methodology

This research explores the relationship between UK imports and their determinants on the basis of the Symmetric ARDL Bounds Testing approach (Pesaran *et al.*, 2001) and the Asymmetric ARDL method (Shin *et al.*, 2013).[1] Both of these models are capable of dealing with both stationary I(0) and nonstationary I(1) variables. As suggested by the literature, exchange rate volatility is stationary whereas the rest of the variables, i.e. imports, real income and relative prices, are widely reported to be nonstationary at level or I(1).

Shin *et al.* (2013) further builds up the analysis of the long-term relationship by including the asymmetric effects of the underlying independent variables on the dependent variable. The authors argue that the earlier cointegration literature assumes that independent variables are symmetric in nature, which is not true, and some of the variables exhibit asymmetric effects, i.e. the positive and negative components of the same variable may have different impacts on

[1] 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.

the dependent variables. Therefore, each regressor needs to be decomposed in terms of positive and negative partial sums, so that along with the long-term relationship, underlying asymmetries of the independent variables can also be tested. These asymmetries, if found significant, will provide more insight into the size/magnitude and direction of the relationship between the independent and dependent variables.

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 the cointegrated variables. Engle and Granger (1987) provide details of the error correction modelling strategy based upon the information provided by the cointegrated variables. 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 research follows Hendry's (1987) "general-to-specific" paradigm.

1.5 Implications

The answers to the above questions have significant implications regarding the importance of the underlying determinants, especially exchange rate volatility, for modelling UK trade flow behaviour. For instance, third country exchange rate risk must be addressed in order to stabilise UK trade flows, otherwise any trade adjustment programme would not be successful. World trade flows declined by one-third in size during the recent financial crisis, as shown in Figure 2.6, causing a long-term structural shift. This research shows that in many instances the sensitivity of the variables has changed after inclusion of the financial crisis period, which implies that the impact of this crisis cannot be ignored while modelling or making policies relating to trade flows. Moreover, this research offers fresh evidence into the asymmetric effect of the underlying determinants of UK trade flows, especially exchange rate volatility. This will help when formulating strategies for scenarios with large variations in exchange rates, as well as for periods with relative calm and stability in the exchange rates.

1.6 Contributions to the literature

This research aims to analyse the orthodox relationship between exchange rate volatility and international trade. However, the major contribution of this study is to explore this relationship in the context of the third country effect, which has not been analysed empirically in detail before. Furthermore, this thesis studies the impact of the current financial crisis on exchange rate volatility and UK imports. The recent financial turmoil has been unique and will continue to affect the global economy in many ways. This research is motivated by the fact that, to the best of my knowledge, no research has been published so far involving UK trade and exchange rate volatility in the context of the third country effect and the recent financial crisis (2007-2011). To summarise, the main contributions of this research to the existing literature will be detailed analysis of: i) the exchange rate volatility and trade flows for the UK; ii) the third country effect on the UK's trade flows; and iii) the impact of the financial crisis on the relationship between exchange rate volatility and the trade flows of the UK.

1.7 Structure

This dissertation has been organized into seven chapters, including this introductory chapter. Chapter 2 explains the underlying conceptual underpinnings as to how and why exchange rate volatility and international trade flows may be related. It also provides information on the global financial crisis and how it affected exchange rate volatilities and international trade flows. This chapter also provides a list of testable hypotheses based on the research questions. The literature review in chapter 3 positions this research with regards to the earlier research carried out on the subject. The main objective of the literature review is to provide a theoretical context for this research, and to highlight how this research builds on the existing evidence and extends current knowledge both theoretically and empirically. Chapter 4 covers the data and the methodology used to analyse this and test the hypotheses set up in chapter 2. It also provides a detailed account of the descriptive and stochastic structure (stationarity) analyses of the underlying variables. Chapters 5 and 6 provide detailed analysis of the data and hypotheses test results based on the (Symmetric) ARDL (Pesaran, Shin and

Smith, 2001) and Asymmetric ARDL (Shin, Yu, Greenwood-Nimmo, 2013) methods for the developed and developing countries, respectively. Chapter 7 concludes the thesis by summarizing the main research and key findings. This chapter also highlights the implications of this research, limitations and future research areas.

Chapter 2: Theoretical Framework

2.1 Introduction

The exchange rate embodies various monetary and macroeconomic aspects of an economy. Exchange rates are the backbone, or the major element, of international trade as they provide a standard medium of monetary exchange between traders from different countries. Therefore, at times exchange rates are more important than even the prices of the traded goods and services involved because the prices are observed to be more stable and predictable in comparison to exchange rate movements (Baumol and Blinder, 2010). For example, a US firms sells its computer costing $500 for £360 in the UK, equivalent to $600 at an exchange rate of $0.6/£. Assuming other things remain the same, the exchange rate moves to $0.65/£ implying that the UK price of the computer will change to £390. With a slight change of 5 cents in the exchange rate (per pound sterling) the price of the computer increased by £30. Using the demand and supply theory, any change in price is followed by a market reaction to achieve equilibrium. In other words, a £30 increase in the price will have implications for both the buyers in the UK and the sellers in the US. The buyers may switch to another brand with a cheaper price, or may agree to pay a higher price which in turn will increase the buyers' cost and reduce their savings/profits, on the other hand the seller may face a decline in the sales volume and will have to find ways to maintain their market share. Similarly, a decrease in the exchange rates would affect the situation in the opposite way, whereby buyers will be able to buy at a lesser price and sellers will benefit in form of increased demand. This example shows how a small change in the exchange rate may cause uncertainties on many fronts for both buyers and sellers in the international markets. The significance of exchange rates for international trade is thus well-established and is a major research area in the field of international economics and finance.

This research is based on two broader themes. The first theme deals with the relationship between exchange rate volatility and international trade, and how the former affects the latter empirically. The second theme looks at the relationship between these two variables in the time before and including the recent global financial crisis.

2.1.1 Exchange Rate Volatility and International Trade

Major research on the impact of exchange rate volatility on international trade started in the post Bretton-Woods era. The collapse of the Bretton-Woods agreement led to a critical decision for choosing an exchange rate regime on behalf of countries across the globe (McKenzie, 1999). Many countries, following the laissez faire rule, decided to let their currencies trade on the basis of supply and demand forces. However, adoption of a floating regime was thought to have an adverse effect on international trade. A floating exchange rate embodies uncertainty on both demand and supply sides, hence there was a risk that unexpected movements in the exchange rates would deter the risk averse exporters, resulting in a decline in the output level on their part (McKenzie, 1999; Bahmani-Oskooee and Hegerty, 2007). Another, similar view, presented by a few theorists, was that the export volume is independent of the exchange rate level. However, exchange rate risk is the major uncertainty regarding an exporter's profit. Therefore, an increase in the exchange rate uncertainty translates into profit risk for the exporter. Assuming the exporters to be risk averse, and the non-diversifiable nature of exchange rate risk, an 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 preliminary view was the starting point of the debate regarding the impact of exchange rate volatility on international trade. Since then, theorists have presented various theoretical models to try and explain the basis and dynamics of the relationship between exchange rate volatility and international trade. However, the literature fails to conclusively describe a clear view. A significant number of models have been put forward to support the negative hypothesis that volatility deters international trade, but the positive impact of volatility over international trade has also been hypothesised by a number of studies (McKenzie, 1999; Bahmani-Oskooee and Hegerty, 2007).

The basic hypothesis found in early literature in this area 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 in the wake of increased volatility these traders will reduce their level of output leading to a reduction in international trade.

2.1.2 Exchange Rate Volatility and International Trade both Before and during the Financial Crisis Scenarios

The second theme of this research is based on the relationship between exchange rate volatility and international trade against the backdrop of the recent financial crisis. The current financial crisis has caused highly volatile movements across all asset classes globally, including foreign exchange markets (Fratzscher, 2009; Melvin and Taylor, 2009). Many researchers consider this turmoil much worse than the great depression of the 1930s, both in terms of its time span, the extent of the severity in both economic and social costs, and the policy interventions by governments around the globe. The main aim of this thesis is to analyse the behaviour of the primary variables of interest, i.e. exchange rate volatility and the international trade of the United Kingdom, in the context of the current financial crisis, to identify the nature and magnitude of these differences and the key factors responsible for such differences.

According to Fratzscher (2009), three main factors were responsible for exchange rate volatility during the current financial crisis. Firstly, the enormous currency depreciations borne by various countries against US dollars who had large financial liabilities relative to the US, especially 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 the cross-country average declined by 23%, while ones above the threshold only deprecated by 7% against the US dollar during the period July 2008 to January 2009 (Fratzscher, 2009). A simultaneous increase in the FX reserve was also observed during the past few decades, particularly by central banks in the emerging markets. Countries with seemingly 'excessive' FX reserves benefited by controlling the pressure on their respective currencies, while economies where certain reserves were accumulated for precautionary motives were not successful enough to absorb the shocks of the financial crisis. Lastly, the third driving factor was the current account position, as countries with higher cross country averages faced only 10% depreciation against the US dollar, whereas those with below average current account balances were depreciated by 22%

(Fratzscher, 2009). The importance of the current account position in this context has been stressed by Chor and Manova (2012) also.

Moreover, the US dollar appreciated against major currencies despite the fact that the US was running large current account imbalances. This incident was in contrast to standard theory whereby a currency is expected to depreciate in order to improve a country's competitiveness by reducing the foreign currency price of its exports and improving the trade deficit position (Blanchard *et al.*, 2005; Obstfeld and Rogoff, 2005; Krugman, 2007; Fratzscher, 2009).

Based on this conflict between the facts and the theory, this theme has been devised to see how this crisis affects the relationship between exchange rate volatility and international trade.

2.2 Financial Crisis (2007-2012): Origin and Causes

2.2.1 Origin & Facts

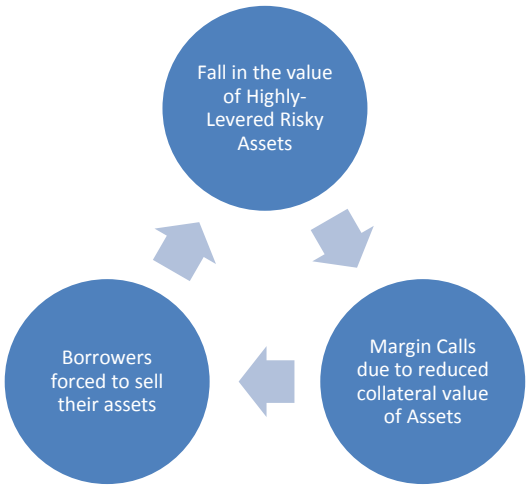
There is no need for a second opinion regarding the unprecedented nature of the current financial crisis. Recent research continues to unfold the various economic, political, legal and social dimensions of this crisis. Other recent financial crises, for instance Black-Monday (1987), the Asian financial crisis (1997-98), the Russian Debt Default (1998), LTCM (1998) and other regional crises during the 1990s, are all superseded by the current turmoil in its scope (global impact), length, effects on various asset classes and the policy interventions seen through the current episode (Blundell-Wingall *et al.*, 2008).

The year 2004 was a critical year with respect to identifying the causality of the current financial crisis (Acharya *et al.*, 2009). Authors have highlighted four factors which were responsible for causing asset bubbles and excess leverage, namely; 1) Introduction of the Zero Equity Mortgage scheme by the US Government for low-income groups; 2) Increased capital requirements and balance sheet controls on Fannie Mae and Freddie Mac by the Federal Housing Enterprise Oversight (OFHEO), making way for banks to increase their share in the mortgage market; 3) Arbitrage Opportunities for banks caused by the Basel II accelerated off-balance sheet business; and 4) the SEC permitted investment banks (IB's) to manage their risk by using the "consolidated supervised entities

program". This program inflated the debt to net equity ratio from 15:1 to 40:1 in some cases, causing a huge excess leverage in the mortgage market. These four factors allowed the banks to increase their off-balance sheet mortgage securitisation by manifolds and exploit it as a key driver to jump their revenues and share prices in a short span of time.

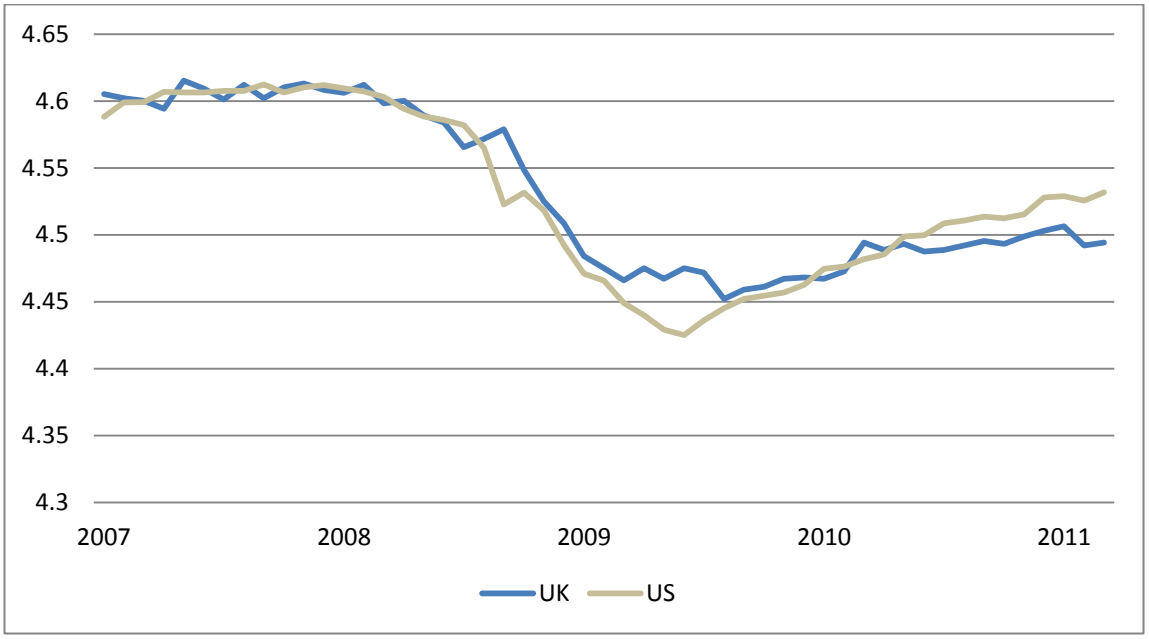
In 2006 the housing market turned when the two basic housing indicators, i.e. spread on credit instruments and ratio of house price to rental income, were at their extremes (spreads at the lowest and price-to-rent ratios at the highest). This triggered the crisis initially in the subprime market in January 2007 with the bankruptcy of Ownit Mortgage Solutions, soon joined by many other large subprime lenders including New Century Financial (Dowd, 2009). The subprime shock shortly converted into systemic meltdown as two of the highly levered hedge funds managed by Bear Sterns collapsed; with the default of subprime securities, assets prices of these funds fell significantly. These events highlight the typical features of this crisis: firstly, a credit boom which led to overleveraging of financial institutions; and secondly an asset price hike exposing the unsustainable nature of the underlying assets. Therefore, the financial crisis initially burst the asset bubble, causing a reduction in asset prices and thereby initiating deleveraging of institutions. This started a chain reaction causing continuous reduction in the asset prices, forcing margin calls on borrowers and resulting in forced selling. With further reductions in asset prices, as well as their collateral value, borrowers were forced to sell more in order to honour their margin calls. The following figure explains the perpetual nature of the above deleveraging process.

Figure 2.1: Vicious Cycle of Falling Asset Prices and Credit Crunch (Deleveraging)



The impact of the crisis was evident on the major economic fundamentals such as production, unemployment and interest rates etc. Figure 2.2 shows the deep and prolonged decline in the log of production indices for the US and the UK, and it is evident that industrial production indices for both countries were not able to recover back to the pre-crisis levels until the end of 2011.

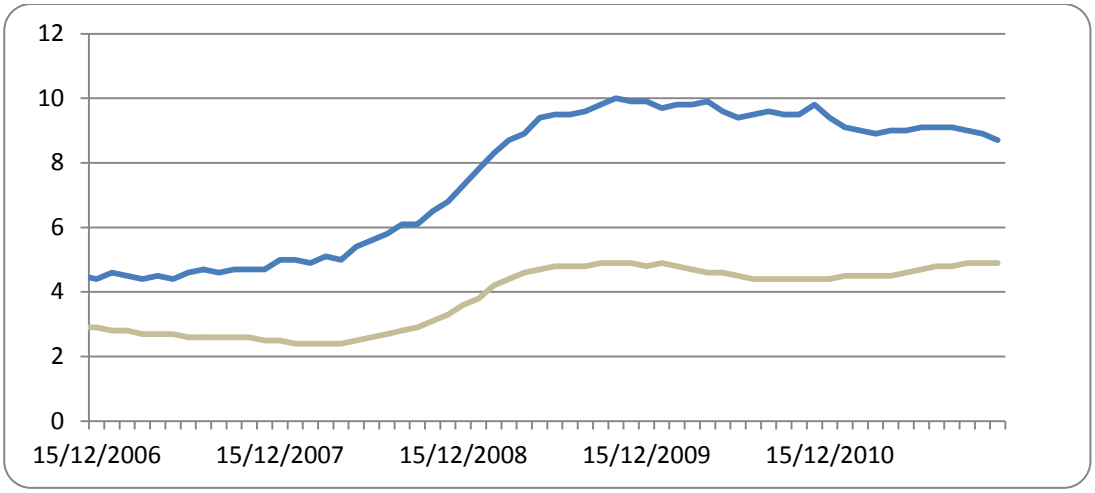
Figure 2.2: Index of Production (Log) for US and UK during Financial Crisis



Source: Datastream

Unemployment is another key macroeconomic factor that shows the impact of the financial crisis, as the corporate sector facing the brunt resorted to downsizing to reduce the financial burden. This caused an upsurge in unemployment, as shown in Figure 2.3. The US, being at the centre of the financial turmoil, had an enormous rise in the unemployment rate, more than 100%, as its rate jumped from around 4% to nearly 10% during the financial crisis. The United Kingdom also experienced a hike in unemployment across the same time period.

Figure 2.3: Unemployment Rates for the US and the UK (2007-2011)



Source: Datastream

2.2.2 Causes

2.2.2.1 Moral Hazards

Moral hazard refers to an incentive to a person/organisation responsible for the interests of others to put his/their interests first (Ben-David, 2009). Financial transactions, by default, are exposed to moral hazards, as managers of financial institutions have a lesser incentive to take care of others' interests. The nature of financial institutions makes the situation even more complicated as the assets of these institutions are very diverse and fungible. Therefore, it is very difficult for the investors to monitor the institutions' activities and adopt remedial strategies in case their interests are not taken care of. The recent financial crisis is an excellent example of moral hazards present in a range of situations, for example the origination of mortgages where properties were valued over and above their actual values, and then financial institutions in the wake of selling more mortgages and charging more fees, did not evaluate the debtor's ability to pay back the loan (Ben-David, 2009; Dowd, 2009) .

2.2.2.2 Mortgage Lending Post-Crisis

In the US, Fannie Mae and Freddie Mac were mostly responsible for the securitisation of mortgage-backed securities. These organisations had certain checks and balances in place both on the borrower as well as the investor or buyer's side. For instance, borrowers were required to meet certain standards

such as high credit scores, large down payments and low ratios of debt service to available income. At the same time these prime mortgages were guaranteed by the two mortgage market giants to safeguard the buyers/investors' interest. Therefore, these prime mortgages were characterised by low delinquency and default rates (Demyanyk and Van Hemert, 2008; Hellwig, 2009).

After the turn of the millennium the mortgage market expanded, with an increased share in private investment banks. The securities of these investment banks were usually not guaranteed and the quality of borrowers was not scrutinised in the manner of Freddie Mac and Fannie Mae. Thus, market share of these government-sponsored organisations reduced from 76% to 43% in selling mortgage-backed securities. The term 'subprime' surfaced in this time period and referred to those mortgages that did not meet the standards of Freddie Mac and Fannie Mae. The share of subprime mortgages in new mortgage approvals rocketed from 9% in 2000 to 40% in 2006 (Danielle and John, 2007; Demyanyk and Van Hemert, 2008; Hellwig, 2009).

These trends in the mortgage market brought the quality of underlying securities down. The blind focus on profitability and growth without sufficient assessment of the risks involved was further motivated by the financial innovations in the fixed-income securities market. This market was seen as an opportunity for substantial growth, but later led to the fall of the mortgage market.

2.2.2.3 Risk Assessment and Credit Agencies

Credit agencies are responsible for assessing the credit quality of both financial institutions and instruments to help investors in selecting and diversifying their portfolios of investment. The current financial crisis has highlighted a major flaw in the risk assessment procedure adopted across the credit rating agencies, that the borrower's capacity to repay his/her debt is overshadowed if the underlying collateral's (property) value is increasing (Hellwig, 2009). This is because an upward trend in an asset's value is considered to reduce the default risk of the underlying asset. This has a dual adverse effect in case appreciation if the value itself is overestimated. This anomaly was observed in 2006 when real-estate prices started declining and delinquency rates rose to record levels. In addition to the above, quantitative risk models were overoptimistic but were heavily relied upon. These models

failed to capture the underlying default risk structure and correlations between various securities across the mortgage market. Lastly, conflict of interest was neglected, as the credit rating agencies were providing consulting services for the very same organizations that they were also rating.

2.2.2.4 Internal Control and Market Discipline

The current financial crisis is an excellent example of a complete failure of market discipline and internal controls. The financial institutions, being the mainstay of any financial system, are more exposed to certain risks such as under-hedging due to over-optimism from the top level management of these institutions. This is explicitly observed as the financial institutions largely underestimated the risks of holding subprime and adjustable rate mortgages. Further insurance agreements to hedge these risks were only a fraction of their total exposure. Moreover, the possibility of a default by counterparties to hedge was almost completely neglected (Dowd, 2009; Melvin and Taylor, 2009). The managerial attitude in this global turmoil was characterised by short-sightedness and greed for compensation and returns while internal controls and risk management were considered to be mere issues of routine.

2.3 Financial Crisis: Impact on Foreign Exchange Volatility and International Trade

The impact of the current financial crisis on the foreign exchange market can be described in four stages (Melvin and Taylor, 2009):

2.3.1 Spill over from the asset classes and carry trade

Carry trade is a well-known FX market strategy whereby investors maintain long positions in the high-interest rate currencies and, simultaneously, short positions in low-interest rate currencies. These investors are taking up positions contrary to the interest rate parity (IRP) theory, which states that the interest rate differentials in long and short currencies lead to offsetting exchange rate movements. However, failure of IRP results in large returns to carry trade investors (Cai *et al.*, 2001; Melvin and Taylor, 2009; Burnside *et al.*, 2011) .

The foreign exchange market showed the first stress signs in August 2007, which is comparatively later than other asset classes such as the debt and equities markets. A major unwinding of carry trade occurred on August 16, 2007 and many carry trade investors suffered significant losses. The following figure shows the huge drop in the Deutsche Bank Carry Trade Index:

Figure 2.4: Deutsche Bank Carry Trade Index

Source: Datastream

Historically, carry trades have unwound during market stress. Prior to the current crisis, the last major unwinding was observed during the Russian Debt default (October 1998) and the Long Term Capital Management (LTCM) collapse (Brown *et al.*, 2009).

Volatility in the foreign exchange market reflected the amplified volatility in other asset classes. Deleveraging, ignited by heavy losses in debt and equity portfolios, spilt into the currency portfolios and induced the investors to reduce their risk exposure in currency trades as well.

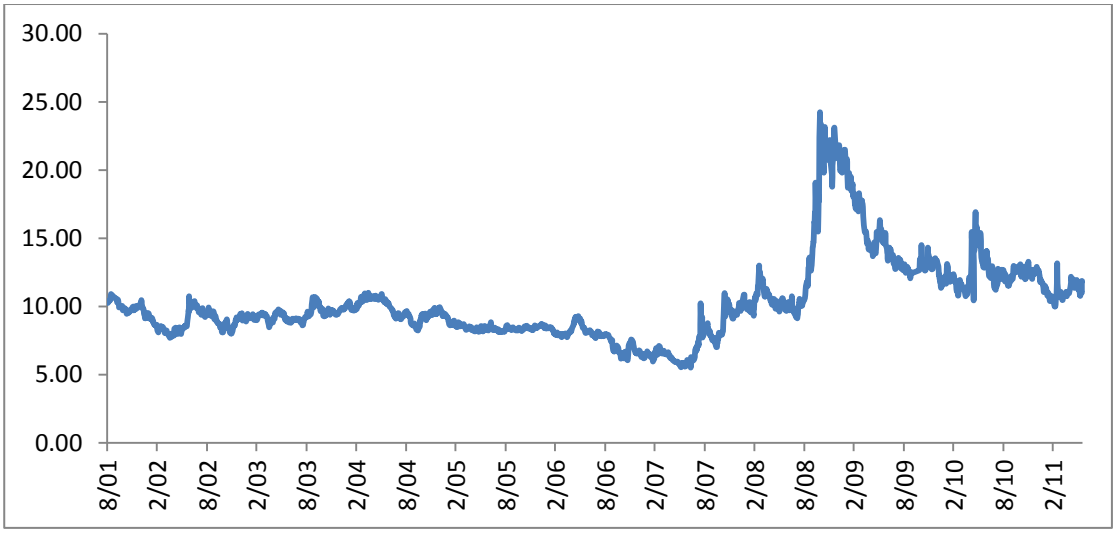
2.3.2 Liquidity and Deleveraging

The carry trade issue was only brief at the start, and the market seemed to have revived back to its normal flow, as shown in Figures 2.4 and 2.5. However, volatility remained relatively high compared to the pre-crisis period and it escalated further from November 2007, as shown in Figure 2.5. Along with the carry trade unwinding, there were major concerns regarding the

liquidity situation in the financial markets. The example of Sentinel (hedge fund) is often quoted as an early illiquidity sign, halting the redemption due to a lack of liquidity (Melvin and Taylor, 2009). An obvious flight to quality was observed during this time, firms were finding it very difficult to issue short term asset backed commercial papers, and simultaneously yields were on the rise. This was due to the investors' increased risk aversion and drying up of market liquidity (Berman, 2009).

The collapse of Bear Sterns and its subsequent takeover by JP Morgan Chase was a major setback to the financial markets and led to higher risk premiums being charged by lenders. But policy interventions by the Federal Reserve, and the organized takeover of Bear Sterns, gave the market some hope and volatility was seen to reduce after the deal was sealed. At this stage illiquidity and deleveraging were moving side-by-side and the market observed various forced sales, where brokers (lenders) were forcing the borrowers to liquidate their positions due to huge losses. In addition, strict risk management controls triggering margin calls/liquidation of positions were imposed by the lenders. Thus liquidity and deleveraging, after carry trade, were the two major drivers of the crisis in the financial markets, to which the FX market was no exception.

Figure 2.5: Deutsche Bank FX Volatility Index



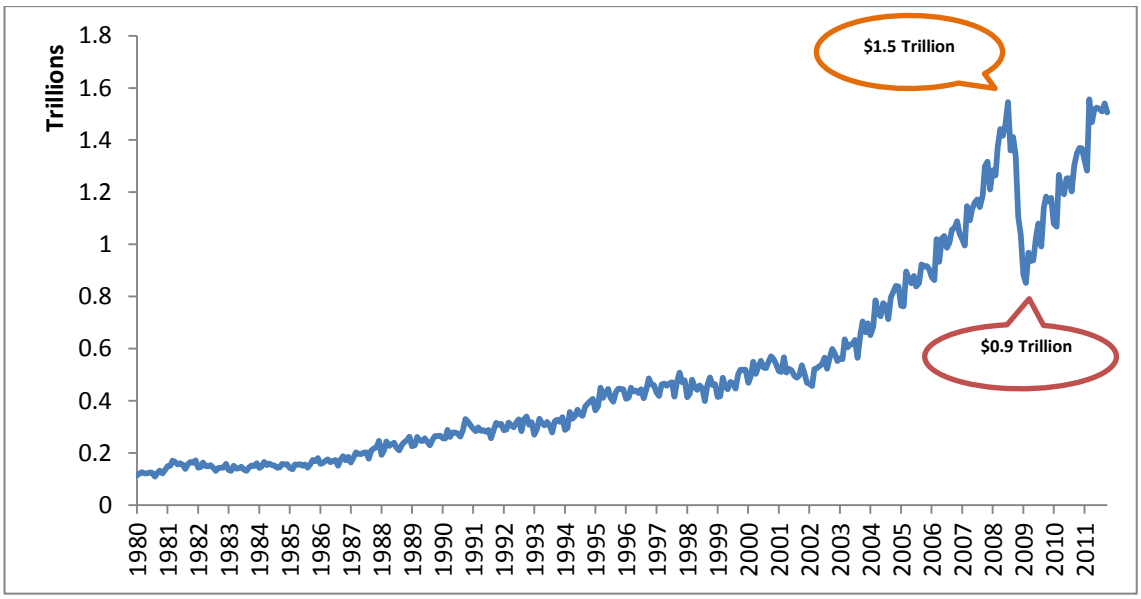
Source: Datastream

2.3.3 Financial Crisis and International Trade

Global trade went through a very deep and simultaneous drop in the last quarters of 2008. This drop was the severest since WWII and many of the researchers have identified the global financial crisis as the main driving force behind this decline in trade, even calling it "The Great Trade Collapse" (Baldwin, 2009). The impact of the financial crisis on the international trade flows was channelled by the recession and decline in global demand, especially durable and investment goods, as well as the international synchronization, which played an important role in the reduction of international trade.

The world export volume (monthly basis) peaked during July 2008 at $1.5 trillion USD and then it experienced a sudden drop over the next year and was recorded as well below $900 billion in February 2009, as shown in Figure 2.6. In other words, during the financial crisis world export volumes shrank more than 33%, which is enormous and is considered to be the steepest drop in the recorded history of world trade. Hence the term "The Great Trade Collapse" coined in the literature (Baldwin, 2009; Abiad *et al.*, 2011).

Figure 2.6: Monthly Export Volume (Monthly, USD)

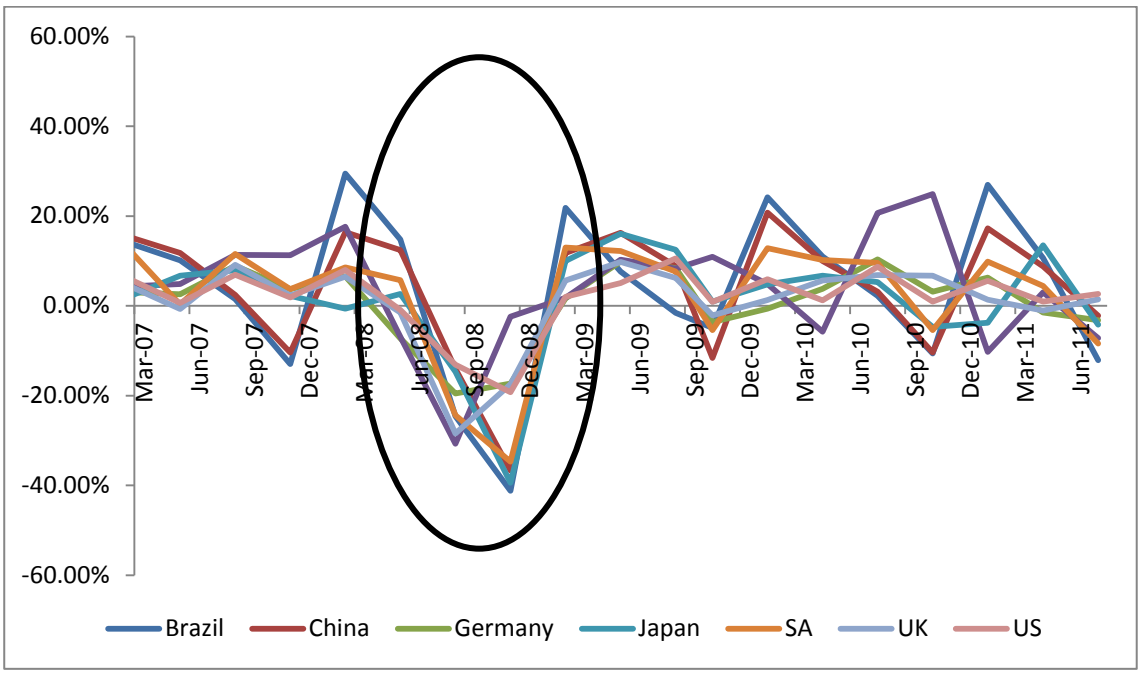


Source: Datastream

Another important aspect in this regard was the synchronised impact of the financial crisis on the trade flows globally. Most of the countries around the globe experienced a fall in both exports and imports during Q2-2008 and Q2-2009. Figure 2.7 shows the export growth rates of the sample countries during

the financial crisis. The encircled area shows the simultaneous drop in the export growth for all the countries, showing the scale of deterioration in global exports. Both the developing and developed countries in the sample went through a rough time, facing a decline in exports ranging from 20-40%.

Figure 2.7: Export Growth (2007 to 2011)



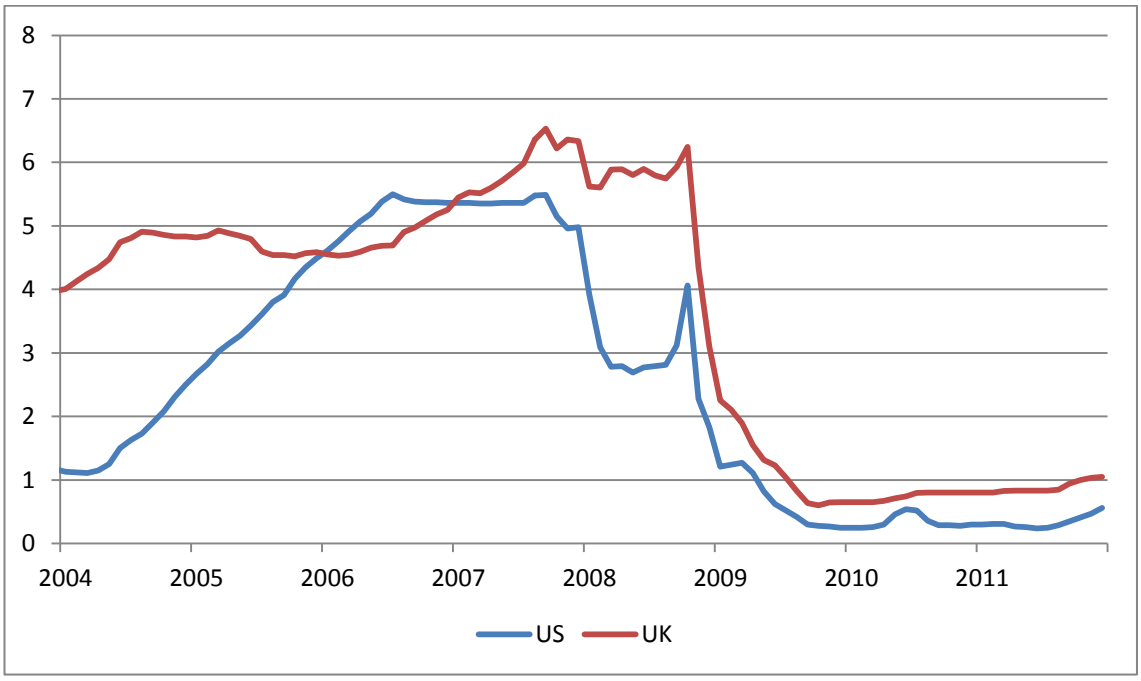
Source: Datastream

Interbank lending rates are generally considered a good indicator of credit conditions and liquidity in an economy. The current financial crisis, beside many other repercussions, also led to volatile inter-bank rates globally. Volatility in inter-bank rates and foreign exchange volatility led to a large increase in uncertainty for both importers and exporters pertaining to the availability of financing and the cost of acquiring these funds. This impact has been shown to be much higher for sectors/economies heavily dependent on external financing. During the financial crisis period, the financial markets' liquidity was seen at the minimum levels, exacerbating the problems for both exporters and importers (Melvin and Taylor, 2009; Chor and Manova, 2012). This adversely affected both the supply and demand sides of international trade. Both the production capacity of exporters and the buying power of importers significantly reduced due to the increase in interbank rates as well as illiquidity, which translated into a higher and more volatile cost of capital for trading partners across the major economies. In continuation to the above argument, the literature shows that the foreign exchange volatility affects the

international exports in two ways: i) due to a variation in relative prices caused by exchange rate movements (competitiveness effect); and ii) changes in the fixed costs of exports (balance sheet effect) (Chor and Manova, 2012) .

The financial crisis has also seen a rise in interest rates in both the pre-crisis and the current financial turmoil, as shown in Figure 2.8. Interest rates were on the rise since 2004 in both the US and the UK, showing a considerable demand for financing. To make the situation worse, inter-bank rates also went sky-high, in the range of 5-6%, for both countries (though more significantly in the case of the UK), increasing the financing cost immensely in both countries as depicted below.

Figure 2.8: Three-Month Average Inter Bank Lending Rates (%)



Source: Datastream

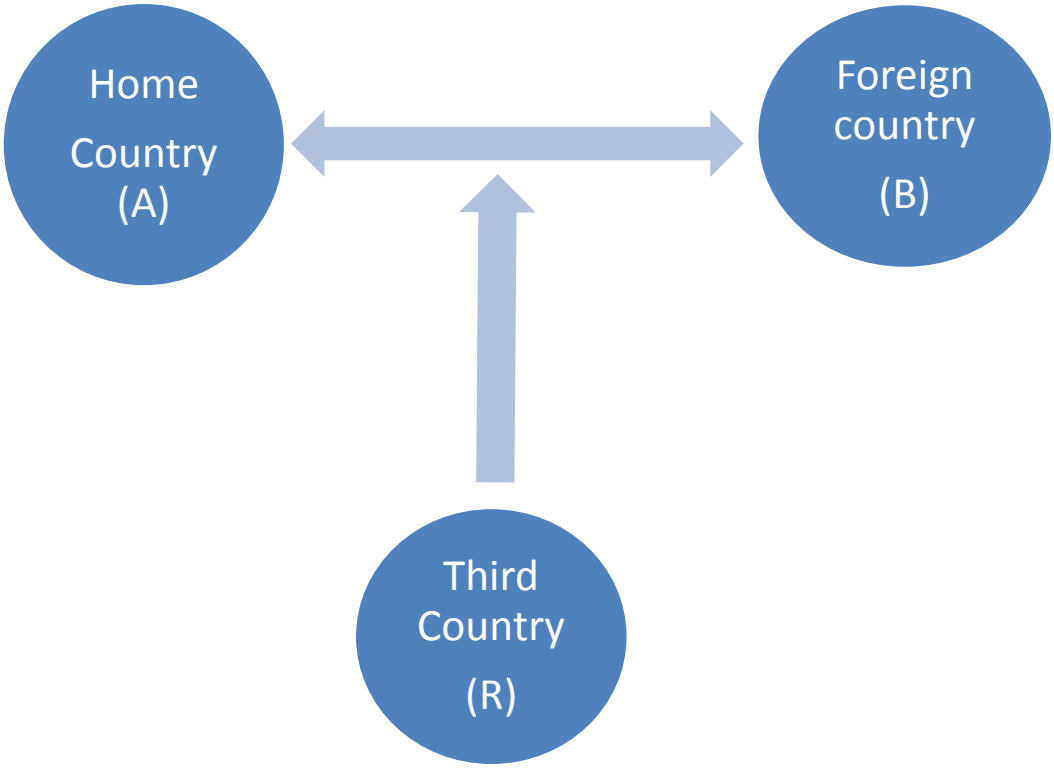
2.4 Theoretical Relationship between Foreign Exchange Rate Volatility and International Trade

2.4.1 Setup

The theoretical framework in this research is based on the work of Viaene and de Vries (1992) and Cushman (1986). The theoretical framework is created in a

three-country world as shown in the following figure, involving a domestic country (A), a foreign country (B) and a third country (R) which can be generalised as rest of the world as well (Bolhassani, 2009). It is assumed that all countries have bilateral trade with each other. For notational convenience and generalisation goods are always invoiced in the trade partners' currency, as it controls the demand uncertainty in foreign markets due to inflation and increasing price levels in the domestic country (Ligthart and Da Silva, 2007).

Figure 2.9: International Trade Setup



Importers are assumed to have minimal impact on the market pricing mechanism and are price takers, but an importer's domestic demand curve is downward sloping. Prices of imports in domestic markets are quoted in the home currency.

Domestic price level (P_t) at time t is assumed to be a non-stochastic variable, whereas price levels in trading partners are denoted by P^c_t at time t and are fixed (c = either of trading partners B or R). Real exchange rate is estimated as $e^c_t = W^c_t P^c_t / P_t$ where W^c_t is the nominal exchange rate (defined as the units of domestic currency for each unit of foreign currency) at time t.

Similarly, expectation of real exchange rate (e^c_t) is $E(e^c_t) = \varepsilon^c_t$, and the variance of real exchange e^c_t is the $Var(e^c_t) = (\sigma^2_c)$.

In the case of an exporter in country A exporting to both countries B and R, prices (both exports and imports) would be denominated in the partner countries' currencies i.e. B and R respectively. For each transaction, contracts are signed at time t and the transactions take place at t+1. Production costs of exports may be shown at t+1 for exporter i in the following:

$$C(X_i^B, X_i^R) = \bar{d}_i + \sum_{c \in (B,R)} \left(d_i^c X_i^c + \frac{1}{2}(X_i^c)^2 \right) \tag{1}$$

Where X^c_i denotes the exports to country c (i.e. either B or R), $\bar{d}_i$ represents fixed costs and d^c_i is a non-zero positive parameter i.e. $d^c_i > 0$ representing the marginal cost of production. Lastly, exports to countries B and R are not perfect substitutes to each other, hence marginal rates of substitution of countries B and R will not be constant and will mainly vary according to the customers' preferences.

In terms of revenues for exporter i (being a price-taker) each unit of exports X^c_i would be sold for P^c_i in foreign currencies. Therefore, total export revenue would constitute $W^c_{t+1}P^c_iX^c_i$ in home currency, where W^c_{t+1} refers to the nominal spot exchange rate at t+1. Hence real profit (π) for the exporter at time t+1 can be expressed as:

$$\pi_{t+1} = \frac{1}{P_{t+1}} \left(\sum_{c \in (B,R)} W_{t+1}^c P_i^c X_i^c - C(X_i^B, X_i^R) \right) \tag{2}$$

$$\pi_{t+1} = \frac{1}{P_{t+1}} \left[\sum_{c \in (B,R)} W_{t+1}^c P_i^c X_i^c - \left\{ \bar{d}_i + \sum_{c \in (B,R)} \left(d_i^c X_i^c + \frac{1}{2}(X_i^c)^2 \right) \right\} \right] \tag{3}$$

$$\pi_{t+1} = \sum_{c \in (B,R)} (e_{t+1}^c P_i^c X_i^c) - \frac{1}{P_{t+1}} \left[\bar{d}_i + \sum_{c \in (B,R)} \left(d_i^c X_i^c + \frac{1}{2}(X_i^c)^2 \right) \right] \tag{4}$$

Risk averse exporter **i** would aim at maximising the following utility function:

$$EU_{i,t+1} = E\pi_{i,t+1} - \frac{1}{2}\alpha_i var\pi_{i,t+1} \qquad (5)$$

Where $\alpha_i > 0$ is the risk aversion parameter and conforms to the positive risk premium required by risk averse investors/traders.

The first term of equation 5, i.e. $E\pi_{i,t+1}$ can be rewritten in terms of the expected value of export revenue and export costs:

$$E\pi_{i,t+1} = \varepsilon^B P_i^B X_i^B + \varepsilon^R P_i^R X_i^R - \frac{1}{P_{t+1}}\left(\bar{d}_i d_i^B X_i^B + \frac{1}{2}\left(X_i^B\right)^2 + \bar{d}_i d_i^R X_i^R + \frac{1}{2}\left(X_i^R\right)^2\right) \qquad (6)$$

Similarly var$\pi_{i,t+1}$ may be expanded on expectation basis in the following form:

$$var\pi_{i,t+1} = var\left(\sum_{c\in(B,R)} e^c P_i^c X_i^c\right)$$

$$\begin{aligned} &= \left(P_i^B X_i^B\right)^2 \sigma_B^2 + \left(P_i^R X_i^R\right)^2 \sigma_R^2 + 2P_i^B X_i^B P_i^R X_i^R cov(e_{t+1}^B, e_{t+1}^R) \\ &= \left(P_i^B X_i^B\right)^2 \sigma_B^2 + \left(P_i^R X_i^R\right)^2 \sigma_R^2 + 2P_i^B X_i^B P_i^R X_i^R \rho_{B,R}\sigma_B^2\sigma_R^2 \end{aligned} \qquad (7)$$

Where $\rho_{B,R}$= corr(e^B_{t+1}, e^B_{t+1}), and the rest of the terms are as defined above.

The above discussion formulates the basis for the exporter's decision i.e. the volume of exports to country B that will maximise the exporter's utility. Maximising equation 5 with respect to the volume of exports to country B provides the solution to the exporter's problem.

$$X_i^B = \frac{\left(\varepsilon^B P_i^B P_{t+1} - d_i^B\right)\left(1 + \alpha_i P_{t+1}\left(P_i^R\right)^2\right) - \left(\varepsilon^R P_i^R P_{t+1} - d_i^R\right)\alpha_i P_{t+1} P_i^B P_i^R \rho_{B,R}\sigma_B\sigma_R}{1 + \alpha_i P_{t+1}((P_i^B)^2\sigma_B^2 + (P_i^R)^2\sigma_R^2) + \alpha_i^2 P_{t+1}^2 (P_i^B)^2 (P_i^R)^2 \sigma_B^2\sigma_R^2(1-\rho^2)} \qquad (8)$$

The above equation implicitly assumes that the expected price in the home currency is greater than the marginal cost of production for both the trading partners', i.e.

$$\varepsilon^B P_i^B P_{t+1} - d_i^B > 0,$$
$$\varepsilon^R P_i^R P_{t+1} - d_i^R > 0$$

This assumption defines the optimal level of exports from domestic country (A) to its trading partners (B and C) where the export prices exceed the marginal production cost.

In order to understand the impact of exchange rate volatility on international trade, first the effects of exchange rate movements to bilateral trade levels are explained and then impact of the volatility is discussed in the following section

2.4.2 Impact of Exchange Rate Movement on Bilateral Trade

The last equation (8) can be used to analyse the impact of the exchange rate movement between the foreign country (B) and the domestic country (A) on the export volume in the following manner:

$$\frac{\partial X_i^B}{\partial \varepsilon^B} = \frac{P_i^B P_{t+1}\left(1 + \alpha_i P_{t+1}\left(P_i^R\right)^2 \sigma_R^2\right)}{1 + \alpha_i P_{t+1}((P_i^B)^2\sigma_B^2 + (P_i^R)^2\sigma_R^2) + \alpha_i^2 P_{t+1}^2 (P_i^B)^2 (P_i^R)^2 \sigma_B^2 \sigma_R^2 (1-\rho^2)} > 0 \qquad (9)$$

This equation states that the rate of change of the direct real exchange rate is positive; implying that an increase (depreciation) in the real exchange rate increases the exports and decreases imports, between domestic (A) and foreign countries (B), and similarly between A and R (third country) as well.

The above framework can also be used to explain the negative impact of exchange rate volatility on bilateral trade between the home country (A) and a foreign country (B)

$$\frac{\partial X_i^B}{\partial \sigma^B} < 0 \qquad (10)$$

Similarly, the increased third-country (R) exchange rate volatility positively affects the bilateral trade between countries (A) and (B) and can be shown using the above model:

$$\frac{\partial X_i^B}{\partial \sigma^R} > 0, \textit{assuming that } \rho \geq 0 \qquad (11)$$

2.5 Hypotheses to be tested in the Dissertation

2.5.1 An increase in the exchange rate volatility reduces the imports volume of the home country (A) from the foreign country (B)

This hypothesis can be tested using the following model, suggested by Bahmani-Oskooee and Hegerty (2007), which comprises the key determinants of international trade, with foreign exchange volatility being the main variable of interest[2].

$$ln\,(M)_t = \beta_0 + \beta_1 y_t + \beta_2 p_t + \beta_3 V_t + u_t \qquad (12)$$

Where

M = Monthly import volume of the home country (A) from the foreign country (B)

β_i = Model parameters where i = 0,1,2 and 3

y_t = log of the UK's real Income

p= log of relative import prices of the home country (A) and the foreign country (B)

V= conditional Volatility of exchange rate.

u = residual term assumed to i.i.d N~ $(0,\delta^2)$

Null Hypothesis (H_0) 1: $\beta_3 = 0$

This hypothesis aims to discover the linear causal relationship between the imports and exchange rate volatility of the home country (A) and the foreign country (B). However, in order to overcome the specification problem two other variables are also included i.e. relative prices and income.

[2] According to the examiners' suggestion, 3-month LIBOR (£) rate (financial variable) was included in the empirical setup and results were obtained for UK imports from the US for all four hypotheses under both ARDL and Asymmetric ARDL methods. As shown in the Appendix-I (p.223), the respective coefficients for 3-month LIBOR rates under all specifications for were insignificant. Also, these results hold under both methods and hence imply no significant impact of the financial variables on UK imports. Therefore, empirical analyses are carried out following the standard literature on the basis of exchange rate volatility, the UK's real income and the relative price ratio.

This hypothesis has two outcomes, i.e. either the null hypothesis will be rejected or vice versa. In the affirmative case it would imply no relationship exists between the two variables, otherwise imports would be dependent on exchange rate volatility. However, the sign of the coefficient for exchange rate volatility is of great significance, because a negative sign i.e. $\beta_3 < 0$ would provide evidence in favour of the negative hypothesis whereby an increase in exchange rate volatility tends to deter international trade flows between two countries; however, $\beta_3 > 0$ would support positive impact of foreign exchange volatility and international trade i.e. an increase in exchange rate volatility leads to an enhancement of international trade flows.

In addition to the above, the other two parameters β_1 and β_2 capture the impact of the relative income of the importing countries and the relative import price ratio. From a standard theoretical perspective, the coefficient of relative income (β_1) should show a positive relationship between the imports and the relative income of the importing country (Bailey *et al.*, 1986; Bailey *et al.*, 1987; McKenzie, 1999; Choudhry, 2005; Bahmani-Oskooee and Hegerty, 2007), as an increase in the real income has a positive impact on the demand for imports (McKenzie, 1999). Relative import prices, however, are expected to have a negative impact on the trade flows, implying $\beta_2 < 0$ and indicating that a higher relative import price ratio reduces the trade flows between the countries (Bailey *et al.*, 1987; McKenzie, 1999; Choudhry, 2005; Bahmani-Oskooee and Hegerty, 2007).

2.5.2 An increase in the exchange rate volatility between the home country (A) and the third country (R) increases the bilateral trade between the home country (A) and the foreign country (B).

The literature on the subject predominantly assumes a two-country world, i.e. where a domestic country trades with only one foreign market. Therefore, almost all of the models are based on the assumption that importers have to decide between doing the business (i.e. buying or selling) domestically or with the sole trading partner. This assumption is a departure from reality, where importers have to select from markets around the globe and are not limited to just one trading partner.

Introduction

This modification in the traditional international trade theory warrants the inclusion of the third country effect, as suggested by Cushman (1986), Mckenzie (1999) and Bahmani-Oskooee and Hegerty (2007). Third country effect is defined by Cushman (1986) as the changes caused in the trade between two countries due to the exchange rate movement of another country. In other words, the exchange rate movement may divert importers in the domestic country from its former trading partner to another country. Similarly, exporters in the domestic country may like to sell their products to another country due to better price prospects.

This hypothesis stems from Cushman (1986), McKenzie (1999) and Bahmani-Oskooee and Hegerty (2007). These studies have challenged the assumption of a home country trading with only one other country. Another country (more generally the rest of world) was introduced in order to understand the trade flows with relative volatilities of more than two currencies. This would explain the impact of the exchange rate volatility of the third country on the bilateral trade between two trading partners. Furthermore, they also indicated the significance of controlling for the comparative advantage of the third country as well.

Third country effect can be defined as the changes in the pattern of bilateral trade between various countries, due to fluctuations in the relative volatility of their currencies, which results in trade diversion, i.e. importers switching to countries with lower selling prices. Exporters in strong economies in this situation are more vulnerable as a relative appreciation in their home currency will increase the prices of their commodities in the foreign markets, thereby the risk of losing market share is very high. This effect is ignored in most of the existing literature on international trade. The exchange rate volatility and its impact on bilateral trade can be explained more realistically by incorporating the third country effect.

This hypothesis may be evaluated using the following framework suggested by Bahmani and Xu (2010):

$$ln\,(M)_t = \beta_0 + \beta_1 y_t + \beta_2 p_t + \beta_3 V_t + \beta_4 TCV_t + u_t \qquad (13)$$

Where

M = Monthly imports volume of the home country (A) from the foreign country (B)

β_i = Model parameters where i = 0,1,2,3 and 4

y_t = log of home country (A)'s real Income

p= log of relative import prices of the home country (A) and the foreign country (B)

V= conditional Volatility of exchange rate between the home country (A) and the foreign country (B)

TCV = Exchange rate volatility between the home country (A) and the third country (R)

u = residual term assumed to i.i.d N~ $(0,\delta^2)$

The above model is similar to equation 12, except for the additional third country volatility variable (TCV), which is also the main variable of interest for this hypothesis.

Null Hypothesis (H_0)2: $\beta_4 = 0$

The null hypothesis states that third-country effect does not exist. However β_4 is expected to be greater than 0 and third-country exchange rate volatility should have a positive impact on the trade flows between the two countries, as shown in equation 11, because the volatility of the exchange rate between the home country (A) and the third country (R) will induce the importers in the home country to divert their trade towards the other trading partner (B) to avoid the uncertainty and exchange rate risk (Bahmani-Oskooee and Hegerty, 2007).

2.5.3 Financial crisis causes a further increase in Exchange Rate Volatility which in turn depresses foreign trade

The third hypotheses posits that during the current financial crisis exchange rate volatility amplified which further depressed the international trade flows and caused a change in the long-term relationship between the underlying variables. The financial crisis has been discussed at length in Section 2.3. As shown in Figure 2.6, global trade volume shrank by one-third during this crisis, showing the severity of its impact on global trade. At the same time, a hike in the exchange rate volatility of different currencies against the British pound can be seen in Figures 4.7 and 4.8. This drop was the severest since WWII and

many of the researchers have named the global financial crisis to be the main driving force behind this decline in trade, even terming it "The Great Trade Collapse" (Baldwin, 2009). The impact of the financial crisis on the international trade flows was channelized by a recession and decline in the global demand, especially for durable and investment goods, as well as the international synchronization which played an important role in the reduction of international trade (Baldwin, 2009; Abiad *et al.*, 2011). Thus, the aim of this hypothesis is to test the linear relationship between UK imports and the rest of the variables, especially exchange rate volatility, and third country exchange rate volatility in the pre-crisis period (January 1990 to June 2007) and the financial crisis period (January 1990 to December 2011).

2.5.4 Exchange Rate Volatilities (both bilateral and third country) affect the imports of Home Country (A) from Foreign Country (B) asymmetrically.

This hypothesis analyses the asymmetric nature of the underlying research variables. The main aim is to test the asymmetric impact of the exchange rate volatilities, both bilateral and third country effect, on UK imports, in addition to other independent variables such as UK real income and relative import price ratio. The Asymmetric ARDL method proposed by Shin, Yu and Greenwood-Nimmoo (2013)[3] is used to test this hypothesis, re-writing equations 12-13 to capture the asymmetric impact of the underlying variables:

$$ln\,(M_t) = \beta_0 + \beta_1^+ {y^+}_t + \beta_2^- {y^-}_t + \beta_3^+ p_t^+ + \beta_4^- p_t^- + \beta_5^+ {V_t}^+ + \beta_6^- {V_t}^- + u_t \qquad (14)$$

$$ln\,(M_t) = \beta_0 + \beta_1^+ {y^+}_t + \beta_2^- {y^-}_t + \beta_3^+ {p^+}_t + \beta_4^- p_t^- + \beta_5^+ {V_t}^+ + \beta_6^- {V_t}^- + \beta_7^+ {TCV_t}^+ + \beta_8^- {TCV_t}^- + u_t \qquad (15)$$

Where

M = Monthly imports volume of the home country (A) from the foreign country (B)

3 Econometric details of the model are provided in Section 4.5.4

β_i = Model parameters where i = 0,1,2,3, 4 ….. 8, whereas superscript "+" and "-" denotes the positive and negative partial sum of each variable under the Asymmetric ARDL approach to capture asymmetric effect.

p= log of relative import prices of the home country (A) and the foreign country (B)

y = log of home country (A)'s real Income

V= conditional exchange rate volatility between the countries (A&B)

TCV = Third country exchange rate volatility between the countries (A&R)

u = residual term assumed to i.i.d N~ $(0,\delta^2)$

Null Hypothesis (H_0)4: $\beta_i^+ = \beta_i^-$

Following Schorderet (2001) and Shin *et al.* (2013), the asymmetric effect hypotheses are tested for possible inequality between the positive and negative coefficients for each variable. If the null hypothesis is rejected and these shocks are not equal statistically, then it will demonstrate the asymmetric nature of the relationship between the underlying variables. It further implies that both positive and negative components of the underlying independent variables have different impacts on the dependent variable, hence imposing a separate relationship between the positive and negative shocks with the dependent variable.

2.6 Contribution to the Literature

This research aims to analyse the traditional relationship between exchange rate volatility and international trade. However, the novelty of this study is that it attempts to explore this relationship in the context of the third country effect, which has not been empirically analysed in detail in the past. Further, this thesis examines the impact of the current fiscal crisis on the exchange rate volatility and international trade flows of the UK. The recent financial turmoil has been unparalleled and has struck the global economy in several ways. This inquiry is motivated by the fact that, to the best of my knowledge, no research has been carried out thus far looking at UK trade and exchange rate volatility in the context of the third country effect and the current financial crisis (2007-2011).

To summarise, the main contribution of this research to the existing literature would be detailed analysis of: i) the exchange rate volatility and trade flows for the UK; ii) the third country effect on the UK's trade flows; iii) the impact of the financial crisis on the relationship between exchange rate volatility and trade flows of the UK; and iv) whether the exchange rate volatility (bilateral and third country) affects UK imports asymmetrically.

Chapter 3: Literature Review

3.1 Introduction

The impact of exchange rate volatility on international trade has been discussed since the collapse of the Bretton Woods system of fixed exchange rates in 1973. As currencies in the post Bretton Woods era started to fluctuate it was observed that these fluctuations caused a surge in the uncertainty for the traders and thereby adversely affected the volume of international trade (Bahmani-Oskooee and Hegerty, 2007).

This chapter provides a critical review of the existing body of literature around the research hypotheses formed in the previous chapter. The existing literature is presented in two broad sections, namely: i) exchange rate volatility and international trade, and ii) the impact of the financial crisis on exchange rate volatility and international trade.

3.2 Exchange Rate Volatility and International Trade

This section comprises of literature looking at establishing the direction of the causal relationship between exchange rate volatility and international trade flows, i.e. whether volatility positively or negatively affects the trade flows, as well as the theoretical dynamics of the underlying relationship.

Since the advent of the floating exchange epoch, numerous papers have been published to explain how increased exchange rate uncertainty (volatility) theoretically affects the trade, and even more papers have been written to empirically evaluate these theories using various methods and models. However, no consensus has been reached regarding modelling and measuring the exchange rate volatility and magnitude, or the direction of the relationship between volatility and international trade. Considering the nature of the literature on this issue the papers are broadly classified into the following two groups:

3.2.1 Theoretical Literature

Ethier (1973), in his pivotal study, analysed the importers' strategy to maximise their profits under uncertainty. The strategy assumed various alternatives based on varying i) the volume of imports, and ii) the forward rate cover, from which the importer was free to decide. The criterion for the best alternative was the one maximizing the importer's profit. The profits were shown to be based on the following:

$$\pi\ (M, \alpha) = PM - V(M) - MQ[\alpha R_F + (1 - \alpha)R]$$

π = is the importers profit, as a function of varying M (Volume of imports) and α (forward rate cover proportion)

P = Sale Price of imports in domestic currency

V(M) = cost of value-addition to imports

Q = price of imports in foreign currency

α = proportion of import amount covered by forward rate

RF = Forward Rate

R = Spot Rate

In the above equation, the firm was deemed free to decide on the import volume (M) and forward cover (α). With the exception of a scenario where full forward cover would exist i.e. α =1, in all other cases the foreign exchange uncertainty would affect the importers profitability though both the cost of imports MQ and the sales price of the imports in the domestic currency (P). In the case of P, the environment in which the importers operate, i.e. competitors' policies and the foreign price elasticity of imports, beside other factors, would affect the nature of the impact. Profit uncertainty caused by the cost of imports (MQ) may be reduced to a large extent by obtaining forward cover (α), however, the import price in domestic terms is largely independent of forward cover and hence remains a major source of uncertainty for importers' profitability.

This analysis was based on certain assumptions, such as: risk aversion; the import prices to be denominated in foreign currency; and the ability of the firm to accurately estimate profit level at any given exchange rate value. Under

these settings, no significant effect of exchange rate volatility was found on international trade, however the hedging extent through the forward rate was found to be significant. In another attempt, removing the assumption of the firms' accurate estimation of profit, a significant effect of exchange rate uncertainty was found on international trade.

Clark (1973) independently found similar results for risk-averse firms. He developed a theoretical framework which includes exchange rate volatility in the simple trade model. He focused on the effect of exchange rate volatility on the lever of a country's export. He considered a representative firm that produces a homogeneous good under perfect competition and sells its entire product abroad. This firm does not have any importing input and it receives its income in terms of foreign currency (i.e. it is facing a price uncertainty). It is also assumed that the firm is paid in foreign currency for its exports and these earnings are sold in the forward exchange rate market. There is no hedging opportunity against fluctuations in the exchange rate for this firm. Using profit maximization conditions, Clark concluded that if the firm is risk-averse the greater the exchange rate volatility, price risk and risk premium would be. This increases the supply price of exports and thus causes the supply curve of the firm to shift backward. This reduces the volume of international trade. Hence, he deduced that exchange rate volatility has a negative effect on trade flows.
Baron (1976) however, highlighted that the forward markets may not be sufficiently developed and traders may be uncertain about the extent of forward exchange cover, causing lesser reductions in the exchange rate risk for the traders.

Viaene and de Vries (1992) added to the above, by explaining that importers and exporters are on different sides of the forward markets, therefore, increased exchange rate volatility may have different impacts on trading partners depending upon their net foreign currency exposure and nature of risk aversion.

Demers (1991) extended the negative hypothesis by showing that risk aversion is not required for proving the adverse effect of exchange rate volatility on international trade. He modelled a risk neutral competitive firm facing uncertainty about the demand level due to uncertain prices, which is in turn caused by the exchange rate movement. He showed that international trade

reduces because of exchange rate volatility as the firms are deterred by the fear of the irreversibility of investment in physical capital.

Franke (1991), using optioning pricing methodology, showed that a risk neutral exporting firm will increase its output in order to increase its net present value of expected cash flows. He further maintained that the transaction costs (i.e. entry and exit) associated with entering/leaving a foreign market is weighed against the profits from exports.

Sercu and Vanhulle (1992) have supported the argument presented by Franke (1991) that exchange rate volatility enhances the exports. They showed that a rise in the exchange rate volatility increases the value of an exporting firm.

Another explanation of the relationship between exchange rate volatility and international trade was given by De Grauwe (1988). He claimed that, assuming the prices of exports and imports are fixed and the only source of risk for producers is the changes in the exchange rates, the nature of the relationship depends on the expected marginal utility of the producers' income as a concave or convex function of the exchange rate. However, where producers are extremely risk averse, they will worry about the worst possible outcome. This means that an increase in exchange rate risk will raise the expected marginal utility of export revenue as producers will want to export more to avoid a drastic decline in their revenue stream. The model on which this result is based does not allow for the diversification of exchange rate risk.

Dellas and Zilberfarb (1993) provided additional evidence as to the uncertain nature of the impact of volatility using a standard asset portfolio model. However, unlike most other studies which focus on the variance of the exchange rate when defining volatility, the authors specify unanticipated fluctuations in the exchange rate as constituting risk. The asset in their model is a nominal unhedged trade contract which contains a risk element in the form of an exposure to changes in the exchange rate (the probability distribution of which is known). Their analysis examines a single individual who consumes as well as imports and exports available goods (no production is incorporated in the model). The results of this model indicated that an increase in the riskiness of the return on these assets (i.e. an increase in exchange rate volatility) may increase or decrease investment (i.e. trade) depending on the nature of the risk aversion parameter assumed. If a convex function is assumed, then an increase

in risk increases the level of exports. The reverse is true where concavity is assumed. The result is found to be robust to the presence of a forward market with non-zero transactions costs and the introduction of production.

3.2.2 Empirical Literature

3.2.2.1 Aggregate Trade Data

Akhtar and Hilton (1984), in a report presented at the GATT, showed that exchange rate volatility negatively affects German exports, German imports and US imports, however, no effect was observed for US exports. This study was based on the aggregate quarterly exports and imports (1974-1981) of Germany and the US. The authors used the polynomial distributed lag model to analyse the impact of exchange rate volatility on international trade. Other independent variables besides volatility for modelling exports also included foreign income, foreign capacity utilisation and relative prices. Imports were considered to be a function of domestic income, a ratio of foreign and domestic capacity utilisation and relative prices, in addition to exchange rate volatility based on standard deviation of daily nominal exchange rate observations in the last three-month period.

Gotur (1985) challenged the results of the above study, and presented very different results. Using the same approach as Akhtar and Hilton (1984) and after including France, the UK and Japan in the sample, this study repeated the above methodology. Interestingly, it was shown that seven out of ten data series were not statistically affected by the exchange rate volatility, only three showed a significant effect. In the latter group, German exports and imports were adversely affected whereas Japanese exports significantly increased due to exchange rate volatility. While assessing the robustness of Akhtar and Hilton's (1984) results, Gotur (1985) highlighted that the Cochrane-Orcutt procedure was applied unnecessarily for handling autocorrelation even where the problem did not exist. However, both studies failed to account for issues relating to stationarity and cointegration, hence the results of these two studies are considered spurious by later studies (Bahmani-Oskooee and Hegerty, 2007).

Kenen and Rodrik (1986), using Almon lag[4], analysed the effect of exchange rate volatility (six different measures) on imports and reported that exchange rate volatility depresses international trade. Among the volatility measures used were: 1) standard deviation of monthly percentage changes in the real effective exchange rates; 2) errors obtained from log-linear trend equations; and 3) residuals of the AR(1) process on the real effective exchange rates. These three measures were then estimated on both 24 and 12 month horizons. This research analysed the data from 1979-1984 on a quarterly basis. Beside exchange rate volatility, other independent variables included income, real exchange rates and a trend variable. The sample countries comprised of the G-7 in addition to Belgium, the Netherlands, Sweden and Switzerland. Like other earlier studies, this research also faced criticism for not considering the dynamics of other variables or, in other words, the cointegration properties of the variables were ignored for most of the variables as only lags of the exchange rates were included in the model (Bahmani-Oskooee and Hegerty, 2007). Another possible weakness may be the sample size, which was quite small with only 20 observations, resulting in smaller degrees of freedom.

Bailey *et al.* (1987) evaluated the positive and negative hypotheses with respect to exchange rate volatility and international trade and reported that little evidence is found for either. Their study empirically tested the quarterly data for eleven OECD countries from 1973-1984 and used four different volatility measures, including absolute percentage changes in the nominal and real effective exchange rates and moving standard deviation of both nominal effective exchange rates (NEER) and real effective exchange rates (REER). Variables of interest included export volume as the dependent variable with income, relative export prices and export earnings of oil-producing countries.

Perée and Steinherr (1989), using the annual aggregate trade data (1960-1985) for the UK, Belgium, Japan and the US, showed that the exchange rate volatility in most of the cases negatively affected the export volume. Other explanatory variables used in their study were Income, RER and terms of trade. The volatility measure devised for this study was based on a combination of long-

4 A type of finite distributed lag model, named after Almon (1965)

term disparities arising out of "accumulated variations" and "misalignment" in exchange rates. The first component was the percentage change between the minimum and maximum value of exchange rates over a given period of time, and the second component was given by misalignment measured as the geometric percentage difference between actual and equilibrium values of growing exchange rates. However, the authors concluded that their measure of volatility did not perform any better than other methods used at that time (Bahmani-Oskooee and Hegerty, 2007).

Caballero and Corbo (1989) construed that a risk-neutral firm might benefit from increased risk due to increased marginal returns, however, at the same time a risk-averse firm may react negatively to uncertainty. The authors then applied this theory to less-developed countries in Asia and South America. Approximating volatility as a four-quarter moving standard deviation of the real exchange rate, the authors used OLS and instrumental variables to estimate the export demand functions of Chile, Colombia, Peru, the Philippines, Thailand and Turkey. Annual data was used in this research, but the time period covered was not specified. In addition to other determinants, they included lagged exports to capture learning by doing. The authors stated that OLS will result in a downward bias for price elasticities. Therefore, the logs of the relative CPIs of DCs and LDCs, world demand, lagged exports, and time, as well as the standard deviation of the log real exchange rate, were chosen as instruments. They found that when they used the IV estimation, volatility was shown to have a clear, negative effect on export volumes.

Medhora (1990) applied OLS to the annual pooled import volume of the countries of the West African Monetary Union: Benin, Cote d'Ivoire, Niger, Senegal, Togo and Burkina Faso. The author noted that the Union's exports followed a completely different specification, which depended on such factors as government policies and weather. Exchange rate volatility was measured using the Akhtar-Hilton definition: the standard deviation of the nominal effective exchange rate (NEER) within each year – testing various ranges of possible sub-periods (weekly, monthly, and quarterly), estimating what has become a popular, yet simple, model of export volume as a function of world income, relative prices, and volatility. An analysis of the period 1976-1984 found no significant impact of volatility on import volume, and results were similar under different volatility proxies.

Bahmani-Oskooee and Ltaifa (1992) reported that uncertainty caused by exchange volatility adversely affected export volumes. Moreover, uncertainty had a greater impact on the exports of less-developed countries compared to developed countries. Their analysis was based on OLS analysis of annual data (1973-80) and comprised of 19 developed countries and 67 less-developed countries. Export volumes of the respective countries were the dependent variable and independent variables including population, currency devaluation, income and exchange rate volatility. The population variable was included following Brada and Mendez (1988) to account for the possible excess labour effect on exports in countries with higher populations. Volatility was estimated through standard deviation of percentage changes in the REER for the respective countries.

Bahmani-Oskooee and Payesteh (1993) investigated the exchange rate variability impact on the trade flows from 1973-1990 (quarterly figures) of some of the lesser developed countries including Greece, Pakistan, South Korea, the Philippines, South Africa and Singapore. According to this research, no statistically significant relationship between the variables of interest was found. This study used Granger's cointegration method to model the relationship between exchange rate volatility and trade flows (both imports and exports). Exchange rate volatility was proxied by standard deviation of percentage changes in the REER, following Bahmani-Oskooee and Ltaifa (1992). Explanatory variables included lagged REER, income and trend.

However, Bahmani-Oskooee (1996) later replicated the above study, with the only difference being replacing the Engle-Granger methodology with Johansen's cointegration test, and reported instead a negative relationship for both imports and exports. This analysis was based on quarterly data (1973-1990) for Greece, Korea, Pakistan, the Philippines, Singapore and South Africa. The author further criticised the application of the earlier methodology in the presence of stationary features, and showed that the later cointegration test is more robust than the Engle-Granger method.

Lastrapes and Koray (1990) applied the Vector Autoregression method to their analysis of US trade. The author viewed VAR to be superior because the procedure did not require the specification of exogenous variables. Their VAR incorporated eight variables: export volume, import volume, volatility

(measured as the 12-month moving standard deviation of the REER), the M1 money supply, the three-month T-bill rate, income, and the consumer price index. Using monthly data (1973-1987), the authors found no effect of exchange rate volatility on exports, however they reported a small negative effect on imports.

Co-integration analysis continued to make inroads during the early 1990s. Asseery and Peel (1991), using Granger's cointegration method, provided significant evidence for the negative impact of exchange rate volatility on export volumes. Their study included quarterly data from 1972-1987 covering Australia, Japan, West Germany, the US and the UK. Beside exchange rate volatility others variables included income and relative prices. The volatility measure was based on the residuals from an ARIMA process fitted to the log RER. They found a positive effect of exchange rate volatility for most of the countries.

In a similar study, Chowdhury (1993) interestingly reported a negative effect of exchange rate volatility on the export volume of the G-7 countries i.e. Canada, Italy, France, Germany, Japan, the UK and the US. His study was based on Granger's cointegration and used quarterly data. Variables of interest included foreign income and relative prices, as well as exchange rate volatility. Volatility was measured on the basis of an eight-quarter moving standard deviation of the growth rate in REER.

Kroner and Lastrapes (1993) showed mixed results, for some countries a positive effect was record and for others a negative effect was shown. Their study regressed the GARCH-in-Mean volatility against the export volumes of France, Germany, Japan, the UK and the US, along with exchange rates, relative prices, labour costs, income and three lags of export volumes. This study covered monthly data from 1973-1990. Positive results were shown for the exports of France and Germany, whereas the exports of the UK and the US were negatively affected by exchange rate volatility. For Japan no significant effect was found.

Qian and Varangis (1994) supported the negative hypothesis. Their empirical evidence was based on aggregate and bilateral monthly trade data (1973-1990). Countries under analysis included Australia, Canada, Japan, Sweden, the Netherlands and the UK. This study used the first difference OLS method,

modelling export volume as a function of nominal exchange rate, foreign prices, and real wage rate, lagged exports and lagged prices. Their results showed that in most cases exchange rate volatility negatively affected the bilateral trade. This was the same for the aggregate trade data as well, except in the case of Sweden where a positive effect was reported. However, this study did consider the cointegrating features of the variables and hence is advised to be considered with caution (Bahmani-Oskooee and Hegerty, 2007).

Arize and Ghosh (1991) also contributed to the body of literature that supports the negative hypothesis. Using Granger's cointegration method, this study included income and relative prices along with the exchange rate volatility as the determinants of export flows for the US. This study used four different measures to estimate volatility, i.e. 1) four-quarter moving average standard deviation of quarterly exchange rate growth, 2) ARCH, 3) recursive residuals from AR(4) of exchange rate growth; and 4) residuals of ARIMA(1,1,0) based on the log of exchange rates.

With the advent of error-correction modelling, economists have been further able to analyse both the short-term and long-term effects of uncertainty. Increased volatility may produce a temporary effect, but this may be reduced or eliminated over time as equilibrium is again reached. Using this approach, Arize (1995) models export volume as a function of income, relative price, and volatility which is approximated as an eight-quarter moving standard deviation of the log of the REER. An analysis of the Netherlands, Sweden, Denmark and Switzerland over the period 1973:II-1992:IV finds that volatility has had a significant negative effect for all countries for both the short and the long-term. Additional papers by this author, which generally use a very similar empirical specification as the 1995 paper, have provided a wealth of information about numerous countries, the trade flows of most of which appear to have been depressed by exchange-rate volatility. These studies use either the Engle-Granger method of co-integration, which tests for stationarity in the residuals of an OLS estimation of stationary variables, or the Johansen approach, which tests for the presence of one or more co-integrating vectors. One example of a study that employs the Engle-Granger method of co-integration is Arize (1996), who assesses UK exports and concurs with Arize and Ghosh (1994) that the trade-flow equation is incorrectly specified if it

omits volatility. Arize (1996) reports different results from previous studies of G-7 trade flows, obtaining significantly negative results for all countries.

Arize and Malindretos (1998) look at Australia and New Zealand, using ARCH as well as a recursive method to capture volatility. They find mixed results: volatility is shown to have had a positive effect for Australia, and a negative effect for New Zealand. Arize and Shwiff (1998) re-examine the import flows of the G-7 countries, as per Kenen and Rodrik (1986), using two additional measures of volatility: the log deviation of the REER from the expected value given by an AR(4) process, as well as predicted changes in the REER. They show positive results for Canada and insignificant results for Germany. Arize et al. (2003), who perform the classic study for Turkey, Korea, Malaysia, Indonesia, and Pakistan, obtained negative results. Those papers that employ the Johansen co-integration procedure include Arize (1998), who analyses the effects of volatility on the import volume of Belgium, Denmark, Finland, France, Greece, the Netherlands, Spain and Sweden; and Arize et al. (2000), who study the export volume of 13 LDCs. While most results support the adverse effect of exchange-rate volatility, Finland's volatility coefficient was shown to be insignificant, and Greece and Sweden showed positive and significant coefficients.

The body of literature outlined here shows mixed, but mostly negative effects of exchange rate volatility on trade flows. It is important to note that these models, like much of the literature of the past ten years, also use simple specification – often employing only income, relative prices, and volatility as determinants of trade flows.

Most recent literature makes use of similar methods of time-series analysis (either the Engle-Granger or the Johansen method of co-integration), and similar model specifications that use income and relative prices, even if there is no single, consistent measure of volatility. Using the Engle-Granger method, Doroodian (1999) measures volatility with both ARMA residuals and a GARCH-based measure to study the exports of India, Malaysia, and South Korea over the period 1973:II-1996:III. The author finds significant negative effects of exchange-rate volatility on trade flows. Sukar and Hassan (2001) used a GARCH-based measure as well, and find a similar negative result for US exports from 1975:I to 1993:II. Doğanlar (2002), using volatility as a four- or eight-

quarter moving standard deviation of the real exchange rate, also finds that volatility depressed the exports of Turkey, South Korea, Malaysia, Indonesia and Pakistan. Poon and Granger (2005) achieved mixed results, modelling the export volume of Indonesia, Japan, South Korea, Singapore, and Thailand as functions of world income, the REER, the terms of trade and volatility (approximated by the 12-period moving standard deviation of the log REER) over the quarterly span from 1973:II to 2002:II, the authors found that volatility depressed the exports for Japan, South Korea, and Singapore, and had a significantly positive effect on those of Thailand.

Sauer and Bohara (2001) used a panel-data model to evaluate volatility's influence on the exports of 91 developed and less-developed countries. Three measures of volatility were tested: one is ARCH-based, the second uses the eight-quarter moving standard deviation of the errors from an AR(1) process on the log RER, and the third uses an eight-quarter moving standard deviation. Employing both the fixed- and random-effect models, the authors model export volume as a function of world income, and one or both of two relative-price measures: the real effective exchange rate (RER) and each country's terms of trade (TOT). The terms of trade measure of relative price is seen to be significant in all specifications, but the real exchange rate – or both terms together – is also significant in most cases. When the countries are evaluated together, the effect of volatility is significantly negative; when the countries are separated by region, the developed countries and Asia register no effect, but Africa and Latin America show a significantly negative effect. The authors attributed this regional disparity to the differing opportunities for currency hedging in the different countries.

3.2.2.2 Bilateral Trade Data

While studies of countries' aggregate trade flows produced important results – that exchange-rate volatility generally depressed trade flows – there was still a possibility that significant results might be concealed. The well-known "aggregation bias" was a potential problem if a country's bilateral trade flows with different partners produced offsetting positive and negative effects that cancelled each other out at the aggregate level. Thus, bilateral studies may provide a more accurate analysis, as they evaluate the bilateral exchange rate – which is the rate that is actually used by exporters and importers. Just as has

been shown to be the case with aggregate studies, over time the empirical methods used in bilateral studies have improved, but the results have always been consistent. However, these studies differ in another aspect in that the model specification employed has incorporated a wide range of explanatory variables. The first studies made use of more variables than more recent ones have, while gravity models are also popular in studies of exchange-rate uncertainty. In addition, other papers have measured the growth rates, rather than the levels, of the variables in question to make them stationary.

The first bilateral analyses of the effects of exchange-rate volatility also incorporate more economic variables than do later studies. Hooper and Kohlhagen (1978) performed one of the first bilateral studies, using OLS (with a Cochrane-Orcutt correction) to assess the trade flows of the US and Germany with their trading partners over the period 1966I-1975IV. Volatility is proxied in three different ways: using the standard deviation of the 13 weekly spot and forward exchange-rate observations within each period, and the absolute average difference over the 13-week period. The authors find that volatility had no significant effect on the volume of trade; they conclude that their focus on short-run volatility may have neglected certain effects on quantity that may have been caused by long-run volatility. In addition, their study also formulates a price equation that showed that exchange-rate volatility had a significant impact on prices.

Cushman (1988) tests a number of different volatility measures which include: the four-quarter standard deviation of percentage changes in exchange rates, the 12-month moving standard deviation of the same measure, the nominal three-month exchange-rate expectations based on the forward rate, and the 12-month moving standard deviation based on expectations. Quarterly data for the floating period for the UK, the Netherlands, France, Germany, Canada and Japan demonstrate negative results for ten of the 12 flows, and those volatility measures based on the forward rate and assuming a “time-varying risk premium” appear to have a slightly better significance level. Trade flows to Japan show a positive effect. Thus, these early analyses find that exchange-rate uncertainty had mixed results.

While these early models of bilateral trade used a number of purely economic variables, gravity models use a more geographic approach. Trade might take

place because of two countries' proximity to each other, the size of their markets, common borders, or common language between the two. Thus, favourable prices and exchange rates (substitution effects) may not matter as much as being right next door. This type of model generally captures imperfect competition rather than completely free trade.

Abrams (1980) uses a gravity-type model to assess the value (rather than the volume) of the bilateral exports of 19 countries using pooled OLS. He utilizes the standard deviations of both the levels and the rate of change of the 12 monthly exchange-rate values within each year to proxy risk, in order to capture two types of risk: that based on recent changes and that based on trend. Abrams formulates export value as a function of the importing and exporting countries' GDPs, the distance between each pair of countries, the percentage difference in each pair's real per capita income, and dummies for membership in the European Economic Community. Annual data over the period 1973-1976 shows that uncertainty had a significantly negative effect for the pooled sample for equations using both proxies for volatility.

A different gravity specification is used by Thursby and Thursby (1987), who studied the export values of 17 countries using annual data over the period 1974-1982. In this model, the value of trade flows is broken into a price component and a quantity component. The determinants of trade flows are: both countries' CPIs and GDPs; a variable that captures consumer tastes; relative export and import prices; transport costs; tariff rates (proxied by dummies for membership in trade blocs); the nominal exchange rate; and hedging opportunities. The estimate of volatility used is the standard deviation of the spot rate around a predicted trend; the estimation technique is OLS with lagged variables. The authors find that in the majority of cases (10 out of 17), uncertainty depressed trade flows. In addition, Thursby and Thursby test the "Linder Hypothesis," which states that, because producers design their goods to match domestic tastes, they export those goods mainly to countries that have similar incomes, which corresponds to similar tastes. They find strong support for this hypothesis as well.

Additional papers have incorporated gravity models in their bilateral analyses. Brada and Méndez (1988) tested the export values of 30 developed and less-developed countries as a function of foreign income, population, distance, and

the existence of preferential trade agreements between each pair of nations. In order to avoid reliance on a specific measure of volatility, simple dummy variables are applied to represent fixed and floating exchange-rate regimes between each pair of countries. Many of the countries evaluated in the study were members of cooperative agreements such as the European Monetary system; many of the countries' currencies were pegged to the US dollar, and other currencies were allowed to float to some degree. Using OLS for annual data over the time span 1973-1977, which includes both "tranquil" and volatile periods, the authors' results confirmed the results of past research: that volatility reduces trade. Nevertheless, they concluded that this reduction is not as bad as the reduction of trade brought on by the restrictive trade policies of countries that maintain fixed exchange rates.

Tenreyro (2007) addresses a number of the problems associated with the gravity model of bilateral trade, including properties of the error term, and potential endogeneity – volatility may be partially determined by the level of trade. Using a pseudo-maximum likelihood procedure, she corrects for the relevant biases. Likewise, an instrumental variable method, modelled as a logit procedure, is used to eliminate endogeneity. Volatility is modelled as the standard deviation using the moving standard deviation method on the nominal exchange rate, and a gravity model examines exports as a function of distance, per capita GDP, population, area, and dummies for free-trade agreements, contiguity, common language, and colonial heritage. Analysing 104 countries over the period from 1970-1997 using this nonlinear method, Tenreyro finds that nominal exchange-rate volatility has no effect on trade. In addition, De Grauwe (1987) finds that the measure of volatility is important when assessing its impact on trade flows. The basic method common to both papers is a regression of the average yearly growth rate of bilateral exports on a measure of trade integration, the growth rate of world income, the rate of change of the real bilateral exchange rate, and a volatility term. De Grauwe (1987) pointed out that most previous studies evaluated the effects of short-term rather than long-term exchange-rate volatility by focusing on weekly or monthly fluctuations. For this reason, they measure volatility by the standard deviation of the yearly growth rates of the nominal and real exchange rates around the mean. De Grauwe (1987) performs Seemingly Unrelated Regressions (SUR) analysis for the G-7 countries plus Belgium, the Netherlands,

and Switzerland over the periods 1960-1969 (fixed exchange-rate system) and 1973-1984 (floating period). The result: volatility has led to a slowdown in the growth of trade, but the coefficient was significant only if real, not nominal volatility is used. Other factors may be more important in contributing to the slowdown in world trade, however, including the slowdown in trade integration during the 1970s and the decline in the growth rate in world output. The coefficients are significant in reducing trade flows, especially when the real effective exchange rate is used; at the same time, the effects of exchange-rate volatility are reduced when the new variable is added. Thus, introducing third countries to the analysis gives significant results.

Arize *et al.* (2003) have reported similar results using the developing countries data and applying Johansen's co-integration test. Following a traditional view, citing Chowdhury (1993) and Arize (1995), they modelled export volumes of developing countries as a function of world demand situation, relative prices and volatility. This study was based on quarterly data (1973-1998) for Burkina Faso, Colombia, Costa Rica, Jordan, Kenya, Korea, Myanmar, Pakistan, South Africa and Venezuela. The volatility was estimated as the log of moving standard deviation. Their results confirmed that as the world demand increases the demand for exports will rise. However, an increase in the relative prices will deter export demand. Lastly, higher risk increases the trading cost, thus deterring the export volume. They also claimed that the negative relationship implies unpredictability and non-existent or inaccessible forward markets in the developing countries. Therefore, exchange rate risk for LDCs is not completely hedged. This further explains the negative relationship between volatility and foreign trade.

Choudhry (2005), in a similar study, has shown the negative relationship between exchange rate volatility and real exports from the US to Canada and Japan. Citing Bailey *et al.* (1986) and Bailey *et al.* (1987), Choudhry (2005) also supported the above studies in terms of the positive effect of real income increase and the negative impact of relative prices on the exports. Similarly, exchange rate variability was shown to be a discouraging factor for international trade.

Bououiyour and Rey (2005) used annual data over the period 1960-2000 to study the behaviour of the real effective exchange rate (REER) of the Moroccan

Dirham against the European Currencies and its effect on the trade flows. They calculated a moving standard deviation of the growth rate of quarterly REER, and used their average within a year as a measure of volatility. Using the Seemingly Unrelated Regression (SUR) methodology, they reported a negative effect of the volatility variable on the trade balance for the second and third year and a positive coefficient for the first year, but none were statistically significant. They also found a negative relationship between volatility and exports, which was also statistically insignificant for the first and second year, but significant for the third year.

Cheong *et al.* (2005) investigated the effect of exchange rate volatility on price competitiveness and trade volumes in the UK by using a simple standard VAR framework. They used monthly sectoral data on the UK one-digit SITC levels of manufacturing export over the period of January 1976 to January 2000. The exchange rate volatility was obtained using the estimated GARCH (1, 1). They found that exchange rate volatility affects prices positively and trade volumes negatively, which results in a decrease in overall international trade. These findings contradict previous empirical results in two ways. First, Kroner and Lastrapes (1993) found that in the case of UK aggregated data, the magnitude of the impact of exchange rate volatility is mostly absorbed in the price of exports and does not affect the trade volume significantly. However, Cheong *et al.'s* (2005) findings show that the effect of exchange rate volatility on trade is significant and greater in magnitude than on prices. Second, they found that exchange rate volatility consistently discourages exports across individual sectors, but Klein (1990) and McKenzie (1998), using disaggregated sectoral data for the US and Australia, found that this effect differs both in magnitude and direction between individual sectors.

Baldwin *et al.* (2005) uses a monopolistic competition set-up to find the impact of Europe's monetary union and the decrease in exchange rate volatility on trade flows. Their paper adds two elements to the literature on the euro's trade impact. First, they provide a theoretical framework to explain how introducing the euro could have increased trade. Second, they find evidence supporting the hypothesis of a convex trade volatility relationship. The first reason for this convexity is that exchange rate volatility affects small firms more than large firms. The second reason is that the empirical distribution of firms in the European nations is skewed heavily towards small firms and marginal costs are

quite different across sectors. Hence, they use bilateral industry level import data instead of aggregate data to eliminate the aggregation bias due to this convexity. They use sectoral bilateral import data in two-digit and three-digit ISIC manufacturing sectors for 18 industrial countries (12 euro-area nations, 3 non-euro EU members, Australia, Canada, Norway, Japan, and the US). The exchange rate risk term is proxied by two alternative measures: the variance of the nominal exchange rate return and the absolute forecast premium. There is also an EMU dummy in the model. The results suggest that the effect of exchange rate uncertainty is negatively significant and robust to changes in the specification. The creation of the EMU has increased trade by 70-112% based on a pooled regression and by 21-108% when allowing for sector specific coefficients.

Kargbo (2009) uses a vector error correction (VEC) model to estimate the supply and demand relationship for agricultural trade flows in South Africa over the period 1960-2004. He specifies two models: South Africa's agricultural export supply, and import demand functions. He finds that real exchange rate volatility plays a significant role in South Africa's international trade of agricultural products. It has a significantly negative effect on agricultural imports and exports.

Brandi *et al.* (2007) uses a sectoral gravity model to estimate the impact of real bilateral exchange rate volatility on trade among members of the Mercosur2 trade agreement. They use two measures of exchange rate volatility. Their results show that a reduction in exchange rate volatility can increase bilateral trade among members of Mercosur. They suggest the implementation of stable and integrated policies for these countries, aiming to reduce the adverse effects of the exchange rate volatility on bilateral trade.

Bahmani-Oskooee and Wang (2007) investigate the effect of exchange rate volatility on the trade volume between the US and China using disaggregated data for 88 industries from two-digit and three-digit SITC commodity groupings. They estimate import and export demand functions over the period of 1978-2002 using a bounds testing approach to cointegration and error-correction modelling. Their results for import demand function reveal that in 36 out of 88 industries exchange rate volatility has a significant effect on trade, in which half of the coefficient carry a negative and the other half a

positive sign. They also find that the negative coefficients are mostly for non-durable commodities, and the size of an industry does not play an important role in the trade equation. Their results for the export demand function show that a little less than half of the exporting industries are sensitive to exchange rate volatility. All of these coefficients, except for five, carry a positive sign. It can be concluded that, in contrast to imports, exchange rate volatility has a positive impact on exports.

Wang and Barrett (2007) investigate the impact of the conditional variance of the real exchange rate on Taiwan's exports to its major trading partner, the United States. They estimate a rational expectation based multivariate GARCH-M model using sector and destination-specific monthly data over the period of 1989-1998 for eight different sectors. These sectors are based on the Standard Classification of Commodities (SCC) codes of the Republic of China and are as follows: animal and vegetable products and prepared foods; textiles and textile articles; wood, paper, pulp and articles; optical and precision instruments; electronic machinery; and transportation. Their findings support the hypothesis that agricultural trade volumes show more sensitivity to exchange rate uncertainty than other sectors. The estimated effect of expected exchange rate volatility on trade is small and insignificantly different from zero in seven out of eight sectors. However, Taiwan's agricultural exports respond negatively and statistically significantly to expected exchange rate volatility. This is consistent with theoretical literature and also empirical evidence, which argues that the agricultural sector is more susceptive to exchange rate uncertainty.

Baak *et al.* (2007) investigated the impact of exchange rate volatility on the exports of four East Asian countries (Hong Kong, South Korea, Singapore and Thailand) to the United States and Japan using quarterly data over the period of 1981 to 2004. They used a long-run model as well as a dynamic error correction model to find the short-term impacts of exchange rate volatility on exports. Johansen cointegration tests confirm the existence of a long-run relationship amongst the variables in the model. They find that the exchange rate volatility has a significantly negative impact on the exports of South Korea, Singapore, and Thailand to the US and Japan. The coefficient of the exports of Hong Kong to Japan and the US is positive but insignificant for the former and significant for the latter country. Negative short-term impacts of exchange rate

volatility on exports is detected for the exports of Singapore to Japan and the exports of Hong Kong and South Korea to the United States.

Arize *et al.* (2008) investigated empirically the impact of real exchange-rate volatility on the export flows of eight Latin American countries over the quarterly periods of 1973–2004. Estimates of the cointegrating relations were obtained using different cointegration techniques. Estimates of the short-term dynamics were obtained for each country utilizing the error-correction technique. Exchange rate volatility estimates were based on the ARCH(1) model proposed by Engle (1983). The major results showed that increases in the volatility of the real effective exchange rate, approximating exchange-rate uncertainty, exerted a significant negative effect upon export demand in both the short- and the long-term in each of the eight Latin American countries.

Byrne *et al.* (2008) considered the impact of exchange rate volatility on the volume of bilateral US trade (both exports and imports) using sectoral data. Amongst the novelties in their approach are the use of sectoral industrial price indices, rather than an aggregate price index, and the construction of the sectoral groupings, which are based on economic and econometric criteria. They found that separating trade into differentiated goods and homogeneous goods results in the most appropriate sectoral divisions, and they also reported evidence to suggest that exchange rate volatility has a robust and significantly negative effect across sectors, although it is strongest for exports of differentiated goods.

Choudhry (2008) investigates the influence of exchange rate volatility on the real imports of the United Kingdom from Canada, Japan and New Zealand during the period 1980–2003. The Johansen multivariate cointegration method and the constrained error correction (general-to-specific) method are applied to study the relationship between real imports and its determinants (including exchange rate volatility). Conditional variance from the GARCH(1,1) model is applied as exchange rate volatility. Both nominal and real exchange rates are employed in the empirical study. Results indicate a significant effect of the exchange rate volatility on real imports. These exchange rate volatility effects are mostly positive.

Baum and Caglayan (2010) presented an empirical investigation of the hypotheses that exchange rate uncertainty may have an impact on both the

volume and variability of trade flows by considering a broad set of industrial countries' bilateral real trade flows over the period 1980–1998. Similar to the findings of earlier theoretical and empirical research, the first set of results shows that the impact of exchange rate uncertainty on trade flows is indeterminate. The second set of results provided new and novel findings that exchange rate uncertainty has a consistent positive and significant effect on the volatility of bilateral trade flows, helping us to better understand macroeconomic volatility.

Chit *et al.* (2010) examined the impact of bilateral real exchange rate volatility on the real exports of five emerging East Asian countries, both amongst themselves as well as to 13 industrialised countries. Panel unit root and cointegration tests were used to verify the long-term relationships among the variables. The results provided evidence that exchange rate volatility has a statistically significant negative impact on the exports of emerging East Asian countries. Estimation results also showed that an increase in the price competitiveness of other emerging East Asian countries has a negative impact on a country's exports to a destination market, but the magnitude of the impact is relatively quite small.

Mougoue and Aggarwal (2011) reported that the relationship between trading volume and volatility in foreign exchange markets continues to be of much interest, especially given the higher than expected volatility of returns. Allowing for nonlinearities, this study tested competing hypotheses on the possible relationship between volatility and trading volume using data for three major currency futures contracts denominated in US dollars, namely the British pound, the Canadian dollar and the Japanese yen. They found that trading volumes and return volatility are negatively correlated, implying a lack of support for the mixture of distributions hypothesis (MDH). Using linear and nonlinear Granger causality tests, they documented significant lead–lag relations between trading volumes and return volatility, consistent with the sequential arrival of information (SAI) hypothesis. These findings are robust and not sample-dependent or due to heterogeneity of beliefs as proxied by open interest. Furthermore, results were insensitive to the modelling approach used to recover volatility measures. Overall, their findings support the contention that short- to medium-term currency relationships may be dominated by trading dynamics and not by fundamentals.

Mukherjee and Pozo (2011) used a gravity model to analyse the impact of exchange-rate volatility on the volume of bilateral international trade. Semi parametric regression methods are applied to the pooled data for over 200 countries. Results indicated that volatility affects trade negatively, although at very high levels of volatility the effect diminishes and eventually becomes statistically indistinguishable from zero. Countries apparently find avenues to mitigate the detrimental impact of exchange rate uncertainty when volatility attains very high levels. These results help to reconcile the contradictory findings often found in the literature on the impact of exchange-rate uncertainty on trade volume.

3.3 Exchange Rate Volatility, International Trade and the Current Financial Crisis

Financial crises have been a consistent element of economic history. In more recent times, debt and financial (banking) crises have become comparatively more frequent (Reinhart and Rogoff, 2009b; Reinhart and Rogoff, 2009a). Therefore, a large number of studies have tried to encompass the effects of financial crises. Based on these studies, certain stylized facts have been described relating to financial crises and their impact on macroeconomic variables, for example, large and persistent declines in output and employment, deep and prolonged asset market downfalls and surges in government debt generally follow periods of financial tumult (Baldwin, 2009; Abiad *et al.*, 2011).

However, limited literature is available whereby the impact of a financial crisis on international trade has been analysed. Moreover, papers assessing the effect of a financial crisis on trade flows through the exchange rate volatility channel are even more scarce (Abiad *et al.*, 2011).

In the available literature, many channels have been reported through which the financial crises possibly have affected the trade flows globally. However, in this section, those papers would be of main interest where the exchange rate volatility has been the intervening variable.

Abiad *et al.* (2011), using data from the last 40 years, have attempted to explain various channels through which financial crises may have affected the

imports/exports around the globe. They have reported that, beside other variables, exchange rate volatility is one of the most important intervening variables explaining the changes in the trade flows in the pre/post financial crisis scenarios. Other channels include reduction in output, global/regional demand and protectionism, etc.

This research is aiming to add to the existing body of knowledge on the subject both in terms of an empirical explanation of the relationship between the variables, i.e. exchange rate volatility and international trade, in the presence/absence of third country effect, and the recent global financial crisis. As the above literature review shows, the bare relationship between exchange rate volatility and international trade has been evaluated by a large number of researchers using varied data sets, time horizons, frequency and methodologies. However, the role of the third country effect and the channels (with focus on the exchange rate volatility) through which the current financial crisis has affected the international trade flows provide new areas of research, as suggested by McKenzie (1999), Bahmani-Oskooee and Hegerty (2007) and Abiad *et al.* (2011).

Both these aspects have significant implications for understanding the relationship dynamics between exchange rate volatility and trade. Third country effect is important from the point of view of competition in the global market place, as every exporting country is competing against many other countries. In this scenario, exchange rate movement in their respective currencies may act both as an edge or otherwise, depending on the extent and direction of the movement.

The current financial crisis is well-known for its multi-faceted impact on the global economy, and exchange rate volatility and trade are not beyond the influence of the largest and deepest slump in economic history.

3.4 Contribution to the Literature

This research aims to analyse the traditional relationship between exchange rate volatility and international trade. However, the novelty of this study is that it attempts to explore this relationship in the context of the third country effect, which has not been empirically analysed in detail before. Furthermore,

this thesis studies the impact of the current financial crisis on the exchange rate volatility and international trade flows of the UK. The recent financial turmoil has been unique and has affected the global economy in various ways. This research is motivated by the fact that, to the best of my knowledge, no research has been published so far involving UK trade and exchange rate volatility in the context of the third country effect and the current financial crisis (2007-2011).

To summarise, the main contribution of this research to the existing literature would be detailed analysis of: i) the exchange rate volatility and trade flows for the UK; ii) the third country effect on the UK's trade flows iii) the impact of the financial crisis on the relationship between exchange rate volatility and the trade flows of the UK; and iv) whether the underlying independent variables, especially exchange rate volatility, affect the UK trade flows asymmetrically?

Chapter 4: Data and Methodology

4.1 Introduction

The volatility of exchange rates became a global phenomenon soon after the collapse of the Bretton Woods system in 1973, with significant impacts on international trade flows becoming a norm. This area has become a major field of interest in international economics and finance trying to identify and understand the underlying relationship between exchange rate volatility and trade flows

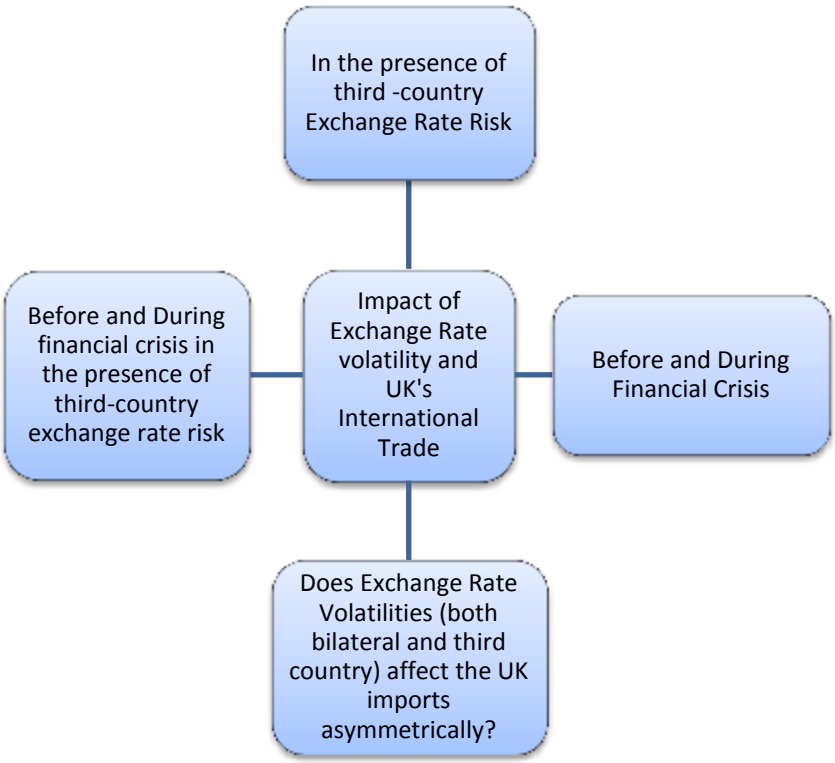
This research issue has been explored both theoretically and empirically by many researchers, as shown earlier in the literature review chapter. This thesis builds upon the existing literature and further explores the impact of third-country exchange risk on the exchange rate volatility and trade flow relationship. The impact of the current financial crisis (2007-2012) on trade flows was immense, considered to be the severest since WWII. Global trade flows shrank by 33% ($1.5 trillion), the steepest drop in the recorded history of world trade and hence termed as "The Great Trade Collapse" by Baldwin (2009) and Abiad *et al.* (2011). Therefore, this research aims to empirically evaluate the relationship between exchange rate volatility and trade flows both before and during financial crisis scenarios. In addition, differences in the effects for developing and developed trading partners will be outlined.

This section is followed by separate sections on the research hypotheses to be tested; data and variables; Stationarity and Unit Root tests, Volatility Estimation; and finally econometric modelling. The last section discusses in detail both the ARDL-bound testing approach (Pesaran *et al.*, 2001) as well as the Nonlinear Asymmetric ARDL method (Shin *et al.*, 2013).

4.2 Research Hypotheses

A detailed account of the hypotheses formulated for this research is provided in section 1.5. However, the empirical hypotheses tested in this study can be summarised in the following figure:

Figure 4.1: Research Hypotheses to be tested



As shown above, this research aims to test the impact of exchange rate volatility on the UK trade flows as well as the dynamics of a few other important aspects, which have not been addressed in the existing literature (McKenzie, 1999; Bahmani-Oskooee and Hegerty, 2007). These include: i) the third-country exchange rate risk; ii) the impact of financial crisis; iii) how third country exchange rate risk has affected the UK trade flows before and during the financial crisis; and finally iv) how the variations in the trade flows differ in the case of both developed and developing trade partners of the UK.

4.3 Stationarity and Unit Root Tests

Classical econometric literature assumes and requires that all the variables should be stable over time and stationary. The desired properties of a stationary series are described as; i) constant mean, ii) constant variance, and iii) constant autocovariances for each of its given lags. Stationarity is considered a major test for considering the stability and degree of reliability of results presented under various econometric methods (Brooks, 2008). The literature on the subject shows that use of non-stationary series leads to

spurious regressions, implying unreliable and inconsistent results. Furthermore, the standard distributions, such as t and F statistics, are not valid for non-stationary series (Granger and Newbold, 1974).

4.3.1 Types of Stationary Series

4.3.1.1 Strictly Stationary

A strictly stationary process is one where, for any time period, t_1, t_2.....t_T ε Z, any k ε Z and T = 1,2.....

$$Fy_{t1}, y_{t2} \dots \dots y_{tT}(y_1, y_2 \dots \dots y_T) = Fy_{t1+k}, y_{t2+k} \dots \dots y_{tT+k}\,(y_1, y_2 \dots \dots y_T) \qquad (16)$$

Where F denotes the joint distribution function of the set of random variables (Tong, 1990). In other words, a strictly stationary series' distribution is invariant to time, or remains unchanged as time progresses. This has a very important implication with regards to the stability of inference, that is the probability of y falling within a particular interval is the same irrespective of the time of the occurrence of the event, whether in the past or the future.

4.3.1.2 Weakly Stationary

A weakly stationary process is traditionally defined as the one satisfying the following conditions:

$$E(y_t) = \mu \qquad (17)$$

$$E(y_t - \mu)^2 = \sigma^2 < \infty \qquad (18)$$

$$E(y_t - \mu)(y_{t+k} - \mu) = \gamma_k \qquad (19)$$

Equations 17-19 above define the characteristics of a weakly stationary series i.e. i) constant mean, ii) constant variance, and iii) constant autocovariance γ_k of each of the lags.

4.3.2 Stationarity/Unit Root Tests

4.3.2.1 Dickey Fuller Test

Unit root tests are very popular for testing the stationarity features of time series data. These are essentially based on regression, where a time series variable (Y_t) is regressed against its own first lag (Y_{t-1}) and with the general assumption that the residuals (u_t) are white noise. If the coefficient of the first lag is equal to 1, it signifies the existence of a unit root. The same may be shown in the following equation:

$$Y_t = \rho Y_{t-1} + u_t \tag{20}$$

In practice however, the above equation is estimated as following:

$$\Delta Y_t = \delta Y_{t-1} + u_t \tag{21}$$

Where ΔY_t is the difference between Y_t and Y_{t-1} and the null hypothesis of δ=0 is tested. If the null hypothesis is accepted then Y_t is said to have a unit root and is non-stationary, or Y_t is a random walk. Moreover, δ < 0 implies that the underlying time series is stationary. According to Dickey and Fuller (1979) the standard t-test cannot be applied here as the t values computed for this test do not follow asymptotic normal distribution. They computed the critical values, also known as the tau statistic/test, hence this test is known as the Dickey-Fuller Test. Interestingly, as cited by Gujarati (2003), if δ=0 (i.e. Y_t is stationary) then the standard t-test can be applied.

The Dickey Fuller test has also been used in the literature with slightly different settings than in equation 21:

Y_t is random walk with drift:

$$\Delta Y_t = \alpha_0 + \delta Y_{t-1} + u_t \tag{22}$$

Y_t is random walk with drift around stochastic trend:

$$\Delta Y_t = \alpha_0 + \alpha_1 t + \delta Y_{t-1} + u_t \tag{23}$$

Where α_0 is the drift or mean term and α_1 is the elasticity of Y_t to time or trend variable t. Now if the null hypothesis is rejected i.e. $\delta < 0$ then the alternative hypothesis in case of equation 22 will be that Y_t is stationary around a non-zero mean (α_0/1- ρ) and Y_t is stationary around a deterministic trend, as shown in equation 23.

The hypothesis testing procedure consists of initially estimating equations 21-23 using OLS and then dividing the coefficient of Y_{t-1} (δ) by the standard error to obtain the tau-statistic. If the computed absolute values are greater than the corresponding critical values provided by DF, the null hypothesis of $\delta = 0$ is rejected and the Y_t is stationary.

4.3.2.2 Augmented Dickey Fuller

This test is a modification of the above Dickey Fuller Test. The above test assumes that υ_t is the white noise, which in turn implies that υ_t is not correlated ($Cov_{\upsilon_t, \upsilon_{t-1}}=0$). However, if υ_t is correlated, then the above test is "augmented" by including the lagged values of the dependent variable ΔY_t. Thus, the above equations 21-23 may be re-written as:

$$\Delta Y_t = \delta Y_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Y_{t-i} + \varepsilon_t \tag{24}$$

$$\Delta Y_t = \alpha_0 + \delta Y_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Y_{t-i} + \varepsilon_t \tag{25}$$

$$\Delta Y_t = \alpha_0 + \alpha_1 t + \delta Y_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Y_{t-i} + \varepsilon_t \tag{26}$$

4.3.2.3 KPSS

Kwiatkowski *et al.* (1992) introduced a test known by the authors' names, KPSS, whereby the null hypothesis that the underlying time series is stationarity is tested. Interestingly, the null hypothesis in this test is opposite to other conventional tests, as both the DF and ADF assume the null of the unit root (non-stationary). This test complements other stationarity tests in identifying stochastic characteristics of the underlying variables in terms of stationarity at levels or around a deterministic trend. Furthermore, this test is

embedded with the lags of the dependent variable and uses Newey-west methods to estimate residuals in order to account for serial correlation of residuals.

This test initially estimates the following regression:

$$Y_t = \alpha + \gamma t + \varepsilon_t \tag{27}$$

The above equation models a time series variable Y_t as a function of α, the intercept and γ coefficient of trend variable (t). Alternatively Y_t is regressed against an intercept and time, ε_t are residuals and assumed to be white noise These residuals are the basis of the hypothesis tested in equation 28. The null hypothesis under KPSS is that Y_t is stationary around its own trend.

$$\eta_t(q) = T^{-2} \sum_{t=1}^{T} \frac{s_{\varepsilon_t}^{2}}{\sigma_\varepsilon^2(q)} \tag{28}$$

Where η_t is the KPSS test statistic based on the first q number of lags. T is the total number of observations and s^2 is the sum of the squared residual (ε^2_t) estimated in equation 27 whereas σ^2_ε is the variance of the error term (ε) and it is estimated using the Newey-West method. The Newey-West method adopts the Bartlett windows approach and uses the first q number of lags to sample auto-covariance. Hence q is the truncation parameter above. In simple words, KPSS tests for any time series variable and employs its residuals estimated using linear regression with an intercept and a trend variable. Another modification of the test is used when a time series does not follow any trend or if γ=0, the null hypothesis then states that Y_t is level stationary and thus it is stable over time.

The asymptotic consistency has been shown to hold even for small samples (Kwiatkowski et al., 1992). Further, the KPSS test is consistent in the case of stationary fractional alternatives. Similarly, this test is acknowledged for consistently differentiating between short and long memory stationary processes, and separating these two processes from nonstationary long-memory and unit root. However, this test fails to consistently distinguish between long-memory and unit root. (Lee and Schmidt, 1996; Lee and Amsler, 1997)

4.4 Volatility Estimation – Generalized Autoregressive Conditional Heteroskedasticity (GARCH)

This research studies the impact of exchange rate volatility on UK imports. Therefore, exchange rate volatility needs to be estimated. Following the available literature, various techniques were used to estimate the exchange rate volatility including rolling standard deviation (RSD), exponentially weighted moving average (EWMA) and generalized autoregressive conditional heteroskedasticity (GARCH). The GARCH specification was finally adopted as it provided the most stable estimates of exchange rate volatility. The GARCH model in this research captures the uncertainty or conditional variance of exchange rate volatility using both nominal and real exchange rates for the sample countries. Econometric details of the GARCH model are provided in section 4.4. Both bilateral and third country exchange rate volatilities are estimated using a GARCH model. These volatility estimates represent the volatility variables throughout the model estimations and hypothesis testing in this research.

The GARCH (p,q) model with conditional normal distributions is the most popular ARCH specification in empirical research, particularly when modelling daily returns (Brooks, 2008; Taylor, 2011). The popularity of GARCH (p,q) may be explained by three observations. First, the model has only four parameters and these can be estimated easily. Second, it provides an explanation for the major stylized facts for daily returns. Third, it is often found that the volatility forecasts from this specification have similar accuracy to forecasts from more complicated specifications. Initially, we assume conditional normal distributions following Bollerslev (1986) and Taylor (1986), who independently defined and derived properties of the GARCH (p,q) model.

In the GARCH model, the conditional variance of a time series depends upon the squared residuals of the process, and thus it has the advantage of incorporating heteroskedasticity into the estimation procedure of the conditional variance (Bollerslev, 1986). The conditional variance of a series from a GARCH(p, q) model is the predictable component of volatility, and it is an important determinant of the risk premium in financial markets. According to Bollerslev *et al.* (1992), the GARCH model can be viewed as a reduced form

of a more complicated dynamic structure for time-varying conditional second order moments.

GARCH and ARCH models are much celebrated in the financial econometric world as they solved dealing with heteroskedasticity, volatility clustering and leptokurtosis (peaked and fat tail distributions) in the data. For financial time series, the variance of errors is unlikely to be constant over time, i.e. errors have heteroskedasticity, and also most of the financial asset return series bear characteristics of unpredictability, fat tails (large number of extreme values) and volatility clustering (Engle, 2004). The ARCH model has been designed around these characteristics; it describes how variance of errors evolves. The ARCH model uses weighted averages of lagged squared forecast errors, with greater weights (and influence) for recent information than for that in the distant past. The following equation presents the ARCH model in its general form. The conditional variance depends on q lags of the squared errors. The conditional variance, h_t is a positive value. $\alpha_i \geq 0$

$$y_t = \beta_1 + \beta_2 x_{2t} + \beta_3 x_{3t} + \cdots + u_t \qquad u_t \sim N(0, \sigma_t^2) \tag{29}$$

$$\sigma_t^2 = h_t = \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 u_{t-2}^2 + \cdots + \alpha_q u_{t-q}^2 \tag{30}$$

The GARCH model came as a successor to the ARCH model, to overcome the limitations of the ARCH model and also to account for volatility clustering and leptokurtosis. Another significant deficiency of the ARCH models was its inability to capture leverage or asymmetric effect, which was later estimated in some of the GARCH specifications. In a GARCH model, the conditional variance is dependent upon its own previous lags and the lags of the squared errors (ARCH effect), as given in the following equation, known as GARCH (p,q) :

$$\sigma_t^2 = h_t = \alpha_0 + \Sigma_{i=1}^{q} \alpha_i u_{t-i}^2 + \Sigma_{j=1}^{p} \beta_j \sigma_{t-j}^2 \tag{31}$$

In GARCH (p,q), the conditional variance (σ^2_t) would depend upon q lags of the squared error (u^2_{t-i}) and p lags of the conditional variance (σ^2_{t-i}). A famous simplification of the GARCH (p,q) model is GARCH (1,1) where conditional variance at time '*t*' is modelled on the basis of one lag of each squared error and conditional variance:

$$\sigma_t^2 = h_t = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \tag{32}$$

Lastly, to impose the non-negativity condition, the model requires α_0 and $\alpha_1 > 0$, $\beta_1 \geq 0$. GARCH (p,q) follows the theory that volatility changes symmetrically to positive and negative shocks, whereas in more recent years it has been observed that volatility rises more in magnitude as a consequence of negative shocks than it falls as a result of positive shocks. Many extensions and modifications of GARCH models have been made, encompassing this asymmetric effect (leverage effect) since the original Bollerslev (1992) model was presented. However, GARCH (1-1) still remains as a preferred model for many, usually deemed sufficient and a good starting point for academic finance.

4.5 Econometric Modelling

4.5.1 Basic Model

This section builds upon the theoretical relationship and research hypotheses (sections 1.4 and 1.5)[5]**.** Demand for imports is generally modelled as any other demand model, i.e. 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:

$$ln\,(M_t) = \beta_0 + \beta_1 lnY_{H,t} + \beta_2 lnP_t + \beta_3 V_t + \eta_t \qquad (33)$$

$$ln\,(M_t) = \beta_0 + \beta_1 lnY_{H,t} + \beta_2 lnP_t + \beta_3 V_t + \beta_4 TCV_t + u_t \qquad (34)$$

Where $\ln(M_t)$ is the natural log of UK imports and $\ln(Y_{H,t})$ is the natural log of the income of the home (H) country, which is the UK throughout in this research. P_t and V_t denote the relative prices and exchange rate volatility between the UK and its trading partners. Lastly β_i and α_i represent model parameters. Equation 33 can be extended in the form of equation 34, to include third-country exchange rate volatility (TCV) as an additional determinant of imports.

In the context of exchange rate volatility and international trade, econometric/empirical methodology has evolved from the traditional ordinary least-square method to more complex regression analysis and later to co-

5 Sections in the theoretical framework chapter explain how exchange rate volatility affects trade mathematically.

integration analyses, error-correction models and autoregressive distributed lag (ARDL) using the bound testing approach proposed by Pesaran *et al.* (2001) and as cited by Bahmani-Oskooee and Hegerty (2007). All these developments have taken place against the backdrop of advancements both in the field of econometrics as well as the availability and emergence of more sophisticated and specialized software.

Earlier studies in the 1980s and early 1990s used the OLS based methods to evaluate the effect of exchange rate volatility and trade flows, such as Hooper and Kohlhagen, (1978); Akhtar and Hilton, (1984); Gotur, (1985); Bailey *et al.*, (1986); Cushman, (1986); Kenen and Rodrik, (1986); De Grauwe, (1988); Caballero and Corbo, (1989); Perée and Steinherr, (1989); Medhora, (1990); Bahmani-Oskooee and Ltaifa, (1992); and Qian and Varangis, (1994).

After the introduction of co-integration techniques into the literature, due to Engle and Granger (1987) and Johansen (1988), most of the researchers preferred co-integration over the OLS estimates due to the integrating properties of the underlying variables and the fact that OLS estimates were considered to provide inconsistent and spurious results (Engle and Granger, 1987; Johansen, 1988; Bahmani-Oskooee and Hegerty, 2007).

This led to the application of co-integration analysis in assessing the exchange rate volatility impact on the trade flows, and hence many studies are reported by McKenzie (1999) and Bahmani-Oskooee and Hegerty (2007) using this framework. For many years afterwards, co-integration techniques were considered to be very sound and provided efficient and reliable results both from theoretical as well as empirical standpoints.

As discussed in the literature review earlier, the findings/results of the early studies provided conflicting results, which is partly due to their different empirical methods, as different econometric models have their peculiar assumptions/contexts. For example, many of these studies initially used ordinary least square based methods which essentially did not account for the integrating properties of the variables, hence were criticised heavily for ignoring this important aspect and their findings were termed as '*unreliable' and 'spurious'* by later studies (McKenzie, 1999; Bahmani-Oskooee and Hegerty, 2007).

4.5.2 ARDL – BOUNDS TESTING APPROACH

This research uses the Autoregressive Distributed Lag (ARDL) bounds test approach proposed by Pesaran *et al.* (2001) to estimate the long-term trade model in equations 33-34. The main advantage of this technique over the other cointegration methods is that it is robust enough to cope with the stochastic behaviour of the variables and has no underlying assumptions about the order of integration of the variables. This approach avoids the pre-testing problem associated with the order of integration of variables that standard cointegration techniques encounter. It also allows the researcher to distinguish between the short-term and long-term effects of the variables, which is important in economic analysis (Pesaran *et al.*, 2001; Bahmani-Oskooee and Hegerty, 2007).

An ARDL model includes the lags of the variables in the model. Lags are presented in economic models for different reasons. The economic lags consist of the recognition lag, the decision lag, and the effect lag. Models that include these lags into the analysis are very attractive for economic analysis (Brooks, 2008). One of the most applicable models of this kind is the error correction model (ECM). The error correction model is a short-run dynamic model consisting of the first difference of the variables and an error correction term. It is a modified version of an ARDL model. In an ARDL model, the dependent variable y is a function of its own lag and other independent variables and their lags. A general ARDL(1,1) model can be written as follows:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 x_t + \alpha_3 x_{t-1} + u_t \qquad (35)$$

This general model above can easily be transformed into an error correction model by subtracting y_{t-1} from both sides of the equation and using the first difference of x (Δx_t):

$$\Delta y_t = \alpha_0 + (\alpha_1 - 1) y_{t-1} + \alpha_2 \Delta x_t + (\alpha_2 + \alpha_3) x_{t-1} + v_t \qquad (36)$$

Furthermore, in order to use the error correction (ECM) model, the following assumption is required:

$$(\alpha_1 - 1) = -(\alpha_2 + \alpha_3) \tag{37}$$

Or

$$(\alpha_1 + \alpha_2 + \alpha_3) = 1$$

Alternatively describing the above assumption requires the sum of all coefficients in equation (37) to be equal to 1. This is the short-term relationship between y and x. To find the long-term relationship, it is assumed that the variables are at their steady states and the first difference terms are zero. Equations 33-34 are the long-term relations among the variables in our trade model. To implement the ARDL approach to cointegration into this model, first the short-term dynamics need to be added into the long-term. The short-run equations corresponding to the long-run equations (33-34) can be written as follows:

$$\Delta m_t = \beta_0 + \beta_1 \sum_{j=1}^{n1} \Delta m_{t-j} + \beta_2 \sum_{j=0}^{n2} \Delta y_{H,t-j} + \beta_3 \sum_{j=0}^{n3} \Delta p_{t-j} + \beta_4 \sum_{j=0}^{n4} \Delta V_{t-j} + \left(\lambda_1 m_{t-1} + \lambda_2 y_{H,t-1} + \lambda_3 p_{t-1} + \lambda_4 V_{t-1}\right) + \upsilon_t \tag{38}$$

$$\Delta m_t = \beta_0 + \beta_1 \sum_{j=1}^{n1} \Delta m_{t-j} + \beta_2 \sum_{j=0}^{n2} \Delta y_{H,t-j} + \beta_3 \sum_{j=0}^{n3} \Delta p_{t-j} + \beta_4 \sum_{j=0}^{n4} \Delta V_{t-j} + \beta_5 \sum_{j=0}^{n5} \Delta TCV_{t-j} + \left(\lambda_1 m_{t-1} + \lambda_2 y_{H,t-1} + \lambda_3 p_{t-1} + \lambda_4 V_{t-1} + \lambda_5 TCV_{t-1}\right) + \upsilon_t \tag{39}$$

Here the small case letters m and y are the natural logged values of the UK imports from Brazil, China, Germany, Japan, South Africa and the US, whereas y_H represents the UK's real income. Short-run relationship parameters are given by $\alpha_{1...5}$ and $\beta_{1.....5}$ in equations (38-39) respectively. Long-run relationship coefficients are given by $\lambda_{1...5}$. Lags of I(1), or first differenced short-run variables are determined using AIC/BC and the number of lags used in the models are denoted by $n_{1...5}$ above.

As mentioned earlier, all the differenced terms tend to zero, and equations 38-39 will converge back to equations 33-34, which are the long-run relationships between the variables. The ARDL method requires testing of the existence of the long-run relationship by evaluating the joint significance of the lagged level variables, also called the error correction term. Because without lagged level

variables, equations 33-34 only suffice to explain the short-run relationship between the variables. Therefore, the lagged level variables are tested for a null of $\lambda_{1...4}$ being jointly equal to zero which implies that the variables are co-integrating. The hypothesis testing in this case is done using the F-Statistic for which critical values are provided by Pesaran *et al.* (2001). There are two sets of critical values: one of the sets is generated assuming all variables are integrated of level 1 or I(1), and the other set is for the I(O) variable class. This covers all the possible scenarios based on the degree of integration of the variables. This also implies that this approach is only valid for I(O) and I(1) classes of variables.

An alternative way to test for the existence of a long-run relationship among the variables of the model is to substitute the lagged level variables with an error correction term and test for the significance of its coefficient. To obtain these coefficients, the short-run error correction equation (38) needs to be estimated. Then the error correction terms can be calculated as the sum of the lagged level terms using the estimates of λ_1 through λ_4 from equation 38. In the next step, the lagged level term in each equation will be replaced by the lagged value of the constructed error correction term and the model is estimated one more time with the same optimum number of lags selected by AIC. If the coefficient estimate for this variable is negative and statistically significant, it implies that the short-run coefficients are adjusting toward their long-run value and a cointegration relationship exists. After testing for the existence of the long-run relationship amongst the variables in the model, one can proceed to the next stage and estimate the long-run relations in equations 33-34.

Indeed, some diagnostic tests have been performed in order to check the stability of the model and the goodness of fit. Since many lagged dependent variables are present in the model, it is necessary to test for the existence of autocorrelation in the model. The Ljung-Box (LB) test for autocorrelation is performed for all the equations and results are reported in the diagnostics tables.

The other measure which is designed to test the functional form and misspecification of the linear regression model is the Ramsey's Regression Equation Specification Error Test (RESET) test. This is a test that examines if

any power of explanatory variables belongs to the model. If this hypothesis is rejected the model is well specified.[6]

4.5.3 General to Specific Causality

Literature on econometric modelling gives us two polar empirical approaches to model development i.e. simple-to-general, and general-to-specific methods (Hendry, 1995; Brooks, 2008). According to the simple-to-general or bottom-up approach, the model building starts with a relatively simple model and gradually more variables are added to improve the description of reality. This method is mostly attributed to Koopmans (1935). This method has been severely criticised by Hendry (1987) and many other authors mainly on the grounds that diagnostic testing is undertaken, if at all, almost as an after-thought and in a very limited fashion. This in turn invalidates all earlier inferences. Moreover, if it turns out that the initial model is misspecified, this approach heavily relies on diagnostic tests to indicate the source of the problem, which demonstrates the theoretical inefficiency and inadequacy of this method.

The general-to-specific method essentially suggests starting with a large model which is statistically adequate and gradually restricting and rearranging the model to arrive at a parsimonious final formulation. This approach argues that an optimal model should be consistent both with data and theory. Furthermore, diagnostic tests should be extensively used to arrive at a statistically adequate model (Hendry, 1995). Parsimony and appropriate theoretical bases of interpretation are other desirable attributes of the empirical model (Hendry, 1987).

---

6 According to the examiners' suggestion, the Dynamic Stability Test (Giles, 2013) was also conducted. This is a standard post-estimation test for autoregressive models, whereby inverted AR roots are tested for the possibility of a unit root i.e. if any of these roots is ≥ 1. Giles suggests that if a unit root is found, then the model may be re-specified by using the first-difference series of the underlying dependent variable. This test was applied and all the results for both developed and developing countries were found to be dynamically stable, as all the inverted roots in each case were within the unit root circle. The results of these tests are provided in appendix - IV for the examiners' reference. Each table in the appendix-IV cross-references the corresponding table in the main text.

Data and Methodology

This research employs general-to-specific causality to arrive at the final parsimonious formulation of the model. The following equations show the general specification of the UK's trade flows, along with the constrained error correction term:

$$\Delta m_t = \beta_0 + \beta_1 \sum_{j=1}^{n1} \Delta m_{t-j} + \beta_2 \sum_{j=0}^{n2} \Delta y_{H,t-j} + \beta_3 \sum_{j=0}^{n3} \Delta p_{t-j} + \beta_4 \sum_{j=0}^{n4} \Delta V_{t-j} + \mathrm{EC}_{m,t-1} + \upsilon_t \quad (40)$$

$$\Delta m_t = \beta_0 + \beta_1 \sum_{j=1}^{n1} \Delta m_{t-j} + \beta_2 \sum_{j=0}^{n2} \Delta y_{H,t-j} + \beta_3 \sum_{j=0}^{n3} \Delta p_{t-j} + \beta_4 \sum_{j=0}^{n4} \Delta V_{t-j} + \beta_5 \sum_{j=0}^{n5} \Delta TCV_{t-j} + \mathrm{EC}_{m,t-1} + \upsilon_t \quad (41)$$

According to Granger (1988), in the above equations causality may be traced to two sources i.e. the long and short-run. The long-run equilibrium correction in the imports is captured by $EC_{t-1,}$ however, the first-difference lags of the underlying independent variables may also be causing changes in the UK's imports. Thus the causality may be determined on the basis of the significance of these constrained error corrections and the lags of the first-difference of the level variables. In the case that the constrained error term (EC_{t-1}) is statistically insignificant, this implies that there is no significant long-run relationship between the underlying variables, although short-run causality may still exist.

Then, as required by the general-to-specific method, the dimensions of the parameter space were reduced to their final parsimonious specifications by eliminating insignificant coefficients or by imposing statistically insignificant coefficients. Under the general-to-specific approach, diagnostic tests of the statistical adequacy of the model come first, with an examination of the inferences for the theory drawn from the model left until after a statistically adequate model has been found (Brooks, 2008).[7] According to Brooks (2008)

7 This approach may not be suitable for small or moderate sample sizes. In such instances, the large number of explanatory variables will imply a small number of degrees of freedom. Also, the decision about which variables to drop may have profound implications for the final specification of the model

this approach is empirically efficient and practical, as optimal lag structures are not known a priori. Therefore, lags are determined on the basis of the data itself. In addition, the statistical implications of excluding relevant variables are usually considered to be far more serious than including irrelevant variables.

4.5.4 Asymmetric ARDL Method

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

According to Keynes (1936), macroeconomic variables generally 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 variables shifting within different states over a period of time has given rise to the need for modelling of asymmetry and nonlinearity in order to improve our understanding of the long-run relationships between various macroeconomic variables (Kahneman and Tversky, 1979; Shiller, 1993; Shiller, 2005; Shin *et al.*, 2013).

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

(Brooks, 2008).

8 This method has been cited in some of the more 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); Katrakilidis and Trachanas, (2012)

Data and Methodology

Standard cointegration literature establishes long and short-run relationships between the variables, however, it implicitly assumes that the relationship is symmetric, or that the impact of the 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 relationships among various macroeconomic variables (Schorderet, 2001; Shin *et al.*, 2013, Park and Phillips, 2001; Saikkonen and Choi, 2004; Escribano *et al.*, 2006; Bae and De Jong, 2007). Granger and Yoon (2002) coined the term "hidden cointegration" which is attributed to the long-run equilibrium relationship between positive and negative components of the underlying variables.

Regime-switching models, on the other hand, are based on the view that linear models are unable to provide strong inferences, or to yield consistent and reliable forecasts, because the linearity assumption may be restrictive in most of the macroeconomic scenarios (Shin et al. 2013). Over more recent years these studies have started to address the problems of asymmetry, nonlinearity and non-stationarity, however the focus of these studies has been limited to one and/or some of these problems.

The Asymmetric nonlinear ARDL method proposed by Shin *et al.* (2013) is shown to deal with all the above three areas. This model uses the ARDL bound-testing approach (Pesaran *et al.*, 2001) for testing the long-run equilibrium relationship between the underling variables, irrespective of the order of integration of the regressors i.e. I(0) or I(1) or a mix of both, whereas nonlinearity and asymmetry are modelled using the partial sum processes approach (Schrderet, 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 (Schorderet, 2001):

$$y_t = \alpha_0 + \beta^+ x_t^+ + \beta^- x_t^- + u_t \qquad (42)$$

Where the independent variable x_t is decomposed into the 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 case of both I(0) and I(1) variables. The following defines both the processes:

$$x_t^+ = \sum_{j=1}^{t} \Delta x_t^+ = \sum_{j=1}^{t} \max(\Delta x_j, 0); \;\; x_t^- = \sum_{j=1}^{t} \Delta x_t^- = \sum_{j=1}^{t} \min(\Delta x_j, 0) \qquad (43)$$

Here $\triangle x_t$ is the changes in x_t, whereas the + and – superscripts indicate the positive and negative processes. In equation 43 above, the threshold is set to zero, which delineates the positive and negative shocks in the independent variables. Though ideally the first difference series should be normally distributed with zero mean, financial time series often tend to have non-normal distribution, which implies 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 regime 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 43 above may be re-written in the following manner to set the mean as the threshold level:

$$x_t^+ = \sum_{j=1}^{t} \Delta x_t^+ = \sum_{j=1}^{t} \max(\Delta x_j, \bar{x}); \;\; x_t^- = \sum_{j=1}^{t} \Delta x_t^- = \sum_{j=1}^{t} \min(\Delta x_j, \bar{x}) \qquad (44)$$

Thus the long-run relationship described above in equations 33-34 can be rewritten in terms of positive and negative partial sums in the following manner:

$$\boldsymbol{ln}\,(\boldsymbol{M_t}) = \boldsymbol{\beta_0} + \boldsymbol{\beta_1^+ ln Y^+}_{H,t} + \boldsymbol{\beta_2^- ln Y^-}_{H,t} + \boldsymbol{\beta_3^+ ln \mathrm{P}^+} + \boldsymbol{\beta_4^- ln \mathrm{P}_t^-} + \boldsymbol{\beta_5^+ V_t}^+ + \boldsymbol{\beta_5^- V_t}^- + \boldsymbol{u_t} \qquad (45)$$

$$\boldsymbol{ln}\,(\boldsymbol{M_t}) = \boldsymbol{\beta_0} + \boldsymbol{\beta_1^+ ln Y^+}_{H,t} + \boldsymbol{\beta_2^- ln Y^-}_{H,t} + \boldsymbol{\beta_3^+ ln \mathrm{P}^+} + \boldsymbol{\beta_4^- ln \mathrm{P}_t^-} + \boldsymbol{\beta_5^+ V_t}^+ + \boldsymbol{\beta_5^- V_t}^- + \boldsymbol{\beta_5^+ TCV_t}^+ + \boldsymbol{\beta_5^- TCV_t}^- + \boldsymbol{u_t} \qquad (46)$$

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 error correction methods, described earlier in section 4.5.2 under the ARDL bounds testing approach, where all the level and first differenced variables are replaced by their respective positive and negative partial sums in levels as well as in the first difference form. Hence, error-correction versions of equations 45-46 are as follows:

$$\begin{aligned}\Delta m_t = {} & \beta_0 + \beta_1 \sum_{j=1}^{n1} \Delta m_{t-j} + \beta_2^+ \sum_{j=0}^{n2} \Delta y_{F,t-j}^+ + \beta_3^- \sum_{j=0}^{n3} \Delta y_{F,t-j}^- + \beta_4^+ \sum_{j=0}^{n4} \Delta \mathrm{p}_{t-j}^+ + \beta_5^- \sum_{j=0}^{n5} \Delta \mathrm{p}_{t-j}^- \\ & + \beta_6^+ \sum_{j=0}^{n6} \Delta \mathrm{V}_{t-j}^+ + \beta_7^- \sum_{j=0}^{n7} \Delta \mathrm{V}_{t-j}^- \\ & + \left(\lambda_1 m_{t-1} + \lambda_2^+ y_{H,t-1}^+ + \lambda_3^- y_{F,t-1}^+ + \lambda_4^+ p_{t-1}^+ + \lambda_5^- p_{t-1}^- + \lambda_6^+ V_{t-1}^+ + \lambda_7^- V_{t-1}^-\right) \\ & + \upsilon_t\end{aligned} \tag{47}$$

$$\begin{aligned}\Delta m_t = {} & \beta_0 + \beta_1 \sum_{j=1}^{n1} \Delta m_{t-j} + \beta_2^+ \sum_{j=0}^{n2} \Delta y_{F,t-j}^+ + \beta_3^- \sum_{j=0}^{n3} \Delta y_{F,t-j}^- + \beta_4^+ \sum_{j=0}^{n4} \Delta \mathrm{p}_{t-j}^+ + \beta_5^- \sum_{j=0}^{n5} \Delta \mathrm{p}_{t-j}^- \\ & + \beta_6^+ \sum_{j=0}^{n6} \Delta \mathrm{V}_{t-j}^+ + \beta_7^- \sum_{j=0}^{n7} \Delta \mathrm{V}_{t-j}^- + \beta_8^+ \sum_{j=0}^{n8} \Delta \mathrm{TCV}_{t-j}^+ + \beta_9^- \sum_{j=0}^{n9} \Delta \mathrm{TCV}_{t-j}^- \\ & + \left(\lambda_1 m_{t-1} + \lambda_2^+ y_{H,t-1}^+ + \lambda_3^- y_{F,t-1}^+ + \lambda_4^+ p_{t-1}^+ + \lambda_5^- p_{t-1}^- + \lambda_6^+ V_{t-1}^+ + \lambda_7^- V_{t-1}^-\right) \\ & + \lambda_8^+ TCV_{t-1}^+ + \lambda_9^- TCV_{t-1}^- + \upsilon_t\end{aligned} \tag{48}$$

Similar to the earlier equations, all Greek letters with + and - superscripts are positive and negative partial sum processes whereas $\triangle$ denotes the first difference of the underlying variables. All other terms are as already defined above.

Log-run relationship coefficients are given by $\lambda_{1...7 \text{ or } 9}$. Lags of I(1) or first differenced short-run variables are determined using AIC/BC, and the number of lags used in the models are denoted by $n_{1...7 \text{ or } 9}$ above.[9]

Following Schorderet (2001) and Shin *et al.* (2013), the long and short-run asymmetry hypotheses are tested for possible equality between the positive and negative coefficients for each variable, and in both long and short-run scenarios. If the null hypothesis is rejected and these shocks are not equal statistically, then it demonstrates the asymmetric nature of the relationship in the respective time horizon (long or short-run). It implies that both positive and negative components of the underlying independent variables have a different impact on the dependent variable, hence imposing a long and short-run equilibrium relationship between the positive and negative shocks with the dependent variable separately.

The presence of long and short-run asymmetries requires that the positive and negative shocks to a single variable are modelled separately, as both will affect the dependent variable differently. It means that the variability may be in terms of both sign (direction) and size (sensitivity) of the coefficients. This information gives a lot more inference and information compared to the standard (symmetric) long-run equilibrium models, whereby inference is limited to average sensitivity among the variables, which at times would average out the positive and negative changes, seriously limiting the inferential or forecasting capability of the underlying model. However, decomposition of the variables into positive and negative regimes inherits a lot more flexibility and captures the fluctuations simultaneously under both regimes.

9 The number of terms in equation 47 is 7 whereas in equation 48 the number of terms is 9 for both long and short-run variables.

4.6 Data and Variables

4.6.1 Data

This research revolves around UK imports, and the demand for UK imports is modelled similarly to any other demand model. In the literature, most of the research studies describe trade flows as a function of real income, relative prices and exchange rate volatility estimated both in nominal and real terms, using different methods (McKenzie, 1999; Bahmani-Oskooee and Hegerty, 2007).

This research uses monthly data for the above variables from January 1991 to December 2011. The data have been obtained from DataStream. As earlier explained in section 2 of this chapter, this research revolves around UK imports, therefore, the UK is considered to be the home country and six of its trade partners i.e. the US, Germany, Japan, China, Brazil and South Africa, are included in the research sample.[10][11] The sample countries are selected to have an equal number of developing and developed countries, and are geographically dispersed in order to cover different regions around the globe.

4.6.2 Variables

The research variables in this thesis comprise of bilateral monthly imports, relative import price ratios, the real income of the sample countries and exchange rates in both nominal and real terms. These variables represent the

10 Germany, Japan and the United States are some of the major trading partners of the United Kingdom. Direction of trade data (IMF, 2012) shows that UK exports to these countries account for 26% of its total exports and 34% of its exports to advanced countries. Similarly UK imports from these countries are 27% and 34% of total imports and imports from advanced countries. For the year 2011, UK total exports and imports were about $463 billion and $693 billion respectively. The exports and imports from these countries constituted around 25% and 34% respectively of the aggregate figures. These countries are geographically dispersed which adds to the diversity and significance of the dataset and findings.

11 This research was initially aimed at analysing UK imports from BRICS i.e. Brazil, China, India, Russia and South Africa, as these countries represent emerging developing markets, which have gained more economic and political significance in the global market. However, India and Russia were later excluded as the data for variables such as price indices and imports for these countries was not available for the full sample length. Data for these countries was only available from July 2005, which was not sufficient for the hypothesis testing; hence these countries were not included in the analysis.

standard import demand function widely cited in the literature (Gotur, 1985; McKenzie, 1999; Choudhry, 2005; Bahmani-Oskooee and Hegerty, 2007; Choudhry, 2008). This research analyses the UK's bilateral imports from Brazil, China, South Africa, Japan, Germany and the US. Thus, the log of monthly imports is the dependent variable for all the hypothesis testing and empirical estimations.

Among the independent variables, real income is represented by the indices of industrial production for the sample countries. Similarly, relative prices are calculated as the log of the ratio between the import price indices of the UK and each of the other countries. Exchange rates, both in terms of nominal and real for each country, represent a ratio of their respective currency exchange rates in terms of the British Pound (£).

Descriptive analysis of the log-level and first difference series of the underlying variables is presented in appendix-II (Tables 4.1-4.2). The mean of the log-level variables are positive for all the countries. However, the mean for almost all the first-difference variables for all the countries is zero or close to zero. In terms of the normality of the underlying variables, the null hypothesis of normality under the Jarque-Berra test is rejected in most of the cases, implying a large number of variables exhibit non-normal distributions.

Graphic representations of the underlying variables are provided through Appendix-III (Figures 4.2 to 4.8) for all the sample countries. Figure 4.2, for instance plots UK imports from the sample countries. In most of the subplots a decline can be seen towards the end of the time line, which represents the financial crisis period. Another feature that can be observed is that the imports from the developing countries are more stable compared to the developed countries, which show more variations.

Figure 4.3 describes the log index of production for the sample countries, including the UK. The impact of the financial crisis can be noticed with a sudden decline towards the end of the time axis. The UK, Japan and Germany show a relatively larger decline in index of production compared to the other countries in the sample.

Figure 4.4 shows the trends in relative import price ratios for the sample countries. In most of the countries an upward trend is visible, except for China

and Japan, implying an increase in the UK's price levels relative to the other countries.

Stationarity and unit-root analysis of the underlying variables is shown in Table 4.3. As expected, the log-level variables contain a unit-root under various forms of the Augmented Dickey-Fuller Test at the 1% or 5% significance level. 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 the case of first-difference variables, the null hypothesis of the unit-root is rejected under the ADF test at the 1% or 5% significance levels. These results have been confirmed in the majority of cases under the KPSS test, where most of the first-difference variables are found to be stationary. However, some conflicting results have been reported for log-level Brazilian imports, nominal and real exchange rates and German relative import prices, whereas under ADF a variable is considered I(0), under KPSS it is 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, however, these conflicting results are not considered to be of any serious concern.

4.7 Conclusion

This chapter provides a discussion of the research hypotheses and a description of the unit-root, stationary tests and volatility estimation methods adopted in this research. Further detailed sections on the autoregressive distributed lag method (ARDL) bounds testing approach, the general-to-specific causality approach and the Asymmetric nonlinear ARDL approach to cointegration with zero and mean thresholds are also included in this chapter. All of these models have been discussed at length, and their theoretical and econometric underpinnings and application to this research have also been highlighted. Some critical discussion on their merits is also provided. The econometric methodology section is followed by a comprehensive description of the data and variables (including their different transformations) used in this research. This section concludes with a brief discussion of the descriptive and unit-root/ stationary analysis with the help of various tables and graphs.

To conclude, this chapter outlines the various empirical aspects of this research. It includes the research hypotheses to be tested, a selection of

econometric methodology and its application to this research, followed by a discussion of the descriptive and stochastic structure (unit-root/stationarity) analysis of the data.

Chapter 5: Analysis – Developed

5.1 Introduction

This research revolves around the impact of exchange rate volatility and the recent financial crisis on UK imports. The main focus of this research has been to assess the relationship between exchange rate volatility and UK Imports. For this purpose a set of testable hypotheses has been constructed in section 2.6, and methodology explaining the procedures and methods to evaluate these hypotheses provided in chapter 4. This chapter presents and discusses the empirical results based on the hypothesis tests conducted using the (Linear) ARDL bounds testing approach (Pesaran *et al.*, 2001) and the Nonlinear Asymmetric ARDL method (Shin *et al.*, 2013).

This research is significant because, unlike the majority of studies, which generally focus on bilateral trade, the impact of third country exchange rate volatility on UK imports is investigated here. The third country effect is important from the point of view of competition as every exporting country is competing against other countries (Cushman, 1986). 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).

Further, to my knowledge, this is the first study to explore the impact of the recent 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 the volatility tends to increase (Fratzscher, 2009; Melvin and Taylor, 2009).[12]

[12] Along with global trade imbalances and the credit crunch, other supply and demand side factors triggering the massive decline in international trade that have been cited include: disruption of global value chains, rise in protectionism polices, 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)

Lastly, existing evidence is extended 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)) as research on the relationship between UK trade and exchange rate volatility has been tested only within a linear framework so far.

5.2 Empirical Analysis Process

Under both approaches, the data is analysed in the following steps:

1. The first step in estimating ARDL is to identify the optimal lag structure for the underlying variables. According to standard practice, the optimal fit is explored on the basis of information criteria ratios such as the Akaike, Schwarz/Bayesian and Henien-Quinn methods. These methods draw the optimal lag structure from a set of regressions determined by p^n i.e. the maximum number of lags to be used (p) to the power of the number of variables (n) in the equation. The optimal lag structure suggested is then used for model estimation followed by hypothesis testing and post estimation diagnostics. If any of the diagnostics, such as autocorrelation, specification or heteroskedasticity, indicate a problem/irregularity in one or more of these aspects the underlying model has to be altered for rectification.
2. This research proposes an alternative method to the above practice. A procedure has been developed in RATS whereby regression results, along with post estimation diagnostics for all possible models based on p^n, are obtained first hand. At this point, information criteria ratios are considered for only those lag structures where the null hypotheses under all diagnostic tests are accepted. From these filtered results, the optimal lag structure indicated by AIC, SBC and HQ is finally selected to estimate the unrestricted error correction models for each of the four hypotheses described in section 2.5. This method enables estimation of the optimal lag structure, which also conforms to the diagnostic tests, improving the reliability and consistency of results.
3. After selecting the optimal lag structure, the unrestricted error correction models are estimated. The long-run equilibrium relationship is tested using F-statistics between the dependent variables (imports

and its determinants, i.e. real income, relative price ratio and exchange rate volatility).

4. Analysis of the normalized long-run coefficients/elasticities of the demand for imported goods in the UK with respect to each underlying regressors.
5. Error correction and short term causality based on the general to specific causality framework (Hendry, 1987)
6. In the case of the nonlinear Asymmetric ARDL method, the null hypothesis of no asymmetric effect is further tested for both long and short-run regressors using Wald-statistics.
7. The above empirical estimations are supported by providing various diagnostic results to ensure the reliability and stability of the results. These tests include: normality of residuals – JB statistics; autocorrelation - Ljung-Box Test; misspecification – Ramsey's Test; and heteroskedasticity/ARCH effects – ARCH Test and dynamic stability test.

5.3 Overview of the Hypotheses Test Results

Table 5.1 provides an overview of the hypothesis test results for the developed countries i.e. Germany, Japan and the US. The impact of both nominal and real exchange rate volatility on UK imports from these countries have mostly been negative, i.e. with an increase in the exchange rate uncertainty the volume of imports has reduced over the sample period. This relationship has been stable in most of the cases even after inclusion of the financial crisis. The impact of the financial crisis can be in terms of increase in the sensitivity/elasticity of UK imports with respect to exchange rate risk. Similarly, third country volatility has a negative impact on the UK imports in most of the cases, except in the cases where third country exchange rate volatility is represented by USD/GBP, where it has a positive impact. Lastly, null hypothesis of symmetric impact of exchange rate volatility has also been rejected in all of the cases, which confirms the evidence of asymmetric relationship between exchange rate volatility and UK imports. Detailed analysis of the results for both ARDL and Asymmetric ARDL methods are provided in the following sections.

Table 5.1: Summary of Hypotheses Test Results

Countries	Research Questions	ARDL		Asymmetric ARDL	
		Nominal	Real	Nominal	Real
Germany	1. Impact of Exchange Rate Volatility on UK Imports	Negative	Negative	Negative	No Cointegration
	2 Impact of Third County Exchange Rate Volatility on UK Imports	Negative	Negative	Negative	Negative
	3.1 Impact of Exchange Rate Volatility after Financial Crisis on UK Imports	No Cointegration	No Cointegration	Negative	No Cointegration
	3.2 Impact of Third Country Exchange Rate Volatility after Financial Crisis on UK Imports	Negative	Negative	Negative	Negative
	4. Impact of Exchange Rate Volatilities (Symmetric or Asymmetric)	Not Applicable	Not Applicable	Asymmetric	Asymmetric
Japan	1. Impact of Exchange Rate Volatility on UK Imports	Negative	Negative	No Cointegration	Negative
	2 Impact of Third County Exchange Rate Volatility on UK Imports	Negative	Negative	No Cointegration	Negative
	3.1 Impact of Exchange Rate Volatility after Financial Crisis on UK Imports	Negative	Negative	No Cointegration	Negative
	3.2 Impact of Third Country Exchange Rate Volatility after Financial Crisis on UK Imports	Negative	Negative	Negative	Negative
	4. Impact of Exchange Rate Volatilities (Symmetric or Asymmetric)	Not Applicable	Not Applicable	Asymmetric	Asymmetric
US	1. Impact of Exchange Rate Volatility on UK Imports	Negative	Negative	Negative	Negative
	2 Impact of Third County Exchange Rate Volatility on UK Imports	Negative	Negative	Positive	Positive
	3.1 Impact of Exchange Rate Volatility after Financial Crisis on UK Imports	Negative	Negative	Negative	Negative
	3.2 Impact of Third Country Exchange Rate Volatility after Financial Crisis on UK Imports	Negative	Negative	No Cointegration	Positive
	4. Impact of Exchange Rate Volatilities (Symmetric or Asymmetric)	Not Applicable	Not Applicable	Asymmetric	Asymmetric

5.4 ARDL – Bounds Testing Approach

5.4.1 ARDL Cointegration Results

This section describes the hypotheses test results based on the ARDL – Bounds Testing approach proposed by Pesaran *et al.* (2001). Tables 5.1-5.4 present the ARDL cointegration test results. The significance of the coefficients is presented at the 10%, 5% and 1% levels. Cointegration results are supported by diagnostic statistics such as the JB-statistic, Ljung-Box, Reset and ARCH (1) and

ARCH (3). The adjusted R-square, sum of standard error of estimates and the sum of squared residuals and optimal lag length are also reported for each country in these tables.

5.4.1.1 Exchange rate volatility and UK Imports before and including the Financial Crisis

Tables 5.1-5.8 present the cointegration results based on the ARDL-bounds testing approach for the developed countries during the pre-crisis period (5.1 and 5.3) and the crisis period (5.2 and 5.4) using both nominal and real exchange rate volatilities. These results provide empirical support for testing the hypotheses formulated in section 2.5. Each country's detailed hypothesis tests based on these results are as follows:

5.4.1.1.1 Germany

Tables 5.1 and 5.3 show significant cointegration for Germany at the 1% significance level, confirming a long-run relationship between UK imports and Euro-GBP nominal exchange rate volatility. Other determining variables included in this relationship are the UK's real income and the relative price ratio between the two countries. These results hold both before the financial crisis and after inclusion of the recent financial crisis period data. This implies inter-temporal stability of the results for both data samples.

However, as shown in Tables 5.2 and 5.4, using the Euro-GBP real exchange rate, no evidence of cointegration is found between the underlying variables at any threshold significance level i.e. 1%-10%. Furthermore, this result holds both before and including the financial crisis periods.

5.4.1.1.2 Japan

In the case of Japan, a long-run relationship is reported between UK imports and Yen/GBP exchange rate volatility both in nominal and real terms along with other regressors (Tables 5.1 and 5.3). Thus, the null hypothesis of no cointegration is rejected at the 5% significance level for the period prior to the recent financial crisis. After extending the data sample to include the recent financial crisis period, this relationship holds, indicating a stable and significant long-run relationship at the 5% level under both nominal and real exchange rate volatilities (Tables 5.2 and 5.4).

5.4.1.1.3 US

Tables 5.1 and 5.3 also show significant cointegration between UK imports and USD/GBP exchange rate volatility estimated both in nominal and real terms. Thus, in the case of the US, the null hypothesis is also rejected at the 1% significance level, showing a strong long-run relationship between the underlying variables. This relationship holds even after the inclusion of the recent financial crisis period. Thus, a long-run equilibrium association between the underlying variables is reported for both sample lengths.

5.4.1.1.4 Summary

To summarize, Euro/GBP exchange rate volatility (nominal and real) along with real income and relative prices affects the UK imports in the long-run for the pre-crisis period. However, this relationship does not exist after the sample length is increased to include the financial crisis period as well. In the case of Japan, a significant long-run relationship is found between the underlying regressors and UK imports for both sample periods using both nominal and real exchange rate volatilities. The diagnostic test results show that the residuals are normally distributed, and no evidence of autocorrelation, heteroskedasticity (ARCH effect) or misspecifications is found.

Table 5.1: ARDL Results - Impact of Nominal Exchange Rate Volatility on UK Imports Before the Financial Crisis (Jan-1991 to June 2007)

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
Germany	8.27***	0.58	0.07	0.81	0.17	1.24	0.34	0.41	2.42
Japan	4.79**	0.39	0.07	0.79	1.39	1.29	1.5	1.7	2.4
US	5.95***	0.39	0.08	1.06	0.49	1.55	0.5	0.05	3.3

Table 5.2: ARDL Results - Impact of Nominal Exchange Rate Volatility on UK Imports Including the Financial Crisis (Jan-1991 to Dec-2011)

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
Germany	3.42	0.52	0.07	1.17	3.28	1.50	0.36	0.47	2.33
Japan	6.39***	0.40	0.07	1.33	1.52	1.54	1.17	2.26	3.12
US	7.68***	0.39	0.07	1.27	0.96	1.24	0.79	0.23	3.47

Table 5.3: ARDL Results - Impact of Real Exchange Rate Volatility on UK Imports Before the Financial Crisis (Jan-1991 June 2007)

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
Germany	7.19***	0.58	0.07	0.81	0.48	1.14	1.16	0.033	1.173
Japan	4.28**	0.39	0.072	0.84	1.34	1.58	2.13	1.625	2.471
US	5.94***	0.39	0.079	1.057	0.49	1.53	1.8	0.115	0.461

Table 5.4: ARDL Results - Impact of Real Exchange Rate Volatility on UK Imports Including the Financial Crisis (Jan-1991 to Dec-2011)

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
Germany	2.43	0.52	0.08	1.12	4.47	1.39	1.83	0.916	2.009
Japan	5.72***	0.39	0.07	1.34	1.43	1.54	3.01	2.07	3.13
US	7.34***	0.39	0.07	1.27	0.98	1.35	2.59	0.191	1.43

Note:
1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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;

5.4.1.2 Exchange rate volatility and UK Imports in the presence of Third Country Exchange Rate Risk Before and Including the Financial Crisis

As per section 2.5.2, the second hypothesis aims to test the impact of third country exchange rate volatility on the relationships tested in the previous section. Tables 5.5 and 5.7 provide results for the period before the financial crisis based on nominal exchange rate volatility estimates. Tables 5.6 and 5.8 show the results for the period including the financial crisis. Each country's detailed hypothesis tests are discussed in the following sub-sections:

5.4.1.2.1 Germany

According to Tables 5.5 and 5.7, significant cointegration is reported in the case of Germany among the variables of interest in the pre-crisis scenario. These variables include UK imports, the UK's real income, relative price ratio and the Euro/GBP nominal exchange rate volatility, in addition to the third-

country exchange rate risk, which is proxied by USD/GBP nominal exchange rate volatility. Hence, the null hypothesis is rejected for no cointegration at the 1% significance level following Pesaran *et al.* (2001). This result holds even after including the recent financial crisis period using nominal exchange rate volatilities (Tables 5.6 and 5.8).

5.4.1.2.2 Japan

In the case of Japan, a long-run relationship is reported amongst the underlying variables under both nominal and real exchange rate volatilities for both before and including the financial crisis period (Tables 5.5-5.8). Thus, the null hypothesis of no long-run relationship (cointegration) in the presence of third-country exchange rate risk is rejected at the 1% or 5% significance level in all cases. Third country exchange rate risk here has been proxied by USD/GBP exchange rate volatility both in nominal and real terms.

5.4.1.2.3 US

The results for the US show a significant long-run equilibrium relationship among the underlying variables using both nominal and real exchange rate volatilities. These results hold for both data samples, i.e. before and including the financial crisis. Hence, the second null hypothesis of no cointegration in the presence of third-country exchange rate risk is rejected at the 1% significance level in all cases. Third country exchange rate risk in the case of the US-UK relationship is proxied by Euro-GBP nominal and real exchange rate volatilities because, after US dollars, the Euro is the largest traded currency in the world (Fratzscher, 2009).

5.4.1.2.4 Summary

To summarize, significant cointegrating relationships are reported between the underlying variables for all countries under both nominal and real exchange rate volatilities for both sample lengths. The results, based on the ARDL method proposed by Pesaran *et al.* (2001), suggest that real income, relative price ratio and exchange rate volatilities are significant determinants of UK demand for US goods. This is also true when the third country exchange rate (Euro/GBP) volatility is included in the relationship. The demand for German and Japanese goods by UK consumers is influenced by the crisis period. When

the dollar-pound volatility is added to the relationship to account for the third country effect, the financial crisis seems to have the same effect.

5.4.2 Normalized Equations and Long-Run Elasticities

Normalized equations are estimated for inferring the long-run relationship between the underlying regressors and the dependent variable. In this case, the independent variables, i.e. real income, relative price ratio and exchange rate volatility, have been normalized on the UK imports. These estimates provide long-run elasticities of the respective independent variables and represent the percentage change in UK imports due to a unit change in these independent variables. Tables 5.9-5.12 present the estimated normalized equations for the different hypotheses. The significance of the coefficients is presented for 10%, 5% and 1% levels.

Table 5.5: ARDL Results - Impact of Nominal Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk Before the Financial Crisis (Jan-1991 to June-2007)

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
Germany	5.35***	0.575	0.07	0.80	1.651	1.142	2.83	0.715	1.07
Japan	3.7**	0.39	0.07	0.83	0.376	1.593	1.05	1.03	2.19
US	5.78***	0.397	0.08	1.05	0.295	1.347	3.59	0.101	1.13

Table 5.6: ARDL Results - Impact of Nominal 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)
Germany	3.99**	0.583	0.071	1.013	1.05	1.377	3.61	1.215	1.691
Japan	4.706**	0.411	0.078	1.288	1.99	1.560	2.39	1.799	1.989
US	7.229***	0.379	0.079	1.351	1.38	1.830	1.71	1.81	2.14

Table 5.7: ARDL Results - Impact of Real Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk Before the Financial Crisis (Jan-1991 to June-2007)

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
Germany	5.79***	0.58	0.07	0.81	0.95	1.362	3.722	1.253	1.743
Japan	3.61**	0.387	0.07	0.07	0.22	1.563	2.464	1.855	2.051
US	5.33***	0.392	0.08	1.05	0.269	1.301	1.763	1.866	2.206

Table 5.8: ARDL Results - Impact of Real 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)
Germany	4.11**	0.580	0.071	1.018	1.197	1.376	3.479	1.171	1.629
Japan	4.73**	0.461	0.075	1.050	1.550	1.326	2.303	1.734	1.917
US	6.97***	0.422	0.076	1.125	0.966	0.895	1.648	1.744	2.062

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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.

5.4.2.1 Exchange rate volatility and UK Imports Before and Including the Financial Crisis Period

5.4.2.1.1 UK Real Income

Based on standard economic theory, an increase in UK real income should result in an increase in the demand for imported (normal) goods. The results in Tables 5.9-5.12 show that the coefficients for UK real income in all the cases[13] are positive and significant. Hence these results are in line with the existing evidence on the subject (McKenzie, 1999; Bahmani-Oskooee and Hegerty, 2007). In the context of the financial crisis, the size of the income elasticity increases when the crisis period data is added to the sample, which may imply that during this time UK imports became more sensitive to changes in UK real income because of an upsurge in economic volatility, indicating possible rational behaviour on the part of the UK customers being cautious of the economic turbulence and realizing the most efficient allocation of their resources.

The results in Table 5.9 show that income elasticities for German imports in the UK are 0.315 and 0.9252 where exchange rate volatilities are estimated based on nominal and real rates, respectively. This means a 1% increase (decrease) in the UK's real income would increase (decrease) UK imports from Germany by 0.315% and 0.9252%, respectively, for nominal and real exchange rate volatility. After inclusion of the financial crisis period, no cointegration was reported for Germany in section 5.2.1.1, thus normalized coefficients could not be estimated. Therefore, comparison in the post financial crisis scenario as to how much income elasticity changed after the inclusion of the crisis period cannot be made.

In the case of Japan, the real income coefficient was 1.4503 when exchange rate volatility is estimated using nominal rates, implying a 1.4503% increase in UK imports from Japan due to a one per cent increase in the UK's real income. Real income coefficients with respect to real exchange rate volatility are not

13 i.e. for both nominal and real exchange rate volatilities, with and without the presence of third-country effect and for the pre-crisis and financial crisis sample periods.

available because there was no cointegration, as reported earlier in Section 5.2.1.1 (Table 5.9). After inclusion of the crisis period, real income elasticity is shown to be 0.6798 for Japanese goods for the nominal volatility equation, whereas for the real volatility equation the elasticity is 1.2756.

This shows that after the sample period was extended the elasticity for the nominal equation has decreased from 1.4503 to 0.6798, i.e. it has reduced more than 50% after the financial crisis. This may be attributed to the fall in UK real income during the financial crisis and/or a massive decline in regional and global trade flows.

In the case of US goods, high elasticities are reported under all the cases, i.e. both nominal and real exchange rate volatilities for the pre-crisis and financial crisis periods (Tables 5.9-5.12). For instance, coefficients for real income are 3.799 and 3.791 indicating high UK income elasticity for US goods. After inclusion of the crisis period, these coefficients are observed to slightly increase to 4.06 and 4.07 with respect to nominal and real exchange rate volatilities.

5.4.2.1.2 Relative Price Ratio

The relative price ratio compares import prices of the partner countries (i.e. Germany, Japan and the US) against the home country (i.e. the UK). An increase in the ratio implies an increase in the import prices of the partner countries relative to the home country and would discourage imports from that particular partner country. Thus, a negative coefficient is expected under this proposition (Arize *et al.*, 2003; Bahmani-Oskooee and Kara, 2005).

As per the results in Tables 5.9 and 5.10, the relative price coefficients are all significant. However, in terms of the direction of the relationship, mixed findings are reported as both negative and positive coefficients are found for relative prices.

In the case of Germany, for instance, relative import price coefficients are -2.45 and -16.16 for nominal and real exchange rate equations respectively. This shows an inverse relationship between the import prices and UK imports, i.e. any increase in the import prices is followed by a decline in UK imports.

Analysis - Developed

For Japan, the coefficients are 0.7531 for the nominal exchange rate before the financial crisis period, which increases to -2.419 and -1.93 for nominal and real exchange rates, respectively. This shows that after inclusion of the financial crisis period: i) the relationship has been altered from positive to negative, and ii) the coefficients have increased in size. Thus, a change in direction of the relationship and an increase in the size of coefficients may be attributed to the financial crisis.

Relative import prices for the US show high elasticity, but with positive signs in most the cases, i.e. both pre and including the financial crisis period. The coefficients for the pre-crisis period are 4.371 and 4.376 (Table 5.9) for nominal and real exchange rate equations. These coefficients are slightly reduced, to -3.361 and 3.392 (Table 5.10), for the full sample length. As can be seen, all coefficients have a negative sign (as suggested in some of the existing literature) meaning that UK imports from the US increase irrespective of an increase in the US price levels.

5.4.2.1.3 Nominal/Real Exchange Rate Volatility

Exchange rate volatility, as explained in the Data and Methodology chapter, has been estimated on the basis of the GARCH (1,1) model using both nominal and real exchange rates for the sample country.

The relationship between the exchange rate volatility and imports is not clear in the current literature. Many studies have explored this relationship and have concluded in three possible ways: there is a negative underlying effect of exchange rate volatility (negative hypothesis); exchange rate volatility positively affects the trade flows (positive hypothesis); or there is no relationship between the two variables (McKenzie, 1999; Bahmani-Oskooee and Hegerty, 2007).

This thesis, as shown in the theoretical framework chapter, expects a negative relationship between the two variables. The long-run volatility coefficients for Germany and Japan are significant, whereas in the case of the US these coefficients are insignificant. The estimated coefficients for Germany are -7.84 and -10.15, which shows that for a one per cent increase (decrease) in nominal and real exchange rate volatilities before the financial crisis the UK imports decrease (increase) by 7.84% and 10.15% respectively. No results are available

for the full sample because no cointegration is reported for Germany in that period. Similarly, in the case of Japan the long-run volatility coefficients are -4.98, -6.87 and -4.11 for nominal volatility (before the crisis) and real exchange rate volatilities for before and including the financial crisis, respectively. On the basis of these results, comparison of nominal volatility in the pre-crisis and financial crisis periods highlights a significant increase in the sensitivity of UK imports from Japan towards exchange rate volatility. These coefficients represent multiplier effects to UK imports due to a one per cent change in the Euro/Pound exchange rate volatility.

The price elasticity increases from the pre-crisis to crisis period in the third country volatility tests. But it decreases after adding the crisis period data in the first tests. The volatility elasticities are all negative and significant. They are large in size in absolute value. And they tend to increase in size from the pre-crisis to the crisis period. The third country volatilities are also all negative and mostly significant. In most cases, the volatility increases after inclusion of the financial crisis period.

Table 5.9: Normalized Coefficients - Impact of Exchange Rate Volatility on UK Imports Before the Financial Crisis (Jan 1991 – June 2007)

Countries	Constant	Real Income	Relative Prices	Volatility
	Nominal Volatility			
Germany	4.505***	0.315**	-2.45***	-7.843***
Japan	0.299	1.450***	0.753**	-4.985***
US	-14.085***	3.799***	4.371***	-3.058
	Real Volatility			
Germany	25.349***	0.926***	-16.165***	-1.012***
Japan	0.131	1.191**	0.649***	-1.473***
US	-14.05***	3.791***	4.376***	-5.550

Table 5.10: Normalized Coefficients - Impact of Exchange Rate Volatility on UK Imports Including the Financial Crisis (Jan 1991 – Dec 2011)

Countries	Constant	Real Income	Relative Prices	Volatility
	Nominal Volatility			
Germany	-	-	-	-
Japan	7.429***	0.679***	-2.419***	-6.874***
US	-14.294***	4.061***	-3.361***	-6.722***
	Real Volatility			
Germany	-	-	-	-
Japan	3.584***	1.276***	-1.93***	-4.171***
US	-14.374***	4.071***	3.393***	-7.963

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.

5.4.2.2 Exchange rate volatility and UK Imports in the presence of Third Country Exchange Rate Risk Before and Including the Financial Crisis

5.4.2.2.1 UK Real Income

Normalized coefficients for UK real income are significant for 10 out of the 12 cases (Tables 5.11-5.12). In the case of Germany, the coefficients were 0.5654 before the financial crisis for the nominal volatility equation. It implies that a one per cent increase in UK real income during the pre-crisis period would increase UK imports from Germany by 0.56 per cent. However, the coefficient for the full sample period is insignificant, hence the sensitivity of UK imports with respect to UK real income cannot be inferred for the time period including the financial crisis.

Demand for Japanese goods in the UK demonstrates significant income elasticity in the pre-crisis period under both nominal and real exchange rate volatilities with a 1% significance level. The coefficients for real income are 0.3541 and 0.0352. However, after inclusion of the financial crisis period real income is only significant under the real exchange rate volatility model with a 1% significance level. The coefficient of real income in this case is 1.956. The sign and size of the coefficient are important to estimate the impact of a certain variable over the dependent variable. As shown in Tables 5.11-5.12, all the coefficients reported for UK real income are positive, implying a direct relationship between UK imports and UK real income. Similarly, the size of the coefficient equates to the magnitude of the impact and these coefficients are considered to be multipliers, which reflect the impact of the underlying variables on the dependent variables due to a one per cent increase (decrease) in UK real income. A comparison of Japanese results in the context of the financial crisis period reveals an increase in the income elasticity of demand for Japanese imports in the UK.

UK real income coefficients for imports from the US are all significant with a 1% level. Further, these coefficients grow significantly after the financial crisis period is included, i.e. 0.0434 increases to 3.865 (nominal volatility model), and 0.61 to 4.14. This indicates an upsurge in the income elasticity of the demand for US imports in the UK. The major reasons behind this increased sensitivity is that both UK imports and real income dropped significantly

during the financial crisis and both variables showed significant co-movement, due to which the elasticity of income has increased massively.

5.4.2.2.2 Relative Import Price Ratio

As shown in Tables 5.11-5.12, relative import price ratio coefficients provide mixed results both in terms of sign as well as their sizes. In the pre-crisis period, coefficients for the US are 0.1293 and 0.756 under nominal and real exchange rate volatilities, respectively. In terms of the sign of the coefficients, these results are similar to those reported in Section 5.2.2.1 in that the UK imports from the US increase, irrespective of an increase in the US prices. Both the coefficients are highly significant at the 1% level. These coefficients increase to 2.9765 and 3.2650, respectively, highlighting an increased import price elasticity of demand for US goods in the UK, which may be attributed to the global financial crisis.

5.4.2.2.3 Nominal/Real Exchange Rate Volatility

Both the nominal and real exchange rate volatility coefficients in most of the cases are negative and significant, implying an inverse relationship with UK imports and showing that an increase in the exchange rate volatility (uncertainty) leads to a reduction in UK imports from Germany, Japan and the US. Another important observation is that the sign of the coefficients, like other variables, remains intact while the size of the corresponding coefficients increases after inclusion of the financial crisis period. This explains the increased magnitude of the independent variables, and even a small change in these regressors result in a greater impact on the UK imports.

5.4.2.2.4 Third-Country Nominal/Real Exchange Rate Volatility

Tables 5.11 and 5.12 show the results for the third country exchange rate risk for the developed countries. Coefficients in all the cases show a negative relationship between third country exchange rate volatility and UK imports. Furthermore, a relative increase in the size of most of these coefficients is observed, similar to the other independent variables between the pre-crisis and financial crisis periods.

Table 5.11: Normalized Coefficients - Impact of Nominal Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk Before the Financial Crisis (Jan 1991 – June 2007)

Countries	Constant	Real Income	Relative Prices	Volatility	3rd Country Volatility
	Nominal Volatility				
Germany	-2.512***	0.565***	-0.371	-4.911***	-1.402***
Japan	7.0956***	0.3541***	-1.054	-3.427***	-6.932***
US	0.8710***	0.0434***	0.129***	-4.142	-8.510***
	Real Volatility				
Germany	-13.9677	3.8354	4.172	-17.4507***	-1.682
Japan	0.879***	0.0352***	-0.394***	-18.758***	-1.419***
US	3.712***	0.610***	0.756***	-1.522	-1.059***

Note:
1. ***,**, and * denote significant at 1%, 5% and 10% respectively.

Table 5.12: Normalized Coefficients - Impact of Nominal Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk (Jan-1991 to Dec-2011)

Countries	Constant	Real Income	Relative Prices	Volatility	3rd Country Volatility
	Nominal Volatility				
Germany	-6.217***	3.076***	2.903***	-5.453***	-8.795***
Japan	12.891***	0.264	-3.342***	-6.943***	-19.78***
US	-12.920***	3.866***	2.977***	-6.512***	-9.410***
	Real Volatility				
Germany	-2.771***	0.515***	7.479***	-2.55***	-5.029***
Japan	-2.141***	1.957***	0.294	-2.917***	-2.096***
US	-14.581***	4.146***	3.265***	-4.477**	-3.832***

Note:
1. ***,**, and * denote significant at 1%, 5% and 10% respectively.

5.4.3 Causality between Real UK Imports and its Determinants

Tables 5.13-5.16 show the estimated error correction model specification presented in equation 7 with respect to both nominal and real exchange rate volatility. Tables 5.13 and 5.14 present the 'General-to-Specific' causality results with nominal exchange rate volatility, whereas Tables 5.15 and 5.16 report results where exchange rate volatility is expressed in real terms. The following sub-sections describe the specific country causality results in detail:

5.4.3.1 Exchange rate volatility and UK Imports Before and Including the Financial Crisis period

5.4.3.1.1 Germany

As reported in section 5.4.1.1.1 above, a long-run relationship in the case of Germany is only reported for nominal exchange rate volatility, and no evidence of a long-run relationship is found among the underlying variables when real exchange rate volatility is employed. Hence, the 'General-to-Specific' causality (Hendry, 1987) results are reported for nominal exchange rate volatility only. The error correction term is significant in both the pre-crisis and the financial crisis period, therefore UK imports are Granger caused by the underlying variables collectively. Moreover, nominal exchange rate volatility, along with the UK's real income, also significantly affects UK imports in the short-run.

5.4.3.1.2 Japan

In the case of Japan, error correction terms are significant in all cases, i.e. both nominal and real exchange rate volatilities and before/including the financial crisis period. This shows that the underlying variables Granger cause UK imports jointly, irrespective of the time period selected and the type of exchange rate volatility employed. In terms of short-term relationships, lagged UK imports, for example lags 1 (-0.237)[14], 10 (-0.102), 12 (0.483) and 13 (0.136), the UK's real income and relative import price ratio between the UK and Japan are all important determinants of UK imports. Only in one out of the four cases is exchange rate volatility reported as a weakly significant short-term factor (Table-5.16).

5.4.3.1.3 US

Error correction terms for the US are significant in all cases at the 1% level, implying a strong causal relationship among the underlying variables. This relationship holds for both nominal and real exchange rate volatilities and also for before and after inclusion of the financial crisis period. A relative increase

[14] Figures in brackets represent the coefficients of each lag and are interpreted as percentage changes in the dependent variables due to a one per cent change in the underlying regressors

in the absolute value of the estimated error correction term is observed from the pre-crisis period to the full period. Besides the long-run perspective, the short-term impact is observed from lagged imports at various lags, for instance: 1 (-0.256), 7 (-0.1009), 10 (-0.1144), 12 (0.3884) and 13 (0.1448). Relative price ratio, in one instance, has also been reported as a short-term factor for the full sample period.

5.4.3.2 Exchange rate volatility and UK Imports in the Presence of Third-Country Exchange Rate Risk in Periods Before and Including the Financial Crisis

This section discusses the error correction and 'General-to-Specific' causality results in the context of third country exchange rate risk (section 2.5.2). This is particularly important since changes in bilateral trade between two countries may be affected by exchange rate fluctuations with respect to a third country, which, in turn, may influence trading competition. For example, in tests between the UK and Germany (or Japan), the third country effect is captured by including the volatility of the USD/GBP exchange rate in the model. As such, Tables 5.17-5.20 present the results with respect to both nominal and real exchange rate volatilities. The error correction model is estimated both during the pre-crisis sub-period (Tables 5.17 and 5.18) and then for the full period (Tables 5.19 and 5.20) in order to analyse the impact of the recent financial crisis on international trade. A discussion of the results in this context for each specific country is as follows:

5.4.3.2.1 Germany

The error correction estimates are significant across both data samples as well as all types of exchange rate volatility employed. This shows strong Granger causality jointly caused by changes in third country exchange rate volatility, in addition to other underlying variables. Another important element is that the size of these terms increases when the financial crisis period is included. This shows an increase in the speed equilibrium correction after the financial crisis period across both nominal and real exchange rate volatilities. Third-country exchange rate volatility (risk), in addition to its long-term significance, also affects UK imports in the short-run, especially after inclusion of the financial crisis.

5.4.3.2.2 Japan

In the case of Japan, error correction terms are significant across all instances, showing strong Granger causality between UK imports and all underlying determinant variables. However, a gradual decline is observed in the case of real exchange rate volatility after inclusion of the financial crisis period. Besides changes in imports at various lags, other important short-term variables include nominal exchange rate volatility and UK real income. No evidence of the third-country affect is reported in the short-run, despite a strong long-run impact on UK imports.

5.4.3.2.3 US

As shown in Tables 5.17-5.20, all cases show significant evidence of causality from the determinant variables to UK real imports and the overall impact is similar to the previous results. In both nominal and real terms of exchange rate volatility, the speed of adjustment to deviations from the long-run equilibrium is relatively higher when imports from the US are considered.

5.4.3.2.4 Summary

In line with the corresponding results from the full sample period, a positive and significant short-term effect of the USD/GBP exchange rate volatility on UK imports is observed. However, we find that UK imports are not affected by the third country volatility effect when the UK is trading with Japan or the US. As seen in Tables 5.19 and 5.20, this result holds even in the full sample which includes the crisis period.

Lastly, all of the above results also include the respective diagnostic test results for the main anomalies such as: normality of residuals, heteroskedasticity/ARCH effects, Ramsey's misspecification test, Ljung box autocorrelation test, in addition to adjusted R-square, standard error of estimates and the sum of squared residuals.

5.5 Asymmetric ARDL Method

This research extends the current empirical evidence in this area by applying the asymmetric nonlinear ARDL method, proposed by Shin *et al.* (2013), to study the relationship between UK trade flows and its determinants.

5.5.1 Asymmetric ARDL Cointegration Results

This section explains the hypotheses test results based on the asymmetric ARDL model as shown in Tables 5.21-5.24. Tables 5.21 and 5.22 present the pre-crisis and the total period results, respectively. Tables 5.23 and 5.24 show the corresponding results when we account for the third country effect in our model. Further results are provided for both nominal and real exchange rate volatilities. The statistical significance of the estimates is evaluated at the conventional thresholds of 10%, 5% and 1% levels. Country specific discussion is provided in the following sub-sections:

5.5.1.1 Exchange rate volatility and UK Imports Before and Including the Financial Crisis Period

5.5.1.1.1 Germany

In the case of Germany, cointegration, or a long-run equilibrium relationship, is reported only under the Asymmetric ARDL method when exchange rate volatility is expressed in nominal terms. The relationship with nominal volatility holds across both sample lengths, i.e. before and after including the financial crisis period. However, when real exchange rate volatility is employed, Asymmetric ARDL methods fail to indicate a significant long-run relationship between UK imports and its determinants for both before and including the financial crisis samples. These results indicate that UK imports are collectively determined by the nominal exchange rate volatility (Euro/GBP) along with UK real income and relative import price ratio. Secondly, UK imports respond differently to positive and negative shocks to the determinant variables in the long-run. Thirdly, results show consistency over both sample lengths, implying a stable long-run relationship among the underlying variables.

Lastly, cointegration results under both Symmetric ARDL (section 5.4.1.1.1) and Asymmetric ARDL, as discussed earlier in this section, are similar, i.e. significant cointegration is only reported under nominal exchange rate volatility and no evidence is found when real exchange rate volatility is employed. This further adds to the consistency of the relationship among the variables.

5.5.1.1.2 Japan

In contrast to Germany, significant cointegration is reported for Japan only when real exchange rate volatility is employed, for both before and including the financial crisis period (Tables 5.21-5.22). Hence, a long-run equilibrium relationship is reported for UK imports and Yen/GBP exchange rate volatility only in real terms along with UK real income and relative import price ratio between the two countries. Due to the application of the Asymmetric ARDL, rejection of the null hypothesis implies that the underlying long-run relationship is asymmetric in nature, i.e. positive and negative shocks in the independent variables affect UK imports differently. Detailed analysis of the positive and negative components of the respective independent variables is provided in section 5.5.2, and formal tests of the asymmetric effect of the independent variables, both in the short and long-run, are discussed in section 5.5.4.

5.5.1.1.3 US

Tables 5.21-5.22 reveal a long-run asymmetric cointegration, or equilibrium relationship, for the US for 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 the US.

5.5.1.1.4 Summary

To summarize the findings regarding the impact of exchange rate volatility (both nominal and real terms) on UK imports in the context of the financial crisis, Tables 5.21 and 5.22 provide sufficient evidence of a long-run asymmetric relationship among the underlying variables. In the case of the US, the relationship is significant irrespective of the time period and type of exchange rates selected, whereas for Germany, the long-term relationship exists only under nominal exchange rate volatility, and in the case of Japan, cointegration is reported for real exchange rate volatility only. However, these relationships hold both before and after inclusion of the financial crisis, implying the stochastic stability of the underlying relationships. Lastly, this evidence contributes to the literature by identifying the asymmetric dimension of exchange rate volatility and the trade flow relationship, whereby the import

demand responds differently to positive and negative shocks to the independent variables.

5.5.1.2 Exchange rate volatility and UK Imports in the presence of Third Country Exchange Rate Risk Before and Including the Financial Crisis Period

After testing the basic relationship between exchange rate volatility and UK imports often cited in the literature, this research introduces the third-country exchange rate risk and explores the possibility of any impact on the basic relationship. Theoretical details of third-country exchange rate risk are provided in section 2.4 and a formal hypothesis to test the third-country effect empirically is described in section 2.5.2. Third-country exchange rate risk is proxied by USD/GBP exchange rate volatility when the relationship between the UK and Germany or Japan is being tested, and Euro/GBP volatility in the case of the UK and the US relationship. Empirical results for the F-Test under the Asymmetric ARDL method are provided in Tables 5.23 (before the financial crisis) and 5.24 (after inclusion of the financial crisis).

5.5.1.2.1 Germany

In the case of Germany, an asymmetric long-run equilibrium relationship is indicated for both nominal and real exchange rate volatilities for both sample lengths. This indicates that USD/GBP (third-country) volatility, along with the rest of the underlying variables, is an additional determinant of UK imports from Germany. Furthermore, this relationship holds in all cases where different volatility or time periods are employed, adding to the reliability and stability of this relationship.

5.5.1.2.2 Japan

The evidence in the case of Japan is similar to Germany, with significant asymmetric cointegration reported irrespective of the volatility type and sample periods employed. Thus, USD/GBP (third-country) exchange rate risk is also observed to be an additional regressor along with the rest of the variables. Thus, the null hypothesis of no cointegration is rejected at the 1%-5% significance level in most of the cases, the exception being where the significance level is 10%.

5.5.1.2.3 US

For the US, the null hypothesis of no cointegration is rejected in most of the instances at the 1%-5% significance levels, with the exception of nominal exchange rate volatility before the financial crisis period where the null hypothesis could not be rejected. This shows sufficient evidence of an asymmetric long-run relationship in the presence of third-country exchange rate risk, especially in real terms, for the US as well.

5.5.1.2.4 Summary

Tables 5.23 and 5.24 include the third-country exchange rate risk as an additional determinant of the UK's imports. Third country exchange rate risk has been proxied by dollar-pound real exchange rate volatility, in the case of UK imports from Germany and Japan, and the euro-pound real exchange rate volatility in the case of US. The null hypothesis of no asymmetric cointegration is rejected in most of the cases for both the pre-crisis and total periods for all the three countries at the 1%-5% conventional level. This finding provides strong evidence in support of the third-country exchange rate risk being an important determinant of UK imports. This is especially significant in the case of Germany and Japan where in some cases no cointegration is found without the third country risk (sections 5.5.1.1.1 and 5.5.1.1.2 above). The diagnostic test results reject the null hypotheses of serial correlation, heteroskedasticity and misspecification for these asymmetric ARDL estimates.

5.5.2 Normalized Equations and Long-Run Elasticities

Following traditional cointegration methodology, normalized equations are estimated for inferring the long-run relationship between the underlying regressors and the dependent variable. In this case, independent variables are represented by positive and negative partials of underlying variables i.e. real income, relative price ratio and exchange rate volatility, and these have been normalized on the UK imports. These estimates provide long-run elasticities of the respective independent variables and represent the percentage change in UK imports due to a unit change in these independent variables. Tables 5.25-

5.28 present the estimated normalized equations for the different hypotheses. The significance of the coefficients is presented for the 10%, 5% and 1% levels.

5.5.2.1 Exchange rate volatility and UK Imports Before and Including the Financial Crisis Period

Tables 5.25 and 5.26 show the normalized equations for Germany both before and including the financial crisis Normalized equations are only reported for nominal exchange rate volatility, as no long-run relationship was found under real exchange rate volatility for Germany. Therefore, discussion of the long-run coefficients will be limited to nominal rates only. Similarly, in the case of Japan, the long-run relationship is reported only under real terms, hence discussion of normalized equations for Japan is limited to these results only. Results for the respective variables follow in the proceeding sub-sections:

5.5.2.1.1 UK Real Income

Tables 5.25 and 5.26 show that a 1% positive change in the underlying variable increases the demand for imports from Germany by 4.93%, whereas a 1% negative change in the UK real income only reduces imports by 2.75% before the financial crisis period. After inclusion of the financial crisis, the elasticity in the case of positive changes in real income declines from 4.93% to 1.205%, whereas, in the case of negative changes in real income, the sensitivity increases as a 1% negative change depresses imports by 3.703%. This shows the significant asymmetric effect of UK real income, which becomes further evident after the financial crisis is included. The results also show that UK imports from Germany become less elastic to positive changes in UK real income, but elasticity to negative changes in UK real income increases significantly.

In the case of Japan, similarly, a 1% positive change in UK real income increases UK imports by 5.98%, whereas a 1% negative change is responded to by a decline in the imports from Japan by 0.635% before the financial crisis. However, after inclusion of the recent financial crisis period, Table 5.26 shows a decline in UK imports towards positive real income elasticity, or in other words, any positive change in the real income after inclusion of the financial crisis period results in a relatively smaller increase in imports, i.e. 1.766% as compared to 5.98% before the financial crisis period. Interestingly, the

coefficient for the negative change in real income is 1.065% for the full sample length, which implies that the elasticity changes from negative to positive after inclusion of the financial crisis period.

Lastly, for the US, using nominal exchange rate volatility, the UK imports show a decline in positive income elasticity across the two sample lengths, i.e. after inclusion of the financial crisis, the sensitivity of UK imports to positive changes in UK real income has reduced significantly (Tables 5.25-5.26). However, import elasticity to negative changes in real income has increased, from 0.937% to 3.098%, after inclusion of the financial crisis period. This shows that demand for US exports in the UK increased irrespective of domestic real income after inclusion of the financial crisis period. Similar results are reported under real exchange rate volatility as well.

5.5.2.1.2 Relative Imports Price Ratio

Tables 5.25 and 5.26 report the normalized coefficients for this variable. In the case of Germany, negative import price elasticity is reported for both positive and negative changes in the underlying variable. It implies that a unit increase in the relative price causes UK imports to decline by 7.08%, whereas a unit decrease creates only a 1.69% reduction in UK imports in the pre-crisis sample. However, after inclusion of the financial crisis, sensitivity to positive variations in import prices is noted at -6.8, whereas the coefficient for negative changes is 0.524, implying a change in the respective long-run import price elasticities after inclusion of the financial crisis period.

In the case of Japan, similar results are reported where sensitivity to both positive and negative changes in the import price ratio have increased from -0.138 to -0.057 and from 0.78 to 2.66, respectively. This may be explained by increased risk-aversion amongst the UK's domestic market, where any relative positive (negative) change in the import prices is responded by a greater decline (rise) in the demand for Japanese imports in the UK.

Demand for US exports in the UK responds differently to positive and negative changes in import prices before and after inclusion of the financial crisis. In the case of a positive unit change, UK imports respond by 4.13% and 6.08% for both sample lengths respectively, whereas a negative unit change results in an increase in UK imports by 3.54% and 18.56%, respectively. This shows the

significant asymmetric effect found across both sample lengths with respect to the underlying variables.

5.5.2.1.3 Exchange Rate Volatility (Nominal and Real)

Tables 5.25 and 5.26 provide the normalized coefficient estimates for the exchange rate volatility variable (both nominal and real), which is also the main independent variable of interest in this thesis. In the case of Germany, estimates for nominal exchange rate volatility are not available as no cointegration was reported for real exchange rate volatility (section 5.21). The positive (negative) component coefficients provide evidence for the sensitivity of UK imports against a positive (negative) unit change or increase in the volatility. The sign of each coefficient shows the direction of the exchange rate volatility changes on UK imports from the respective countries. For instance, a unit increase in the Euro/GBP nominal volatility results in a 0.53% decline in imports from Germany. Similarly, a unit negative change in the underlying volatility increases imports by 1.01%. In simple words, UK imports respond differently to positive and negative changes in Euro/GBP nominal volatility. This asymmetric relationship holds even after inclusion of the financial crisis period. Overall, however, UK imports have shrunk irrespective of the decline in Euro/GBP volatility, which may be explained by the overall reduced aggregated demand for imported goods.

In the case of Japan, a similar asymmetric effect is reported under real exchange rate volatility for both sample lengths. A change in the response of UK markets towards Yen/GBP real volatility can be seen over the two sample periods. Before the financial crisis, the results are pretty standard as a negative impact of positive changes (increase) in volatility on UK imports is observed, whereas an increase in imports is caused by a decline in exchange rate volatility. However, after inclusion of the financial crisis, the sensitivity of UK imports towards Yen/GBP real volatility has increased for both positive and negative changes, indicating a rise in risk aversion on the part of the buyers in the UK.

Exchange rate volatility (both nominal and real) for USD/GBP adversely affects UK imports during both sample periods (Tables 5.25 and 5.26). Furthermore, the long-run parameters for volatilities in all cases for the US shows greater sensitive of UK imports towards real volatility shocks compared to nominal

volatility. After inclusion of the financial crisis, interestingly, an increase in the coefficients is reported for nominal volatility, but in case of real volatility the sensitivity for sample lengths shows a decline. This shows that, although overall an increase in the exchange rate volatility means UK imports are depressed, in terms of real value, USD/GBP has been more resistant compared to other currencies included in the analysis above, such as Euro/GBP and Yen/GBP.

5.5.2.2 Exchange rate volatility and UK Imports in the Presence of Third-Country Exchange Rate Risk Before and Including the Financial Crisis Period

Tables 5.27 and 5.28 provide normalized long-run coefficients for the underlying independent variables under the second hypothesis, whereby the impact of the third-country exchange rate risk is assessed over the basic bilateral relationship between UK imports and the exchange rate volatility of its trade partners, as explained in section 2.5.2. These coefficients represent the percentage change in UK imports against a 1% change in the underlying independent variables. A detailed description of these coefficients for each respective variable is provided in the following sections:

5.5.2.2.1 UK Real Income

In the case of Germany, the long-run coefficients are mostly significant for both positive and negative components ranging from the 1% to 5% significance levels, with the exception of one case, where, after inclusion of the financial crisis, the long-run coefficient for negative changes in UK real income is insignificant. This shows the asymmetric effect of the changes in UK real income over its imports and further strengthens the evidence regarding asymmetry in economic/financial time series. Furthermore, the above findings hold even after extending the sample to include the recent financial crisis, showing the stability of the long-run estimates for this variable.

For Japan, UK real income is shown to be a significant determinant of bilateral trade between the two countries, after controlling for third-country exchange rate risk proxied by USD/GBP exchange rate volatility. UK imports are observed to be more sensitive where exchange rate volatilities are estimated in nominal terms compared to real exchange rate volatility. Furthermore, the UK imports

become more elastic towards real income after inclusion of the financial crisis. This shows the demand for Japanese products in the UK is relatively more affected due to negative changes (decline) in the real income than to positive variations (rise)

Lastly, in the case of the US, income elasticity increases after inclusion of the financial crisis period, where volatilities are expressed in real terms as reported for Japan in the above paragraph. Parameters are significantly asymmetric under nominal volatilities only before the financial crisis, no cointegration is reported after inclusion of the financial crisis period.

5.5.2.2.2 Relative Prices

Relative price ratios are reported to be significant in most of the cases for Germany and Japan, with a significance level ranging from 1% to 5% (Tables 5.27 and 5.28). Further asymmetric effect is found in all significant cases as well. After inclusion of the recent financial crisis period, the import price elasticity further increases, especially for negative changes in the import price ratio, providing evidence that UK imports are relatively more affected by negative variations in the import price elasticity than positive ones. This shows evidence of the asymmetric effect found in the data.

Relative price elasticity in the case of the US shows a greater effect on UK imports both in terms of asymmetry and inter temporal shift due to the financial crisis. In the case of the US, the results under nominal volatility are only shown for before the financial crisis period, as no cointegration is reported for the full sample length.

5.5.2.2.3 Exchange Rate Volatility (Nominal and Real)

Tables 5.27 and 5.28 provide the normalized coefficient estimates for the exchange rate volatility variable (both nominal and real), which is also the main independent variable of interest in this thesis. Here, the positive (negative) component coefficients demonstrate the sensitivity of UK imports towards a positive (negative) unit change or increase in the volatility. The sign of each coefficient shows the direction of the exchange rate volatility changes on the UK imports from respective countries. In simple words, UK imports respond differently to positive and negative changes in Euro/GBP nominal volatility. This asymmetric relationship holds even after inclusion of the financial crisis period.

Overall, however, UK imports have shrunk irrespective of the decline in Euro/GBP volatility, which may be explained by the overall reduced aggregated demand for imported goods.

In the case of Japan a similar asymmetric effect is reported under real exchange rate volatility for both sample lengths. A change in the response of UK markets towards Yen/GBP real volatility can be seen over the two sample periods. Before the financial crisis, the results are pretty standard as a negative impact of positive changes (increase) in volatility on UK imports is observed, whereas an increase in imports is caused by a decline in exchange rate volatility. However, after inclusion of the financial crisis period, the sensitivity of UK imports towards Yen/GBP real volatility increased for positive and negative changes, indicating a rise in risk aversion on the part of the buyers in the UK.

Exchange rate volatility (both nominal and real) for USD/GBP adversely affects UK imports during both sample periods (Tables 5.27 and 5.28). Furthermore, long-run parameters for volatilities in all cases for the US show a greater sensitive of UK imports towards real volatility shocks compared to nominal volatility. After inclusion of the financial crisis period, interestingly, an increase in the coefficients is reported for nominal volatility but for real volatility the sensitivity for sample lengths shows a decline. This shows that overall, although an increase in the exchange rate volatility means UK imports are depressed, in terms of real value USD/GBP has been more resistant compared to other currencies included in the analysis above, such as Euro/GBP and Yen/GBP.

Tables 5.27 and 5.28 show that a 1% positive change in the underlying variable increases the demand for imports from Germany to 4.93%, whereas a 1% negative change in UK real income only reduces imports by 2.75%, before the financial crisis period. After inclusion of the financial crisis, the elasticity of positive changes in real income declines from 4.93% to 1.205%, whereas, in the case of negative changes in real income, the sensitivity increases as a 1% negative change depresses imports by 3.703%. This shows the significant asymmetric effect of UK real income, which becomes further evident after the financial crisis is included. The results also show that UK imports from

Germany become less elastic to the positive changes in UK real income but more sensitive to negative changes.

Tables 5.25-5.28 present the normalized long-run coefficients for the independent variables, under the different hypotheses. The tables show the positive and negative long-run (asymmetric) elasticities of UK imports with respect to each of the independent variables: real income, relative prices and real exchange rate volatility during the pre-crisis and total periods. Tables 5.25 and 5.26 tabulate the coefficient 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% confidence level. We report 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 exchange rate volatility and trade.

Interestingly, after inclusion of the third-country exchange rate risk, the UK's imports respond differently to the two volatility variables. For example, in the case of Germany, the real exchange rate (euro-pound) volatility is significant and positive, but the third country (dollar-pound) volatility coefficients are significant and negative. These findings imply that the UK's imports from Germany increase with respect to euro-pound volatility but they decline in response to the dollar-pound volatility. The demand for Japanese exports in the 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 whereas third country (euro-pound) volatility causes an increase in the UK's imports from the US during both the pre-crisis and financial crisis periods. In absolute value, third country volatility imposes a larger effect. This clearly indicates the importance of taking into consideration the third country effect when investigating the relationship between exchange rate volatility and trade.

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 UK's imports respond negatively to dollar-pound volatility but

euro-pound and yen-pound volatilities cause an increase in the UK's imports over both sample periods.

5.5.2.2.4 Third-Country Exchange Rate Volatility (Nominal and Real)

Third country exchange rate risk in this thesis has been proxied by USD/GBP nominal and real exchange rate volatilities where UK imports from Germany and Japan are analysed. However, Euro/GBP volatility is employed where UK-US imports are being tested empirically. Parameters for both positive and negative changes in the third-country exchange rate volatility are mostly significant at 1% or 5%. This re-affirms that third-country exchange rate risk is an important determinant of UK imports, along with bilateral volatility and other variables. Furthermore, it affects UK imports asymmetrically, i.e. a rise or decline in exchange rate volatility is not perceived equally by importers and exporters, but rather, more weight or sensitivity is shown towards an increase in volatility as it increases the uncertainty towards the pricing of imports, and thereby the profits of the importers. This research thus reports an inverse effect of the exchange rate volatility on UK imports. This result is in agreement with the traditional theoretical inverse relationship between exchange rate volatility and trade.

5.5.3 Causality between UK Imports and its Determinants

Tables 5.29-5.32 present the causality results. Tables 5.29 and 5.30 show the pre-crisis and total period results (without the third country effect), respectively. We do not test for Germany as no cointegration was indicated at the 5% level. Tables 5.31 and 5.32 show the third country effect causality test results during the pre-crisis and total period, respectively.

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 is determined by the size of the coefficient on the error term, ranging from 0.370 to 0.005 in absolute value. A coefficient of size 0.370 for UK imports from Japan during the pre-crisis period implies that 37% of the adjustment towards the long-run equilibrium takes place per month. The lowest speed of adjustment (0.005) is found in the case of UK imports from Japan in the presence of 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 of adjustment increases from the pre-crisis to the total period (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. Results also provide ample evidence of short-term causality from all the determinant variables towards 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 exchange rate volatility in the estimation of import demand. Similar results are obtained when employing third country exchange rate volatility (Tables 5.31 and 5.32) for both periods. Including the third country exchange rate volatility does not diminish the importance of the real exchange rate volatility.

5.5.4 Long and Short-run Asymmetric Effects

The Wald test is applied to test for the long and short-run asymmetric effect, and tables 5.33 and 5.34 provide these Wald-test results. The long and the short-run asymmetry hypotheses are tested for possible equality between the positive and negative coefficients for each variable, and in both long and short-run scenarios. As stated earlier, in the case where the null hypothesis is rejected, and these shocks are not equal statistically, then it shows the asymmetric nature of the relationship in the respective time horizon (long or short-run). The presence of long and short-run asymmetries implies that the positive and negative shocks to a single variable are to be modelled separately as both will affect the dependent variable differently. It means that the variability may be in terms of both sign (direction) and size (sensitivity) of the coefficients.

Table 5.33 presents results without the third country exchange rate volatilities. The Wald-test statistics show 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 the UK's imports differently. Hence, the long-run 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 especially true in the case of the US. Real rate volatility is found to be asymmetric both in the long and 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 exhibits long-run asymmetry within the pre-crisis period.

Including the third country effect (table 5.6) enhances the evidence for the asymmetric effect. Nevertheless, third country real volatility is found to be less asymmetric when the crisis period is added to the sample.

The results derived above with respect to the asymmetric effect offer a lot more information and inference compared to the 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 average-out, seriously limiting the inferential or forecasting capability of the underlying model.

5.6 Conclusion

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 research extends a relatively small body of work and investigates the effect of exchange rate volatility on UK real imports from Germany, Japan and the US using monthly data between 1991:01-2011:12. The research sample includes the recent global financial crisis, which enables us to examine the issue within a period that is inherently associated with higher volatility. Moreover, unlike most studies which focus on the bilateral trade between two countries, this research contributes to the existing literature, both theoretical and empirical, by offering evidence on the third country effect (in terms of exchange rate volatility) which is an important aspect from the point of view of competition in the global markets. Moreover, this research provides fresh empirical evidence by employing the ARDL bounds testing approach, Pesaran *et al.* (2001), and the asymmetric autoregressive distributed lag (ARDL) approach to cointegration, Shin et al. (2011), which, to the best of my knowledge, has not been applied in studies related to international trade. Causality tests (constrained error correction model and general-to-specific approach) are used to study the relationship between real imports and its

determinants, which are: real UK income, import price ratio and 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 volatility (between the euro and the pound) is included in the relationship. The dollar-pound exchange rate volatility shows the least volatility increase during the crisis. The demand for 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 UK imports. The asymmetric elasticities in the case of Japan and the US are mostly significant, but 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 during both the pre-crisis period and the full sample 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 above suggest that exchange rate volatility is important for modelling UK import behaviour, especially during the current crisis period. Any trade adjustment programmes by the UK that discourage import expansion could be unsuccessful if exchange rates and the third country exchange 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. The findings of this research advocate further study using data from a larger set of countries to expand the evidence on the third country effect and its implications.

Table 5.13: ECM – Causality Results: Impact of Real Exchange Rate Volatility on UK Imports Before the Financial Crisis (Jan 1991 – Jun 2007)

Germany							
Lags	**Const.**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Volatility**	
0	0.11***	-		-	-	-	
1	-	-0.013***	-0.511***	-2.196***	-	-65.54***	
2	-	-	-0.331***	-	-	-30.763*	
3	-	-	-0.197***	-	-	-	
10	-	-	-0.099*	-	-	-	
12	-	-	0.454***	-	-	-	
13	-	-	0.141**	-	-	-	
Diagnostics							
R^2	0.58	SSR	1.17	LB(12)	8.15	ARCH(1)	0.47
SSE	0.07	JB	0.051	RESET(3)	0.36	ARCH(3)	2.33
Japan							
Lags	**Const.**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Volatility**	
0	0.832***	-	-	-	-2.179*	-	
1	-	-0.117***	-0.185***	-	-	-	
12	-	-	0.476***	-	-	-	
13	-	-	0.128*	-	-	-	
Diagnostics							
R^2	0.4	SSR	1.33	LB(12)	7.75	ARCH(1)	2.26
SSE	0.07	JB	2.61	RESET(3)	1.17	ARCH(3)	3.12
United States							
Lags	**Const.**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Volatility**	
0	0.695***	-	-	-	-	-	
1	-	-0.086***	-0.175***	-	-	-	
7	-	-	-0.127**	-	-	-	
10	-	-	-0.111*	-	-	-	
12	-	-	0.390***	-	-	-	
Diagnostics							
R^2	0.39	SSR	1.27	LB(12)	9.27	ARCH(1)	0.23
SSE	0.07	JB	0.76	RESET(3)	1.24	ARCH(3)	3.47

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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 5.14: ECM – Causality Results: Impact of Real Exchange Rate Volatility on UK Imports Including the Financial Crisis (Jan 1991 – Dec 2011)

Japan						
Lags	**Const.**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Volatility**
0	0.657***	-		-	-	-
1	-	-0.093***	-0.187***	-	-	-37.77*
10	-	-	-0.098*	-	-	-
12	-	-	0.481***	-	-	-
13	-	-	0.115*	-	-	-

Diagnostics							
R^2	0.412	SSR	1.371	LB(12)	11.186	ARCH(1)	2.33
SSE	0.072	JB	0.68	RESET(3)	1.206	ARCH(3)	3.216

United States						
Lags	**Const.**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Volatility**
0	0.732***	-	-	-	3.687**	-
1	-	-0.912***	-0.255***	-	-	-
7	-	-	-0.101*	-	-	-
10	-	-	-0.114**	-	-	-
12	-	-	0.388***	-	-	-
13	-	-	0.145**	-	-	-

Diagnostics							
R^2	0.385	SSR	1.281	LB(12)	10.454	ARCH(1)	2.178
SSE	0.067	JB	0.636	RESET(3)	1.127	ARCH(3)	3.006

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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 5.15: ECM – Causality Results: Impact of Nominal Exchange Rate Volatility on UK Imports in the Presence of Third-Country Exchange Rate Risk: Before the Financial Crisis (Jan 1991 – Jun 2007)

Germany							
Lags	**Const.**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Volatility**	**Δ 3rd Volatility**
0	-0.0266*	-	-	1.96***	-	-	-
1	-	0.0036*	-0.43***	-	-	-	-
2	-	-	-0.24***	1.73***	-	-	30.027*
3	-	-	-0.11**	-	-	-	-
7	-	-	-0.15***	-	-	-	-
10	-	-	-0.15**	-	-	-	-
12	-	-	0.47***	-	-	-	-
13	-	-	0.106*	-	-	-	-
Diagnostics							
R^2	0.575	SSR	0.81	LB(12)	1.149	ARCH(1)	0.715
SSE	0.073	JB	1.651	RESET(3)	2.83	ARCH(3)	1.09
Japan							
Lags	**Const.**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Volatility**	**Δ 3rd Volatility**
0	0.388***	-	-	-	-	39.689*	-
1	-	-0.06***	-0.15***	-	-	-	-
10	-	-	-0.11***	-	-	-	-
12	-	-	0.541***	-	-	-	-
Diagnostics							
R^2	0.39	SSR	0.83	LB(12)	1.593	ARCH(1)	1.03
SSE	0.077	JB	0.376	RESET(3)	1.059	ARCH(3)	2.19
United States							
Lags	**Const.**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Volatility**	**Δ 3rd Volatility**
0	0.7***	-	-	-	3.566*	-	-
1	-	-0.09***	-0.17***	-	-	-	-
7	-	-	-0.126**	-	-	-	-
10	-	-	-0.111*	-	-	-	-
12	-	-	0.390***	-	-	-	-
Diagnostics							
R^2	0.387	SSR	1.05	LB(12)	1.347	ARCH(1)	0.101
SSE	0.08	JB	0.295	RESET(3)	3.59	ARCH(3)	1.13

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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 5.16: ECM – Causality Results: Impact of Nominal Exchange Rate Volatility on UK Imports in the Presence of Third-Country Exchange Rate Risk: Before the Financial Crisis (Jan 1991 – Dec 2011)

Germany							
Lags	**Const.**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Vol.**	**Δ 3rd Country Vol.**
0	0.19***	-	-	1.569***	4.68*	-	37.49**
1	-	-0.024***	-0.466***	-1.177**	-	-	-
2	-	-	-0.268***	0.99*	-	-	37.69**
3	-	-	-0.134**	-	-	-	49.54***
7	-	-	-0.134***	-	-	-	-
9	-	-	-	-	-9.844***	-	-
10	-	-	-0.122***	-	-	-	-
12	-	-	0.46***	-	-	-	-
13	-	-	0.139**	-	-	-	-
Diagnostics							
R^2	0.583	SSR	1.019	LB(12)	1.377	ARCH(1)	1.215
SSE	0.063	JB	1.05	RESET(3)	3.61	ARCH(3)	1.691
Japan							
Lags	**Const.**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Vol.**	**Δ 3rd Country Vol.**
0	0.497***	-	-	-	-	46.3**	-
1	-	-0.07***	-0.235***	-	-	-	-
4	-	-	-	-	-	44.5**	-
12	-	-	0.541***	-	-	-	-
13	-	-	0.155**	-	-	-	-
Diagnostics							
R^2	0.411	SSR	1.288	LB(12)	1.566	ARCH(1)	1.799
SSE	0.078	JB	1.99	RESET(3)	2.39	ARCH(3)	1.989
United States							
Lags	**Const.**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Vol.**	**Δ 3rd Country Vol.**
0	0.73***	-	-	-	3.566*	-	-
1	-	-0.09***	-0.19***	-	-	-	-
7	-	-	-0.103*	-	-	-	-
10	-	-	-0.128**	-	-	-	-
12	-	-	0.35***	-	-	-	-
Diagnostics							
R^2	0.379	SSR	1.351	LB(12)	1.83	ARCH(1)	1.81
SSE	0.079	JB	1.38	RESET(3)	1.71	ARCH(3)	2.14

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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 5.17: ECM – Causality Results: Impact of Real Exchange Rate Volatility on UK Imports in the Presence of Third-Country Exchange Rate Risk: Before the Financial Crisis (Jan 1991 – Jun 2007)

Germany							
Lags	**Const.**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Volatility**	**Δ 3rd Volatility**
0	0.042***	-	-	1.139*	-	-	54.161**
1	-	-0.005***	-0.528***	-1.820***	-	-63.977***	-
2	-	-	-0.335***	1.732***	-	-	-
3	-	-	-0.188***	-	-	-	-
10	-	-	-0.101*	-	-	-	-
12	-	-	0.463***	-	-	-	-
13	-	-	0.160**	-	-	-	-
Diagnostics							
R^2	0.58	SSR	1.013	LB(12)	1.377	ARCH(1)	1.253
SSE	0.078	JB	1.05	RESET(3)	3.722	ARCH(3)	1.743
Japan							
Lags	**Const.**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Volatility**	**Δ 3rd Volatility**
0	1.054***	-	-	-	-	-	-
1	-	-0.148***	-	-	-	-	-
12	-	-	0.447***	-	-	-	-
Diagnostics							
R^2	0.387	SSR	0.91	LB(12)	1.563	ARCH(1)	1.855
SSE	0.059	JB	0.22	RESET(3)	2.464	ARCH(3)	2.051
United States							
Lags	**Const.**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Volatility**	**Δ 3rd Volatility**
0	0.699***	-	-	-	-	-	-
1	-	-0.087***	-0.175***	-	-	-	-
7	-	-	-0.127**	-	-	-	-
10	-	-	-0.111*	-	-	-	-
12	-	-	0.390***	-	-	-	-
Diagnostics							
R^2	0.392	SSR	1.231	LB(12)	1.301	ARCH(1)	1.639
SSE	0.083	JB	0.269	RESET(3)	1.763	ARCH(3)	2.929

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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 5.18: ECM – Causality Results: Impact of Real Exchange Rate Volatility on UK Imports in the Presence of Third-Country Exchange Rate Risk: (Jan 1991 – Dec 2011)

Germany							
Lags	**Const.**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Vol.**	**Δ 3rd Country Vol.**
0	0.199***	-	-	1.971***	-	-	36.23**
1	-	-0.024***	-0.462***	-	-	-	-
2	-	-	-0.259***	1.318**	-	-	32.67*
3	-	-	-0.122**	-	-	-	49.75***
7	-	-	-0.138***	-	-8.963***	-	-
10	-	-	-0.124***	-	-	-	-
12	-	-	0.461***	-	-	-	-
13	-	-	0.138**	-	-	-	-
Diagnostics							
R^2	0.593	SSR	1.018	LB(12)	1.376	ARCH(1)	1.171
SSE	0.061	JB	1.197	RESET(3)	1.326	ARCH(3)	1.629
Japan							
Lags	**Const.**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Vol.**	**Δ 3rd Country Vol.**
0	0.543***	-	-	-	-	-	-
1	-	-0.077***	-0.129**	-	-	-	-
2	-	-	-	1.312**	-	-	-
8	-	-	-	1.551***	-2.151**	-	-
10			-0.101*				
12	-	-	0.482***	-	-	-	-
Diagnostics							
R^2	0.461	SSR	1.050	LB(12)	1.326	ARCH(1)	1.734
SSE	0.075	JB	1.55	RESET(3)	2.303	ARCH(3)	1.917
United States							
Lags	**Const.**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Rel. Prices**	**Δ Vol.**	**Δ 3rd Country Vol.**
0	0.654***	-	-	-	4.547**	-	-
1	-	-0.081***	-0.293***	-	-	-	-
2	-	-	-0.169*	-	-	-	-
4	-	-	-	-1.0733*	-	-31.5*	-
5	-	-	-	1.1602*	-	-	-
9	-	-	-	-1.004*	-	-	-
12	-	-	0.397***	-	-	-	-
13	-	-	0.235**	-	-	-	-
14	-	-	0.178***	-	-	-	-
Diagnostics							
R^2	0.422	SSR	1.135	LB(12)	0.895	ARCH(1)	1.744
SSE	0.076	JB	0.966	RESET(3)	1.648	ARCH(3)	2.062

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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 5.19: Asymmetric ARDL Results - Impact of Exchange Rate Volatility on UK Imports Before the Financial Crisis (Jan-1991 to June-2007)

Nominal

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
Germany	5.97***	0.595	0.0048	0.5421	5.035*	7.362	0.336	0.4128	2.432
Japan	3.65	0.464	0.0046	0.404	1.913	9.382	1.540	1.70	2.3747
US	5.50***	0.44	0.0058	0.51	0.332	12.85	0.504	0.0504	3.334

Real

Countries	F-stat	Diagnostics							
		R^2	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 5.20: Asymmetric ARDL Results - Impact of Exchange Rate Volatility on UK Imports (Jan-1991 to Dec-2011)

Nominal

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
Germany	4.07**	0.53	0.01	0.94	2.74	7.88	1.106	0.032	1.5
Japan	2.107	0.43	0.01	0.83	0.896	7.508	2.163	1.723	2.747
US	6.26***	0.4	0.01	0.86	1.83	6.09	1.378	0.005	0.614

Real

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
Germany	3.92	0.534	0.0754	0.938	2.41	7.986	1.041	0.018	1.293
Japan	9.83***	0.5276	0.0703	1.054	2.85	9.763	2.46	1.48	1.94
US	4.41**	0.384	0.0783	0.7615	0.29	5.904	0.056	1.178	4.741

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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 5.21: Asymmetric ARDL Results - Impact of Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk Before the Financial Crisis (Jan-1991 to June-2007)

Nominal

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
Germany	4.74***	0.5819	0.005	0.428	0.724	10.579	1.58	0.977	4.171
Japan	5.72***	0.33	0.0058	0.169	2.59	18.56	2.96	1.32	3.48
US	6.37***	0.424	0.006	0.358	1.11	11.44	0.625	2.37	2.79

Real

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
Germany	5.37**	0.580	0.005	0.430	0.957	10.2	1.6	0.980	4.24
Japan	6.07***	0.424	0.005	0.295	6.2009	2.6485	1.856	0.922	1.098
US	6.582***	0.435	0.006	0.351	0.75926	10.983	0.505	2.193	3.6

Table 5.22: 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)

Nominal

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
Germany	6.55***	0.556	0.0054	0.752	0.5	8.9	0.559	0.0006	1.56
Japan	3.99*	0.394	0.006	0.527	5.4	14.77	2.32	2.16	4.01
US	3.63	0.399	0.006	0.685	1.02	7.15	1.46	0.007	0.265

Real

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
Germany	6.29***	0.55308	0.00545	0.758	0.49	8.975	0.694	0.00426	1.600
Japan	4.1**	0.40989	0.00615	0.695	2.153	7.067	2.382	2.3071	2.697
US	4.05**	0.40081	0.00605	0.684	0.297	7.216	1.537	0.00011	0.048

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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 5.23: Normalized Coefficients - Impact of Exchange Rate Volatility on UK Imports Before the Financial Crisis (Jan 1991 – June 2007)

Nominal

Countries	Constant	Real Income		Relative Prices		Real Volatility	
		Positive	Negative	Positive	Negative	Positive	Negative
Germany	7.696***	4.93***	-2.75***	-7.08***	-1.69***	-0.53***	1.010***
Japan	-	-	-	-	-	-	-
US	7.79***	7.141***	0.937***	4.13***	30.54***	-1.29**	-0.98

Real

Countries	Constant	Real Income		Relative Prices		Real Volatility	
		Positive	Negative	Positive	Negative	Positive	Negative
Japan	6.96***	5.97***	-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 5.24: Normalized Coefficients - Impact of Exchange Rate Volatility on UK Imports (Jan 1991 – Dec 2011)

Nominal

Countries	Constant	Real Income		Relative Prices		Real Volatility	
		Positive	Negative	Positive	Negative	Positive	Negative
Germany	7.804***	1.205***	-3.703***	-6.8***	0.524	-0.93***	-0.525**
Japan	-	-	-	-	-	-	-
US	8.106***	2.460***	3.098***	6.078***	18.569***	30.167***	27.946***

Real

Countries	Constant	Real Income		Relative Prices		Real Volatility	
		Positive	Negative	Positive	Negative	Positive	Negative
Japan	7.199***	1.766***	1.0652***	-0.0568	2.659***	-0.492***	-0.812***
US	7.0858***	2.303***	1.608***	0.24072	14.807***	-9.616***	-11.206***

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.

Table 5.25: Normalized Coefficients - Impact of Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk Before the Financial Crisis (Jan 1991 – June 2007)

Nominal

Countries	Const.	Real Income		Relative Prices		Nominal Volatility		Third Country Nominal Volatility	
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative
Germany	7.88***	2.47***	-3.4***	-6.11***	-1.26	0.96***	1.88***	-2.39***	-2.27***
Japan	7.24***	13.67***	0.987	-7.00***	-0.11	6.49***	8.77***	0.08	3.21*
US	8.50***	4.55***	3.39***	14.34***	35.07***	-5.08**	-3.3	12.15***	10.35***

Real

Countries	Const.	Real Income		Relative Prices		Real Volatility		Third Country Real Volatility	
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative
Germany	8.61***	-3.42***	2.311*	7.527***	-51.6***	5.403***	6.46***	-9.3***	-9.24***
Japan	7.76***	-2.17***	0.17	1.297***	5.91***	4.477***	1.78*	-15.4***	-14.9***
US	7.74***	2.787***	1.501*	4.379***	27.28***	-9.38***	-9.39***	3.99***	2.81**

Table 5.26: Normalized Coefficients - Impact of Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk Including the Financial Crisis (Jan 1991 – Dec 2011)

Nominal

Countries	Const.	Real Income		Relative Prices		Nominal Volatility		Third Country Nominal Volatility	
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative
Germany	8.52***	-2.16***	-4.05***	-4.51**	-23.6***	1.13	1.82**	2.04*	2.45**
Japan	7.46***	7.66***	4.66***	-3.58***	-12.5***	-4.18	-0.532	29.9***	30.8***
US	-	-	-	-	-	-	-	-	-

Real

Countries	Const.	Real Income		Relative Prices		Real Volatility		Third Country Real Volatility	
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative
Germany	7.81***	2.974**	0.311	-0.685	-19.997*	2.7*	4.464**	-6.578**	-6.847**
Japan	7.83***	3.6**	-12.6***	-8.54***	-1.298	33.7***	36.6***	-56.12***	-53.21***
US	8.49***	4.246**	4.926***	17.4***	30.21***	-7.1**	-5.439*	13.66***	11.7***

Note:

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

Table 5.27: ECM-Causality Results: Impact of Exchange Rate Volatility on UK Imports Before the Financial Crisis (Jan 1991 – June 2007)

Nominal

Germany									
LAGS	Constant	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Nominal Volatility	
				Positive	Negative	Positive	Negative	Positive	Negative
0	-	-	-	4.567***	-2.14***	-	-	-0.317***	-
1	-	-0.619***	-	-4.188***	-	-	-	-	-
7	-	-	-0.0841***	-	-	-	-	-	-
10	-	-	-0.175***	-	-	-	-	-	-
11	-	-	-0.141***	-	-	-	-	-	-
12	-	-	0.345***	-	-	-	-	-	-
Diagnostics									
R^2	0.62631	SSR	0.78929	LB(12)	16.99	ARCH(1)	0.4537	-	-
SSE	0.00451	JB	3.328	RESET(3)	0.701	ARCH(3)	2.0926	-	-
US									
LAGS	Constant	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Nominal Volatility	
				Positive	Negative	Positive	Negative	Positive	Negative
0	-0.02**	-	-	-	-	-	-	-	-
1	-	-0.864***	-	-	-	-	-	-	-
3	-	-	-0.118***	-	-	-	-	-	-
4	-	-	-	-	-	-	-	0.702**	-
5	-	-	-	-	5.162***	8.564**	-	-	-
7	-	-	-	-	-2.91***	-	-	-	-
8	-	-	0.129**	-	-	-	-	-	-
10	-	-	-	2.567**	-	-	-	-	-
11	-	-	0.162***	-	-	-	-10.95**	-	-
12	-	-	0.44***	-	-	-	-	-	-
Diagnostics									
R^2	0.548	SSR	0.82332	LB(12)	17.4	ARCH(1)	0.177	-	-
SSE	0.00479	JB	0.0826	RESET(3)	0.312	ARCH(3)	0.1784	-	-

Real

Japan									
LAGS	Constant	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Real Volatility	
				Positive	Negative	Positive	Negative	Positive	Negative
0	0.0369***	-	-	-	2.129**	-	-	-0.906***	-
1	-	-0.216***	-0.255***	-	-	-	-6.69***	-	-
3	-	-	-	-	-	-	-	-	-2.597***
4	-	-	-	-	1.534*	-4.146**	6.56***	-0.518**	-
8	-	-	-	-	-	-	-	-	-1.448**
9	-	-	-	-2.50**	-	-11.2***	-	-	-
10	-	-	-	-	-	-	-	-0.594*	-
12	-	-	0.5299***	-	-	-	4.179**	0.725***	-
13	-	-	0.1789***	-	-	-	-	-	-
14	-	-	-	-	3.642***	-	-	-	-1.095**
Diagnostics									
R^2	0.57971	SSR	0.59101	LB(12)	11.87	ARCH(1)	2.64		
SSE	0.00367	JB	2.34	RESET(3)	2.03	ARCH(3)	3.34		

Table 5.29 (Continued)

US									
LAGS	Constant	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Real Volatility	
				Positive	Negative	Positive	Negative	Positive	Negative
1	-	-0.039***	-0.374***	-	-	-	-	-	-
3	-	-	-	3.01**	-	-	-	-1.234***	-
4	-	-	-	-	-	-10.472**	15.314***	-	-
5	-	-	-	-	3.158***	-	-	-	1.113***
6	-	-	-	-	-	13.714***	-	-	-
7	-	-	-	-	-2.254**	-	-	-	-
11	-	-	0.124**	-	-	-	-	-	-
12	-	-	0.508***	-	-	-	-	-	-
13	-	-	0.229***	-	2.476**	-	-	-	-
Diagnostics									
R^2	0.4414	SSR	0.96912	LB(12)	17.53	ARCH(1)	0.533		
SSE	0.0058	JB	3.713	RESET(3)	0.139	ARCH(3)	3.54		

Table 5.28: ECM–Causality Results: Impact of Exchange Rate Volatility on UK Imports (Jan 1991 – Dec 2011)

Nominal

Germany

LAGS	Constant	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Nominal Volatility	
				Positive	Negative	Positive	Negative	Positive	Negative
0	-	-	-	3.212***	-	-8.35***	18.452***	-0.167**	-
1	-	-0.188***	-0.328***	-	-	-	-	-	-
2	-	-	-0.226***	-	2.403***	-	-	-	-
3	-	-	-0.103**	-	-	-	-	-	-
7	-	-	-0.123***	-	-	-	-	-	-
10	-	-	-0.176***	-	-	-	-	-	-
11	-	-	-0.106*	-	-	-	-	-	-
12	-	-	0.368	-	-	-	-	-	-
Diagnostics									
R^2	0.581	SSR	1.148	LB(12)	12.33	ARCH(1)	0.0429		
SSE	0.0051	JB	4.514	RESET(3)	0.366	ARCH(3)	0.3338		

US

LAGS	Constant	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Nominal Volatility	
				Positive	Negative	Positive	Negative	Positive	Negative
1	-	-0.675***	-	-1.962*	-	-	-	-	-
2	-	-	-	-	-	-	6.11**	-	-
3	-	-	-0.085*	-	-	-	-	-	-
4	-	-	-	-	-1.71**	-	-	1.052***	-
5	-	-	-	-	3.87***	-	-	-	-
6	-	-	-	-	-	-	-	-0.633**	-
7	-	-	-	-	-3.07***	-	-	-	-
8	-	-	0.152***	3.08**	-	-6.393**	-	-0.588**	-
11	-	-	0.132***	-	-	-	-	-	-
12	-	-	0.372***	-	-	-	-	-	-
Diagnostics									
R^2	0.5021	SSR	1.121	LB(12)	11.97	ARCH(1)	0.198		
SSE	0.0051	JB	3.21	RESET(3)	2.03	ARCH(3)	0.282		

Real

JAPAN

LAGS	Constant	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Real Volatility	
				Positive	Negative	Positive	Negative	Positive	Negative
0	-	-	-	-	1.63**	-	-	-	-
1	-	-0.371***	-	-	-	-	-	-	1.064**
2	-	-	-	-	-	-4.074*	-	-	-
3	-	-	-	-2.141**	-	-	-	-	-
4	-	-	-	-	-	-3.497**	-	-0.71***	-
5	-	-	-	-	1.725**	-	-	-	-
8	-	-	-	-	2.651***	-	-4.498**	-	-1.231***
10	-	-	-0.086*	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-
12	-	-	0.451***	-	-	-	-	-	1.201***
13	-	-	-	-	-	-	-	-	0.955**
14	-	-	-	-2.868**	1.511*	-	-	-	-
Diagnostics									
R^2	0.5422	SSR	1.0459	LB(12)	9.562	ARCH(1)	1.56		
SSE	0.06926	JB	3.163	RESET(3)	2.734	ARCH(3)	1.03		

US

LAGS	Constant	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Real Volatility	
				Positive	Negative	Positive	Negative	Positive	Negative
0	-0.031***	-	-	-	-	8.454***	-	-	-
1	-	-0.073***	-0.401***	-2.044*	-	-	-	0.911***	-
2	-	-	-0.229***		-	-	-	-	-
3	-	-	-0.117**	2.853**	-	-	-	-	1.0678***
4	-	-	-	-	-	-	-	-	0.794***
5	-	-	-	-	3.690***	-	-	-	-
7	-	-	-	-	-1.914**	-	-	-	-
8	-	-	-	-	-	-	-	-	-0.466*
10	-	-	-	2.270*	-	-	-	-	-
11	-	-	0.138***	-	-	-	-8.447***	-	-
12	-	-	0.406***	-	-	-	-	-	-
13	-	-	0.212***	-	-	-	-	-	-
14	-	-	0.166***	-	-	-	-	-	-0.4910**
Diagnostics									
R^2	0.453	SSR	1.173	LB(12)	9.93	ARCH(1)	0.213		
SSE	0.0738	JB	0.242	RESET(3)	0.015	ARCH(3)	2.255		

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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 5.29: ECM–Causality Results: Impact of Exchange Rate Volatility on UK Imports in the Presence of Third-Country Exchange Rate Risk: Before the Financial Crisis (Jan 1991 – June 2007)

Nominal

GERMANY

Lags	Const.	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Nominal Volatility		Δ Third Country Nominal Volatility	
				+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0	-0.03**	-	-	-	-	-	-	-	0.66**	-	-1.45***
1	-	-0.43***	-	-4.061***	-	-	-	-	-	-	-
2	-	-	-	-	-	-	13.28**	-	-0.82**	-	-
3	-	-	-	-	-	-	-	-	-	-1.3***	-
4	-	-	0.086*	-	-	-	-	-	-	1.1***	-
5	-	-	-	-	-	-	15.25***	-0.5***	-	-	-
7	-	-	-0.118**	-	-1.626*	-	-	-	-	-	-
10	-	-	-0.103**	-	-	-12.11**	-	-0.54***	0.73**	-	-
11	-	-	-	-	-	11.61**	-	0.57***	-	-	-
12	-	-	0.423***	-	-	-	-	-	-	-	-
Diagnostics											
R^2	0.67	SSR	0.653	LB(12)	6.1	ARCH(1)	-	-	-	-	-
SSE	0.0039	JB	0.75	RESET(3)	2.049	ARCH(3)	-	-	-	-	-

JAPAN

Lags	Const	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Nominal Volatility		Δ Third Country Nominal Volatility	
				+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0	0.10**	-	-	-	1.56*	-	-	-	-	-0.62**	-
1	-	-0.05**	-0.33***	-	-	-	-	-	-	-0.72**	-
2	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-2.95***	-	-1.15***
4	-	-	-	-	2.43**	-	-	-1.52***	-	-	-
5	-	-	-	-	2.18**	-	-	-0.70***	-	-	-
6	-	-	-	-	-	-4.79**	-	-	-	-	-
7	-	-	-	-	-	-	8.94***	-0.65***	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-4.032***	-	-10.2***	-	0.67***	-	-0.63**	-
10	-	-	-	-	-1.64*	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	2.34***	-	-
12	-	-	0.61***	-	-	-	6.95***	1.06***	-	-	-
13	-	-	0.19***	-	-	-	-	-	-2.06***	-	-
14	-	-	-0.11**	-	2.09**	-	-	-	-	-0.703**	-
Diagnostics											
R^2	0.605	SSR	0.528	LB(12)	15.8	ARCH(1)	0.12	-	-	-	-
SSE	0.0034	JB	2.053	RESET(3)	1.59	ARCH(3)	1.52	-	-	-	-

US											
Lags	Const	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Nominal Volatility		Δ Third Country Nominal Volatility	
				+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0	-	-	-	-	-	-	-	0.63*	-	-	-
1	-	-0.07***	-0.224***	-	-	-	-	-	-	-1.05***	-
2	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-0.154***	-	-	-	-	-	-1.05***	-	-
5	-	-	-	-	4.96***	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	0.8***
7	-	-	-	-	-	-3.05***	-	-	-	-	-
9	-	-	-0.12**	-	-	-	-	-	-	-	-
10	-	-	-0.15**	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-10.5**	-	-	-	-
12	-	-	0.35***	-2.63**	-	-	-	-	-	-	-
Diagnostics											
R^2	0.423	SSR	1.034	LB(12)	16.81	ARCH(1)	0.064	-	-	-	-
SSE	0.006	JB	3.68	RESET(3)	0.181	ARCH(3)	4.26	-	-	-	-

Real

GERMANY

Lags	Const.	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Real Volatility		Δ Third Country Real Volatility	
				+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0	0.036***	-	-	2.5**	-	-	-	-	-	-0.59**	-
1	-	-0.061**	-0.43***	-3.26***	-	-	-	-	-	-	-
2	-	-	-0.35***	-	-	-	-	-	-	-	-0.807*
3	-	-	-0.22***	-	-	-	-	-	-	-1.433***	-
7	-	-	-0.107**	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	0.803**
9	-	-	-	-	-	-11.151*	-	-	-	-	-
10	-	-	-0.105**	-	-	-11.56**	-	-	-	-	-
12	-	-	0.411***	-	-	-	-	-	-	-	-
Diagnostics											
R^2	0.62586	SSR	0.763	LB(12)	6.8	ARCH(1)	0.247				
SSE	0.00452	JB	2.871	RESET(3)	1.77	ARCH(3)	0.277				

Analysis - Developed

JAPAN											
LAGS	Constant	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Real Volatility		Δ Third Country Real Volatility	
				+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0	0.023**	-	-	-	1.96**	-	-	-0.551*	-	-	-
1	-	-0.01***	-0.38***	-	-	-	-4.99**	-	1.48***	-	-
2	-	-	-0.23***	-	-	-	-	-	-	-	-
3	-	-	-0.19***	-	-	-	-	-	-	-	-0.99***
4	-	-	-0.152**	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	4.602**	-	-	-	-
9	-	-	-	-	-2.002**	-7.36***	-	-	-	-	-
11	-	-	-0.104*	-	-	-	-	-	1.135**	-	-
12	-	-	0.40***	-	-	-	-	0.97***		-	-
Diagnostics											
R^2	0.50368	SSR	0.71949	LB(12)	13.179	ARCH(1)	0.312				
SSE	0.00431	JB	2.62484	RESET(3)	3.593	ARCH(3)	0.546				

US											
LAGS	Constant	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Real Volatility		Δ Third Country Real Volatility	
				+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0	-	-	-	-	-	-	-	-	-	-	-
1	-	-0.062***	-0.267***							-0.839***	
2	-	-	-0.121**		2.688**						
3	-	-	-0.17***	3.351**		-9.714*			-0.99***		
4	-	-	-	-		-9.082*	15.446***				
5	-	-	-	-	3.519***						
6	-	-	-	-							1.054***
7	-	-	-0.124**	-	-3.283***						
9	-	-	-0.145**	-	-2.778***						
10	-	-	-0.151**	-							
11	-	-	-	-	-2.442**						
12	-	-	0.337***	-2.395*							
Diagnostics											
R^2	0.4786	SSR	0.89578	LB(12)	11.47992	ARCH(1)	0.006144				
SSE	0.0055	JB	1.67538	RESET(3)	0.587	ARCH(3)	0.783206				

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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 5.30: ECM–Causality Results: Impact of Exchange Rate Volatility on UK Imports in the Presence of Third-Country Exchange Rate Risk: Including the Financial Crisis (Jan 1991 – Dec 2011)

Nominal

GERMANY

LAGS	Constant	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Nominal Volatility		Δ Third Country Nominal Volatility	
				+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0	-	-	-	2.97***	-	-	-	-	-	-0.6***	-
1	-	-0.1***	-0.4***	-1.95*	-	-	-	-	-	-0.7***	-
2	-	-	-0.25***	-	1.92**	-	9.46**	-	-	-1.02***	-
3	-	-	-0.15***	-	-	-	-	-	-	-0.85***	-
5	-	-	-	-	1.51*	-	9.01**	-	-	-	-
7	-	-	-	-	-2.4***	-	-	-	-	-	-
8	-	-	0.08*	-	-	-	-	-	-	-	0.55**
9	-	-	-	-	-	-10.72**	-	-	-	-	-
10	-	-	-0.18***	-	-	-	-	-	-	-	-
11	-	-	-0.12***	-	-	-	-	-	0.36***	-	-
12	-	-	0.36**	-	-	-	-	-	-	-	-
Diagnostics											
R^2	0.63	SSR	0.96	LB(12)	8.18	ARCH(1)	0.617	-	-	-	-
SSE	0.066	JB	0.622	RESET(3)	0.409	ARCH(3)	0.757	-	-	-	-

JAPAN

Lags	Constant	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Nominal Volatility		Δ Third Country Real Volatility	
				+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0	-	-	-	-	2.16**	-	-	-	-	-	-
1	-	0.01***	-0.31***	-	-	-3.06*	-	-	-	-	-
2	-	-	-0.17***	2.25*	-	-	-	-0.51**	-	-	-
3	-	-	-0.13**	-	-	-	-	-	-	-	-0.72**
4	-	-	-	-	-	-2.94*	-	-	-	-	-
5	-	-	-	-	-	-	4.38***	-		0.51**	-
7	-	-	-	-	-2.45***	-	-	0.659***	-	-	-
9	-	-	-	-	-2.25**	-	-	-	-	-	-
12	-	-	0.44***	-	-	-	-	-	-	-0.54**	-
Diagnostics											
R^2	0.449	SSR	1.25	LB(12)	9.46	ARCH(1)	2.44	-	-	-	-
SSE	0.0057	JB	1.63	RESET(3)	1.508	ARCH(3)	1.80	-	-	-	-

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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.

Real

GERMANY											
Lags	Constant	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Real Volatility		Δ Third Country Real Volatility	
				+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0	-	-	-	3.45***	-	-	9.67**	-0.35***	-	-0.586***	-
1	-	-0.07***	-0.45***	-	-	-	-	-	-	-	0.83***
2	-	-	-0.32***	-	3.05***	-	-	-	-	-	-
3	-	-	-0.17***	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	12.4***	-	-	-	-
7	-	-	-0.13***	2.061*	-2.27***	-	-	-	-	-	-0.8***
9	-	-	-	-	-	-8.98**	-	-	-	-0.572**	-
10	-	-	-0.18***	-	-	-	-9.793**	-	-	-	-
11	-	-	-0.091*	-	-	-	-	-	0.45***	-	-
12	-	-	0.347***	-	-	-	-	-	-	-	-
Diagnostics											
R^2	0.6417	SSR	0.94366	LB(12)	9.554	ARCH(1)	0.0876	-	-	-	-
SSE	0.0043	JB	1.22168	RESET(3)	0.665	ARCH(3)	0.3574	-	-	-	-

JAPAN											
Lags	Constant	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Real Volatility		Δ Third Country Real Volatility	
				+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0	-	-	-	-	-	-	-	-	-	-	-
1	-	-0.032***	-0.302***	-	-	-3.496**	-	-	1.639***	-	-
2	-	-	-0.19***	-	-	-4.99***	3.60***	-	-	-	-
3	-	-	-0.111**	-	-	-	-	-	1.45**	-1.242***	-
4	-	-	-	-	-	-	-	-	-1.61***	-	-
5	-	-	-	1.708**	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-4.09***	-	-	-	-
9	-	-	-	-	-1.98**	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	0.66**
12	-	-	0.445***	-	-	-	-	0.693**	1.43***	-	-
Diagnostics											
R^2	0.4840	SSR	1.1827	LB(12)	11.5107	ARCH(1)	1.7115				
SSE	0.0053	JB	1.6694	RESET(3)	5.417	ARCH(3)	2.2410				

US											
Lags	Constant	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Real Volatility		Δ Third Country Real Volatility	
				+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0	-	-	-	-	-	6.918**	-	-	-	-	-
1	-	-0.04***	-0.29***	-	-	-	-	-	-	-	-0.39**
3	-	-	-0.117**	2.979**	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	1.15***	-	-0.241**	-
5	-	-	-	-	3.95***	-	-	-	0.93***	-	-
7	-	-	-	-	-3.06***	-	-	-	-	-	-
8	-	-	-	-	-	-5.319*	-	-	-0.58*	-	-
10	-	-	-0.112**	1.907*	-	-	-	-	-	-	0.27*
12	-	-	0.332***	-2.99***	-	-	-	-	-	-	-
Diagnostics											
R^2	0.4271	SSR	1.273	LB(12)	15.9443	ARCH(1)	0.196				
SSE	0.0057	JB	0.611	RESET(3)	0.783	ARCH(3)	2.855				

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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.

Long and Short Run Asymmetric Effect

Table 5.31: Impact of Exchange Rate Volatility on UK Imports before the Financial Crisis (Jan 1991 to June 2007)

Nominal

Countries	Real Income		Relative Prices		Real Volatility	
	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm
Germany	-49.67***	1.498	10.651***	-	58.51***	8.98***
Japan	-	-	-	-	-	-
US	-20.39***	-0.169	22.95***	-3.029***	4.099***	-2.468**

Real

Countries	Real Income		Relative Prices		Real Volatility	
	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm
Germany	-	-	-	-	-	-
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 5.32: Impact of Exchange Rate Volatility on UK Imports: Including the Financial Crisis (Jan 1991 to Dec 2011)

Nominal

Countries	Real Income		Relative Prices		Real Volatility	
	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm
Germany	-20.36***	0.346	6.49***	12.11***	26.23***	4.83**
Japan	-	-	-	-	-	-
US	1.618	0.782	6.23***	9.795***	-11.693***	2.926***

Real

Countries	Real Income		Relative Prices		Real Volatility	
	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm
Germany	-	-	-	-	-	-
Japan	83.169***	25.879***	969.46***	1.865	110.352***	9.926***
US	19.396***	19.396***	254.335***	254.335***	470.48***	470.582***

Note:

***, ** and * imply rejection of the null of non-asymmetric at the 1%, 5% and 10% level respectively

Analysis - Developed

Table 5.33: Impact of Exchange Rate Volatility on UK Imports in the Presence of Third-Country Exchange Rate Risk before the Financial Crisis (Jan 1991 to June 2007)

Nominal

Countries	Real Income		Relative Prices		Nominal Volatility		Third Country Nominal Volatility	
	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm
Germany	13.98***	1.72*	1.848*	2.59**	9.438***	1.89*	2.86	2.27**
Japan	8.077***	4.89***	1.827*	7.19***	6.17***	1.53	21.8***	2.61***
US	1.38	4.55***	6.94***	4.089***	11.16***	9.788***	7.31***	4.57***

Real

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***	13.9***
Japan	53.6***	8.579***	3.327**	25.1***	17.5***	7.144***	36.2***	10.2***
US	0.568	1.302	16.7***	12.3***	89.9***	8.159***	61.1***	22.1***

Table 5.34: Impact of Exchange Rate Volatility on UK Imports in the Presence of Third-Country Exchange Rate Risk (Jan 1991 to Dec 2011)

Nominal

Countries	Real Income		Relative Prices		Nominal Volatility		Third Country Nominal Volatility	
	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm
Germany	1.57	0.008	3.35***	3.62***	8.48***	3.13***	3.13***	7.22***
Japan	4.66***	2.42**	3.92***	3.73***	6.93***	0.43	4.09***	1.80*
US	-	-	-	-	-	-	-	-

Real

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	18.78***	5.206**	84.3***	5.253**	88.32***	19.96***	0.379	9.11***
Japan	35.49***	0.051	112.1***	6.793***	181.8***	0.927	66.1***	1.875
US	44.8***	0.171	515.3***	0.132	0.022	2.98*	44.5***	0.261

Note:

***, ** and * imply rejection of the null of non-asymmetric at the 1%, 5% and 10% level respectively

Chapter 6: Analysis – Developing Countries

6.1 Introduction

This chapter describes the hypothesis test results involving UK imports from the developing countries including Brazil, China and South Africa. These countries have been selected on the basis of their trade volume with the UK as well as their geographical significance. These countries represent three major economic regions around the globe, namely Asia, South Africa and South America. This not only provides economic justification but also adds to the generalization in terms of economic theory as well.

The hypothesis tests mainly comprise of two sets of hypotheses. i.e. i) impact of exchange rate volatility on UK imports; and ii) Impact of exchange rate volatility on UK imports in the presence of third-country exchange rate risk. In order to analyse the impact of the recent financial crisis on these relationships, both of the above hypotheses are tested for data samples covering before and then including the financial crisis period.

Hypotheses tests are based on the ARDL method (Pesaran, Shin and Smith, 2001) and the nonlinear Asymmetric ARDL approach (Shin, Yu and Greenwood-Nimmo, 2013) for cointegration. The lag order selection procedure adopted in this research for each equation is explained in detail in section 5.1. Furthermore, following the standard literature on symmetric and asymmetric ARDL methods, (Pesaran, Shin, and Smith, 2001; Shin, Yu, Greenwood-Nimmo, 2013), results for F-statistics, normalized long-run coefficients, long-run equilibrium error correction (ECM), Hendry's (1987) General-to-Specific causality and long/short asymmetric effects[15] are provided through Tables 6.1-6.28. These empirical estimations are further supported by various diagnostic tests to ensure the reliability and stability of the above results, such as: normality of residuals – JB statistics; autocorrelation - Ljung-Box Test; misspecification – Ramsey's Test; and heteroskedasticity/ARCH effects – ARCH Test.

15 Only under the Asymmetric ARDL method (Tables 6.25-6.28)

6.2 Overview of the Hypotheses Test Results

This section provides a summary of the hypothesis results under both ARDL and Asymmetric ARDL methods for the developing countries i.e. Brazil, China and South Africa. Table 6.1 shows that exchange rate volatility has a negative impact on the UK imports from the above development countries. These results imply that given the traders are risk averse, UK imports with an increase in the exchange rate uncertainty the volume of imports has reduced over the sample period. This relationship has been stable in most of the cases even after inclusion of the financial crisis. The impact of the financial crisis can be in terms of increase in the sensitivity/elasticity of UK imports with respect to exchange rate risk. Similarly, third country volatility has a negative impact on the UK imports in most of the cases, except in the cases where third country exchange rate volatility is represented by USD/GBP, where it has a positive impact. Lastly, null hypothesis of symmetric impact of exchange rate volatility has also been rejected in all of the cases, which confirms the evidence of asymmetric relationship between exchange rate volatility and UK imports. Detailed analysis of the results for both ARDL and Asymmetric ARDL methods are provided in the following sections.

Countries	**Research Questions**	**ARDL**		**Asymmetric ARDL**	
		Nominal	**Real**	**Nominal**	**Real**
Brazil	1. Impact of Exchange Rate Volatility on UK Imports	Positive	Positive	None	None
	2 Impact of Third County Exchange Rate Volatility on UK Imports	Negative	Negative	Negative	Negative
	3.1 Impact of Exchange Rate Volatility after Financial Crisis on UK Imports	Negative	Negative	None	None
	3.2 Impact of Third Country Exchange Rate Volatility after Financial Crisis on UK Imports	Negative	Negative	Negative	Positive
	4. Impact of Exchange Rate Volatilities (Symmetric or Asymmetric)	Not Applicable	Not Applicable	Symmetric	Symmetric

China	1. Impact of Exchange Rate Volatility on UK Imports	Negative	Negative	Negative	Negative
	2 Impact of Third County Exchange Rate Volatility on UK Imports	Negative	Negative	Negative	Negative
	3.1 Impact of Exchange Rate Volatility after Financial Crisis on UK Imports	Negative	Negative	None	None
	3.2 Impact of Third Country Exchange Rate Volatility after Financial Crisis on UK Imports	Positive	Positive	Negative	Negative
	4. Impact of Exchange Rate Volatilities (Symmetric or Asymmetric)	Not Applicable	Not Applicable	Asymmetric	Asymmetric
South Africa	1. Impact of Exchange Rate Volatility on UK Imports	Negative	Negative	Negative	Negative
	2 Impact of Third County Exchange Rate Volatility on UK Imports	Positive	Positive	Negative	Negative
	3.1 Impact of Exchange Rate Volatility after Financial Crisis on UK Imports	Negative	Negative	Negative	Negative
	3.2 Impact of Third Country Exchange Rate Volatility after Financial Crisis on UK Imports	Positive	Positive	Negative	Negative
	4. Impact of Exchange Rate Volatilities (Symmetric or Asymmetric)	Not Applicable	Not Applicable	Asymmetric	Asymmetric

6.3 ARDL – Bounds Testing Approach

The ARDL bounds testing approach to cointegration (Pesaran, Shin and Smith, 2001) involves a standard F-test (or Wald test) as a first step to test the null hypothesis of no long-run equilibrium relationship among the underlying variables. If the null hypothesis cannot be rejected, then the results suggest a significant long-run equilibrium relationship. For this purpose, the critical values for two extreme sets of I(1) and I(0) regressors are provided by Pesaran, Shin and Smith (2001). Therefore, UK imports from Brazil, China and South Africa are regressed on UK real income, relative price ratio and their respective exchange rate volatilities (both nominal and real) using the ARDL method to test the possibility of the null hypothesis.

6.3.1 ARDL Cointegration Results

Tables 6.1-6.4 present the ARDL cointegration test results for the developing countries. The significance of the coefficients is presented at the 10%, 5% and 1% levels. Cointegration results are supported by diagnostics statistics such as: JB-statistic, Ljung-Box, Reset and ARCH (1) and ARCH (3). Adjusted R-square, sum

of standard error of estimates and sum of squared residuals and optimal lag length are also reported for each country in these tables.

6.3.1.1 Exchange rate volatility and UK Imports Before and Including the Financial Crisis

Tables 6.1-6.2 present the cointegration results for the developing countries of Brazil, China and South Africa during the pre-crisis period (Table 6.1) and the crisis period (6.2) using both nominal and real exchange rate volatility. These results provide empirical support for testing the hypotheses formulated in section 2.5. Country specific hypothesis tests based on these results are detailed as follows:

6.3.1.1.1 Brazil

The results in Tables 6.1-6.2 show significant cointegration in the case of Brazil at the 1% or 5% significance level, confirming a long-run relationship between UK imports and Real-GBP nominal and real exchange rate volatilities, along with the other determining variables included in this relationship, i.e. the UK's real income and the relative price ratio between the two countries. These results hold both before the financial crisis and after inclusion of the recent financial crisis period data. This shows a stable relationship between the underlying variables across both sample lengths.

6.3.1.1.2 China

Similarly, a long-run relationship is documented for China as well, where significant cointegration is reported for both sample lengths at the 5% level. This shows a long-run relationship between UK imports and its determinants (UK real income and relative price ratio) and Yuan/GBP nominal and real exchange rate volatilities. This relationship also holds after inclusion of the recent financial crisis period, indicating stability of the underlying relationship.

6.3.1.1.3 South Africa

Tables 6.1-6.2 also confirm the long-run equilibrium relationship between UK imports and RAND/GPB exchange rate volatility (both nominal and real terms) in addition to UK real income and relative price ratio. Furthermore, the relationship is stable over both sample periods, implying no significant impact of the

financial crisis on the relationship between UK Imports and its determinants. Thus, the null hypothesis cannot be accepted as evidence of a significant long-run relationship at either the 1% or 5% level.

6.3.1.1.4 Summary

To summarize, exchange rate volatility (nominal and real) for Brazil, China and South Africa, along with real income and relative prices, affects UK imports in the long-run for both sample lengths. This means that, irrespective of the time period and exchange rate volatility (nominal or real), a long-run relationship is reported between UK imports and exchange rate volatilities of developing countries such as Brazil, China and South Africa, in addition to other determinants such as UK real income and relative import price ratio. Lastly, diagnostic test results show that the residuals are normally distributed, and no evidence of autocorrelation, heteroskedasticity (ARCH effect) or misspecifications is found.

6.3.1.1.5 Comparison of Results for Developed and Developing Countries

A long-run relationship, or cointegration, is confirmed for all developing countries in all cases, i.e. across both sample lengths and both exchange rate volatilities (nominal and real). However, with the developed countries, in some instances no cointegration is found, e.g. Germany (both before and after the financial crisis using real volatility) and Japan (after the financial crisis using nominal volatility).

Table 6.1: ARDL Results - Impact of Exchange Rate Volatility on UK Imports Before the Financial Crisis (Jan-1991 to June-2007)

Nominal

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
Brazil	5.22***	0.39	0.023	3.93	3.87	7.211	1.88	3.52	7.11
China	4.91**	0.573	0.0055	0.92	0.176	2.85	1.49	2.24	3.35
SA	5.76***	0.448	0.051	8.97	3.46	4.88	2.07	1.516	2.00

Real

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
Brazil	4.42**	0.417	0.022	3.72	1.32	6.76	1.54	2.98	7.21
China	4.79**	0.573	0.0055	0.923	0.172	3.08	1.45	1.23	1.39
SA	5.98***	0.436	0.052	9.11	2.8	7.06	1.459	1.893	1.06

Note:
1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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 6.2: ARDL Results - Impact of Exchange Rate Volatility on UK Imports Including the Financial Crisis (Jan-1991 to Dec-2011)

Nominal

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
Brazil	5.32***	0.389	0.0255	5.61	2.53	16.33	0.918	2.34	3.57
China	4.28**	0.572	0.0054	1.189	0.433	6.12	1.62	0.632	4.127
SA	5.28***	0.386	0.056	12.53	0.611	1.68	3.61	2.228	2.269

Real

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
Brazil	5.21***	0.408	0.024	5.41	2.81	16.98	1.326	2.075	4.562
China	4.27**	0.572	0.0054	1.188	0.418	2.26	1.60	0.60	4.09
SA	3.99**	0.380	0.057	12.76	0.687	8.84	1.54	1.34	1.42

Note:
1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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.

6.3.1.2 Exchange rate volatility and UK Imports in the Presence of Third-Country Exchange Rate Risk Before and Including the Financial Crisis

Tables 6.3-6.4 present the cointegration results regarding the impact of the developing countries' exchange rate volatility on UK imports in the presence of third country exchange rate risk, proxied by USD/GBP volatility. Moreover, the impact of the financial crisis is assessed by analysing the data covering the time periods before (Table 6.3) and including the financial crisis period (6.4). Hypotheses are tested on the basis of these results for possible third country exchange rate risk effect on the underlying relationship, identified in section 6.3.1.1 above. Country specific details of the hypothesis tests based on these results are as follows:

6.3.1.2.1 Brazil

The results in Tables 6.3-6.4 show significant cointegration in the case of Brazil at the 1% or 5% significance level, confirming a long-run relationship between UK imports and its traditional determinants, i.e. exchange rate volatility, real income and relative price ratio, in the presence of third country exchange rate risk proxied by USD/GBP volatility (both in nominal and real terms). Furthermore, these relationships are significant across both data samples, i.e. before and after including the recent financial crisis. These results imply initial validation of the general specification of the UK imports model in the presence of third-country exchange rate risk, however, its significance as an individual long-term determinant or regressor will be established later when the long-run estimates for normalized coefficients will be discussed.

6.3.1.2.2 China

In the case of China, similar findings are reported and a long-run equilibrium relationship between UK imports and other determinants in the presence of third-country effect is reported at the 1% or 5% significance level (Tables 6.3-6.4). Furthermore, the null hypothesis of no long-run relationship is rejected both before and after inclusion of the recent financial crisis period. Thus, real income, relative price ratio, exchange rate volatility and third country exchange rate volatility are all jointly affecting UK imports.

6.3.1.2.3 South Africa

Tables 6.3-6.4 also confirm the long-run equilibrium relationship between UK imports and RAND/GBP exchange rate volatility (both nominal and real terms), UK real income and relative price ratio, in addition to third country exchange rate volatility (USD/GBP). Furthermore, the relationship is stable over both sample periods, implying a significant and stable relationship between the underlying variables. Thus, the null hypothesis cannot be accepted, as evidence of a significant long-run relationship is reported at the 1% or 5% level, irrespective of the exchange rate volatility employed, i.e. for both nominal and real exchange rate volatilities.

6.3.1.2.4 Summary

To summarize, results under the ARDL bounds testing approach (Pesaran, Shin and Smith, 2001) show that third country exchange rate risk (USD/GBP), along with other determinants as explained earlier, jointly affect UK imports both before and after inclusion of the recent financial crisis. This implies an initial confirmation of third country exchange rate risk as a joint long-run determinant of UK imports, besides the other independent variables. Furthermore, rejection of the null hypotheses of no cointegration across both data samples shows the stability of this underlying long-run relationship.

6.3.1.2.5 Comparison of Results for Developed and Developing Countries

Results for both developed and developing countries show a long-run equilibrium relationship between UK imports and exchange rate volatility, besides other underlying variables, in the presence of third country exchange rate risk across both sample lengths and when either nominal/real exchange rate volatilities are employed. This shows the significance of the third country exchange rate risk as an additional determinant of UK imports from both developed and developing countries.

Table 6.3: ARDL Results - Impact of Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk Before the Financial Crisis (Jan-1991 to June-2007)

Nominal

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET (3)	ARCH (1)	ARCH (3)
Brazil	5.01***	0.417	0.022	3.72	0.153	9.48	1.06	0.0476	2.55
China	4.11**	0.573	0.005	0.919	0.506	7.12	1.89	1.25	2.75
SA	6.75***	0.445	0.051	8.96	3.39	4.38	2.13	1.53	2.04

Real

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET (3)	ARCH (1)	ARCH (3)
Brazil	5.23***	0.426	0.021	3.67	0.411	9.658	1.98	0.182	2.754
China	4.29**	0.573	0.005	0.918	0.50	7.2	1.87	1.24	2.79
SA	7.01***	0.433	0.052	9.11	2.87	7.44	1.46	2.7	3.04

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. $R^{2:}$ Adjusted R-Square; 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 6.4: ARDL Results - Impact of Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk (Jan-1991 to Dec-2011)

Nominal

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET (3)	ARCH (1)	ARCH (3)
Brazil	4.89**	0.399	0.025	5.55	0.47	10.69	1.321	0.62	1.75
China	4.51**	0.58	0.005	1.125	0.404	6.08	1.24	0.7	3.05
SA	6.97***	0.44	0.051	11.09	0.306	7.98	1.7	0.93	2.1

Real

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET (3)	ARCH (1)	ARCH (3)
Brazil	3.9**	0.415	0.024	5.38	0.211	12.85	1.10	0.27	1.14
China	4.4**	0.587	0.005	1.125	0.339	6.11	1.197	0.66	3.08
SA	5.3***	0.442	0.051	11.08	0.48	8.759	1.772	1.80	4.53

Note:
1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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.

6.3.2 Normalized Equations and Long-Run Elasticities

After establishing the long-run relationship among the underlying variables through the joint hypothesis test based on the ARDL bound testing approach, proposed by Pesaran, Shin and Smith (2001), normalized long-run coefficients for the underlying independent variables are estimated. These estimates are discussed in this section. Normalized equations are estimated for inferring the long-run relationship between the underlying regressors and the dependent variable. In this case, the independent variables, i.e. real income, relative price ratio and exchange rate volatility, have been normalized on UK imports. These estimates provide the long-run elasticities of the respective independent variables and represent the percentage change in UK imports due to a unit change in these independent variables. Tables 6.5-6.8 present the estimated normalized equations for the different hypotheses, and the significance of these coefficients is presented for the 10%, 5% and 1% levels.

6.3.2.1 Exchange rate volatility and UK Imports Before and Including the Financial Crisis

6.3.2.1.1 UK Real Income

Tables 6.5 and 6.6 provide normalized long-run coefficients for analysing the impact of exchange rate volatility, in addition to UK real income and relative prices, on UK imports. As explained earlier, based on standard economic theory, an increase in UK real income should result in an increase in the demand for imported (normal) goods. Results show that the coefficients for UK real income in all cases[16] are positive and significant, and therefore are in line with the existing evidence on the subject (McKenzie, 1999; Bahmani-Oskooee and Hegerty, 2007). The size of the income elasticity increases in the case of China and South Africa when the crisis period data is added to the sample, from 1.88 and 4.29 to 6.11 and 4.66, respectively, which means that due to the financial crisis the UK imports from these two countries became more elastic to the changes in UK real income because of an upsurge in the economic volatility. This is also true when the exchange rate volatility is measured in real terms. Thus, an increase in the income elasticity of UK imports from China and South Africa may be indicative of the rational behaviour of UK customers by demonstrating cautiousness due to economic turbulence and realizing the most efficient allocation of their resources.

6.3.2.1.2 Relative Price Ratio

The relative price ratio compares import prices of the developing partner countries (i.e. Brazil, China and South Africa) against the home country (i.e. the UK). An increase in the ratio implies an increase in the import prices of the partner countries relative to the home country and would generally discourage imports from that particular partner country. Thus, a negative coefficient is expected under this proposition (Arize *et al.*, 2003; Bahmani-Oskooee and Kara, 2005).

16 i.e. for both nominal and real exchange rate volatilities for the pre-crisis and including the financial crisis sample periods.

Relative price coefficients are all significant according to the results shown in Tables 6.5 and 6.6; however, in terms of the direction of the relationship, mixed findings are reported as both negative and positive coefficients are found for relative prices.

In the case of Brazil, for instance, relative import price coefficients are 9.06 and 8.824 for nominal and real exchange rate equations, respectively, for the pre-crisis period. This shows a positive relationship between the import prices and UK imports, i.e. any increase in the import prices is followed by an increase in UK imports from Brazil. After inclusion of the financial crisis period, these coefficients reduced to 7.1 and 6.81, respectively, for nominal and real exchange rate equations.

For China, the coefficients for relative import price ratio are -74.75 and -74.66, respectively, for nominal and real exchange rate equations before the financial crisis period, but reduce in absolute terms to -37.96 and -37.71, respectively, after inclusion of the financial crisis period. This shows that, after inclusion of the financial crisis period, although the relationship holds, the import price elasticity of UK imports from China has reduced significantly. This change in the size of the coefficients may thus be attributed to the recent financial crisis.

In the case of South Africa, the coefficients in all cases are positive and significant for both sample lengths. Before the financial crisis, the coefficients are 15.11 and 14.277, whereas after the crisis these reduce to 10.7 and 9.747, respectively. This shows a decline in the import price sensitivity of UK imports after inclusion of the financial crisis period. This characteristic has been consistent throughout for all the developing trade partners, i.e. Brazil, China and South Africa, both under nominal and real model specifications.

6.3.2.1.3 Nominal/Real Exchange Rate Volatility

As explained in the Data and Methodology chapter, exchange rate volatility for the respective currencies of the UK's trading partners from the developing world has been estimated on the basis of the GARCH (1,1) model, using both nominal and real exchange rates for the sample countries.

Current literature on exchange rate volatility and imports does not provide a clear direction of the relationship between the two variables (McKenzie, 1999; Bahmani-Oskooee and Hegerty, 2007). However, as explained in section 2.4.2,

this research expects a negative impact of an increase in the exchange rate volatility on UK imports.

The long-run volatility coefficients for all three countries, i.e. Brazil, China and South Africa, are significant and negative in all cases, as shown in Tables 6.5 and 6.6. This shows that, irrespective of the exchange rate employed (nominal or real) and the sample period selected (i.e. before or after inclusion of the financial crisis), an increase in exchange rate volatility discourages UK imports from these countries. In the literature, this is known as the "negative hypothesis" whereby the buyers and sellers reduce their trading volume due to the uncertainty of earnings caused by uncertain exchange rates of the underlying currencies.

To summarize, based on the results for exchange rate volatilities for all three developing countries using the ARDL bounds testing approach, proposed by Pesaran, Shin and Smith (2001), the null hypothesis of no impact of exchange rate volatility on UK imports can be rejected at the 1% or 5% significance level both before and after inclusion of the financial crisis period.

Table 6.5: Normalized Coefficients – Impact of Exchange Rate Volatility on UK Imports Before the Financial Crisis (Jan-1991 to June-2007)

Nominal

Countries	Constant	Real Income	Relative Prices	Nominal Volatility
Brazil	-29.817***	5.56***	9.06***	0.032***
China	173.65***	-18.81***	-74.75***	-18.54***
SA	11.90***	-4.29***	15.11***	-0.95***

Real

Countries	Constant	Real Income	Relative Prices	Real Volatility
Brazil	-27.01***	5.015***	8.824***	0.022***
China	173.58***	-18.77***	-74.66***	-22.55***
SA	10.48***	-3.835***	14.277***	-0.464***

Note:
1. ***,**, and * denote significant at 1%, 5% and 10% respectively.

Table 6.6: Normalized Coefficients – Impact of Exchange Rate Volatility on UK Imports Including the Financial Crisis (Jan-1991 to Dec 2011)

Nominal

Countries	Constant	Real Income	Relative Prices	Nominal Volatility
Brazil	-19.43***	3.76***	7.10***	-0.018**
China	28.53	6.11**	-37.96***	-64.42***
SA	-25.55***	4.66***	10.7***	-0.59**

Real

Countries	Constant	Real Income	Relative Prices	Real Volatility
Brazil	16.42***	3.18***	6.81***	-0.04***
China	27.96***	6.27***	-37.71***	-75.95***
SA	24.15***	4.582***	9.747***	-0.748***

Note:
1. ***,**, and * denote significant at 1%, 5% and 10% respectively.

6.3.2.2 Exchange rate volatility and UK Imports in the presence of Third Country Exchange Rate Risk Before and Including the Financial Crisis

6.3.2.2.1 UK Real Income

Tables 6.7 and 6.8 show that UK real income has been a significant log-run determinant of UK imports, irrespective of the nominal or real exchange rate volatility or the sample period chosen (i.e. before or after inclusion of the financial crisis period). These results are in line with the earlier findings discussed in section 6.3.2.1.1 and also with the existing literature on the subject (McKenzie, 1999; Bahmani-Oskooee and Hegerty, 2007). These results also reiterate the reduction in income elasticity of UK imports after the inclusion of the financial crisis period, as discussed in section 6.3.2.1.1.

6.3.2.2.2 Relative Price Ratio

The relative price ratio compares the import prices of the developing partner countries (i.e. Brazil, China and South Africa) against the home country (i.e. the UK). An increase in the ratio implies an increase in the import prices of the partner countries relative to the home country and would generally discourage imports from that particular partner country. Thus, a negative coefficient is

expected under this proposition (Arize *et al.*, 2003; Bahmani-Oskooee and Kara, 2005).

Relative price coefficients are all significant according to the results shown in Tables 6.7 and 6.8; however, in terms of the direction of the relationship, mixed findings are reported as both negative and positive coefficients are found for relative prices.

In the case of Brazil, for instance, the relative import price coefficients are 6.35 and 6.93 for nominal and real exchange rate equations, respectively, for the pre-crisis period. This shows a positive relationship between import prices and UK imports, i.e. any increase in the import prices is followed by an increase in UK imports from Brazil. After inclusion of the financial crisis period, these coefficients reduced to 7.79 and 6.58, respectively, for nominal and real exchange rate equations.

For China, the coefficients for relative import price ratio are -12.97 and -12.58, respectively, for nominal and real exchange rate equations before the financial crisis period, which reduces in absolute terms to -6.02 and 36.16 respectively after inclusion of the financial crisis period. This shows that, after inclusion of the financial crisis period, although the relationship holds, the import price elasticity of UK imports from China has significantly increased (reduced) for nominal (real) exchange rate volatility. This change in the size of coefficients may be attributed to the recent financial crisis.

In the case of South Africa, the coefficients in all cases are positive and significant for both sample lengths. Before the financial crisis, coefficients are 12.42 and 12.19, whereas after the crisis these reduce to 11.18 and 11.05, respectively. This shows a slight decline in the import price sensitivity of UK imports after inclusion of the financial crisis period.

6.3.2.2.3 Nominal/Real Exchange Rate Volatility

The long-run volatility coefficients for all three countries, i.e. Brazil, China and South Africa, are significant and negative in all cases, as shown in Tables 6.5 and 6.6. This shows that irrespective of the exchange rate employed (nominal or real) and the sample period selected (i.e. before or after inclusion of the financial crisis), an increase in the exchange rate volatility discourages UK

imports from these countries. These results further confirm the "negative hypothesis" effect of exchange rate volatility whereby trade volume declines due to an increase in the exchange rate volatility (risk) leading to a reduction in the trade flows.

6.3.2.2.4 Third Country (USD/GBP) Nominal/Real Exchange Rate Volatility

USD/GBP exchange rate volatility is used as a proxy for third country exchange rate risk for all three developing countries. Further results, under both nominal and real exchange rate volatilities, are presented to be in line with the empirical research design of this research.

USD/GBP volatility is observed to have a negative effect on UK Imports from Brazil and China but a positive effect is noted in the case of South Africa. These results are also stable across both data samples, confirming the stability of the long-run impact of USD/GBP volatility on UK imports from these countries. Interestingly, the bilateral exchange rate volatilities of these countries against the UK have increased after inclusion of the financial crisis, whereas sensitivity to USD/GBP volatility has significantly reduced after inclusion of the financial crisis period. This may be indicating that their domestic exchange rate volatilities have more adversely affected the trade flows with the UK than the USD volatility during the financial crisis.

Table 6.7: Normalized Coefficients – Impact of Exchange Rate Volatility on UK Imports in the Presence of Third-Country Exchange Rate Risk Before the Financial Crisis (Jan-1991 to June-2007)

Nominal

Countries	Constant	Real Income	Relative Prices	Real Volatility	Third Country Real Volatility
Brazil	5.44***	3.07***	6.35***	-0.02***	-0.49*
China	2.13***	-21.60***	-129.7***	-79.37***	-9.91***
SA	-28.05***	4.79***	12.42***	-1.06***	5.67***

Real

Countries	Constant	Real Income	Relative Prices	Real Volatility	Third Country Real Volatility
Brazil	-18.27***	3.55***	6.93***	-0.024***	-0.566*
China	2.2***	-18.73***	-125.8***	-84.05***	-8.36***
SA	-2.27***	4.67***	12.19***	-0.627***	5.652***

Note:
1. ***,**, and * denote significant at 1%, 5% and 10% respectively.

Table 6.8: Normalized Coefficients – Impact of Exchange Rate Volatility on UK Imports in the Presence of Third-Country Exchange Rate Risk Including the Financial Crisis (Jan-1991 to Dec-2011)

Nominal

Countries	Constant	Real Income	Relative Prices	Real Volatility	Third Country Real Volatility
Brazil	1.21***	3.58***	7.79***	-0.01**	-1.34**
China	1.7***	7.86***	-6.02***	-7.17***	1.14***
SA	4.54***	7.76***	11.18***	-1.16***	4.85***

Real

Countries	Constant	Real Income	Relative Prices	Real Volatility	Third Country Real Volatility
Brazil	3.1***	2.533***	6.589***	-0.034***	-1.108***
China	1.55***	8.61***	-36.16***	-4.97***	3.13***
SA	3.59***	7.13***	11.05***	-0.587***	5.556***

Note:
1. ***,**, and * denote significant at 1%, 5% and 10% respectively.

6.3.3 Causality between Real UK Imports and its Determinants

Tables 6.9-6.12 show the estimated error correction model specification presented in equation 7 with respect to both nominal and real exchange rate volatility. Each table presents the 'General-to-Specific' causality results under both nominal and real exchange rate volatility. The following sub-sections describe the specific country causality results in more detail:

6.3.3.1 Exchange rate volatility and UK Imports Before and Including the Financial Crisis

6.3.3.1.1 Brazil

As shown in Tables 6.9-6.10, the restricted error correction terms are significant and negative in all the cases, which suggests a long-run equilibrium relationship between UK imports and the underlying determinant variables. In other words,

UK imports are Granger caused by the underlying variables collectively. Moreover, nominal/real exchange rate volatility, along with the UK's real income and relative prices, also significantly affects UK imports in the short-run.

6.3.3.1.2 China

Error correction terms in the case of China are also significant in all cases, i.e. both under nominal and real exchange rate volatilities as well as both before and after inclusion of the financial crisis period. This shows that the underlying variables Granger cause UK imports jointly, irrespective of the time period selected and the type of exchange rate volatility employed. In terms of the short-term relationships, lagged UK imports, for example lags 1 (-0.149)[17], 5 (-0.15), 7(0.093) and 12 (0.56), the UK's real income, relative import price ratio and exchange rate volatility (both nominal and real) are important determinants of UK imports in the short-term as well.

6.3.3.1.3 South Africa

Error correction terms for South Africa are significant in all cases at the 1% level, implying a strong causal relationship among the underlying variables. This relationship holds for both nominal and real exchange rate volatilities and also for before and after inclusion of the financial crisis period. A relative increase in the absolute value of the estimated error correction term is observed from the pre-crisis period to the full period.

[17] Figures in brackets represent the coefficients of each lag and are interpreted as percentage changes in the dependent variables due to a one per cent change in the underlying regressors

Table 6.9: **ECM – Causality Results: Impact of Exchange Rate Volatility on UK Imports (Jan 1991 – June 2007)**

Nominal

Brazil

Lags	Constant	ECM	Δ Imports	Δ Real Income UK	Δ Relative Prices	Δ Nominal Volatility
0	-	-	-	-	-	-
1	-	-0.16***	-0.44***	-	6.09***	-0.011**
4	-	-	-	-2.60*	-	-
5	-	-	-0.17***	-	-	-
7	-	-	-0.14**	-	-	-0.008*
8	-	-	-0.21***	-	-	-
12	-	-	-	-2.51*	-	-

Diagnostic Tests

R^2	SSE	RSS	JB	LB	RESET	ARCH1	ARCH3
0.403	0.022	3.92	3.86	7.21	1.90	1.52	7.11

China

Lags	Constant	ECM	Δ Imports	Δ Real Income UK	Δ Relative Prices	Δ Nominal Volatility
0	-	-	-	2.193***	-	-
1	-	-0.013**	-0.149**	-	-	-
2	-	-	-	2.55***	-11.78***	1.12**
5	-	-	-0.15***	-	-5.85*	1.14**
6	-	-	-	-	9.10***	-
7	-	-	-0.093*	-	-	-
9	-	-	-	-	9.91***	-
12	-	-	0.56***	-	-	-

Diagnostic Tests

R^2	SSE	RSS	JB	LB	RESET	ARCH1	ARCH3
0.581	0.005	0.923	0.176	2.85	2.08	2.24	3.35

South Africa

Lags	Constant	ECM	Δ Imports	Δ Real Income UK	Δ Relative Prices	Δ Nominal Volatility
1	-	-0.76***	-	-	-	-
4	-	-	-	42.18***	-	-
5	-	-	-0.096*	-	-	-
7	-	-	-	-	-2.79**	-
9	-	-	0.11*	-	-	-
12	-	-	-	-	-3.55**	-

Diagnostic Tests

R^2	SSE	RSS	JB	LB	RESET	ARCH1	ARCH3
0.457	0.05	8.97	3.46	4.88	2.08	1.516	2.00

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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.

Real

Brazil							
Lags	**Constant**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Real Volatility**	
0	-	-	-	-	-	-	
1	-	-0.16***	-0.41***	-	7.25***	-0.012***	
4	-	-	-	-2.61**	-	-	
5	-	-	-0.17***	-	-	-	
7	-	-	-0.16**	-	-	-0.01**	
8	-	-	-0.22***	-	-	-	
10	-	-	-	-	-	0.012**	
12	-	-	-	-2.53**	-	-0.009*	
Diagnostic Tests							
R^2	**SSE**	**RSS**	**JB**	**LB**	**RESET**	**ARCH1**	**ARCH3**
0.427	0.022	3.72	1.324	6.76	1.5	1.98	2.2
China							
LAGS	**Constant**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Real Volatility**	
0	-	-	-	2.19***	-	-	
1	-	-0.014**	-0.15***	-	-11.7***	-	
2	-	-	-	2.54***	-5.88*	1.45**	
5	-	-	-	-	-	1.45**	
6	-	-	-0.15**	-	9.09***	-	
7	-	-	-0.09*	-	-	-	
9	-	-	-	-	9.92***	-	
12	-	-	0.56***	-	-	-	
Diagnostic Tests							
R^2	**SSE**	**RSS**	**JB**	**LB**	**RESET**	**ARCH1**	**ARCH3**
0.581	0.0054	0.9237	0.172	3.09	2.3	2.23	3.39
South Africa							
LAGS	**Constant**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Real Volatility**	
1	-	-0.71***	-	-	-	-	
4	-	-	-0.11*	-	32.13**	-	
5	-	-	-0.15**	-	-	-	
7	-	-	-	-	-31.9**	-	
9	-	-	-	-	-24.8*	-	
12	-	-	-	-	-	-0.17**	
Diagnostic Tests							
R^2	**SSE**	**RSS**	**JB**	**LB**	**RESET**	**ARCH1**	**ARCH3**
0.445	0.051	9.11	2.8	7.06	1.45	2.1	3.06

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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 6.10: ECM – Causality Results: Impact of Exchange Rate Volatility on UK Imports (Jan 1991 – Dec 2011)

Nominal

Brazil							
LAGS	**Constant**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Nominal Volatility**	
0	-	-	-	-	-	-	
1	-	-0.16***	-0.44***	-	6.09***	-0.011**	
4	-	-	-	-2.60*	-	-	
5	-	-	-0.17***	-	-	-	
7	-	-	-0.14**	-	-	-0.008*	
8	-	-	-0.21***	-	-	-	
12	-	-	-	-2.51*	-	-	
Diagnostic Tests							
R^2	**SSE**	**RSS**	**JB**	**LB**	**RESET**	**ARCH1**	**ARCH3**
0.403	0.022	3.92	3.86	7.21	1.90	1.52	7.11
China							
LAGS	**Constant**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Nominal Volatility**	
0	-	-	-	2.193***	-	-	
1	-	-0.013**	-0.149**	-	-	-	
2	-	-	-	2.55***	-11.78***	1.12**	
5	-	-	-0.15***	-	-5.85*	1.14**	
6	-	-	-	-	9.10***	-	
7	-	-	-0.093*	-	-	-	
9	-	-	-	-	9.91***	-	
12	-	-	0.56***	-	-	-	
Diagnostic Tests							
R^2	**SSE**	**RSS**	**JB**	**LB**	**RESET**	**ARCH1**	**ARCH3**
0.581	0.005	0.923	0.176	2.85	2.08	2.24	3.35
South Africa							
LAGS	**Constant**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Nominal Volatility**	
1	-	-0.76***	-	-	-	-	
4	-	-	-	42.18***	-	-	
5	-	-	-0.096*	-	-	-	
7	-	-	-	-	-2.79**	-	
9	-	-	0.11*	-	-	-	
12	-	-	-	-	-3.55**	-	
Diagnostic Tests							
R^2	**SSE**	**RSS**	**JB**	**LB**	**RESET**	**ARCH1**	**ARCH3**
0.457	0.05	8.97	3.46	4.88	2.08	1.516	2.00

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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.

Real

Brazil							
LAGS	**Constant**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Real Volatility**	
0	-	-	-	-	-	-	
1	-	-0.16***	-0.41***	-	7.25***	-0.012***	
4	-	-	-	-2.61**	-	-	
5	-	-	-0.17***	-	-	-	
7	-	-	-0.16**	-	-	-0.01**	
8	-	-	-0.22***	-	-	-	
10	-	-	-	-	-	0.012**	
12	-	-	-	-2.53**	-	-0.009*	
Diagnostic Tests							
R^2	**SSE**	**RSS**	**JB**	**LB**	**RESET**	**ARCH1**	**ARCH3**
0.427	0.022	3.72	1.324	6.76	1.5	1.98	2.2
China							
LAGS	**Constant**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Real Volatility**	
0	-	-	-	2.19***	-	-	
1	-	-0.014**	-0.15***	-	-11.7***	-	
2	-	-	-	2.54***	-5.88*	1.45**	
5	-	-	-	-	-	1.45**	
6	-	-	-0.15**	-	9.09***	-	
7	-	-	-0.09*	-	-	-	
9	-	-	-	-	9.92***	-	
12	-	-	0.56***	-	-	-	
Diagnostic Tests							
R^2	**SSE**	**RSS**	**JB**	**LB**	**RESET**	**ARCH1**	**ARCH3**
0.581	0.0054	0.9237	0.172	3.09	2.3	2.23	3.39
South Africa							
LAGS	**Constant**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Real Volatility**	
1	-	-0.71***	-	-	-	-	
4	-	-	-0.11*	-	32.13**	-	
5	-	-	-0.15**	-	-	-	
7	-	-	-	-	-31.9**	-	
9	-	-	-	-	-24.8*	-	
12	-	-	-	-	-	-0.17**	
Diagnostic Tests							
R^2	**SSE**	**RSS**	**JB**	**LB**	**RESET**	**ARCH1**	**ARCH3**
0.445	0.051	9.11	2.8	7.06	1.45	2.1	3.06

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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.

6.3.3.2 Exchange rate volatility and UK Imports in the Presence of Third-Country Exchange Rate Risk Before and Including the Financial Crisis

This section discusses the error correction and 'General-to-Specific' causality results in the context of third country exchange rate risk (section 2.5.2). This is particularly important since changes in bilateral trade between two countries may be affected by exchange rate fluctuations with respect to a third country which, in turn, may influence trading competition. Tables 6.11-6.12 present the results with respect to both nominal and real exchange rate volatilities. The error correction model is estimated during both the pre-crisis sub-period and then for the full period in order to analyse the impact of the recent financial crisis on UK imports. Country specific discussion of the results in this context is as follows:

6.3.3.2.1 Brazil

The error correction estimates are significant at the 1% level across both data samples, as well as both types of exchange rate volatilities employed. This shows strong Granger causality jointly caused by changes in third country exchange rate volatility in addition to the other underlying variables. Another important element is that the size of these terms increases when the financial crisis period is included. This shows an increase in the speed equilibrium correction after the financial crisis period across both nominal and real exchange rate volatilities. Third-country exchange rate volatility (risk), in addition to its long-term significance, also affects UK imports in the short-run, especially after inclusion of the financial crisis.

6.3.3.2.2 China

In the case of China, the error correction terms are significant across all instances, showing strong evidence of Granger causality between UK imports and all underlying determinant variables. However, a gradual decline is observed in the case of real exchange rate volatility after inclusion of the financial crisis period. Besides changes in imports at various lags, other important short-term variables include nominal exchange rate volatility and UK real income. Third-country exchange rate volatility is also shown to affect UK imports in the short-run as well.

6.3.3.2.3 South Africa

As shown in Tables 6.11 and 6.12, all cases provide significant evidence of causality from the determinant variables to UK real imports, and the overall impact is similar to the previous results. In both nominal and real terms of exchange rate volatility, the speed of adjustment to deviations from the long-run equilibrium is slightly higher when the financial crisis period is included in the analysis.

Lastly, all of the above results also include respective diagnostic test results for main anomalies such as: normality of residuals, heteroskedasticity/ARCH effects, Ramsey's misspecification test, and Ljung box autocorrelation test in addition to adjusted R-square, standard error of estimates and sum of squared residuals.

Table 6.11: **ECM – Causality Results: Impact of Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk Before the Financial Crisis (Jan 1991 – June 2007)**

Nominal

Brazil							
LAGS	**Constant**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Nominal Volatility**	**Δ Third Country Volatility**
1	-	-0.18***	-0.47***	4.20**	-	-	-1.23**
2	-	-	-0.16***	-	-	-	-
3	-	-	-0.11**	4.34**	-	-	-1.92***
5	-	-	-0.11**	-	-	-	-
7	-	-	-0.22***	-	-	-0.009*	-
8	-	-	-0.2***	-	-	-	-
11	-	-	-3.85***	-	-	-	-
12	-	-	-2.54**	-	-	-	-
Diagnostic Tests							
R^2	**SSE**	**RSS**	**JB**	**LB**	**RESET**	**ARCH1**	**ARCH3**
0.406	0.0248	5.58	1.153	11.76	0.307	0.336	3.001
China							
LAGS	**Constant**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Nominal Volatility**	**Δ Third Country Volatility**
1	-	-0.0028**	-0.24***	1.9***-	-	-0.712**	-0.54**
2	-	-	-0.13***	2.48***	-11.32***	-	-
5	-	-	-0.15***	-	-	1.217***	-
6	-	-	-0.2***	-	4.96*	-	-
7	-	-	-0.24***	-	-	-	-
8	-	-	-0.12***	-	-	-	-
9	-	-	-	-	7.62***	-	0.472**
12	-	-	0.46***	-1.18**	-	-	-
Diagnostic Tests							
R^2	**SSE**	**RSS**	**JB**	**LB**	**RESET**	**ARCH1**	**ARCH3**
0.603	0.005	1.107	0.267	7.30	0.64	0.292	2.60
South Africa							
LAGS	**Constant**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Nominal Volatility**	**Δ Third Country Volatility**
0	-	-	-	6.47***	-	-	-
1	-	-0.226***	-0.44***	-	-	-	-2.73***
2	-	-	-0.34***	-	-	-	-
3	-	-	-0.28***	4.04**	-	-	-2.52***
4	-	-	-0.25***	-	3.57***	-	-
5	-	-	-0.25***	-	-	-	-
6	-	-	-	-	2.69**	-	-
9	-	-	-	-	-	-	-
10	-	-	-0.1**	-	-2.40***	-	-

11	-	-	-	-	-	-	-1.48**
12	-	-	-	-	-	-	-1.23*
Diagnostic Tests							
R^2	**SSE**	**RSS**	**JB**	**LB**	**RESET**	**ARCH1**	**ARCH3**
0.432	0.052	11.58	1.225	5.325	0.523	0.345	1.183

Real

Brazil							
LAGS	**Constant**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Real Volatility**	**Δ Third Country Volatility**
0	-	-	-	-	-	-	-
1	-	-0.18***	-0.46***	-	4.17**	-	-1.23**
2	-	-	-0.17***	-	-	-	-
3	-	-	-	-	4.88**	-	-1.95***
5	-	-	-0.1*	-		0.008*	-
7	-	-	-0.23***	-	-	-0.009*	-
8	-	-	-0.21***	-	-	-	-
11	-	-	-	-3.93***	-	0.012**	-
12	-	-	-	-2.46**	-	-	-
Diagnostic Tests							
R^2	**SSE**	**RSS**	**JB**	**LB**	**RESET**	**ARCH1**	**ARCH3**
0.424	0.024	5.375	1.401	11.17	0.304	0.512	2.485
China							
LAGS	**Constant**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Real Volatility**	**Δ Third Country Volatility**
0	-	-	-	1.89***	-	-	-
1	-	-0.003***	-0.24***	-	-	-0.822**	-0.61**
2	-	-	-0.13***	2.47***	-11.27***	-	-
5	-	-	-0.15***	-	-	1.47***	-
6	-	-	-0.2***	-	4.95*	-	-
7	-	-	-0.24***	-	-	-	-
8	-	-	-0.12***	-	-	-	-
9	-	-	-	-	7.63***	-	-
10	-	-	-	-	-	-	0.53**
12	-	-	0.45***	-1.18**	-	-	-
Diagnostic Tests							
R^2	**SSE**	**RSS**	**JB**	**LB**	**RESET**	**ARCH1**	**ARCH3**
0.603	0.005	1.109	0.224	7.365	0.594	0.324	2.59

South Africa							
LAGS	**Constant**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Real Volatility**	**Δ Third Country Volatility**
0	-	-	-	6.31***	-	-	-
1	-	-0.217***	-0.45***	-	-	-	-2.82***
2	-	-	-0.34***	-	-	-	-
3	-	-	-0.29***	4.06**	-	-	-2.76***
4	-	-	-0.25***	-	3.54***	-	-
5	-	-	0.26***	-	-	-	-
6	-	-	-	-	2.39**	-	-
9	-	-	-	-	-	-	-
10	-	-	-0.102**	-	-3.18**	-	-
11	-	-	-	-	-	-	-1.61**
12	-	-	-	-	-	-	-1.33*
Diagnostic Tests							
R^2	**SSE**	**RSS**	**JB**	**LB**	**RESET**	**ARCH1**	**ARCH3**
0.431	0.0522	11.60	1.22	5.32	0.549	0.3449	1.183

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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 6.12: ECM – Causality Results: Impact of Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk Including the Financial Crisis (Jan 1991 – Dec 2011)

Nominal

Brazil							
LAGS	**Constant**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Nominal Volatility**	**Δ Third Country Volatility**
1	-	-0.18***	-0.48***	-	-	-	-1.094**
2	-	-	-0.19***	-	-	-	-
3	-	-	-	-	5.92***	-	-1.4***
5	-	-	-0.093**	-	0.009*	-0.009**	-
7	-	-	-0.23***	-	-	-	-
8	-	-	-0.211***	-	-	-0.0094**	-
11	-	-	-	-3.58***	-	-	-
12	-	-	-	-2.22*	-	-	-
Diagnostic Tests							
R^2	**SSE**	**RSS**	**JB**	**LB**	**RESET**	**ARCH1**	**ARCH3**
0.409	0.0246	5.55	0.474	10.69	1.141	0.620	1.755
China							
LAGS	**Constant**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Nominal Volatility**	**Δ Third Country Volatility**
0	-	-	-	2.12***	-	-1.105**	-
1	-	-0.011**	-0.245***	-	-	-	-0.554***
2	-	-	-0.109**	2.36***	-.1043***	1.037**	-
5	-	-	-0.127***	-	-	1.013**	-
6	-	-	-0.211***	-	-	-	-
7	-	-	-0.208***	-1.00*	-	-	-0.403*
8	-	-	-0.113**	-	.0920***	-	-
12	-	-	0.505	-1.15**	-	-	-
Diagnostic Tests							
R^2	**SSE**	**RSS**	**JB**	**LB**	**RESET**	**ARCH1**	**ARCH3**
0.5954	0.0051	1.125	0.4043	6.084	1.080	0.7022	3.051
South Africa							
LAGS	**Constant**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Nominal Volatility**	**Δ Third Country Volatility**
0	-	-	-	5.745***	-	-	-
1	-	-0.151***	-0.537***	-	-	-	-2.447***
2	-	-	-0.423***	4.132**	-	-	-1.85***
3	-	-	-0.328***	-	-	-	-2.13***
4	-	-	-0.275***	-	43.814***	-	-
5	-	-	-0.288***	-	-	-	-
6	-	-	-	-	29.379***	-	-
10	-	-	-	-	-40.114***	-	-
11	-	-	0.156***	-	19.612*	-	-
12	-	-	0.090*	-	-	-	-
Diagnostic Tests							
R^2	**SSE**	**RSS**	**JB**	**LB**	**RESET**	**ARCH1**	**ARCH3**
0.4455	0.051	11.27	0.245	6.26	2.55	5.8379	6.255

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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.

Real

Brazil							
LAGS	**Constant**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Real Volatility**	**Δ Third Country Volatility**
0	-	-	-	-	-	-	-
1	-	-0.159***	-0.464***	-	3.893*	-	-1.294**
2	-	-	-0.193***	-	-	-	-
3	-	-	-	-	6.074***	0.009*	-1.719***
5	-	-	-0.089*	-	-	-	-
7	-	-	-0.233***	-	-	-0.0112**	-
8	-	-	-0.213***	-	-	-0.013**	-
11	-	-	-	-3.457***	-	-	-
12	-	-	-	-	-	-	-
Diagnostic Tests							
R^2	**SSE**	**RSS**	**JB**	**LB**	**RESET**	**ARCH1**	**ARCH3**
0.425	0.024	5.38	0.211	12.85	1.014	0.2726	1.144
China							
LAGS	**Constant**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Real Volatility**	**Δ Third Country Volatility**
0	-	-	-	2.139***	-	-1.415**	-
1	-	-0.0114**	-0.245***	-	-	-	-0.642***
2	-	-	-0.109**	2.367***	-0.10419***	1.323**	-
5	-	-	-0.129***	-	-	1.27**	-
6	-	-	-0.212***	-	-	-	-
7	-	-	-0.206***	-1.004*	-	-	-0.469***
8	-	-	-0.114**	-	-	-	-
9	-	-	-	-	9.173***	-	-
12	-	-	0.504***	-1.172**	-	-	-
Diagnostic Tests							
R^2	**SSE**	**RSS**	**JB**	**LB**	**RESET**	**ARCH1**	**ARCH3**
0.595	0.0051	1.125	0.3392	6.119	0.998	0.660	3.086
South Africa							
LAGS	**Constant**	**ECM**	**Δ Imports**	**Δ Real Income UK**	**Δ Relative Prices**	**Δ Real Volatility**	**Δ Third Country Volatility**
0	-	-	-	6.011***	-	-	-
1	-	-0.174***	-0.499***	-	-	-	-2.94***
2	-	-	-0.4***	-	-	0.14*	-2.09***
3	-	-	-0.3***	4.67***	-	-	-2.25***
4	-	-	-0.263***	-	0.426***	-	-
5	-	-	-0.280***	-	-	-	-
6	-	-	-	-	0.281**	-	-
10	-	-	-	-	-0.363***	-	-
11	-	-	0.117**	-	19.95*	-	-
Diagnostic Tests							
R^2	**SSE**	**RSS**	**JB**	**LB**	**RESET**	**ARCH1**	**ARCH3**
0.447	0.05	11.23	0.483	8.759	1.63	0.803	5.53

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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.

6.4 Asymmetric ARDL Method

This section extends the evidence relating to exchange rate volatility and UK imports from the developing countries, including Brazil, China and South Arica, by employing the asymmetric nonlinear ARDL method, proposed by Shin *et al.* (2013), in addition to the ARDL bounds testing approach (Pesaran, Shin and Smith, 2001).

Tables 6.13-6.27 show the results under the various hypotheses tested with this method. The following section discusses the cointegration results for all three countries included in the sample.

6.4.1 Asymmetric ARDL Cointegration Results

This section presents the hypothesis test results based on the asymmetric ARDL model, as shown in Tables 6.13-6.16. Tables 6.13-6.14 include the F-test results for the basic hypothesis analysing the impact of bilateral exchange rate volatility on UK imports from Brazil, China and South Africa, whereas Tables 6.15-6.16 provide the F-test results for the second major hypothesis evaluating the role of third country exchange rate volatility on the basic relationship identified in the first hypothesis. Each of these hypotheses further analyses the impact of the recent financial crisis on the underlying relationship by discussing the results for before the financial crisis and then after inclusion of the crisis period. Further results are provided for both nominal and real exchange rate volatilities under each hypothesis in this thesis. Third country exchange rate volatility (risk) has been proxied by the dollar-pound volatility throughout this section. The statistical significance of the estimates is evaluated at the conventional thresholds of the 10%, 5% and 1% levels. Country specific discussion of these results is provided in the following sub-sections:

6.4.1.1 Exchange rate volatility and UK Imports Before and Including the Financial Crisis

6.4.1.1.1 Brazil

In the case of Brazil, significant cointegration, or a long-run equilibrium relationship, is reported in all cases under the Asymmetric ARDL method at the 1% level (Tables 6.13 and 6.14). It means that this relationship holds irrespective

of the nominal or real exchange rate volatilities or the time period, whether before or after inclusion of the financial crisis. These results indicate that UK imports are collectively determined by the exchange rate volatility (Real/GBP) along with UK real income and relative import price ratio. Secondly, UK imports respond differently to positive and negative shocks to the determinant variables in the long-run. Thirdly, the results show consistency over both sample lengths, implying a stable long-run relationship among the underlying variables.

Lastly, the cointegration results under both the Symmetric ARDL (section 6.3.1.1.1) and the Asymmetric ARDL as discussed here, are similar, i.e. significant cointegration is reported under both nominal and real exchange rate volatility. This further adds to the consistency of the relationship among the variables.

6.4.1.1.2 China

Similar to Brazil, significant cointegration is reported for China for both nominal and real exchange rate volatilities for both before and including the financial crisis periods (Tables 6.13 and 6.14). Hence, a long-run equilibrium relationship is reported for UK imports and Yuan/GBP exchange rate volatility along with UK real income and relative import price ratio between the two countries. Due to the application of the Asymmetric ARDL, rejection of the null hypothesis implies that the underlying long-run relationship is asymmetric in nature, i.e. positive and negative shocks in the independent variables affect UK imports differently. Detailed analysis of the positive and negative components of the respective independent variables is provided in section 6.4.2, and formal tests of the asymmetric effect of the independent variables, both in the short and long-run, are discussed in section 5.5.4.

6.4.1.1.3 South Africa

Table 6.13 reveals a long-run asymmetric cointegration or equilibrium relationship for South Africa for all periods. These results show 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 South Africa.

6.4.1.1.4 Summary

To summarize the findings regarding the impact of exchange rate volatility (both nominal and real terms) on UK imports in the context of the financial crisis, Tables 6.13 and 6.14 provide strong evidence of a long-run asymmetric relationship among the underlying variables across all three developing countries, i.e. Brazil, China and South Africa. Moreover, these relationships hold both before and after inclusion of the financial crisis, implying the stochastic stability of the underlying relationships. Lastly, 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.

6.4.1.1.5 Comparison of Results for Developed and Developing Countries

Comparison between the developed and developing countries shows that an asymmetric relationship is found in most cases in the developed countries however, in the case of the developing countries, the long-run relationship using Asymmetric ARDL is significant irrespective of the time period or volatility method (nominal/real) selected. This is similar to the findings reported in section 6.3.1.1.5 above. This implies stronger evidence for the exchange rate volatility impact on UK imports for developing countries compared to developed economies.

Table 6.13: Asymmetric ARDL Results - Impact of Exchange Rate Volatility on UK Imports Before the Financial Crisis (Jan-1991 to June-2007)

Nominal

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB (12)	RESET (3)	ARCH (1)	ARCH (3)
Brazil	10.96***	0.57	0.016	2.654	4.04	14.94	0.261	0.913	2.341
China	5.64***	0.66	0.004	0.66	2.521	6.85	1.10	0.181	3.007
South Africa	24.42***	0.53	0.043	7.155	1.269	7.175	0.86	0.291	0.579

Real

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	21.8***	0.522	0.044	7.45	1.96	1.85	0.270	1.024	1.253

Africa									

Note:
1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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 6.14: Asymmetric ARDL Results - Impact of Exchange Rate Volatility on UK Imports (Jan-1991 to Dec-2011)

Nominal

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB (12)	RESET (3)	ARCH (1)	ARCH (3)
Brazil	12.6***	0.53	0.019	4.25	3.57	9.95	0.771	0.78	4.25
China	6.96***	0.62	0.0048	1.01	0.19	8.90	0.97	1.089	3.381
South Africa	23.2***	0.48	0.047	10.043	1.64	6.86	1.706	0.8967	2.395

Real

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-Square; 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.

6.4.1.2 Exchange rate volatility and UK Imports in the presence of Third Country Exchange Rate Risk Before and Including the Financial Crisis

After testing the basic relationship between exchange rate volatility and UK imports often cited in the literature, this research then explores third-country exchange rate risk and the possibility of any impact on the basic relationship tested in section 6.4.1.1. Theoretical details of third-country exchange rate risk are provided in section 2.4 and a formal hypothesis to empirically test the third-country effect is described in section 2.5.2. Third-country exchange rate risk is proxied by USD/GBP exchange rate volatility when the relationship between the UK and these developing countries is tested. Empirical results for the F-Test

under the Asymmetric ARDL method for both samples lengths are provided in Tables 6.15 and 6.16.

6.4.1.2.1 Brazil

In the case of Brazil, an asymmetric long-run equilibrium relationship is indicated for both nominal and real exchange rate volatilities for both sample lengths. This indicates that USD/GBP (third-country) volatility, along with the rest of the underlying variables, is an additional determinant of UK imports from Brazil. Furthermore, this relationship holds in all cases where different volatility or time periods are employed, adding to the reliability and stability of this relationship.

6.4.1.2.2 China

The evidence in the case of China is similar to Brazil, with significant asymmetric cointegration reported irrespective of the volatility type and sample periods employed. Thus, USD/GBP (third-country) exchange rate risk is observed to be an additional regressor along with the rest of the variables. Therefore, the null hypothesis of no cointegration is rejected at the 1% or 5% significance level in all instances.

6.4.1.2.3 South Africa

For South Africa, the null hypothesis of no cointegration is rejected in all the cases at the 1% or 5% significance levels. This shows strong evidence of an asymmetric long-run relationship in the presence of third-country exchange rate risk. Furthermore, this result is in line with the findings presented for Brazil and China above.

6.4.1.2.4 Summary

Tables 6.15 and 6.16 include the third-country exchange rate risk as an additional determinant of the UK's imports. Third country exchange rate risk has been proxied by the dollar-pound real exchange rate volatility for UK imports from Brazil, China and South Africa. The null hypothesis of no asymmetric cointegration is rejected across all countries for both the pre-crisis and total periods at the 1%-5% conventional level. This finding provides clear evidence in support of 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.

6.4.1.2.5 Comparison of Results for Developed and Developing Countries

Results for both developed and developing countries show a long-run equilibrium relationship between UK imports and exchange rate volatility, besides other underlying variables, in the presence of third country exchange rate risk across both sample lengths and when either nominal/real exchange rate volatilities are employed. This shows the significance of third country exchange rate risk as an additional determinant of UK imports from both developed and developing countries using the Asymmetric ARDL method. Furthermore, these findings are in line with the results reported under the ARDL method in section 6.3.1.2.5.

Table 6.15: Asymmetric ARDL Results - Impact of Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk Before the Financial Crisis (Jan-1991 to June-2007)

Nominal

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB (12)	RESET (3)	ARCH (1)	ARCH (3)
Brazil	8.7***	0.597	0.015	2.454	1.05	12.89	0.713	0.07	0.77
China	5.28***	0.647	0.004	0.723	2.41	7.074	1.01	0.058	3.855
South Africa	8.33***	0.649	0.0325	5.016	1.31	5.43	2.8	0.28	1.34

Real

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 6.16: 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)

Nominal

Countries	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB (12)	RESET (3)	ARCH (1)	ARCH (3)
Brazil	12.9***	0.54	0.018	4.068	1.89	17.33	0.62	0.135	1.317
China	6.2***	0.614	0.005	1.037	0.30	6.69	0.168	1.114	1.850
South	23.5***	0.545	0.0418	8.745	1.73	3.960	0.545	0.219	0.432

Africa									

Real

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-Square; 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.

6.4.2 Normalized Equations and Long-Run Elasticities

This section presents estimates for the long-run normalized coefficients of the underlying independent variables, following traditional cointegration methodology. These estimates help in inferring the long-run relationship between the underlying regressors (UK real income, relative price ratio and exchange rate volatility) and the dependent variable (UK imports). In this case, the independent variables are represented by the positive and negative partials of the underlying variables, i.e. real income, relative price ratio and exchange rate volatility, and these have been normalized on UK imports. These estimates provide long-run elasticities of the respective independent variables and represent the percentage change in UK imports due to a unit change in these independent variables. Tables 6.17-6.20 present the estimated normalized equations for the different hypotheses for the developing countries. The significance of the coefficients is presented for the 10%, 5% and 1% levels.

6.4.2.1 Exchange rate volatility and UK Imports Before and Including the Financial Crisis

Tables 6.17-6.18 show the normalized equations under the Asymmetric ARDL method (Shin, Yu and Greenwood-Nimmo, 2013) for Brazil, China and South Africa before and including the financial crisis period under both nominal and real exchange rate volatilities. Results for the respective independent variables follow in the proceeding sub-sections:

6.4.2.1.1 UK Real Income

Tables 6.16 and 6.17 show that a 1% positive change in the underlying variable increases the demand for imports from Brazil by 0.126%, whereas a 1% negative change in UK real income reduces imports by 2.692% before the financial crisis period. After inclusion of the financial crisis, the elasticity in the case of positive changes in real income increases to 5.66%, whereas in the case of negative changes in real income, the sensitivity decreases as a 1% negative change depresses imports by only 0.67%. This shows the significant asymmetric effect of UK real income, which becomes further evident after the financial crisis is included. The results also show that UK imports from Brazil become more elastic to the positive changes in UK real income, however, elasticity to negative changes in UK real income decreases significantly under both nominal and real exchange rate volatility specifications.

In the case of China, similarly, a 1% positive change in UK real income increases UK imports by 4.65%, whereas a 1% negative change is responded to by a decline in the imports from China of 1.843% before the financial crisis. However, after inclusion of the recent financial crisis period, Table 6.17 shows a massive increase in the positive real income elasticity of UK imports, or in other words, any positive change in real income after inclusion of the financial crisis period results in a relatively higher increase in imports, i.e. 12.14% as compared to 1.843% before the financial crisis period. Interestingly, the coefficient for negative changes in real income is 0.346% for the full sample length, which implies that the elasticity changes from negative to positive after inclusion of the financial crisis period.

Lastly, for South Africa, using nominal exchange rate volatility, UK imports show an inverse relationship with positive real income elasticity before the financial crisis, with a coefficient of -2.84% (Table 6.16). However, in many cases real income coefficients are insignificant in the case of South Africa, which makes it relatively difficult to infer clearly regarding the impact of the positive and negative income elasticity of UK imports across both samples.

6.4.2.1.2 Relative Imports Price Ratio

In the case of Brazil, a direct relationship is documented between import price elasticity and UK imports for both positive and negative changes in the

underlying variable. It implies that a unit increase in the relative price causes the UK imports to increase by 0.957%, whereas a unit decrease is responded to by a 3.428% increase in UK imports in the pre-crisis sample. However, after inclusion of the financial crisis, sensitivity to a positive variation in import prices is noted at -2.31 whereas the coefficient for negative changes is 0.78, implying a change in both the direction (sign) as well as the magnitude (size) of the respective long-run import price elasticities after inclusion of the financial crisis period. As a result, UK imports from Brazil show greater import price elasticity after inclusion of the financial crisis. Similar effects are reported for real exchange rate volatility. This increase in import price elasticity after inclusion of the financial crisis may be attributed to an increase in the degree of risk aversion of the buyers/sellers, whereby any small change in the import price leads to a greater reaction in the form of a reduction in trade volume.

In the case of China, similar results are reported where sensitivity to both positive and negative changes in the import price ratio increases from 5.73 to -16.3, and 2.18 to 14.35, respectively. Results under the real exchange rate specification show the same effect due to the inclusion of the financial crisis period. This, as already noted above, may be explained by an increased risk-aversion among the UK's domestic market, where any relative positive (negative) change in the import prices is responded to by a greater decline (rise) in the demand for Chinese imports in the UK.

Demand for South Africa exports in the UK responds differently to positive and negative changes in import prices before and after inclusion of the financial crisis. In the case of a positive unit change, UK imports respond by 17.88% and 11.903% for both sample lengths, whereas a negative unit change results in a decline in UK imports by 2.13% and 5.09%, respectively. This shows the significant asymmetric effect found across both sample lengths with respect to the underlying variables.

6.4.2.1.3 Exchange Rate Volatility (Nominal and Real)

Tables 6.16 and 6.17 provide the normalized coefficient estimates for exchange rate volatility variables (both nominal and real), which are also the main independent variables of interest in this thesis. In the case of Brazil, estimates for both nominal and real exchange rate volatility are significantly negative at the 5% level, with some evidence of asymmetric effect as well. Here, the positive

(negative) component coefficients provide evidence of the sensitivity of UK imports against a positive (negative) unit change or increase in volatility. The sign of each coefficient shows the direction of the exchange rate volatility changes on the UK imports from the respective countries. For instance, a unit increase in the Real/GBP nominal volatility results in a 0.006% decline in imports from Brazil. Similarly, a unit negative change in the underlying volatility decreases imports by 0.002%. In simple words, UK imports respond slightly differently to positive and negative changes in Real/GBP nominal and real exchange rate volatility. This asymmetric relationship holds even after inclusion of the financial crisis period. Overall, however, UK imports have shrunk, irrespective of the decline in Real/GBP volatility, which may be explained by an overall reduced aggregate demand for imported goods.

In the case of China, a similar asymmetric effect is reported under real exchange rate volatility for both sample lengths. A change in the response of UK markets towards Yuan/GBP real volatility can be seen over the two sample periods. Before the financial crisis, the results are pretty standard as a negative impact of positive changes (increase) in volatility on UK imports is observed, whereas an increase in imports is caused by a decline in exchange rate volatility. However, after inclusion of the financial crisis, the sensitivity of UK imports towards Yuan/GBP real volatility has increased for both positive and negative changes, indicating a rise in risk aversion on the part of the buyers in the UK.

Exchange rate volatility (both nominal and real) for USD/GBP adversely affects UK imports during both sample periods (Tables 6.16 and 6.17). Further long-run parameters for volatilities in all cases for South Africa show greater sensitivity of UK imports towards real volatility shocks as compared to nominal volatility. Interestingly, after the inclusion of the financial crisis, an increase in the coefficients is reported for nominal volatility, whereas in the case of real volatility, the sensitivity for sample lengths shows a decline. This shows that, overall, an increase in exchange rate volatility means UK imports are depressed, but in terms of real value, USD/GBP has been more resistant compared to other currencies included in the analysis above, such as Real/GBP and Yuan/GBP.

Table 6.17: Normalized Coefficients - Impact of Exchange Rate Volatility on UK Imports Before the Financial Crisis (Jan 1991 – June 2007)

Nominal

Countries	Constant	Real Income		Relative Prices		Nominal Volatility	
		Positive	Negative	Positive	Negative	Positive	Negative
Brazil	4.86***	0.126	-2.692***	0.957	3.428**	0.0066	0.0018
China	4.96***	4.65***	-1.84***	5.73**	2.18**	-2.49***	2.354***
South Africa	4.09***	-2.84***	-1.29	17.88*	-21.3	-0.63***	-0.63***

Real

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 6.18: Normalized Coefficients - Impact of Exchange Rate Volatility on UK Imports Including the Financial Crisis (Jan 1991 – Dec 2011)

Nominal

Countries	Constant	Real Income		Relative Prices		Nominal Volatility	
		+ve	-ve	+ve	-ve	+ve	-ve
Brazil	5.004***	5.66***	-0.67*	-2.31***	7.08***	0.01	0.006
China	4.91***	12.14***	0.346**	-16.3***	14.35***	14.82	15.01
South Africa	4.352***	1.021	7.612***	11.903	-50.9***	-0.35	-1.02

Real

Countries	Constant	Real Income		Relative Prices		Real Volatility	
		+ve	-ve	+ve	-ve	+ve	-ve
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-Square; 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.

6.4.2.2 Exchange rate volatility and UK Imports in the Presence of Third-Country Exchange Rate Risk Before and Including the Financial Crisis

Tables 6.18 and 6.19 provide normalized long-run coefficients for the underlying independent variables under the second hypothesis, whereby the impact of third-country exchange rate risk is assessed over the basic bilateral relationship between UK imports and exchange rate volatility of its trade partners, as explained in section 2.5.2. These coefficients represent the percentage change in UK imports against a 1% change in the underlying independent variables. Detailed descriptions of these coefficients for the respective variables are provided in the following sections:

6.4.2.2.1 UK Real Income

In the case of Brazil, long-run coefficients are mostly significant for both positive and negative components ranging from the 1% to 5% significance levels, with the exception of one case, where, after inclusion of the financial crisis, the long-run coefficient for negative changes in UK real income is insignificant. This shows the asymmetric effect of the changes in UK real income over its imports and further strengthens the evidence regarding asymmetry in economic/financial time series. Furthermore, the above findings hold even after extending the sample to include the recent financial crisis, showing the stability of the long-run estimates for this variable.

For China, UK real income is shown to be a significant determinant of bilateral trade between the two countries, after controlling for third-country exchange rate risk proxied by USD/GBP exchange rate volatility. UK imports are observed to be more sensitive where exchange rate volatilities are estimated in nominal terms compared to real exchange rate volatility. Furthermore, UK imports become more real income elastic after inclusion of the financial crisis. This shows the demand for Chinese products in the UK is relatively more depressed due to negative changes (decline) in the real income then positive variations (rise)

Lastly, in the case of South Africa, income elasticity increases after inclusion of the financial crisis period, where volatilities are expressed in real terms, as reported for China in the above paragraph. Parameters are significantly

asymmetric under nominal volatilities only before the financial crisis, as no cointegration is reported after inclusion of the financial crisis period.

6.4.2.2.2 Relative Prices

Relative price ratios are reported to be significant in most of the cases for Brazil and China, with a significance level ranging from 1% to 5% (Tables 6.18 and 6.19). The asymmetric effect is found in all significant cases as well. After inclusion of the recent financial crisis period, the import price elasticity further increases, especially for the negative change in the import price ratio, providing evidence that UK imports are relatively more affected by negative variations in import price elasticity than positive ones. This shows evidence of the asymmetric effect found in the data.

Relative price elasticity in the case of South Africa shows a greater effect on UK imports both in terms of asymmetry and inter temporal shift due to the financial crisis. The results under nominal volatility are shown only for before the financial crisis period, as no cointegration is reported for the full sample length.

6.4.2.2.3 Exchange Rate Volatility (Nominal and Real)

Tables 6.18 and 6.19 provide the normalized coefficient estimates for the exchange rate volatility variable (both nominal and real), which is also the main independent variable of interest in this thesis. Here, the positive (negative) component coefficients demonstrate the sensitivity of UK imports against a positive (negative) unit change or increase in the volatility. The sign of each coefficient shows the direction of exchange rate volatility changes on the UK imports from the respective countries. In simple words, UK imports respond differently to positive and negative changes in Real/GBP nominal volatility. This asymmetric relationship holds even after inclusion of the financial crisis period. Although overall UK imports have shrunk, irrespective of the decline in Real/GBP volatility, this may be explained by the reduced aggregated demand for imported goods.

In the case of China, a similar asymmetric effect is reported under real exchange rate volatility for both sample lengths. A change in the response of UK markets towards Yuan/GBP real volatility can be seen over the two sample periods. Before the financial crisis, the results are pretty standard as a negative impact of

positive changes (increase) in volatility on UK imports is observed, whereas an increase in imports is caused by a decline in exchange rate volatility. However, after inclusion of the financial crisis, the sensitivity of UK imports towards Yuan/GBP real volatility has increased for positive and negative changes, indicating a rise in risk aversion on the part of the buyers in the UK.

Exchange rate volatility (both nominal and real) for USD/GBP adversely affects UK imports during both sample periods (Tables 6.18 and 6.19). Furthermore, long-run parameters for volatilities in all cases for South Africa show the greater sensitive of UK imports towards real volatility shocks as compared to nominal volatility. Interestingly, after inclusion of the financial crisis, an increase in the coefficients is reported for nominal volatility, whereas in the case of real volatility the sensitivity for sample lengths shows a decline. This shows that, overall, due to an increase in exchange rate volatility, UK imports are depressed, but in terms of real value, USD/GBP has been more resistant compared to other currencies included in the analysis above, such as Real/GBP and Yuan/GBP.

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 UK's imports respond negatively to dollar-pound volatility, whereas real-pound and yuan-pound volatilities cause an increase in the UK's imports over both sample periods.

Table 6.19: Normalized Coefficients - Impact of Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk Before the Financial Crisis (Jan 1991 – June 2007)

Nominal

Countries	Const.	Real Income		Relative Prices		Nominal Volatility		Third Country Nominal Volatility	
		+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
Brazil	4.978***	-0.463	-3.11***	1.688	3.304***	0.012*	0.005	-1.11***	-0.766**
China	4.68***	-0.57	-5.81***	3.15	-1.76*	2.09***	3.62***	-2.19***	-2.43***
South Africa	4.68***	3.66*	-0.03	6.86	1.98	-0.55***	-0.52***	-0.49	1.39***

Real

Countries	Const.	Real Income		Relative Prices		Real Volatility		Third Country Real Volatility	
		+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
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 6.20: Normalized Coefficients - Impact of Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk Including the Financial Crisis (Jan 1991 – Dec 2011)

Nominal

Countries	Const.	Real Income		Relative Prices		Nominal Volatility		Third Country Nominal Volatility	
		+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
Brazil	5.09***	5.25***	-0.93**	-1.21	6.73***	0.009	0.006	-1.53***	-1.05***
China	5.38***	10.39***	-0.098	-10.5***	10.82***	1.27**	4.402***	-3.5***	-3.09***
South Africa	4.86***	4.90***	3.38***	6.60	19.78	-0.32**	-0.73***	-4.85***	-2.35***

Real

Countries	Constant	Real Income		Relative Prices		Real Volatility		Third Country Real Volatility	
		+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
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-Square; 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.

6.4.2.2.4 Third-Country Exchange Rate Volatility (Nominal and Real)

Third country exchange rate risk in this thesis has been proxied by USD/GBP nominal and real exchange rate volatilities for UK imports from Brazil, China and South Africa. Parameters for both positive and negative changes in third-country exchange rate volatility are mostly significant at the 1% or 5% level. This re-affirms the idea that third-country exchange rate risk is an important determinant of UK imports, along with bilateral volatility and other variables. Furthermore, it affects UK imports asymmetrically, i.e. a rise or decline in exchange rate volatility is not perceived equally by importers and exporters, but rather, more weight or sensitivity is shown towards an increase in the volatility as it increases the uncertainty towards the pricing of imports, and thereby the profits of the importers. This research thus reports an inverse effect of exchange rate volatility on UK imports. This result is in agreement with the traditional theoretical inverse relationship between exchange rate volatility and trade.

Interestingly, after inclusion of the third-country exchange rate risk, the UK's imports respond differently to the two volatility variables. For example, in the case of Brazil, real exchange rate (real-pound) volatility is significant and positive, whereas the third country (dollar-pound) volatility coefficients are significant and negative. These findings imply that the UK's imports from Brazil increase with respect to real-pound volatility while they decline in response to dollar-pound volatility. The demand for Chinese exports in the UK responds in a similar way. That is, positively to the yuan-pound volatility and negatively to the dollar-pound volatility. In the case of South Africa, real exchange rate (rand-pound) volatility has a significant negative impact, whereas third country (dollar-pound) volatility causes an increase in the UK's imports from South Africa during both the pre-crisis and the financial crisis periods. In absolute value, third country volatility imposes a larger effect. This clearly indicates the importance of taking into consideration the third country effect when investigating the relationship between exchange rate volatility and trade.

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 UK's imports respond negatively to dollar-pound volatility, whereas real-pound and yuan-pound volatilities cause an increase in the UK's imports over both sample periods.

6.4.3 Causality between UK Imports and its Determinants

Tables 6.20 – 6.23 present the causality results. Tables 6.20 and 6.21 show the pre-crisis and total period results (without the third country effect), respectively. Each table presents the 'General-to-Specific' causality results under both nominal and real exchange rate volatility. The following sub-sections describe the country specific causality results in detail:

6.4.3.1 Exchange rate volatility and UK Imports Before and Including the Financial Crisis

6.4.3.1.1 Brazil

As shown in Tables 6.20 and 6.21, restricted error correction terms using the Asymmetric ARDL method are significant and negative in all the cases, which suggest a long-run equilibrium relationship between UK imports from Brazil and

the underlying determinant variables. In other words, UK imports are Granger caused by the underlying variables collectively. The speed of adjustment before the financial crisis, as determined by the size of the coefficient on the error term, using nominal volatility is -0.72 and declines to -0.628 after inclusion of the financial crisis. This shows a delay in adjustment towards the long-run equilibrium caused by the financial crisis. Similarly, the speed of adjustment shows a reduction in the real volatility case as well. Moreover, positive changes in real income, positive and negative changes in relative import price ratio, and nominal/real exchange rate volatility also significantly affect UK imports in the short-run (Tables 6.20 and 6.21).

6.4.3.1.2 China

Error correction terms in the case of China are also significant in all cases, i.e. both under nominal and real exchange rate volatilities as well as both before and after inclusion of the financial crisis period. This shows that the underlying variables Granger cause UK imports jointly, irrespective of the time period selected and the type of exchange rate volatility employed. The size of the error correction term or speed of adjustment in the case of China also shows some delay after inclusion of the financial crisis period, as reported above for Brazil. In terms of the short-term relationships, positive and negative changes in the nominal/real exchange rate volatility, along with UK real income and relative import price at different lags, also affect UK imports from China in the short-run (Tables 6.20 and 6.21).

6.4.3.1.3 South Africa

Error correction terms for South Africa are significant in all cases at the 1% level, implying a strong causal relationship among the underlying variables. This relationship holds for both nominal and real exchange rate volatilities and also for before and after inclusion of the financial crisis period. A relative decrease in the absolute value of the estimated error correction term is observed from the pre-crisis period to the full period under both nominal and real exchange rate volatilities, strengthening the evidence regarding the delay in the long-run equilibrium correction across all developing countries after inclusion of the financial crisis period.

6.4.3.1.4 Comparison of Causality Results from Developed and Developing Countries

Error correction terms for both developed and developing countries under the Asymmetric ARDL method are significantly negative at the 1% level for both before and after inclusion of the financial crisis. Furthermore, after inclusion of the financial crisis, the error correction term or speed of adjustment towards the long-run equilibrium slows down. In the short-run, UK imports are affected, besides its own lags, by positive and negative changes in exchange rate volatility, the UK's real income and the relative import price ratio.

Table 6.21: ECM – Causality Results: Impact of Exchange Rate Volatility on UK Imports Before the Financial Crisis (Jan 1991 – June 2007)

Nominal

Brazil								
Lags	**ECM**	**Δ Imports**	**Δ Real Income**		**Δ Relative Prices**		**Δ Nominal Volatility**	
			+ve	**-ve**	**+ve**	**-ve**	**+ve**	**-ve**
0	-	-	-	-	-	-	-0.011*	-
1	-0.72***	-0.18***	-	-	-	10.50***	-0.02***	-
3	-	-	-	-	10.14***	-	-	-
4	-	0.094*	-	-	-	7.17**	-	-
6	-	-	-7.02***	-	-	-	-	0.013**
7	-	-0.23***	-7.11***	-	-	-	-	-
8	-	-0.25***	-	-	-	-	-	-
10	-	-	-	-	-	-	0.023***	-
Diagnostics								
R2	0.59	SSR	2.65	LB(12)	14.94	ARCH(1)	0.913	-
SSE	0.0155	JB	4.04	RESET(3)	0.265	ARCH(3)	2.34	-
China								
Lags	**ECM**	**Δ Imports**	**Δ Real Income**		**Δ Relative Prices**		**Δ Nominal Volatility**	
			+ve	**-ve**	**+ve**	**-ve**	**+ve**	**-ve**
0	-	-	2.96***	-	-	-	-	-
1	-0.19***	-0.21***	-3.53***	-	-	-	-	-
2	-	-	-	2.3**	-	-19.5***	-	-
3	-	-	-	-	-	-	-	-1.99***
4	-	-	-	-	-16.9***	-	-	-1.08**
5	-	-	-	-	-19.4***	-	-	-
6	-	-0.24***	-	3.2***	-	-	-	-0.99**
7	-	-0.19***	-	-	-	-	-	-
Diagnostics								
R2	0.681	SSR	0.66	LB(12)	1.47	ARCH(1)	0.264	-
SSE	0.004	JB	3.21	RESET(3)	6.67	ARCH(3)	3.209	-
South Africa								
Lags	**ECM**	**Δ Imports**	**Δ Real Income**		**Δ Relative Prices**		**Δ Nominal Volatility**	
			+ve	**-ve**	**+ve**	**-ve**	**+ve**	**-ve**
1	-0.87***	-	6.65*	-	-39.1***	112.3***	-	-
2	-	-	-	-	-	67.74**	-	-
3	-	-	-	-5.93**	-	87.48***	-	-
4	-	-0.13**	-	-	-	-	-	-
5	-	0.107**	-	-	-	-	-	-
6	-	-	-	-	-	-122.9***	-	-
7	-	-	6.43*	-6.81**	-	-	-	-
Diagnostics								
R^2	0.552	SSR	7.155	LB(12)	7.17	ARCH(1)	0.292	-
SSE	0.0416	JB	1.269	RESET(3)	0.85	ARCH(3)	0.579	-

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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.

Real

Brazil								
Lags	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Real Volatility	
			+ve	-ve	+ve	-ve	+ve	-ve
1	-0.67***	-0.18***	-	-	-	13.66***	-0.018***	-
3	-	-	-	-	9.37***	-	-	-
4	-	0.09*	-	-	-	6.97**	-	-
6	-	-	-7.49***	-	-	-	-	-
7	-	-0.23***	-7.07***	-	-	-	-0.017***	-
8	-	-0.25***	-	-	-	-	-	0.028**
9	-	-	-	-	-	-	0.021*	-
12	-	-	-	-	-	-	0.026***	-0.0105*
Diagnostics								
R^2	0.607	SSR	2.513	LB(12)	9.25	ARCH(1)	0.0609	-
SSE	0.014	JB	1.796	RESET(3)	0.114	ARCH(3)	1.420	-
China								
Lags	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Real Volatility	
			+ve	-ve	+ve	-ve	+ve	-ve
0	-		2.802***					
1	-0.189***	-0.219***	-3.712***					
2				2.074**		-19.19***	4.07***	
4					-16.50***			
5					-19.87***			
6		-0.255***		3.219***				
7		-0.179***						
8		-0.189***		2.56***	11.65**			
10		-0.113*	4.280***					-1.50***
11		-0.089**			-24.71**	17.05***		
12		0.435***						
Diagnostics								
R^2	0.677	SSR	0.678	LB(12)	6.46	ARCH(1)	0.1739	-
SSE	0.0041	JB	1.794	RESET(3)	1.49	ARCH(3)	3.8205	-
South Africa								
Lags	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Real Volatility	
			+ve	-ve	+ve	-ve	+ve	-ve
1	-0.823***	-	7.33**	-	-38.70	114.54***	-	-
2	-	-	-	-	-	57.11*	-	-
4	-	-	-	-6.35**	-	76.37**	-	-
5	-	-0.14***	-	-	-	-	-	-
10	-	-0.11**	-	-	-	-102.99	-	-
Diagnostics								
R^2	0.541	SSR	7.452	LB(12)	1.85	ARCH(1)	1.024	-
SSE	0.0425	JB	1.96	RESET(3)	0.25	ARCH(3)	1.253	-

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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 6.22: ECM – Causality Results: Impact of Exchange Rate Volatility on UK Imports Including the Financial Crisis (Jan 1991 – Dec 2011)

Nominal

Brazil								
Lags	**ECM**	**Δ Imports**	**Δ Real Income**		**Δ Relative Prices**		**Δ Nominal Volatility**	
			+ve	**-ve**	**+ve**	**-ve**	**+ve**	**-ve**
1	-0.628***	-0.209***	-	-	-	7.817***	-0.020***	-
3	-	-	-	-	7.066**	-	-	-
6	-	-	-7.464***	-	-	-	-	0.017***
7	-	-0.248***	-6.974***	-	9.323***		-	-
10	-	-0.215***	-3.767*	-	-	-	0.019***	-
12	-	-	-4.798**	-5.778	-	-	-	-
Diagnostics								
R2	0.545	SSR	4.257	LB(12)	9.95	ARCH(1)	0.783	-
SSE	0.019	JB	3.577	RESET(3)	0.77	ARCH(3)	4.254	-

China								
Lags	**ECM**	**Δ Imports**	**Δ Real Income**		**Δ Relative Prices**		**Δ Nominal Volatility**	
			+ve	**-ve**	**+ve**	**-ve**	**+ve**	**-ve**
0	-	-	2.57**	1.54*	-	-	-	-1.06**
1	-0.174***	-0.179***	-4.22***	-	-	-	-	-24.72***
2	-	-	1.71*	-	-	-16.21***	5.97***	-
5	-	-0.123***	-	-	-19.1***	-	-	-
6	-	-0.218***	-	-	-	-	-	-
7	-	-0.196***	-2.24**	-	-	-	-	-7.37***
8	-	-0.143***	-	-	8.95*	-	-	-
10	-	-0.112***	-	-	-	-	-	-
12	-	0.45***	-2.45**	-	-	-	-	-
Diagnostics								
R2	0.634	SSR	1.011	LB(12)	4.61	ARCH(1)	1.544	-
SSE	0.0046	JB	0.073	RESET(3)	1.62	ARCH(3)	2.567	-

South Africa								
Lags	**ECM**	**Δ Imports**	**Δ Real Income**		**Δ Relative Prices**		**Δ Nominal Volatility**	
			+ve	**-ve**	**+ve**	**-ve**	**+ve**	**-ve**
1	-0.686***	-	9.584***	-	-	11.45***	-	-
2	-	-	-	-	-	60.23*	-	1.82***
4	-	-0.114**	-	-7.2***	-	1.542***	0.468*	-0.8*
6	-	-	-	-	-	70.92**	-	-
7	-	0.09*	-	--6.04**	-	85.39***	-	-
11	-	0.099*	-	-	25.84**	-	-	-
12	-	0.138***	-	-8.23***	-	66.73**	-	-
Diagnostics								
R2	0.501	SSR	10.09	LB(12)	3.25	ARCH(1)	1.12	-
SSE	0.045	JB	1.16	RESET(3)	0.709	ARCH(3)	5.914	-

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. $R^{2:}$ Adjusted R-Square; 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.

Real

Brazil								
Lags	**ECM**	**Δ Imports**	**Δ Real Income**		**Δ Relative Prices**		**Δ Real Volatility**	
			+ve	**-ve**	**+ve**	**-ve**	**+ve**	**-ve**
1	-0.631***	-0.196***	-	-	-	8.42***	-0.019***	-
3	-	-	-	-	6.36**	-	-	-
6	-	-	-7.35***	-	-	-	-	0.023***
7	-	-0.246***	-7.2***	-	9.14***	-	-	-
8	-	-0.22***	-	-	-	-	-	-
11	-	-	-	-5.02***	-	-	0.0234***	-
12	-	-	-4.38**	-	-	-	-	-
Diagnostics								
R^2	0.551	SSR	4.225	LB(12)	17.17	ARCH(1)	0.717	-
SSE	0.0187	JB	2.37	RESET(3)	0.67	ARCH(3)	4.035	-
China								
Lags	**ECM**	**Δ Imports**	**Δ Real Income**		**Δ Relative Prices**		**Δ Real Volatility**	
			+ve	**-ve**	**+ve**	**-ve**	**+ve**	**-ve**
0	-	-	2.40**	1.63**	-	-	-	-1.21*
1	-0.183***	-0.164***	-3.52***	-	-	-15.1***	8.41***	-28.9***
2	-	-	-	1.41*	-	-	-	-9.47***
5	-	-0.115**	-	-	-18.42***	-	-	-
6	-	-0.225***	-	-	-	-	-	-
7	-	-0.202***	-2.33**	-	-	-	-	-
8	-	-0.141***	-	-	9.92**	-7.008*	-	-
10	-	-0.099**	-	-	-	-	-	-
12	-	0.439***	-2.45**	-	-	-	-	-
Diagnostics								
R^2	0.639	SSR	0.9947	LB(12)	8.14	ARCH(1)	0.916	-
SSE	0.0045	JB	0.1588	RESET(3)	1.73	ARCH(3)	1.963	-
South Africa								
Lags	**ECM**	**Δ Imports**	**Δ Real Income**		**Δ Relative Prices**		**Δ Real Volatility**	
			+ve	**-ve**	**+ve**	**-ve**	**+ve**	**-ve**
1	-0.685***	-	6.75**	5.53**	-	111.84***	-	-
2	-	-	-	-	-	61.22*	-	0.33***
4	-	-	-	-7.01***	-	147.15***	-	-
5	-	-0.131***	-	-	-	58.43*	-	-
10	-	-0.09*	-	-5.297**	-	84.62***	-	-
11	-	-	-	-	25.04**	-	-	-
12	-	-	6.26**	-8.32***	-	62.36***	-	-
Diagnostics								
R^2	0.477	SSR	10.68***	LB(12)	5.76	ARCH(1)	0.0178	-
SSE	0.0481	JB	1.282	RESET(3)	0.724	ARCH(3)	1.395	-

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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.

6.4.3.2 Exchange rate volatility and UK Imports in the Presence of Third-Country Exchange Rate Risk Before and Including the Financial Crisis

This section discusses the error correction and 'General-to-Specific' causality results in the context of third country exchange rate risk (section 2.5.2) using the Asymmetric ARDL method. This is particularly important since changes in bilateral trade between two countries may be affected by exchange rate fluctuations with respect to a third country which, in turn, may influence trading competition. Tables 6.22-6.23 present the results with respect to both nominal and real exchange rate volatilities. The error correction model is estimated during both the pre-crisis sub-period and then for the full period in order to analyse the impact of the recent financial crisis on UK imports. Country specific discussion of the results in this context is as follows:

6.4.3.2.1 Brazil

The error correction estimates are significant at the 1% level across both data samples as well as both types of exchange rate volatilities employed. This shows strong Granger causality whereby UK imports from Brazil are jointly caused by changes in third country exchange rate volatility in addition to other underlying variables. Another important element is that the size of these terms reduces when the financial crisis period is included. This shows a decrease in the speed equilibrium correction after the financial crisis period across both nominal and real exchange rate volatilities. This demonstrates that UK imports from Brazil are affected by both positive and negative changes in third-country exchange rate volatility (risk) at different lags, in addition to its long-term significance, which also affects UK imports in the short run.

6.4.3.2.2 China

In the case of China, error correction terms are significant across all instances, showing strong evidence of Granger causality between UK imports and all underlying determinant variables, including third country exchange rate volatility (risk). However, a gradual decline is again observed in the speed of the equilibrium correction after the inclusion of the financial crisis period. Besides changes in imports at various lags, other important short-term variables include positive and negative changes in nominal/real exchange rate

volatility and UK real income. Positive and negative changes in third-country exchange rate volatility are shown to affect UK imports in the short-run as well in some cases.

6.4.3.2.3 South Africa

As shown in Tables 6.22 and 6.23, all cases provide significant evidence of causality from the determinant variables to UK real imports, and the overall impact is similar to the previous results. In both nominal and real terms of exchange rate volatility, the speed of adjustment to deviations from the long-run equilibrium is slower when the financial crisis period is included in the analysis.

Lastly, all of the above results also include the respective diagnostic test results for the main anomalies such as: normality of residuals, heteroskedasticity/ARCH effects, Ramsey's misspecification test, and Ljung box autocorrelation test, in addition to adjusted R-square, standard error of estimates and sum of squared residuals.

6.4.3.2.4 Comparison of Causality Results from Developed and Developing Countries

In the presence of third country exchange rate risk, the error correction terms across all countries reduce in size. In other words, coefficients are larger in size without the third country effect, and the size of these coefficients reduces significantly after the third country exchange rate volatility is included as a long-run variable.

Table 6.23: ECM – Causality Results: Impact of Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk Before the Financial Crisis (Jan 1991 – June 2007)

Nominal

Brazil										
Lag	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Nominal Volatility		Δ Third Country Volatility	
			+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0	-	-	-5.0***		-	-	-0.011*	-	-	-
1	-0.7***	-0.19***	-		-	-	-0.02**	-	-	-
2	-	-	-		-	-	-	-	-	2.98***
4	-	0.14***	-		-	-	-	-	-	-
5	-	-	-		-	-	-	-	2.64***	-
6	-	-	-6.7***		-	-	-	0.013**	-	-
7	-	-0.19***	-7.8***		-	-	-	-	-	-
8	-	-0.21***	-		-	-	-	-	-	-
10	-	-	-		-	-	0.02***	-	-	-
12	-	-	-3.8**	-	-	-	-	-	-	-
Diagnostics										
R^2	0.61	SSR	2.45	LB(12)	12.89	ARCH(1)	0.07	-	-	-
SSE	0.014	JB	1.04	RESET(3)	0.747	ARCH(3)	0.77	-	-	-

China										
Lag	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Real Volatility		Δ Third Country Volatility	
			+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
1	-0.15***	-0.2***	-3.6***	-	-	-	-1.55**	-0.93*	-	-
2	-	-	3.13***	-	-	-0.15***	-	-	-	-
3	-	-	-	-	-	-	-	-1.15**	0.49*	-
5	-	-0.101*	-	-	-	-	-	0.92*	-	-
6	-	-0.2***	-	2.29**	-	-	-	-	-	-
7	-	-0.15***	-	-	-	-	-	-	-	-
8	-	-0.16***	-	-	-	-	-	-	-	-
9	-	-	-	1.95**	0.14***	-	-	-	-	-
10	-	-0.11**	3.12**	-	-	-	-	-	-	-
11	-	-	-	-	-0.24***	0.16***	-	-	-	-
12	-	0.42***	-	-	-	-	-1.25*	-	-	-
Diagnostics										
R^2	0.66	SSR	0.694	LB(12)	2.15	ARCH(1)	0.0014	-	-	-
SSE	0.0431	JB	0.18	RESET(3)	2.66	ARCH(3)	1.90	-	-	-

South Africa										
Lag	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Real Volatility		Δ Third Country Volatility	
			+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0	-	-	9.69***	-	-	-	-	-	-2.2***	-
1	-1.07	0.12**	-7.18**	-	-0.4***	0.94***	-	-	-	-
2	-	-	-	-	-	0.77***	-	-	-	-
3	-	-	-	5.07**	-	-	-	-	-	-5.63**
4	-	-	-	-	-	0.84***	-	-	-	-
5	-	-0.11**	-	-	-	-	-	-	-	-3.85**
9	-	0.104**	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-0.9***	-	-	-	-
12	-	-	9.96***	-6.14**	-	-	-	-	-	-2.78**
Diagnostics										
R^2	0.62	SSR	5.79	LB(12)	7.87	ARCH(1)	0.0042	-	-	-
SSE	0.034	JB	2.54	RESET(3)	0.97	ARCH(3)	2.741	-	-	-

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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.

Real

Brazil

Lag	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Nominal Volatility		Δ Third Country Volatility	
			+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
1	-0.66***	-0.2***	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-6.87**	-	-	-1.8***	-
4	-	0.09**	-	-	-	-	-	-	1.96***	-
6	-	-	-8.6***	3.34*	-	-	-	0.02***	-	-
7	-	-0.2***	-7.4***	-	0.99***	-7.3***	-	-	-	-
8	-	-0.2***	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	0.02***	-	-	-
12	-	-	-4.63**	-	-	-	-	-	-	-
Diagnostics										
R^2	0.63	SSR	2.36	LB(12)	14.08	ARCH(1)	0.35	-	-	-
SSE	0.013	JB	0.908	RESET(3)	1.77	ARCH(3)	0.6	-	-	-

China

Lag	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Real Volatility		Δ Third Country Volatility	
			+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
1	-0.2***	-	-3.6***	-	-	-	-2.15**	-	-	-
2	-	-	3.4***	-	-	-0.13***	-	-	-	-
3	-	-	-	-	-	-	-	-1.97**	-	-
4	-	-	-	-	-	-0.86**	-	-	-	-
5	-	-	-	2.15**	-	-	-	1.14*	-	-
9	-	-	-	1.83*	0.14***	-	-	-	-	-
10	-	-0.11**	-	-	-	0.682*	-	-	-	-
11	-	-	-	-	-0.2***	0.11**	-	-	-	-
12	-	0.49***	-	-	-	-	-1.74*	-	-	-
Diagnostics										
R^2	0.62	SSR	0.804	LB(12)	3.44	ARCH(1)	0.27	-	-	-
SSE	0.0048	JB	3.47	RESET(3)	1.29	ARCH(3)	4.41	-	-	-

South Africa

Lag	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Real Volatility		Δ Third Country Volatility	
			+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0	-	-	0.11***	-	-	-	-0.21**	-	-2.14**	-
1	-1.2***	0.18***	-	-	-0.49**	1.09***	-	-	-	-
2	-	-	-	-	-0.29**	0.67**	-	-	-	-
3	-	-	-	-	-0.26**	-	-	-	-	-6.5***
4	-	-	-	-	-	1.07**	-	-	-	-
5	-	-0.13***	0.82**	-	-	-	-	-	-	-5.8***
7	-	-	-	-	-	0.55***	-	-	-	-
9	-	0.11**	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-0.93**	-	-	-	-
12	-	-	0.97**	-0.6**	-	-	-	-	-	-3.2**
Diagnostics										
R^2	0.638	SSR	5.47	LB(12)	7.94	ARCH(1)	0.43	-	-	-
SSE	0.033	JB	0.038	RESET(3)	1.77	ARCH(3)	1.094	-	-	-

Note: 1. ***, **, and * denote significant at 1%, 5% and 10% respectively. 2. R^2: Adjusted R-Square; 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 6.24: **ECM – Causality Results: Impact of Exchange Rate Volatility on UK Imports in the presence of Third-Country Exchange Rate Risk including the Financial Crisis (Jan 1991 – Dec 2011)**

Nominal

Brazil										
Lag	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Nominal Volatility		Δ Third Country Volatility	
			+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
1	-0.69***	-0.173***	-	-	-	-	-0.02***	-	-	-
4	-	0.096**	-	-	-	-	-	-	1.44***	-
6	-	-	-5.94***	-	-	-	-	0.019***	-	-
7	-	-0.245***	-7.64***	-	7.98***	-	-	-	0.90*	-
8	-	-0.216***	-	-	-	-	-	-	-	-
10	-	-	-	-4.64***	-	-	0.017***	-	-	-
12	-	-	-5.47***	-	-	-	-	-	-	-
Diagnostics										
R^2	0.56	SSR	4.06	LB(12)	17.8	ARCH(1)	0.13	-	-	-
SSE	0.018	JB	1.89	RESET(3)	0.635	ARCH(3)	1.31	-	-	-

China										
Lag	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Real Volatility		Δ Third Country Volatility	
			+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
1	-	-	2.513**	-	-	-	-	-0.97*	-	-
1	-0.137***	-0.199***	-3.68***	-	-	-	-1.55*	-	-	-
2	-	-	2.388***	-	-	-0.14***	1.88**	-	0.54**	-
5	-	-0.157***	-	-	-0.17***	-	-	-	-	-
6	-	-0.225***	-	-	-	0.716*	-	-	-	-
7	-	-0.199***	-2.04*	-	-	-	-	-	-	-
8	-	-0.151***	-	-	0.98**	-	-	-	-	-
10	-	-0.105**	-	-	-	-	-	-	-	-
12	-	0.432***	-2.58**	-	-	-	-	-	-	-
Diagnostics										
R^2	0.63	SSR	1.01	LB(12)	3.73	ARCH(1)	1.29	-	-	-
SSE	0.004	JB	0.212	RESET(3)	1.668	ARCH(3)	1.94	-	-	-

South Africa										
Lag	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Real Volatility		Δ Third Country Volatility	
			+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0	-	-	8.68**	-	-	-	-	-	-	-8.93***
1	-0.81***	-	-6.08*	-	-	0.58**	-	-	-	-
2	-	-	-	-	-	-	-	1.19***	-	-4.91***
3	-	-	7.41**	-	-	-	-	-	-	-5.09***
4	-	-	-	-	0.22**	0.163**	-	-	-	-
5	-	-0.113**	6.72**	-	-	-	-	0.86**	-	-4.50**
7	-	-	-	-	-0.33***	0.67**	-	-	-	-
9	-	0.107**	-	-	-	-0.66**	-	-	-	-
12	-	-	-	-4.08*	-	-	-	0.71*	-	-
Diagnostics										
R^2	0.56	SSR	8.74	LB(12)	3.96	ARCH(1)	0.21	-	-	-
SSE	0.04	JB	1.72	RESET(3)	0.551	ARCH(3)	0.43	-	-	-

Note:

1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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.

Conclusion and Implications

Real

Brazil										
Lag	**ECM**	**Δ Imports**	**Δ Real Income**		**Δ Relative Prices**		**Δ Nominal Volatility**		**Δ Third Country Volatility**	
			+ve	**-ve**	**+ve**	**-ve**	**+ve**	**-ve**	**+ve**	**-ve**
0	-0.63***	-0.20***	-	-	-	-	-0.018	-	-	-
1	-	-	-	-	-	6.7**	-	-	-	-
3	-	-	-	-	5.83**	-	-	-	-	-
5	-	-	-	-	-	-	-	-	1.39**	-
6	-	-	-6.66**	-	-	-	-	0.02***	-	-
7	-	-0.25***	-6.92**	-	8.16***	-	-	-	-	-
8	-	-0.22***	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	0.02***	-	-	-
12	-	-	-4.00**	-4.16***	-	-	-	-	-	-
Diagnostics										
R^2	0.57	SSR	3.99	LB(12)	8.63	ARCH(1)	0.218	-	-	-
SSE	0.017	JB	1.48	RESET(3)	0.49	ARCH(3)	2.32	-	-	-

China										
Lag	**ECM**	**Δ Imports**	**Δ Real Income**		**Δ Relative Prices**		**Δ Real Volatility**		**Δ Third Country Volatility**	
			+ve	**-ve**	**+ve**	**-ve**	**+ve**	**-ve**	**+ve**	**-ve**
0	-	-	2.32**	-	-	-	-	-1.28*	-	-
1	-0.16***	-0.18**	-4.06***	-	-	-	-	-	-	-
2	-	-	2.09**	-	-	-0.14***	2.033*	-	-	-
3	-	-	-	-	-	-	-	-	0.691**	-
5	-	-0.16***	-	-	-17.1**	-	-	-	-	-
6	-	-0.21***	-	-	-	-	-	-	-	-
7	-	0.212**	-2.1**	-	-	-	-	-	-	-
8	-	-0.15***	-	-	-	-	-	-	-	-
10	-	-0.12**	-	-	-	-	-	-	-	-
12	-	0.408**	-2.26**	-	-	-	-	-	-	-
Diagnostics										
R^2	0.622	SSR	1.055	LB(12)	3.14	ARCH(1)	1.389	-	-	-
SSE	0.004	JB	0.26	RESET(3)	1.49	ARCH(3)	2.347	-	-	-

South Africa										
Lag	ECM	Δ Imports	Δ Real Income		Δ Relative Prices		Δ Real Volatility		Δ Third Country Volatility	
			+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
0	-	-	9.17***	-	-	-	-0.23**	-	-	-9.46**
1	-0.81***	-	-8.97***	-	-	0.58**	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-4.33**
3	-	-	7.55**	-	-	-	-	-	-	-6.64**
4	-	-	-	-	-	1.84***	-	-	-	-
5	-	-0.13***	8.05***	-	-	-	-	-	-	-4.76**
7	-	-	-	-	-0.33***	0.76**	-	-	-	-
9	-	0.096**	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-0.71**	-	-	-	-
12	-	-	8.80***	-6.80**	-	-	-	-	-	-2.94**
Diagnostics										
R^2	0.54	SSR	9.04	LB(12)	4.47	ARCH(1)	0.136	-	-	-
SSE	0.041	JB	2.00	RESET(3)	0.643	ARCH(3)	0.619	-	-	-

Note:
1. ***,**, and * denote significant at 1%, 5% and 10% respectively.
2. R^2: Adjusted R-Square; 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.

6.4.4 Long and Short-run Asymmetric Effects

The Wald test is applied to test for long and short-run asymmetric effects, tables 6.22 and 6.23 provide the Wald-test results. The long and short-run asymmetry hypotheses are tested for possible equality between the positive and negative coefficients for each variable, and in both long and short-run scenarios. As stated earlier, if the null hypothesis is rejected, and these shocks are not equal statistically, then it demonstrates the asymmetric nature of the relationship in the respective time horizon (long or short-run). The presence of long and short-run asymmetries implies that the positive and negative shocks to a single variable should be modelled separately as both will affect the dependent variable differently. It means that variability may be found in terms of both the sign (direction) and size (sensitivity) of the coefficients.

Table 6.22 presents the results without the third country exchange rate volatilities. The Wald-test statistics show 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 the UK's imports differently.

Conclusion and Implications

Hence, the long-run 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 especially true in the case of South Africa with real rate volatility found to be asymmetric both in the long and short-run during both periods. The only exception to this is the real exchange rate volatility, which is symmetric with respect to the full sample but exhibits long-run asymmetry within the pre-crisis period.

Including the third country effect (table 6.22) generally enhances the evidence for the asymmetric effect. However, third country real volatility is found to be less asymmetric when the crisis period is added to the sample.

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

Table 6.25: Impact of Exchange Rate Volatility on UK Imports before the Financial Crisis (Jan 1991 to June 2007)

Nominal

Countries	Real Income		Relative Prices		Nominal Volatility	
	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm
Brazil	2.53**	4.73***	0.676	1.82*	1.37	8.21***
China	4.78**	1.90*	0.049	4.31***	5.41**	4.22***
South Africa	0.673	-3.654***-	1.505	3.09***	0.023	--

Real

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 6.26: Impact of Exchange Rate Volatility on UK Imports during Including the Financial Crisis (Jan 1991 to Dec 2011)

Nominal

Countries	Real Income		Relative Prices		Nominal Volatility	
	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm
Brazil	29.27***	26.05***	28.873***	3.72*	1.06	2.80*
China	1.47	10.28***	0.38	0.63	0.098	45.59***
South Africa	7.57***	49.21***	6.944***	53.33***	11.468***	1.32

Real

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 significant at 1%, 5% and 10% respectively.

Table 6.27: 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)

Nominal

Countries	Real Income		Relative Prices		Nominal Volatility		Third Country Volatility	
	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm
Brazil	1.3337	54***	0.1379	--	1.9774	5.4***	0.5971	0.16
China	3.37***	0.43	0.51	0.93	2.36**	1.54	0.58	28***
South Africa	1.56	3.33*	0.2	13.37***	0.13	--	3.64***	20.18***

Real

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

Nominal

Countries	Real Income		Relative Prices		Nominal Volatility		Third Country Volatility	
	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm	Long-Asymm	Short-Asymm
Brazil	-5.41***	41.06***	3.76***	9.66***	-0.94	4.17**	1.69*	27.82***
China	-4.32***	1.78	1.54	0.003	1.81*	1.39	0.762	37.38***
South Africa	0.487	9.48***	0.45	7.97***	1.93*	4.41**	4.54***	90.24***

Note:
1. ***,**, and * denote significant at 1%, 5% and 10% respectively.

Real

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***

Note:
1. ***,**, and * denote significant at 1%, 5% and 10% respectively.

6.5 Conclusion and Implications

In the case of the developing countries, using the ARDL bounds testing approach (Pesaran, Shin and Smith, 2001), a significant long-run relationship is reported between UK imports and its key determinants based on data from Brazil, China and South Africa. These relationships are consistent both under nominal and real exchange rate volatilities and hold both before and after

including the financial crisis period. In addition, these relationships are also significant after the addition to the long-run determinant variables of the third-country exchange rate risk. Normalized coefficients for the variables are significant in most of the cases. Normalized coefficients for exchange rate volatility in the cases of China and South Africa indicate negative impacts on UK imports for both sample lengths. However, in the case of Brazil, REAL/GBP volatility and UK imports are positively related before the financial crisis, but the direction of causality changes from positive to negative after inclusion of the financial crisis period. The third country effect, proxied by USD/GBP volatility, is negative as well, except for some instances for China and South Africa where the coefficients bear positive signs after the inclusion of the financial crisis period. Thus, these results for the developing countries provide significant evidence of the negative impact of exchange rate volatility increase on UK imports. Similarly, the third country effect (USD/GBP volatility) in most of the cases is negative too. Results of the General-to-specific causality tests show that exchange rate volatility and third country exchange rate risk are important short-run determinants of UK Imports as well.

Results based on the Asymmetric ARDL also confirm the long-run 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 inclusion of the financial crisis period. Normalized coefficients for the nominal and real exchange rate volatilities under the Asymmetric ARDL method show a large number of inverse relationships. With respect to the third country exchange rate volatility, which for the developing countries is represented by USD/GBP volatility, this has a negative impact on imports from Brazil, China and South Africa 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 regressors, especially 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 clear evidence of the asymmetric behaviour of the underlying independent variable for all countries, a significant contribution of this thesis to the existing literature. Furthermore, it can be seen that the incidences of long-run asymmetry increase after

inclusion of the financial crisis, which shows the structural shift in the long-run relationship caused by this crisis. These findings also hold in the presence of third country exchange rate risk as well.

The results presented above suggest that exchange rate volatility is important when modelling UK import behaviour, especially during the current 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 of the underlying bilateral and third country (USD/GBP), policy actions aimed at stabilizing these import markets are likely to generate uncertain results. Lastly, this thesis shows clear evidence of the asymmetric behaviour 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 effective, as these variables behave differently under different economic situations. This holds practical implications for international traders (imports), investors in global foreign exchange markets, academics, exchange rate risk management, etc as well as for the policy makers.

Chapter 7: Conclusion and Implications

7.1 Research Outline

One of the major issues since the introduction of the flexible exchange rate in 1973 was whether an increase in exchange rate volatility would affect the international trade flow. Prior to this time, the Bretton Woods agreement fixed the exchange rate system, hence traders and policy makers did not have to worry so much about uncertainty or the volatility of exchange rates around the world.

Since then, numerous papers have been published to explain how increased exchange rate uncertainty (volatility) theoretically affects the trade, and even more papers have been written to empirically evaluate these theories using various methods and models. However, no consensus has been reached regarding the magnitude and direction of the relationship between volatility and international trade. Many studies have explored this relationship, but have generally concluded in one of three different ways: i) there is a negative underlying effect of exchange rate volatility (negative hypothesis) on trade, as the traders becomes more risk averse due to uncertain profitability, and hence the trade volume declines because of a rise in exchange rate volatility; ii) considering trade as an option available to traders to buy or sell, any increase in volatility (exchange rate) should positively affect the trade flows (positive hypothesis); and lastly, iii) there are some researchers who posit that there is no relationship between the two variables (McKenzie, 1999; Bahmani-Oskooee and Hegerty, 2007).

This research, as shown in section 2.4.2, a priori assumes that exchange rate volatility adversely (negatively) affects international trade. Thus, this research focuses on establishing the direction of the relationship between the two variables. Previous research papers on the subject have also highlighted the issue of third country exchange rate risk (volatility) and the lack of evidence in this area (McKenzie, 1999; Bahmani-Oskooee and Hegerty, 2007). The third country effect, in terms of exchange rate volatility, is an important aspect from the point of view of competition, as it may affect the trade flows between two countries.

Conclusion and Implications

On the theoretical front, the recent financial crisis presents another building block for this thesis. The Financial Crisis (2007-2011) caused a massive decline in the international trade flow, however, there is no evidence available in the existing literature as to how it affects the relationship between exchange rate volatility and international trade flows. Thus, this research builds on existing theoretical literature on the subject and aims to bridge the research gap regarding the third country effect and the impact of the financial crisis.

On the empirical side, a large number of research studies initially used simple OLS based estimations, which later changed to the application of cointegration techniques in the 1990s (McKenzie, 1999; Bahmani-Oskooee and Hegerty, 2007), as OLS estimators were declared spurious for not addressing the cointegration properties of the underlying variables. The cointegration techniques prior to the introduction of the ARDL bounds testing approach (Pesaran *et al.* (2001)) were developed on the basis of a restrictive assumption where all the variables were required to have the same integration order. There was a gap on the empirical front for econometric models that involved a mix of I(0) and I(1) variables, which was filled by the ARDL bounds testing approach. Another area of econometric research relevant here is the asymmetric behaviour of economic and financial time series, whereby the underlying dependent variables respond differently to positive and negative changes in the independent variables over a period of time. The Asymmetric ARDL method proposed by Shin, Yu and Greenwood-Nimmo (2013) addresses both the stationarity and asymmetry issues of the underlying variables by decomposing the independent variables separately into positive and negative partial sum processes. This enables the researchers to estimate the separate impact of positive and negative changes in the determinant variables on the dependent variable. This research deals with a mix of both I(0) and I(1) variables and therefore employs both the Symmetric ARDL method (Pesaran, Shin and Smith, 2001) and the Asymmetric ARDL model (Shin, Yu and Greenwood-Nimmo, 2013).

The research questions this thesis aims to answers are: i) does exchange rate volatility affect UK trade flows?; ii) how is the relationship between exchange rate volatility and UK trade flows affected by third-country exchange rate volatility (risk)?; iii) what is the impact of the financial crisis on the relationship

between exchange rate volatility and UK trade flows (with and without the presence of third-country volatility (risk)?; and iv) do the underlying independent variables in the previous questions, especially exchange rate volatility, affect the UK trade flows asymmetrically?

This research thus extends the existing work, investigating the effect of exchange rate volatility on UK real imports from Brazil, China, Germany, Japan South Africa and the US using monthly data between January 1991 to December 2011. These countries are selected in view of their geographical and regional significance in terms of size of trade with the UK. The sample countries represent different regions and currencies and are major trade partners of the UK, hence the findings provide a wide range of evidence both theoretically and empirically.

7.2 Research Contribution

This research aims to bridge the theoretical research gap identified above and analyse the relationship between exchange rate volatility and international trade flows both with and without the presence of third country exchange rate volatility. Earlier bilateral trade models assumed trade was just between two countries, and hence overlooked the important element of competition, which all the countries face in the global trade. Third country exchange rate volatility captures the variations in the exchange rate risk and provides evidence as to how trade between the UK and its respective trade partners is affected by such changes. Another significant theoretical contribution is assessing the impact of the recent financial crisis on the relationship between exchange rate volatility, other determinants, and UK imports.

In order to improve the empirical evidence on the subject, this research combines the benchmark ARDL bounds testing approach (Pesaran *et al.*, 2001) with the recently introduced Asymmetric ARDL method (Shin *et al.*, 2013). The later study is an extension of the bounds testing approach, going one step further to incorporate nonlinearities and asymmetry in the underlying independent variables, and decomposing each variable into positive and negative partial sum processes. This improves the empirical evidence by providing insight into the different impacts on the dependent variables due to the positive and negative changes in the independent variables.

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. As mentioned earlier, fresh evidence is provided by employing the asymmetric autoregressive distributed lag (ARDL) approach to cointegration (Shin *et al.* (2011)) which, to my knowledge, has not been applied in any of the studies related to international trade so far. Causality tests (the constrained error correction model and the general-to-specific approach) are used to study the relationship between real imports and its determinants, which are real UK income, import price ratio and nominal and real exchange rate volatility.

7.3 Main Findings

This section describes the main findings of the analysis presented in Chapters 5 and 6 for the developed and developing countries, respectively. This analysis is based on the relationship between exchange rate volatility and UK imports from Germany, Japan and the US (the developed countries) and Brazil, China and South Africa (the developing economies) (1991:01-2011:12).

7.3.1 Developed Countries

Results for the developed countries under the symmetric ARDL bounds testing approach (Pesaran, Shin and Smith, 2001) suggest that Euro/GBP exchange rate volatility (nominal and real) along with real income and relative prices affects UK imports from Germany in the long-run for the pre-crisis period. However, this relationship does not exist after the sample length is increased to include the financial crisis period as well. In the cases of Japan and the US, a significant long-run relationship is found between the underlying regressors and UK imports for both sample periods, using both nominal and real exchange rate volatilities. In the context of the third country effect (both in real and nominal terms), results indicate a significant negative impact on UK imports for almost all of the countries, with the exception of Germany, where third country effect, proxied by the USD/GBP real exchange rate volatility, is insignificant in the pre-crisis period.

Finally, Granger causality tests show that exchange rate volatility is both a long-run determinant variable and also an important factor for UK imports

across all cases. This result holds both during the pre-crisis and the full sample period. Third country volatility 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.

This thesis, using the Asymmetric ARDL method, reports strong evidence for a long-run asymmetric relationship between UK imports and the underlying variables. In the case of the US, the relationship is significant irrespective of the time period and type of exchange rates selected, whereas for Germany, the long-term relationship exists under nominal exchange rate volatility only and for Japan only for real exchange rate volatility. However, these relationships hold both before and after the inclusion of the financial crisis, implying the stochastic stability of the underlying relationships. Similarly, in the presence of the third country effect, the null hypothesis of no asymmetric cointegration is rejected in most of the cases for both the pre-crisis and total periods for all the three countries at the 1% or 5% significance level. These findings provide clear evidence in support of third-country exchange rate risk being an important determinant of UK imports. This is especially significant in the cases of Germany and Japan, where in some cases no cointegration is found without third country risk (sections 5.5.1.1.1 and 5.5.1.1.2 above). The diagnostic test results show that the residuals are normally distributed, and no evidence of autocorrelation, heteroskedasticity (ARCH effect) or misspecifications is found.

7.3.2 Developing Countries

In the case of the developing countries, using the ARDL bounds testing approach (Pesaran, Shin and Smith, 2001), a significant long-run relationship is reported between UK imports and its key determinants based on data from Brazil, China and South Africa. These relationships are consistent both under nominal and real exchange rate volatilities and hold both before and after including the financial crisis period. In addition, these relationships are also significant after the addition of the third-country exchange rate risk to the long-run determinant variables. Normalized coefficients for the variables are significant in most of the cases. Normalized coefficients for exchange rate volatility in the cases of China and South Africa indicate a negative impact on UK imports for both sample lengths. However, in the case of Brazil, REAL/GBP volatility and UK imports are positively related before the financial crisis, but

the direction of causality changes from positive to negative after inclusion of the financial crisis period. The third country effect, proxied by USD/GBP volatility, is negative in most of the cases, except for some instances for China and South Africa where the coefficients bear a positive sign after inclusion of the financial crisis period. Thus, these results for the developing countries provide sufficient evidence for a negative impact of exchange rate volatility increase on UK imports. Similarly, the third country effect (USD/GBP volatility) is negative in most of the cases too. Results of the General-to-specific causality tests show that exchange rate volatility and third country exchange rate risk are important short-run determinants of UK Imports.

Results based on the Asymmetric ARDL also confirm the long-run 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 inclusion of the financial crisis period. Normalized coefficients for the nominal and real exchange rate volatilities under the Asymmetric ARDL method show a large number of inverse relationships. With respect to the third country exchange rate volatility, which for the developing countries is represented by USD/GBP volatility, this has a negative impact on imports from Brazil, China and South Africa in almost all the cases. Other determinant variables such as real income and relative price ratio are also significant in most of the cases as well. Import demand elasticity towards all regressors, especially real income and exchange rate volatility, significantly changes across both data samples, i.e. before and after the financial crisis. More importantly, results show clear evidence of the asymmetric behaviour of the underlying independent variable for all countries, a significant contribution of this thesis. Furthermore, the rate of incidences of long-run asymmetry increase after inclusion of the financial crisis, which shows the structural shift in the long-run relationship between these variables caused by this crisis. These findings also hold in the presence of third country exchange rate risk as well.

7.4 Implications

The results presented in this research confirm that exchange rate volatility is an important element for determining the UK imports, especially during the current crisis period. Any trade adjustment programmes by the UK that discourage import expansion could be unsuccessful if exchange rates and third country exchange risk 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. This thesis shows clear evidence of the asymmetric behaviour 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 effective, as these variables behave differently under different economic situations. This, holds practical implications for international traders (imports/exporters), investors in global foreign exchange markets, academics, exchange rate risk management, etc as well as the policy makers.

7.5 Limitations

This thesis is an initial attempt to enhance the general understanding relating to the relationship between exchange rates and international trade flows. Although contributing to the existing literature in terms of the third-country effect, asymmetric behaviour of the underlying macroeconomic variables and the impact of the recent financial crisis, this research faces certain limitations. For instance, the number of countries included in this research could be considerably increased to enhance the evidence on the subject. More importantly, demand for imported goods behaves differently depending on the nature of the goods imported. Therefore, use of sectoral import data may offer a much better insight into the impact of exchange rate volatility on imports in different sectors compared to bilateral trade figures. This will have significant implications for trade policy, which may differ sector-to-sector in the light of their sensitivity to exchange rate volatility. However, it should be noted that the availability of sectoral data for a large number of countries and/or over a significant time span would be fairly limited.

Conclusion and Implications

The impact of the recent financial crisis could be estimated in a more formal way by introducing a time series control variable, such as the financial stress index, which would enable better inferences regarding the impact of the financial crisis on the underlying exchange rate volatility and international trade flow relationship.

Therefore, future research extensions based on this thesis may be from two perspectives, the theoretical and the empirical. On the theoretical front, adoption of sectoral data and modelling the financial crisis separately as a control variable could contribute to the literature. Empirically, the Asymmetric ARDL method could be used to model the asymmetric behaviour of other economic/financial time series to address other research problems. Analysis of UK exports could also be another useful extension of this research in the near future.

References

Abiad, A., Mishra, P. and Topalova, P. (2011) *How Does Trade Evolve in the Aftermath of Financial Crises?* International Monetary Fund. Available from: http://books.google.co.uk/books?id=QibDIXVdf5UC.

Abrams, R.K. (1980) International trade flows under flexible exchange rates. *Economic Review,* 65 (3), 3-10.

Acharya, V., Philippon, T., Richardson, M. and Roubini, N. (2009) The Financial Crisis of 2007-2009: Causes and Remedies. *Financial Markets, Institutions & Instruments,* 18 (2), 89-137.

Akhtar, M.A. and Hilton, R.S. (1984) Effects of Uncertainty on German and US Trade. *Federal Reserve Bank of New York Quarterly Review*, 7-16.

Arize, A.C. (1995) The effects of exchange-rate volatility on US exports: an empirical investigation. *Southern Economic Journal*, 34-43.

Arize, A.C. (1996) Real exchange-rate volatility and trade flows: the experience of eight European economies. *International Review of Economics & Finance,* 5 (2), 187-205.

Arize, A.C. and Ghosh, D.K. (1991) Exchange rate uncertainty and recent U.S. export demand instability. *The International Trade Journal,* 8 (3), 347-365.

Arize, A.C., Malindretos, J. and Kasibhatla, K.M. (2003) Does exchange-rate volatility depress export flows: The case of LDCs. *International Advances in Economic Research,* 9 (1), 7-19.

Arize, A.C., Osang, T. and Slottje, D.J. (2008) Exchange-rate volatility in Latin America and its impact on foreign trade. *International Review of Economics & Finance,* 17 (1), 33-44.

Arize, A.C. and Shwiff, S.S. (1998) Does exchange-rate volatility affect import flows in G-7 countries? Evidence from cointegration models. *Applied Economics,* 30 (10), 1269-1276.

Asseery, A. and Peel, D.A. (1991) The effects of exchange rate volatility on exports:: Some new estimates. *Economics Letters,* 37 (2), 173-177.

Baak, S.J., Al-Mahmood, M.A. and Vixathep, S. (2007) Exchange rate volatility and exports from East Asian countries to Japan and the USA. *Applied Economics,* 39 (7-9), 947-959.

Bae, Y. and De Jong, R.M. (2007) Money demand function estimation by nonlinear cointegration. *Journal of Applied Econometrics,* 22 (4), 767-793.

Bahmani-Oskooee, M. (1996) Exchange Rate Uncertainty and Trade Flows of LDCs: Evidence from Johansen's Cointegration Analysis. *Journal of Economic Development,* 21, 23–35.

Bahmani-Oskooee, M. and Goswami, G.G. (2004) Exchange rate sensitivity of Japan's bilateral trade flows. *Japan and the World Economy,* 16 (1), 1-15.

Bahmani-Oskooee, M. and Hegerty, S.W. (2007) Exchange rate volatility and trade flows: a review article. *Journal of Economic Studies,* 34 (3), 211-255.

Bahmani-Oskooee, M. and Kara, O. (2005) Income and price elasticities of trade: some new estimates. *The International Trade Journal,* 19 (2), 165-178.

Bahmani-Oskooee, M. and Ltaifa, N. (1992) Effects of exchange rate risk on exports: crosscountry analysis. *World Development,* 20 (8), 1173-1181.

Bahmani-Oskooee, M. and Payesteh, S. (1993) Budget deficits and the value of the dollar: An application of cointegration and error-correction modeling*. *Journal of Macroeconomics,* 15 (4), 661-677.

Bahmani-Oskooee, M. and Wang, Y. (2007) The Impact of Exchange Rate Volatility on Commodity Trade between the US and China. *ECONOMIC ISSUES-STOKE ON TRENT-,* 12 (1), 31.

Bailey, M.J., Tavlas, G.S. and Ulan, M. (1986) Exchange Rate Variability and Trade Performance: Evidence for the Big Seven Industrial Countries. *Weltwirtschaftliches Archiv,* 1 (22), 466-477.

Bailey, M.J., Tavlas, G.S. and Ulan, M. (1987) The impact of exchange-rate volatility on export growth: Some theoretical considerations and empirical results. *Journal of Policy Modeling,* 9 (1), 225-243.

Baldwin, R. (ed.) (2009) *The Great Trade Collapse: Causes, Consequences and Prospects*. CEPR. Available from: http://books.google.co.uk/books?id=OsGokPMG5aIC.

Baldwin, R.E., Skudelny, F. and Taglioni, D. (2005) Trade Effects of the Euro: Evidence from Sectoral Data. *SSRN eLibrary*.

Baron, D.P. (1976) FLUCTUATING EXCHANGE RATES AND THE PRICING OF EXPORTS. *Economic Inquiry,* 14 (3), 425-438.

Baum, C.F. and Caglayan, M. (2010) On the sensitivity of the volume and volatility of bilateral trade flows to exchange rate uncertainty. *Journal of International Money and Finance,* 29 (1), 79-93.

Baumol, W.J. and Blinder, A.S. (2010) *Macroeconomics: Principles and Policy*. Cengage Learning.

Ben-David, I. (2009) *Financial Constraints, Inflated Home Prices, and Borrower Default during the Real-Estate Boom*. Available from: http://ideas.repec.org/p/ecl/ohidic/2009-1.html.

Berman, N. (2009) Financial Crises and International Trade: The Long Way to Recovery.

Blanchard, O.J., Giavazzi, F. and Sa, F. (2005) The US current account and the dollar. National Bureau of Economic Research Cambridge, Mass., USA.

Blundell-Wingall, A., Atkinson, P. and Lee, S.H. (2008) The Current Financial Crisis: Causes and Policy Issues. *OECD Journal: Financial Market Trends,* 95 (2).

Bolhassani, M. (2009) *The effect of third-country exchange rate volatility on trade: Evidence from the commodity trade between the United States and Canada*, The University of Wisconsin-Milwaukee.

Bollerslev, T. (1986) Generalized autoregressive conditional heteroskedasticity. *Journal of econometrics,* 31 (3), 307-327.

Bollerslev, T., Chou, R.Y. and Kroner, K.F. (1992) ARCH modeling in finance: A review of the theory and empirical evidence. *Journal of econometrics,* 52 (1), 5-59.

Bouoiyour, J. and Rey, S. (2005) Exchange Rate Regime, Real Exchange Rate, Trade Flows and Foreign Direct Investments: The Case of Morocco. *African Development Review,* 17 (2), 302-334.

Brada, J.C. and Méndez, J.A. (1988) Exchange rate risk, exchange rate regime and the volume of international trade. *Kyklos,* 41 (2), 263-280.

Brandi, V.R., Mendes, B.V.D.M., Gomes, F.P. and Santos, M.B.C.D. (2007) Foreign Exchange Volatility and Trading Volume of Derivatives Instruments: Evidence from the Brazilian Market. *Latin American Business Review,* 8 (1), 65-82.

Brooks, C. (2008) *Introductory Econometrics for Finance*. Cambridge University Press.

Brown, S.J., Goetzmann, W.N., Liang, B. and Schwarz, C. (2009) Estimating Operational Risk for Hedge Funds: The-Score. *Financial nalysts Journal,* 65, 43–53.

Burnside, C., Eichenbaum, M., Kleshchelski, I. and Rebelo, S. (2011) Do Peso Problems Explain the Returns to the Carry Trade? *Review of Financial Studies,* 24 (3), 853.

Byrne, J.P., Darby, J. and Macdonald, R. (2008) US trade and exchange rate volatility: A real sectoral bilateral analysis. *Journal of Macroeconomics,* 30 (1), 238-259.

Caballero, R.J. and Corbo, V. (1989) *How does uncertainty about the real exchange rate affect exports?* Country Economics Dept., World Bank.

Cai, J., Cheung, Y.L., Lee, R.S.K. and Melvin, M. (2001) [] Once-in-a-generation'yen volatility in 1998: fundamentals, intervention, and order flow. *Journal of International Money and Finance,* 20 (3), 327-347.

Cheong, C., Mehari, T. and Williams, L.V. (2005) The effects of exchange rate volatility on price competitiveness and trade volumes in the UK: A disaggregated approach. *Journal of Policy Modeling,* 27 (8), 961-970.

Chit, M.M., Rizov, M. and Willenbockel, D. (2010) Exchange Rate Volatility and Exports: New Empirical Evidence from the Emerging East Asian Economies. *World Economy,* 33 (2), 239-263.

Cho, J., Kim, T.-H. and Shin, Y. (2012) Quantile Cointegration in the Autoregressive Distributed-Lag Modelling Framework.

Chor, D. and Manova, K. (2012) Off the cliff and back? Credit conditions and international trade during the global financial crisis. *Journal of International Economics,* 87 (1), 117-133.

Choudhry, T. (2005) Exchange rate volatility and the United States exports: evidence from Canada and Japan. *Journal of the Japanese and International economies,* 19 (1), 51-71.

Choudhry, T. (2008) Exchange rate volatility and United Kingdom trade: evidence from Canada, Japan and New Zealand. *Empirical Economics,* 35 (3), 607-619.

Chowdhury, A.R. (1993) Does exchange rate volatility depress trade flows? Evidence from error-correction models. *The Review of Economics and Statistics*, 700-706.

Clark, P.B. (1973) Uncertainty, Exchange Risk, And The Level Of International Trade. *Economic Inquiry,* 11 (3), 302-313.

Cushman, O. (1986) Has exchange risk depressed international trade? The impact of third-country exchange risk. *Journal of International Money and Finance,* 5 (3), 361-379.

Danielle, D. and John, V.D. (2007) The rise and fall of subprime mortgages. *FRBSF Economic Letter,* (Nov).

De Grauwe, P. (1988) Exchange rate variability and the slowdown in growth of international trade. *Staff Papers-International Monetary Fund*, 63-84.

Dellas, H. and Zilberfarb, B.Z. (1993) Real exchange rate volatility and international trade: a reexamination of the theory. *Southern Economic Journal*, 641-647.

Demers, M. (1991) Investment under uncertainty, irreversibility and the arrival of information over time. *The Review of Economic Studies,* 58 (2), 333.

Demyanyk, Y. and Van Hemert, O. (2008) Understanding the Subprime Mortgage Crisis. *SSRN eLibrary.*

Dickey, D.A. and Fuller, W.A. (1979) Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association,* 74 (366a), 427-431.

Doğanlar, M. (2002) Estimating the impact of exchange rate volatility on exports: evidence from Asian countries. *Applied Economics Letters,* 9 (13), 859-863.

Doroodian, K. (1999) Does exchange rate volatility deter international trade in developing countries? *Journal of Asian Economics,* 10 (3), 465-474.

Dowd, K. (2009) Moral Hazard and the Financial Crisis. *Cato Journal,* 29 (1), 141-166.

Engle, R. (2004) Risk and volatility: Econometric models and financial practice. *The American Economic Review,* 94 (3), 405-420.

Engle, R.F. and Granger, C.W.J. (1987) Co-integration and error correction: representation, estimation, and testing. *Econometrica: journal of the Econometric Society*, 251-276.

Escribano, A., Sipols, A.E. and Aparicio, F. (2006) Nonlinear cointegration and nonlinear error correction: Record counting cointegration tests. *Communications in Statistics—Simulation and Computation®,* 35 (4), 939-956.

Ethier, W. (1973) International trade and the forward exchange market. *The American Economic Review,* 63 (3), 494-503.

Franke, G. (1991) Exchange rate volatility and international trading strategy. *Journal of International Money and Finance,* 10 (2), 292-307.

Fratzscher, M. (2009) What explains global exchange rate movements during the financial crisis? *Journal of International Money and Finance,* 28 (8), 1390-1407.

Fratzscher, M. (2012) Capital flows, push versus pull factors and the global financial crisis. *Journal of International Economics,* 88 (2), 341-356.

Garz, M. (2013) Unemployment expectations, excessive pessimism, and news coverage. *Journal of Economic Psychology,* 34, 156-168.

Gotur, P. (1985) Effects of Exchange Rate Volatility on Trade: Some Further Evidence. *Staff Papers-International Monetary Fund*, 475-512.

Granger, C. and Yoon, G. (2002) Hidden cointegration. *U of California, Economics Working Paper,* (2002-02).

Granger, C.W. and Newbold, P. (1974) Spurious regressions in econometrics. *Journal of econometrics,* 2 (2), 111-120.

Greenwood-Nimmo, M. and Shin, Y. (2011) Shifting Preferences at the Fed: Evidence from Rolling Dynamic Multipliers and Impulse Response Analysis. *Available at SSRN 1810643*.

Gujarati, D.N. (2003) *Basic econometrics*. McGraw Hill.

Hellwig, M. (2009) Systemic Risk in the Financial Sector: An Analysis of the Subprime-Mortgage Financial Crisis. *De Economist,* 157 (2), 129-207.

Hendry, D.F. (1987) Econometric methodology: A personal perspective. *Advances in econometrics,* 2, 29-48.

Hendry, D.F. (1995) *Dynamic Econometrics: Advanced Texts in Econometrics*, 1st ed. UK: Oxford University Press.

Hooper, P. and Kohlhagen, S.W. (1978) The effect of exchange rate uncertainty on the prices and volume of international trade. *Journal of International Economics,* 8 (4), 483-511.

Johansen, S. (1988) Statistical analysis of cointegration vectors. *Journal of economic dynamics and control,* 12 (2), 231-254.

Kahneman, D. and Tversky, A. (1979) Prospect theory: An analysis of decision under risk. *Econometrica: Journal of the Econometric Society*, 263-291.

Karantininis, K., Katrakylidis, K. and Persson, M. (2011) Price Transmission in the Swedish Pork Chain: Asymmetric non linear ARDL *2011 International Congress, August 30-September 2, 2011, Zurich, Switzerland*. European Association of Agricultural Economists.

Kargbo, J.M. (2009) Financial integration and parity reversion in real exchange rates of emerging markets. *Applied Economics Letters,* 16 (1), 29-33.

Katrakilidis, C., Lake, A. and Trachanas, E. (2012) Asymmetric Effects Of Inflation On Stock Market Prices: New Empirical Evidence Using Greek Data. *Journal of Applied Business Research,* 28 (3), 325-332.

Katrakilidis, C. and Trachanas, E. (2012) What drives housing price dynamics in Greece: New evidence from asymmetric ARDL cointegration. *Economic Modelling,* 29 (4), 1064-1069.

Kenen, P.B. and Rodrik, D. (1986) Measuring and Analyzing the Effects of Short-Term Volatility in Real Exchange Rates. *The Review of Economics and Statistics,* 68 (2), 311-315.

Keynes, J.M. (1936) *The General Theory of Employment, Interest, and Money*. London: Macmillan.

Klein, M.W. (1990) Sectoral effects of exchange rate volatility on United States exports. *Journal of International Money and Finance,* 9 (3), 299-308.

Koopmans, T. (1935) On Modern Sampling Theory. *Lectures delivered at Oslo, autumn of.*

Kroner, K.F. and Lastrapes, W.D. (1993) The impact of exchange rate volatility on international trade: reduced form estimates using the GARCH-in-mean model. *Journal of International Money and Finance,* 12 (3), 298-318.

Krugman, P. (2007) Will there be a dollar crisis? *Economic Policy,* 22 (51), 435-467.

Kwiatkowski, D., Phillips, P.C.B., Schmidt, P. and Shin, Y. (1992) Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root? *Journal of econometrics,* 54 (1), 159-178.

Lastrapes, W.D. and Koray, F. (1990) Exchange rate volatility and US multilateral trade flows. *Journal of Macroeconomics,* 12 (3), 341-362.

Lee, D. and Schmidt, P. (1996) On the power of the KPSS test of stationarity against fractionally-integrated alternatives. *Journal of econometrics,* 73 (1), 285-302.

Lee, H.S. and Amsler, C. (1997) Consistency of the KPSS unit root test against fractionally integrated alternative. *Economics Letters,* 55 (2), 151-160.

Ligthart, J.E. and Da Silva, J.A. (2007) Currency Invoicing in International Trade: A Panel Data Approach. *SSRN eLibrary.*

Mckenzie, M.D. (1998) The impact of exchange rate volatility on Australian trade flows. *Journal of International Financial Markets, Institutions and Money,* 8 (1), 21-38.

Mckenzie, M.D. (1999) The Impact of Exchange Rate Volatility on International Trade Flows. *Journal of Economic Surveys,* 13 (1), 71-106.

Medhora, R. (1990) The effect of exchange rate variability on trade: The case of the West African Monetary Union's imports. *World Development,* 18 (2), 313-324.

Melvin, M. and Taylor, M.P. (2009) The crisis in the foreign exchange market. *Journal of International Money and Finance,* 28 (8), 1317-1330.

Mougoue, M. and Aggarwal, R. (2011) Trading volume and exchange rate volatility: Evidence for the sequential arrival of information hypothesis. *Journal of Banking & Finance,* 35 (10), 2690-2703.

Mukherjee, D. and Pozo, S. (2011) Exchange-rate volatility and trade: a semiparametric approach. *Applied Economics,* 43 (13), 1617-1627.

Obstfeld, M. and Rogoff, K.S. (2005) Global current account imbalances and exchange rate adjustments. *Brookings Papers on Economic Activity,* 2005 (1), 67-123.

Park, J.Y. and Phillips, P.C. (2001) Nonlinear regressions with integrated time series. *Econometrica,* 69 (1), 117-161.

Perée, E. and Steinherr, A. (1989) Exchange rate uncertainty and foreign trade. *European Economic Review,* 33 (6), 1241-1264.

Pesaran, M.H., Shin, Y. and Smith, R.J. (2001) Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics,* 16 (3), 289-326.

Poon, S.-H. and Granger, C. (2005) Practical issues in forecasting volatility. *Financial Analysts Journal*, 45-56.

Qian, Y. and Varangis, P. (1994) Does exchange rate volatility hinder export growth? *Empirical Economics,* 19 (3), 371-396.

Reinhart, C.M. and Rogoff, K.S. (2009a) The Aftermath of Financial Crises. *National Bureau of Economic Research Working Paper Series,* No. 14656.

Reinhart, C.M. and Rogoff, K.S. (2009b) Is the 2007 U.S. Sub-Prime Financial Crisis So Different? An International Historical Comparison. *Panoeconomicus* 56 (3), 291-299.

Saikkonen, P. and Choi, I. (2004) Cointegrating smooth transition regressions. *Econometric Theory,* 20 (02), 301-340.

Sauer, C. and Bohara, A.K. (2001) Exchange rate volatility and exports: regional differences between developing and industrialized countries. *Review of International Economics,* 9 (1), 133-152.

Schorderet, Y. (2001) *Revisiting okun's law: an hysteretic perspective*. Citeseer.

Sercu, P. and Vanhulle, C. (1992) Exchange rate volatility, international trade, and the value of exporting firms. *Journal of Banking & Finance,* 16 (1), 155-182.

Shiller, R. (1993) Macro markets: creating institutions for managing society's largest economic risks/Robert J. Shiller. Clarendon. Oxford.

Shiller, R.J. (2005) *Irrational exuberance*. Random House Digital, Inc.

Shin, Y., Yu, B. and Greenwood-Nimmo, M. (2011) Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. *Available at SSRN 1807745*.

Shin, Y., Yu, B. and Greenwood-Nimmo, M. (2013) Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework IN: Horrace, W.C. and Sickles, S.C. (eds.) *Festschrift in Honor of Peter Schmidt*. New York: Springer Science & Business Media.

Sukar, A.-H. and Hassan, S. (2001) US exports and time-varying volatility of real exchange rate. *Global Finance Journal,* 12 (1), 109-119.

Taylor, S.J. (2011) *Asset price dynamics, volatility, and prediction*. Princeton university press.

Tenreyro, S. (2007) On the trade impact of nominal exchange rate volatility. *Journal of Development Economics,* 82 (2), 485-508.

Thursby, J.G. and Thursby, M.C. (1987) Bilateral trade flows, the Linder hypothesis, and exchange risk. *The Review of Economics and Statistics*, 488-495.

Viaene, J.-M. and De Vries, C.G. (1992) International trade and exchange rate volatility. *European Economic Review,* 36 (6), 1311-1321.

Wang, K.L. and Barrett, C.B. (2007) Estimating the effects of exchange rate volatility on export volumes. *Journal of Agricultural and Resource Economics*, 225-255.

International Monetary Fund (2012): Direction of Trade Statistics. MIMAS, University of Manchester. DOI: http://dx.doi.org/10.5257/imf/dots/2013-03}.

Comtrade, U. (2010). United Nations Commodity Trade Statistics Database. in URL: http://comtrade.un.org.

Appendix – I: Hypotheses Test results after inclusion of 3-Month LIBOR Rates (US)

Table – 1: ARDL – F Test Results for Hypotheses 1-4 (US)

Hypotheses	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
1	7.44***	0.79	0.0022	0.2533	0.0023	3.559	1.966	0.2951	0.3139
2	7.42***	0.754	0.00248	0.419	3.32	0.931	4.92	1.07	1.06
3	8.13***	0.81	0.00198	0.2009	1.04	3.13	2.11	0.93	1.03
4	6.57***	0.757	0.00245	0.379	3.91	3.59	0.966	1.91	1.82

Table – 2: Normalized Coefficients under ARDL Method for Hypotheses 1-4 (US)

Hypotheses	Constant	Real Income	Relative Import Price	Nominal volatility	3RD Country Volatility		LIBOR3M (£)
1	-17.43***	4.63***	3.67***	-0.80***			-0.10
2	14.52**	4.19***	3.01***	-0.70**			-0.01
3	-20.72***	5.57***	2.68***	-2.97***	2.51***		-0.098
4	-15.13***	4.25***	3.37***	-1.19***	0.71***		-0.018

Table – 3: Asymmetric ARDL – F Test Results for Hypotheses 1-4 (US)

Hypotheses	F-stat	Diagnostics							
		R^2	SSE	SSR	JB	LB(12)	RESET(3)	ARCH(1)	ARCH(3)
1	3.59*	0.412	0.006	0.954	3.192	0.297	2.332	1.151	1.029
2	4.47**	0.458	0.008	1.251	1.95	0.872	2.184	0.487	0.566
3	4.13**	0.618	0.01	1.64	3.76	1.147	0.458	2.054	1.767
4	5.24***	0.637	0.013	2.15	3.615	0.366	0.217	2.208	1.716

Table – 4: Normalized Coefficients under Asymmetric ARDL Method for Hypotheses 1-4 (US)

Hypotheses	Constant	Real Income		Relative Import Price		Nominal volatility		3RD Country Volatility		LIBOR3M (£)	
		+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
1	7.58***	1.56**	0.05	-2.6	4.5**	-3.5***	-3.97**			0.5	-0.07
2	7.41***	1.89***	0.06*	-3.15**	1.1***	-4.23**	-3.88**			0.61	-0.05
3	5.08***	1.05**	0.03***	-1.74**	9.7***	-2.34**	-2.66***	1.95**	-1.42**	0.34	-0.05
4	6.3***	1.61**	0.04**	-2.68***	12.5**	-3.6***	-3.3**	0.5**	-0.34**	0.52	-0.05

Appendix – II: Descriptive and Stationarity Test Results

Table 4.1: Descriptive Statistics for Level Variables (Log)

Variables	Mean	Variance	Skewness	Kurtosis	JB	
Brazil						
Imports	5.2***	0.198	0.292*	-1.049***	15.192	***
Rel Imp. Prices	1.0***	0.002	0.788***	-0.470	28.501	***
Real Ex. Rate	0.01***	6.333	-2.240***	3.758***	360.374	***
Nom. Ex. Rate	0.009***	7.064	-2.268***	3.903***	377.602	***
China						
Imports	6.6***	1.564	-0.024	-1.346***	19.119	***
Rel Imp. Prices	1.0***	0.001	0.519***	-0.775**	17.684	***
Real Ex. Rate	2.4***	0.038	-0.833***	0.185*	29.649	***
Nom. Ex. Rate	2.5***	0.028	-0.652***	-0.620	21.960	***
Germany						
Imports	8.2***	0.133	0.250***	-1.115***	15.731	***
Rel Imp. Prices	1.0***	0.000	0.703	-0.296	21.764	***
Real Ex. Rate	0.9***	0.014	-0.458**	-1.064***	20.760	***
Nom. Ex. Rate	0.9***	0.015	-0.380***	-1.121***	19.333	***
Japan						
Imports	7.0***	0.034	-0.859***	0.372	32.577	***
Rel Imp. Prices	1.05***	0.001	0.905***	0.284	35.401	***
Real Ex. Rate	4.9***	0.043	-1.219*	0.760**	68.729	***
Nom. Ex. Rate	5.2***	0.033	-0.267***	-0.704**	8.239	**
South Africa						
Imports	5.6***	0.407	0.058***	-1.127	13.535	***
Rel Imp. Prices	0.9***	0.004	-0.455***	-0.893***	17.148	***
Real Ex. Rate	2.4***	0.088	-0.350**	-0.926***	14.205	***
Nom. Ex. Rate	2.2***	0.153	-0.533***	-1.121***	25.198	***
US						
Imports	8.0***	0.055	-0.711***	-0.363	22.718	***
Rel Imp. Prices	1.07***	0.001	1.063***	-0.026	47.646	***
Real Ex. Rate	0.4***	0.007	0.429***	-0.774**	14.070	***
Nom. Ex. Rate	0.5***	0.009	0.531***	-0.571*	15.339	***
UK						
Real Income	4.5***	0.003	-0.606***	-1.148***	29.376	***

Note:

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

Table 4.2: Descriptive Statistics for First Differenced Variables (Log)

Variables	Mean	Variance	Skewness	Kurtosis	JB	
Brazil						
Δ Imports	0.004	0.041	0.076	0.541*	3.314	
Δ Rel. Imp Prices	0.001	0.001	-0.476***	0.763**	15.637	***
Δ Nom. Ex. Rate	0.036	0.011	1.768***	3.309***	246.327	***
Δ Real Ex. Rate	0.040***	0.012	1.715***	2.837***	208.045	***
China						
Δ Imports	0.017**	0.015	0.164	1.001	11.643	***
Δ Rel. Imp Prices	0.000***	0.001	-0.405**	1.531***	31.502	***
Δ Nom. Ex. Rate	0.001	0.001	4.324***	48.86***	25860.551	***
Δ Real Ex. Rate	0.000	0.001	5.113***	59.86***	38725.308	***
Germany						
Δ Imports	0.003	0.012	-0.282*	0.353	4.641	*
Δ Rel. Imp Prices	0.000*	0.001	-0.741***	3.20***	130.759	***
Δ Nom. Ex. Rate	-0.001	0.001	-1.127***	6.30***	470.265	***
Δ Real Ex. Rate	-0.001	0.001	-1.227***	6.96***	572.939	***
Japan						
Δ Imports	0.000	0.011	0.430***	0.66**	12.378	***
Δ Rel. Imp Prices	0.000	0.001	-1.428***	6.75***	564.183	***
Δ Nom. Ex. Rate	-0.003	0.001	-0.201	-0.01	1.696	
Δ Real Ex. Rate	-0.003	0.001	-1.095***	3.11***	152.274	***
South Africa						
Δ Imports	0.003	0.090	-0.053	-0.228	0.660	
Δ Rel. Imp Prices	0.001***	0.001	0.670***	0.505*	21.509	***
Δ Nom. Ex. Rate	0.002	0.002	0.358**	1.923***	44.204	***
Δ Real Ex. Rate	0.004	0.002	0.358***	1.909***	43.668	***
US						
Δ Imports	0.002	0.010	0.101	-0.151	0.664	
Δ Rel. Imp Prices	0.000***	0.001	-1.663***	8.51***	876.133	***
Δ Nom. Ex. Rate	-0.001	0.001	-0.896***	3.34***	150.650	***
Δ Real Ex. Rate	-0.001	0.001	-0.908***	3.17***	140.417	***
UK						
Δ Real Income	0.000	0.001	-1.011***	4.43***	249.274	***

Note:

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

Table 4.3: Stationarity and Unit Root Tests of Log-Level and 1st Difference Variables

Variables	ADF	ADF Intercept	ADF Int. & Trend	KPSS	KPSS with Trend
LOG-LEVEL VARIABLES					
BRAZIL					
Imports	0.894	-1.273	-3.843 **	4.716 ***	0.516 ***
Rel Imp Price	0.847	-0.052	-1.544	2.609 ***	1.17 ***
Real. Ex. Rate	-4.42 ***	-5.458 ***	-4.822 ***	2.529 ***	0.883 ***
Nom. Ex. Rate	-4.38 ***	-5.489 ***	-4.947 ***	2.561 ***	0.866 ***
CHINA					
Imports	2.766	-1.143	-3.066	5.104 ***	0.339 ***
Rel Imp Price	-1.95 **	-0.444	-2.115	4.534 ***	0.446 ***
Real. Ex. Rate	0.381	-2.378	-1.703	2.305 ***	0.782 ***
Nom. Ex. Rate	0.035	-2.304	-1.922	0.983 ***	0.685 ***
GERMANY					
Imports	1.093	-1.166	-2.995	4.515 ***	0.26 ***
Rel Imp Price	0.992	-0.463	-3.304 *	4.054 ***	0.292 ***
Real. Ex. Rate	-0.87	-1.273	-1.416	1.111 ***	0.851 ***
Nom. Ex. Rate	-0.76	-1.448	-1.504	0.899 ***	0.816 ***
JAPAN					
Imports	-0.11	-2.111	-2.521	0.97 ***	0.617 ***
Rel Imp Price	0.225	-1.361	-2.776	2.524 ***	0.552 ***
Real. Ex. Rate	-1.16	-0.063	-1.35	2.722 ***	0.874 ***
Nom. Ex. Rate	-1.01	-1.326	-1.478	0.569 **	0.391 ***
SOUTH AFRICA					
Imports	0.424	-1.405	-1.903	4.398 ***	0.501 ***
Rel Imp Price	4.412	-4.343 ***	-2.394	4.976 ***	1.048 ***
Real. Ex. Rate	0.618	-1.687	-1.446	3.326 ***	0.916 ***
Nom. Ex. Rate	1.182	-1.695	-1.347	4.173 ***	0.94 ***
US					
Imports	0.404	-2.139	-1.919	2.353 ***	0.932 ***
Rel Imp Price	1.402	-0.097	-1.738	3.663 ***	0.879 ***
Real. Ex. Rate	-0.60	-2.388	-2.369	0.414 *	0.299 ***
Nom. Ex. Rate	-0.53	-2.397	-2.425	0.667 **	0.305 ***
UK					
Real Income	0.027	-1.351	-0.909	1.22 ***	1.103 ***

Note:

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

Variables	ADF	ADF Intercept	ADF Int. & Trend	KPSS	KPSS with Trend
1st DIFFERENCE OF LOG-LEVEL VARIABLES					
BRAZIL					
Δ Imports	-8.65 ***	-8.708 ***	-8.689 ***	0.019	0.019
Δ Rel Imp Price	-5.51 ***	-5.593 ***	-5.974 ***	0.85 ***	0.05
Δ Real. Ex. Rate	-2.62 ***	-2.839 *	-3.71 **	1.872 ***	0.333 ***
Δ Nom. Ex. Rate	-2.51 **	-2.686 *	-3.403 *	1.994 ***	0.389 ***
CHINA					
Δ Imports	-8.84 ***	-9.757 ***	-9.777 ***	0.035	0.028
Δ Rel Imp Price	-3.69 ***	-4.023 ***	-4.017 ***	0.094	0.094
Δ Real. Ex. Rate	-6.24 ***	-6.257 ***	-6.482 ***	0.21	0.042
Δ Nom. Ex. Rate	-6.05 ***	-6.039 ***	-6.25 ***	0.191	0.041
GERMANY					
Δ Imports	-6.31 ***	-6.392 ***	-6.373 ***	0.032	0.032
Δ Rel Imp Price	-5.37 ***	-5.469 ***	-5.596 ***	0.176	0.037
Δ Real. Ex. Rate	-6.46 ***	-6.5 ***	-6.495 ***	0.127	0.095
Δ Nom. Ex. Rate	-6.52 ***	-6.54 ***	-6.528 ***	0.113	0.094
JAPAN					
Δ Imports	-7.92 ***	-7.903 ***	-7.945 ***	0.06	0.019
Δ Rel Imp Price	-7.15 ***	-7.152 ***	-7.217 ***	0.156	0.051
Δ Real. Ex. Rate	-5.39 ***	-5.546 ***	-5.688 ***	0.287	0.066
Δ Nom. Ex. Rate	-7.10 ***	-7.195 ***	-7.191 ***	0.132	0.128 *
SOUTH AFRICA					
Δ Imports	-9.51 ***	-9.509 ***	-9.513 ***	0.049	0.035
Δ Rel Imp Price	-2.32 **	-3.521 ***	-4.238 ***	1.22 ***	0.06
Δ Real. Ex. Rate	-7.35 ***	-7.393 ***	-7.469 ***	0.132	0.066
Δ Nom. Ex. Rate	-7.07 ***	-7.277 ***	-7.4 ***	0.171	0.062
US					
Δ Imports	-8.82 ***	-8.825 ***	-8.912 ***	0.088	0.018
Δ Rel Imp Price	-6.73 ***	-6.914 ***	-7.011 ***	0.187	0.028
Δ Real. Ex. Rate	-7.09 ***	-7.092 ***	-7.075 ***	0.082	0.073
Δ Nom. Ex. Rate	-7.12 ***	-7.107 ***	-7.09 ***	0.082	0.069
UK					
Δ Real Income	-5.23 ***	-5.223 ***	-5.857 ***	0.696 **	0.051

Note:

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

Appendices

Table 4.4: Descriptive Statistics for Exchange Rate Volatility

Variables	Mean	Variance	Skewness	Kurtosis	JB-Stat
Brazil					
Nominal Ex. Rate Vol.	0.013***	0.0005930	3.55***	16.33***	33.3254 ***
Real Ex. Rate Vol.	0.012***	0.0005315	3.64***	16.63***	34.6175 ***
Δ Nominal Ex. Rate Vol.	0.0000	0.0004296	-0.04***	59.37***	368.662 ***
Δ Real Ex. Rate Vol.	0.0000	0.0003690	0.042***	60.38***	381.363 ***
China					
Nominal Ex. Rate Vol.	0.0014***	0.0000002	14.2***	220.2***	5179.63 ***
Real Ex. Rate Vol.	0.0008***	0.0000001	1.55***	1.25***	118.146 ***
Δ Nominal Ex. Rate Vol.	0.0000	0.0000004	-2.93***	118.03***	1460.55 ***
Δ Real Ex. Rate Vol.	0.0000	0.0000000	-15.15***	236.03***	5922.83 ***
Germany					
Nominal Ex. Rate Vol.	0.0007***	0.0000008	7.96***	76.43***	640.008 ***
Real Ex. Rate Vol.	0.0006***	0.0000006	7.82***	73.97***	600.336 ***
Δ Nominal Ex. Rate Vol.	0.0000	0.0000006	6.39***	85.22***	776.672 ***
Δ Real Ex. Rate Vol.	0.0000	0.0000005	6.14***	80.25***	689.366 ***
Japan					
Nominal Ex. Rate Vol.	0.0014***	0.0000002	3.15***	11.7***	1855.71 ***
Real Ex. Rate Vol.	0.0009***	0.0000001	1.83***	4.12***	321.03 ***
Δ Nominal Ex. Rate Vol.	0.0000	0.0000001	5.00***	38.89***	168.702 ***
Δ Real Ex. Rate Vol.	0.0000	0.0000001	2.31***	11.87***	169.922 ***
South Africa					
Nominal Ex. Rate Vol.	0.0019***	0.0000011	2.466***	7.98***	925.203 ***
Real Ex. Rate Vol.	0.0022***	0.0000013	2.995***	12.08***	191.034 ***
Δ Nominal Ex. Rate Vol.	0.0000	0.0000007	3.09***	18.02***	379.996 ***
Δ Real Ex. Rate Vol.	0.0000	0.0000010	2.63***	16.32***	307.839 ***
US					
Nominal Ex. Rate Vol.	0.0007***	0.0000002	4.25***	25.32***	749.493 ***
Real Ex. Rate Vol.	0.0006***	0.0000001	4.55***	29.21***	983.365 ***
Δ Nominal Ex. Rate Vol.	0.0000	0.0000001	1.48***	15.62***	264.461 ***
Δ Real Ex. Rate Vol.	0.0000	0.0000001	0.74***	14.89***	234.303 ***

Note:

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

Table 4.5: Unit Root Tests for Exchange Rate Volatility

Level Series

Variables	ADF		ADF Intercept		ADF-Int & Trend		KPSS		KPSS Trend	
Brazil										
Nominal Ex. Rate Vol.	-2.86	***	-3.38	**	-4.09	***	0.16		0.03	
Real Ex. Rate Vol.	-2.83	***	-3.37	**	-4.07	***	0.14		0.03	
China										
Nominal Ex. Rate Vol.	-2.64	***	-6.73	***	-6.88	***	0.23		0.07	
Real Ex. Rate Vol.	-2.22	**	-3.33	**	-4.1	***	0.1		0.08	
South Africa										
Nominal Ex. Rate Vol.	-2.56	**	-4.31	***	-4.59	***	0.26		0.12	
Real Ex. Rate Vol.	-2.47	**	-4.73	***	-4.85	***	0.21		0.12	
Germany										
Nominal Ex. Rate Vol.	-3.4	***	-5.31	***	-5.36	***	0.19		0.1	
Real Ex. Rate Vol.	-3.36	***	-5.33	***	-5.36	***	0.17		0.09	
Japan										
Nominal Ex. Rate Vol.	-2.98	***	-4.45	***	-4.44	***	0.15		0.14	
Real Ex. Rate Vol.	-2.1	**	-4.35	***	-4.35	***	0.12		0.11	
US										
Nominal Ex. Rate Vol.	-2.72	***	-4.13	***	-4.13	***	0.2		0.08	
Real Ex. Rate Vol.	-2.78	***	-4.12	***	-4.15	***	0.24		0.07	

First Difference Series

Variables	ADF		ADF Intercept		ADF-Int & Trend		KPSS	KPSS Trend
Brazil								
Δ Nom. Ex. Rate Vol.	-8.93	***	-8.91	***	-8.89	***	0.02	0.02
Δ Real Ex. Rate Vol.	-8.55	***	-8.53	***	-8.51	***	0.02	0.02
China								
Δ Nom. Ex. Rate Vol.	-11.4	***	-11.37	***	-11.35	***	0.01	0.01
Δ Real Ex. Rate Vol.	-6.76	***	-6.76	***	-6.86	***	0.14	0.04
South Africa								
Δ Nom. Ex. Rate Vol.	-7.97	***	-7.95	***	-7.94	***	0.01	0.01
Δ Real Ex. Rate Vol.	-8.35	***	-8.34	***	-8.32	***	0.01	0.01
Germany								
Δ Nom. Ex. Rate Vol.	-9.18	***	-9.16	***	-9.14	***	0.01	0.01
Δ Real Ex. Rate Vol.	-9.2	***	-9.18	***	-9.16	***	0.01	0.01
Japan								
Δ Nom. Ex. Rate Vol.	-8.32	***	-8.31	***	-8.29	***	0.01	0.01
Δ Real Ex. Rate Vol.	-8.16	***	-8.14	***	-8.12	***	0.01	0.01
US								
Δ Nom. Ex. Rate Vol.	-8.52	***	-8.5	***	-8.5	***	0.01	0.01
Δ Real Ex. Rate Vol.	-8.64	***	-8.63	***	-8.62	***	0.01	0.01

Note:

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

Appendices

Table 4.6: Univariate GARCH(p,q) Results for Nominal and Real Exchange Rate Volatility – Developed Countries

Parameters	Germany		Japan		US	
	Nominal	Real	Nominal	Real	Nominal	Real
M	0.00027	0.00013	-0.0022	-0.00037	0.00011	-0.00004
ω	0.001***	0.001***	0.0003***	0.002***	0.002***	0.002***
A(1)	0.406***	0.413***	0.076***	0.158***	0.174***	0.196***
B(1)	0.438***	0.426***	0.721***	0.617***	0.349***	0.227***
B(2)	--	--	--	--	0.243***	0.323***
L	597.5758	615.11	472.23	530.11	559.56	580.87
Std. Resids (Q-Stat,12)	4.348	3.991	3.282	1.728	6.148	6.028
Sq.Std.Resids (Q-Stat,12)	1.728	1.623	2.082	0.653	2.412	2.436

Table 4.7: Univariate GARCH(p,q) Results for Nominal and Real Exchange Rate Volatility – Developing Countries

Variables	Brazil		China		South Africa	
	Nominal	Real	Nominal	Real	Nominal	Real
M	0.0016	0.0001	0.00006	0.0004	0.0045	0.0022
ω	0.0026***	0.0001 ***	0.0017***	0.00005 ***	0.0004 ***	0.0007 ***
A(1)	0.72***	0.41***	0.037***	0.0082***	0.21***	0.223***
B(1)	0.038***	0.42***	0.21***	1.019***	0.58***	0.46***
L	293.13	614.13	470.67	525.77	446.57	426.12
Std. Residuals (Q-Stat,12)	4.173	3.991	1.999	5.386	5.39	5.73
Sq.Std.Residuals (Q-Stat,12)	0.232	1.623	0.12	0.471	3.34	3.84

Note:

1. ***,**,* denote significance levels at 1%, 5%, and 10% respectively.
2. M: Mean Exchange Rate Variation; ω: Contemporaneous Conditional Variance; α1: ARCH effect; β: GARCH effect; L: Log Likelihood; Std, Resids: Standardised Residuals; Sq.Std.Resids: Squared Standardised Residuals; (Q-Stat, 12): Ljung-Box Autocorrelation Test up to 12 lags.

Appendix – III: Graphic Analysis

Figure 4.2: UK Imports

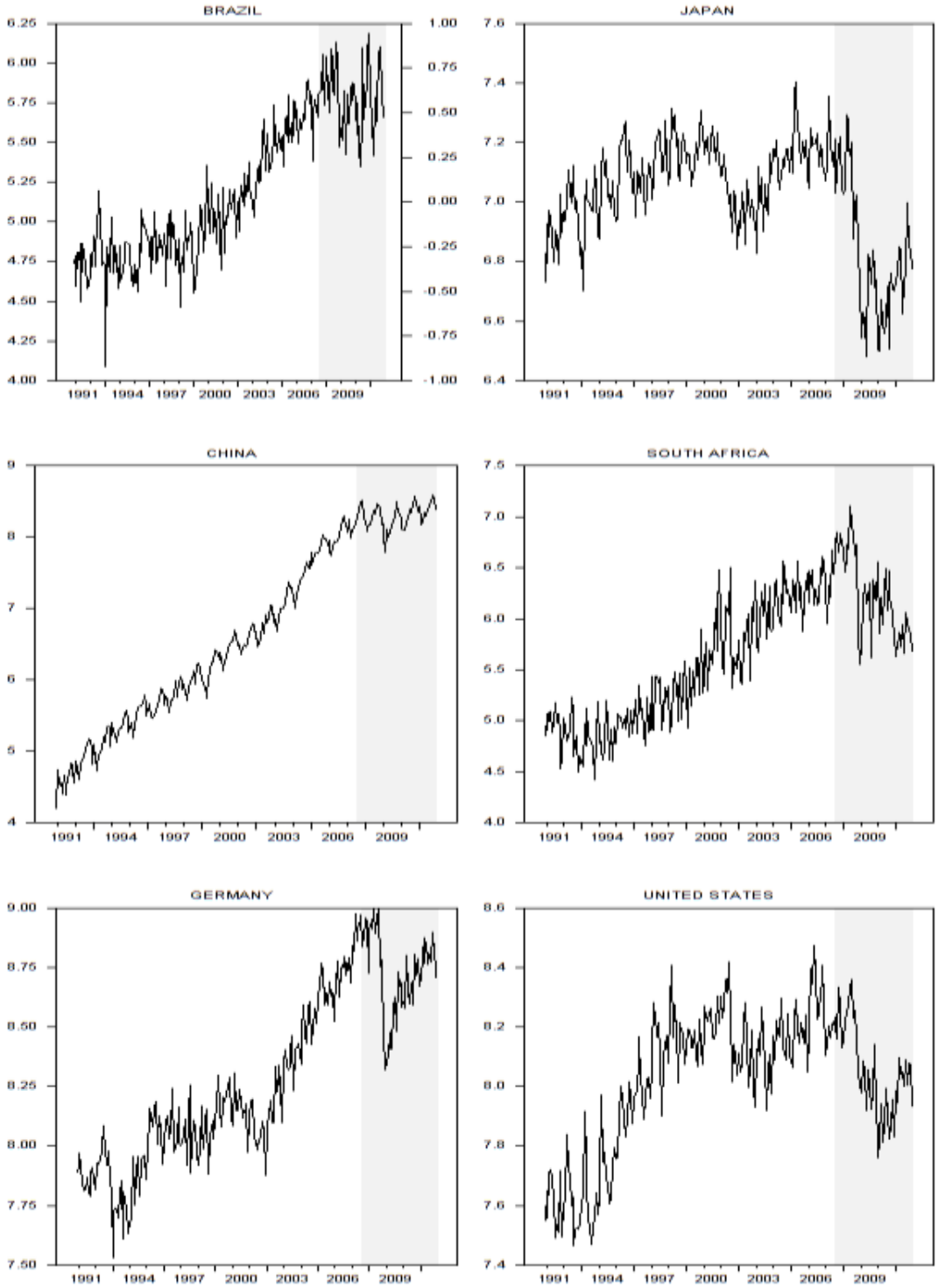


Figure 4.3: UK MONTHLY REAL INCOME (LOG)

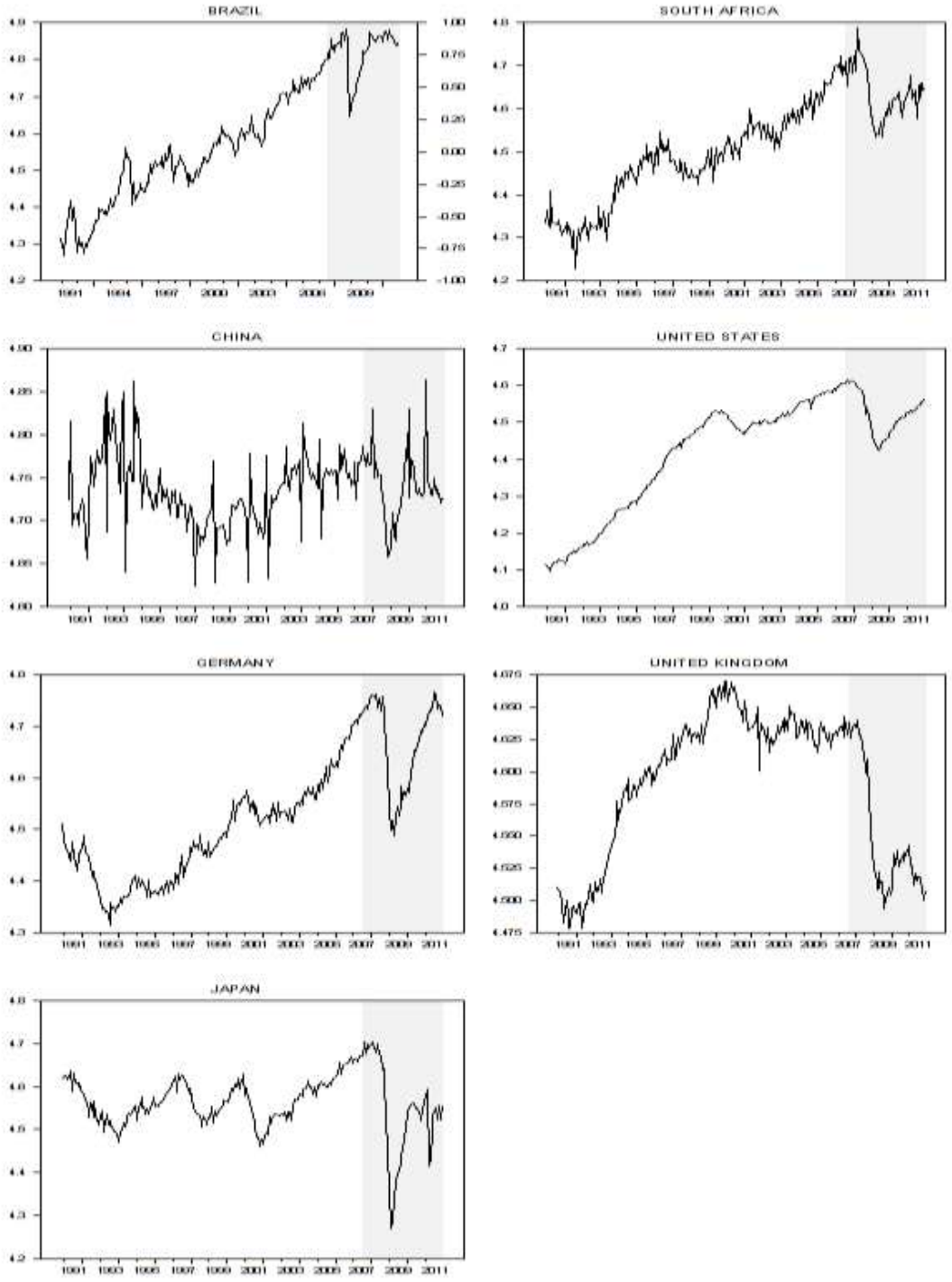


Figure 4.4: UK MONTHLY RELATIVE IMPORT PRICES (LOG)

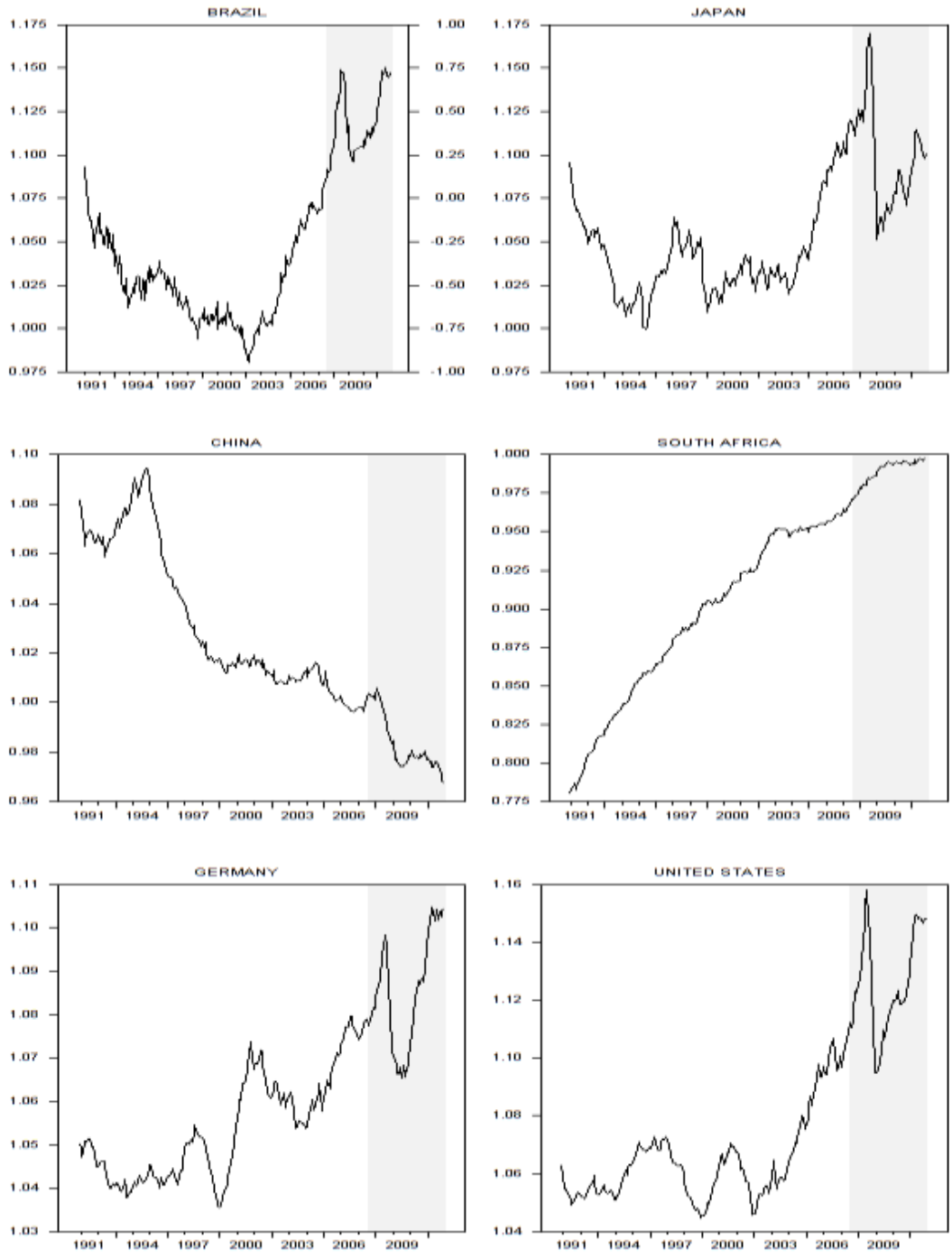


Figure 4.5: UK MONTHLY REAL EXCHANGE RATE (LOG)

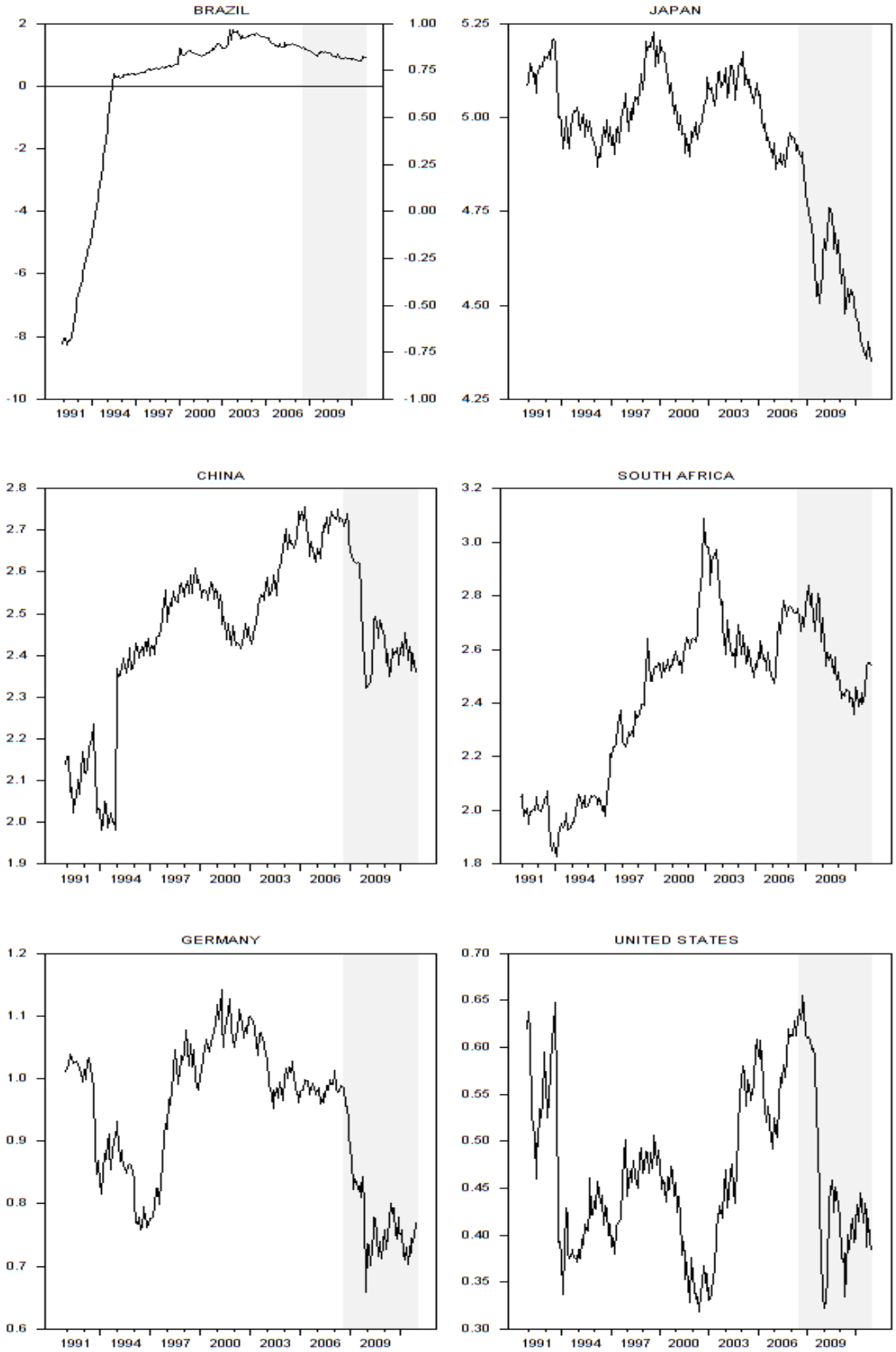


Figure 4.6: UK MONTHLY NOMINAL EXCHANGE RATE (LOG)

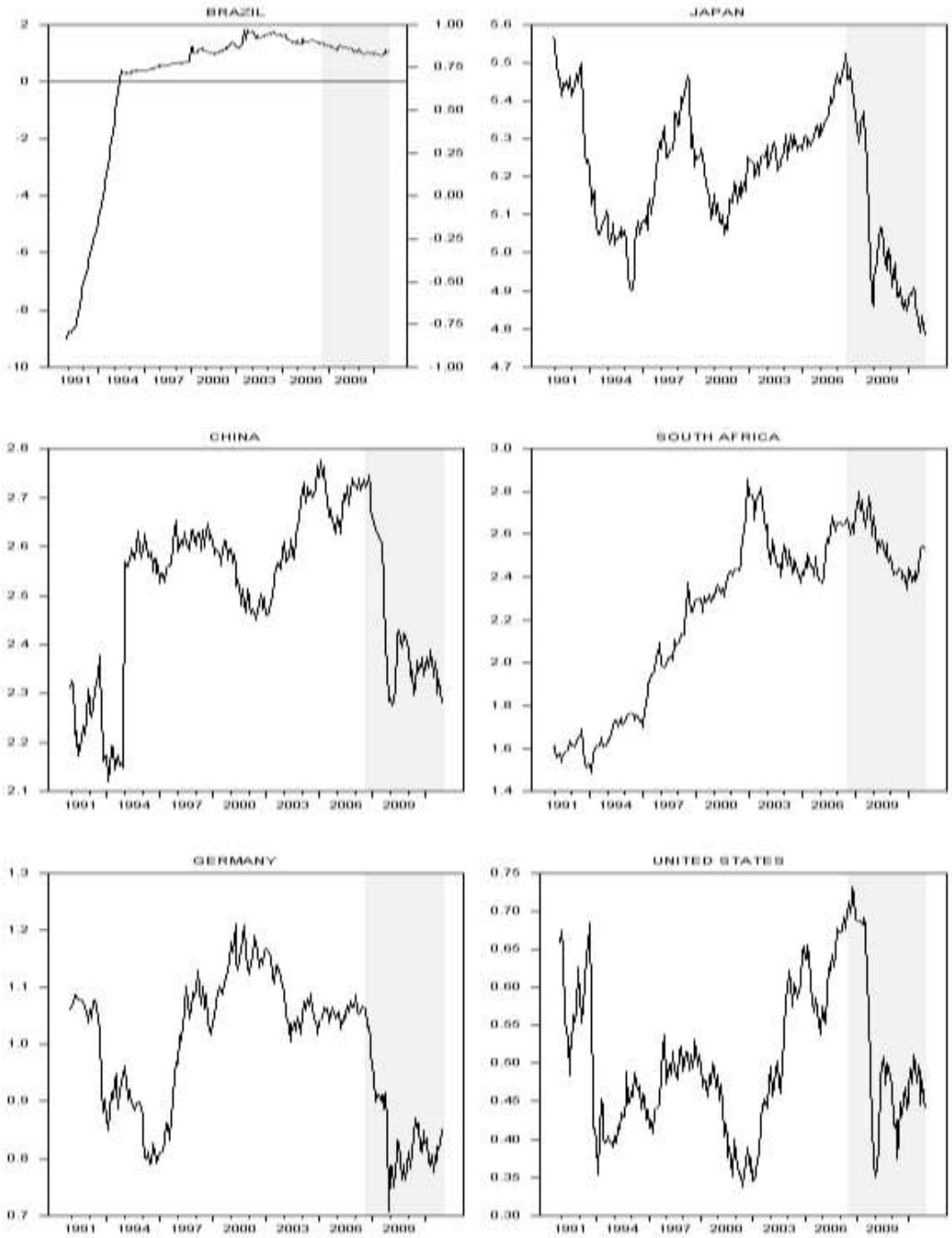


Figure 4.7: Nominal Exchange Rate Volatility - GARCH (p,q)

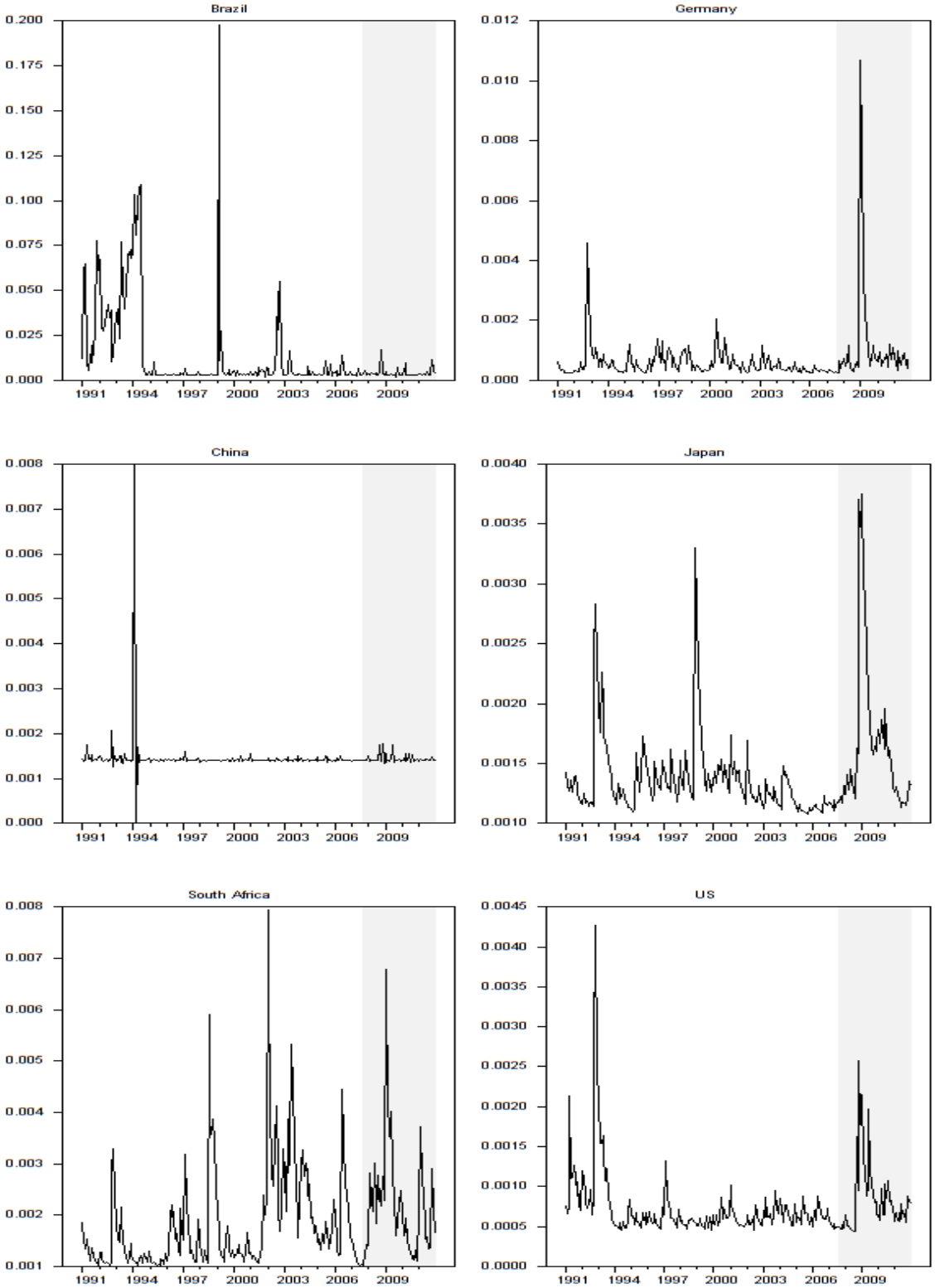
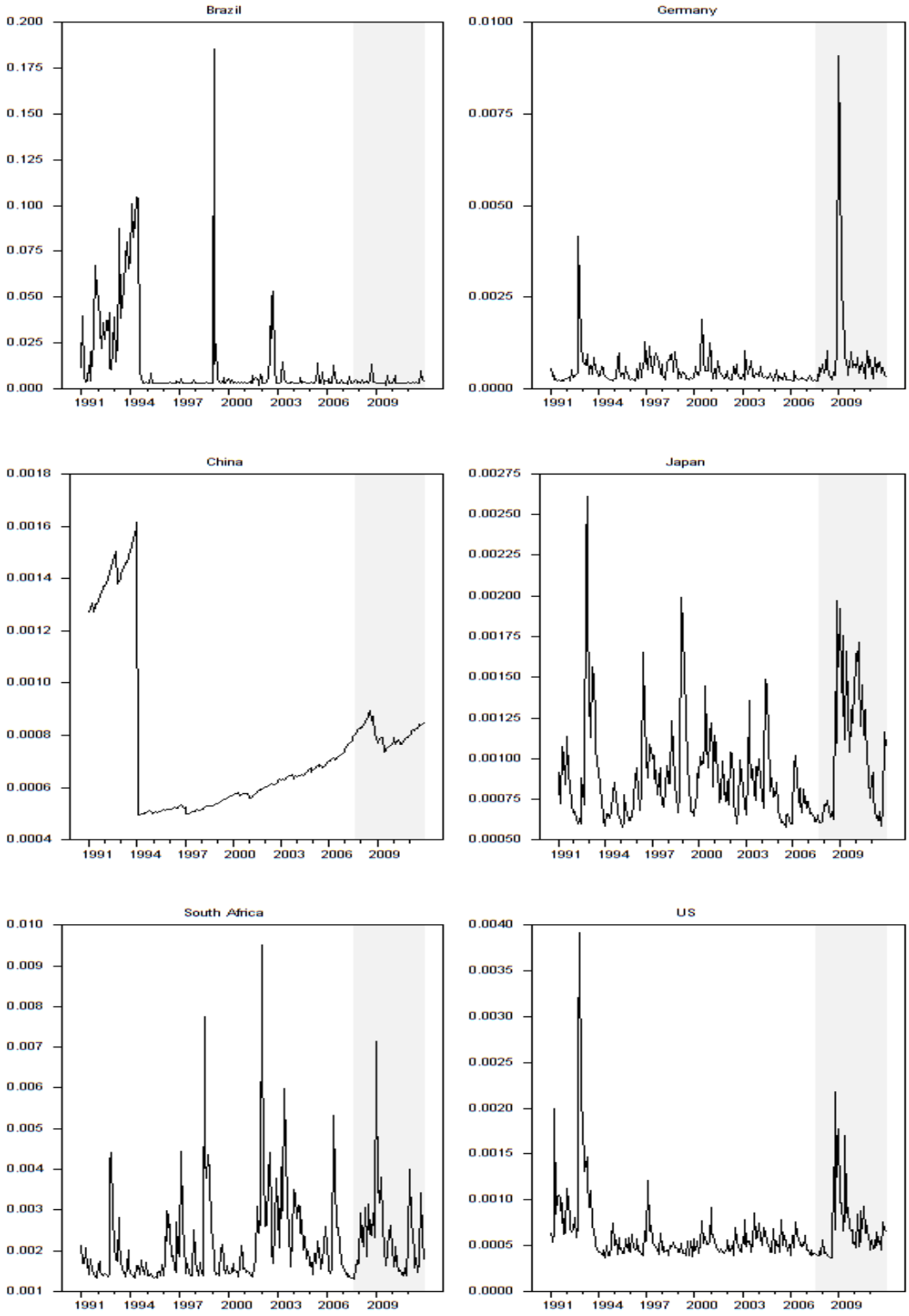


Figure 4.8: Real Exchange Rate Volatility - GARCH (p,q)



Appendix – IV: Auatogressive Dynamic Stability Test

Table 5.1					Table 5.2				
Germany					Germany				
AR Roots	Real	Imag	Modulus	Period	**No Cointegration**				
1	-0.005	0.984	0.984	3.988					
2	-0.005	-0.984	0.984						
3	-0.49	-0.821	0.956						
4	-0.49	0.821	0.956	2.979					
5	0.459	0.827	0.946	5.901					
6	0.459	-0.827	0.946						
7	-0.946	0	0.946						
8	0.772	0.481	0.91	11.282					
9	0.772	-0.481	0.91						
10	-0.775	-0.454	0.898						
11	-0.775	0.454	0.898	2.406					
12	0.844	0	0.844						
13	-0.384	0	0.384						
Japan					Japan				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	0.489	-0.822	0.957		1	0.489	-0.82	0.955	
2	0.489	0.822	0.957	6.073	2	0.489	0.82	0.955	6.085
3	0.009	-0.953	0.954		3	0.011	-0.952	0.952	
4	0.009	0.953	0.954	4.024	4	0.011	0.952	0.952	4.029
5	-0.944	0	0.944		5	-0.941	0	0.941	
6	-0.488	0.801	0.938	2.966	6	-0.492	0.8	0.939	2.961
7	-0.488	-0.801	0.938		7	-0.492	-0.8	0.939	
8	-0.795	-0.477	0.927		8	-0.796	0.479	0.929	2.416
9	-0.795	0.477	0.927	2.415	9	-0.796	-0.479	0.929	
10	0.776	0.475	0.91	11.436	10	0.785	0.459	0.91	11.879
11	0.776	-0.475	0.91		11	0.785	-0.459	0.91	
12	0.828	0	0.828		12	0.863	0	0.863	
US					US				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	0.884	-0.444	0.989		1	0.884	-0.444	0.99	
2	0.884	0.444	0.989	13.508	2	0.884	0.444	0.99	13.502
3	0.488	0.805	0.941	6.125	3	0.487	0.805	0.941	6.121
4	0.488	-0.805	0.941		4	0.487	-0.805	0.941	
5	0.016	-0.937	0.937		5	0.016	0.936	0.937	4.045
6	0.016	0.937	0.937	4.045	6	0.016	-0.936	0.937	
7	-0.925	0	0.925		7	-0.924	0	0.924	
8	-0.484	0.773	0.912	2.949	8	-0.484	0.773	0.912	2.949
9	-0.484	-0.773	0.912		9	-0.484	-0.773	0.912	
10	-0.769	0.441	0.887	2.397	10	-0.769	0.441	0.887	2.397
11	-0.769	-0.441	0.887		11	-0.769	-0.441	0.887	
12	0.403	0	0.403		12	0.402	0	0.402	

Table 5.3					Table 5.4				
Germany					Germany				
AR Roots	Real	Imag	Modulus	Period	**No Cointegration**				
1	-0.005	0.937	0.937	3.798					
2	-0.005	-0.937	0.937						
3	-0.467	-0.782	0.910						
4	-0.467	0.782	0.910	2.837					
5	0.437	0.788	0.901	5.620					
6	0.437	-0.788	0.901						
7	-0.901	0.000	0.901						
8	0.735	0.458	0.867	10.745					
9	0.735	-0.458	0.867						
10	-0.738	-0.432	0.855						
11	-0.738	0.432	0.855	2.291					
12	0.804	0.000	0.804						
13	-0.366	0.000	0.366						
Japan					Japan				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	0.466	-0.783	0.911		1	0.466	-0.781	0.910	
2	0.466	0.783	0.911	5.784	2	0.466	0.781	0.910	5.795
3	0.009	-0.908	0.909		3	0.010	-0.907	0.907	
4	0.009	0.908	0.909	3.832	4	0.010	0.907	0.907	3.837
5	-0.899	0.000	0.899		5	-0.896	0.000	0.896	
6	-0.465	0.763	0.893	2.825	6	-0.469	0.762	0.894	2.820
7	-0.465	-0.763	0.893		7	-0.469	-0.762	0.894	
8	-0.757	-0.454	0.883		8	-0.758	0.456	0.885	
9	-0.757	0.454	0.883	2.300	9	-0.758	-0.456	0.885	0.000
10	0.739	0.452	0.867	10.891	10	0.748	0.437	0.867	11.313
11	0.739	-0.452	0.867		11	0.748	-0.437	0.867	
12	0.789	0.000	0.789		12	0.822	0.000	0.822	
13	-0.197	0.000	0.197		13	-0.198	0.000	0.198	
US					US				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	0.842	-0.423	0.942		1	0.842	-0.423	0.943	
2	0.842	0.423	0.942	12.865	2	0.842	0.423	0.943	12.859
3	0.465	0.767	0.896	5.833	3	0.464	0.767	0.896	5.830
4	0.465	-0.767	0.896		4	0.464	-0.767	0.896	
5	0.015	-0.892	0.892		5	0.015	0.891	0.892	3.852
6	0.015	0.892	0.892	3.852	6	0.015	-0.891	0.892	
7	-0.881	0.000	0.881		7	-0.880	0.000	0.880	
8	-0.461	0.736	0.869	2.809	8	-0.461	0.736	0.869	2.809
9	-0.461	-0.736	0.869		9	-0.461	-0.736	0.869	
10	-0.732	0.420	0.845	2.283	10	-0.732	0.420	0.845	2.283
11	-0.732	-0.420	0.845		11	-0.732	-0.420	0.845	
12	0.384	0.000	0.384		12	0.383	0.000	0.383	

Table 5.5					Table 5.6				
Germany					Germany				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.005	0.89	0.89	3.608	1	-0.004	0.757	0.757	3.067
2	-0.005	-0.89	0.89	0	2	-0.004	-0.757	0.757	0
3	-0.444	-0.743	0.865	0	3	-0.377	-0.632	0.735	0
4	-0.444	0.743	0.865	2.695	4	-0.377	0.632	0.735	2.291
5	0.415	0.749	0.856	5.339	5	0.353	0.637	0.728	4.538
6	0.415	-0.749	0.856	0	6	0.353	-0.637	0.728	0
7	-0.856	0	0.856	0	7	-0.728	0	0.728	0
8	0.698	0.435	0.824	10.208	8	0.593	0.37	0.7	8.677
9	0.698	-0.435	0.824	0	9	0.593	-0.37	0.7	0
10	-0.701	-0.41	0.812	0	10	-0.596	-0.349	0.69	0
11	-0.701	0.41	0.812	2.176	11	-0.596	0.349	0.69	1.85
12	0.764	0	0.764	0	12	0.649	0	0.649	0
13	-0.348	0	0.348	0	13	-0.296	0	0.296	0
Japan					Japan				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	0.443	-0.744	0.865	0	1	0.377	-0.632	0.735	0
2	0.443	0.744	0.865	5.495	2	0.377	0.632	0.735	4.671
3	0.009	-0.863	0.864	0	3	0.008	-0.734	0.734	0
4	0.009	0.863	0.864	3.64	4	0.008	0.734	0.734	3.094
5	-0.854	0	0.854	0	5	-0.726	0	0.726	0
6	-0.442	0.725	0.848	2.684	6	-0.376	0.616	0.721	2.281
7	-0.442	-0.725	0.848	0	7	-0.376	-0.616	0.721	0
8	-0.719	-0.431	0.839	0	8	-0.611	-0.366	0.713	0
9	-0.719	0.431	0.839	2.185	9	-0.611	0.366	0.713	1.857
10	0.702	0.429	0.824	10.346	10	0.597	0.365	0.7	8.794
11	0.702	-0.429	0.824	0	11	0.597	-0.365	0.7	0
12	0.75	0	0.75	0	12	0.638	0	0.638	0
-	-	-	-	-	13	-0.159	0	0.159	0
US					US				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	0.8	-0.402	0.895	0	1	0.68	-0.342	0.761	0
2	0.8	0.402	0.895	12.222	2	0.68	0.342	0.761	10.389
3	0.442	0.729	0.851	5.541	3	0.376	0.62	0.723	4.71
4	0.442	-0.729	0.851	0	4	0.376	-0.62	0.723	0
5	0.014	-0.847	0.847	0	5	0.012	-0.72	0.72	0
6	0.014	0.847	0.847	3.659	6	0.012	0.72	0.72	3.11
7	-0.837	0	0.837	0	7	-0.711	0	0.711	0
8	-0.438	0.699	0.826	2.669	8	-0.372	0.594	0.702	2.269
9	-0.438	-0.699	0.826	0	9	-0.372	-0.594	0.702	0
10	-0.695	0.399	0.803	2.169	10	-0.591	0.339	0.683	1.844
11	-0.695	-0.399	0.803	0	11	-0.591	-0.339	0.683	0
12	0.365	0	0.365	0	12	0.31	0	0.31	0

Table 5.7					Table 5.8				
Germany					Germany				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.003	0.534	0.534	2.165	1	-0.003	0.454	0.454	1.84
2	-0.003	-0.534	0.534	0	2	-0.003	-0.454	0.454	0
3	-0.266	-0.446	0.519	0	3	-0.226	-0.379	0.441	0
4	-0.266	0.446	0.519	1.617	4	-0.226	0.379	0.441	1.374
5	0.249	0.449	0.514	3.203	5	0.212	0.382	0.437	2.723
6	0.249	-0.449	0.514	0	6	0.212	-0.382	0.437	0
7	-0.514	0	0.514	0	7	-0.437	0	0.437	0
8	0.419	0.261	0.494	6.125	8	0.356	0.222	0.42	5.206
9	0.419	-0.261	0.494	0	9	0.356	-0.222	0.42	0
10	-0.421	-0.246	0.487	0	10	-0.358	-0.209	0.414	0
11	-0.421	0.246	0.487	1.306	11	-0.358	0.209	0.414	1.11
12	0.458	0	0.458	0	12	0.389	0	0.389	0
13	-0.209	0	0.209	0	13	-0.178	0	0.178	0
Japan					Japan				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	0.266	-0.446	0.519	0	1	0.226	-0.379	0.441	0
2	0.266	0.446	0.519	3.297	2	0.226	0.379	0.441	2.802
3	0.005	-0.518	0.518	0	3	0.004	-0.44	0.44	0
4	0.005	0.518	0.518	2.184	4	0.004	0.44	0.44	1.856
5	-0.512	0	0.512	0	5	-0.435	0	0.435	0
6	-0.265	0.435	0.509	1.61	6	-0.225	0.37	0.433	1.369
7	-0.265	-0.435	0.509	0	7	-0.225	-0.37	0.433	0
8	-0.431	-0.259	0.503	0	8	-0.366	-0.22	0.428	0
9	-0.431	0.259	0.503	1.311	9	-0.366	0.22	0.428	1.114
10	0.421	0.257	0.494	6.208	10	0.358	0.218	0.42	5.277
11	0.421	-0.257	0.494	0	11	0.358	-0.218	0.42	0
12	0.45	0	0.45	0	12	0.383	0	0.383	0
-	-	-	-	-	-	-	-	-	-
US					US				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	0.48	-0.241	0.537	0	1	0.408	-0.205	0.457	0
2	0.48	0.241	0.537	7.333	2	0.408	0.205	0.457	6.233
3	0.265	0.437	0.511	3.325	3	0.226	0.372	0.434	2.826
4	0.265	-0.437	0.511	0	4	0.226	-0.372	0.434	0
5	0.008	-0.508	0.508	0	5	0.007	-0.432	0.432	0
6	0.008	0.508	0.508	2.195	6	0.007	0.432	0.432	1.866
7	-0.502	0	0.502	0	7	-0.427	0	0.427	0
8	-0.263	0.419	0.496	1.601	8	-0.223	0.356	0.421	1.361
9	-0.263	-0.419	0.496	0	9	-0.223	-0.356	0.421	0
10	-0.417	0.239	0.482	1.301	10	-0.355	0.203	0.41	1.106
11	-0.417	-0.239	0.482	0	11	-0.355	-0.203	0.41	0
12	0.219	0	0.219	0	12	0.186	0	0.186	0
-	-	-	-	-	13	0.167	0	0.167	0
-	-	-	-	-	14	0.15	0	0.15	0

Table 5.21 (Nominal)					Table 5.21 (Real)				
Germany					Germany				
AR Roots	Real	Imag	Modulus	Period	**No Cointegration**				
1	-0.002	0.401	0.401	1.624					
2	-0.002	-0.401	0.401	0					
3	-0.2	-0.335	0.389	0					
4	-0.2	0.335	0.389	1.213					
5	0.187	0.337	0.386	2.402					
6	0.187	-0.337	0.386	0					
7	-0.386	0	0.386	0					
8	0.314	0.196	0.371	4.594					
9	0.314	-0.196	0.371	0					
10	-0.316	-0.185	0.365	0					
11	-0.316	0.185	0.365	0.98					
12	0.344	0	0.344	0					
-	-	-	-	-					
Japan					Japan				
No Cointegration					AR Roots	Real	Imag	Modulus	Period
					1	0.17	-0.284	0.331	0
					2	0.17	0.284	0.331	2.102
					3	0.003	-0.33	0.33	0
					4	0.003	0.33	0.33	1.392
					5	-0.326	0	0.326	0
					6	-0.169	0.278	0.325	1.027
					7	-0.169	-0.278	0.325	0
					8	-0.275	-0.165	0.321	0
					9	-0.275	0.165	0.321	0.836
					10	0.269	0.164	0.315	3.958
					11	0.269	-0.164	0.315	0
					12	0.287	0	0.287	0
					13	0.215	0	0.215	0
US					US				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	0.528	-0.265	0.591	0	1	0.449	-0.226	0.503	0
2	0.528	0.265	0.591	8.066	2	0.449	0.226	0.503	6.856
3	0.292	0.481	0.562	3.658	3	0.249	0.409	0.477	3.109
4	0.292	-0.481	0.562	0	4	0.249	-0.409	0.477	0
5	0.009	-0.559	0.559	0	5	0.008	-0.475	0.475	0
6	0.009	0.559	0.559	2.415	6	0.008	0.475	0.475	2.053
7	-0.552	0	0.552	0	7	-0.47	0	0.47	0
8	-0.289	0.461	0.546	1.761	8	-0.245	0.392	0.463	1.497
9	-0.289	-0.461	0.546	0	9	-0.245	-0.392	0.463	0
10	-0.459	0.263	0.53	1.431	10	-0.391	0.223	0.451	1.217
11	-0.459	-0.263	0.53	0	11	-0.391	-0.223	0.451	0
12	0.241	0	0.241	0	12	0.205	0	0.205	0
-	-	-	-	-	13	0.185	0	0.185	0

Table 5.22 (Nominal)					Table 5.22 (Real)				
Germany					Germany				
AR Roots	Real	Imag	Modulus	Period	**No Cointegration**				
1	-0.004	0.778	0.778	3.152					
2	-0.004	-0.778	0.778	0					
3	-0.388	-0.649	0.755	0					
4	-0.388	0.649	0.755	2.355					
5	0.363	0.654	0.748	4.665					
6	0.363	-0.654	0.748	0					
7	-0.748	0	0.748	0					
8	0.61	0.38	0.72	8.918					
9	0.61	-0.38	0.72	0					
10	-0.613	-0.359	0.71	0					
11	-0.613	0.359	0.71	1.902					
12	0.667	0	0.667	0					
-	-	-	-	-					
Japan					Japan				
No Cointegration					AR Roots	Real	Imag	Modulus	Period
					1	0.35	-0.586	0.683	0
					2	0.35	0.586	0.683	4.346
					3	0.008	-0.68	0.68	0
					4	0.008	0.68	0.68	2.878
					5	-0.672	0	0.672	0
					6	-0.352	0.572	0.671	2.115
					7	-0.352	-0.572	0.671	0
					8	-0.569	0.342	0.664	0
					9	-0.569	-0.342	0.664	0
					10	0.561	0.328	0.65	8.485
					11	0.561	-0.328	0.65	0
					12	0.617	0	0.617	0
					13	-0.149	0	0.149	0
US					US				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	0.632	-0.292	0.65	0	1	0.632	-0.249	0.553	0
2	0.581	0.292	0.65	8.873	2	0.494	0.249	0.553	7.542
3	0.321	0.529	0.618	4.024	3	0.274	0.45	0.525	3.42
4	0.321	-0.529	0.618	0	4	0.274	-0.45	0.525	0
5	0.01	-0.615	0.615	0	5	0.009	-0.523	0.523	0
6	0.01	0.615	0.615	2.657	6	0.009	0.523	0.523	2.258
7	-0.607	0	0.607	0	7	-0.517	0	0.517	0
8	-0.318	0.507	0.601	1.937	8	-0.27	0.431	0.509	1.647
9	-0.318	-0.507	0.601	0	9	-0.27	-0.431	0.509	0
10	-0.505	0.289	0.583	1.574	10	-0.43	0.245	0.496	1.339
11	-0.505	-0.289	0.583	0	11	-0.43	-0.245	0.496	0
12	0.265	0	0.265	0	12	0.226	0	0.226	0
-	-	-	-	-	13	0.203	0	0.203	0
-	-	-	-	-	14	0.183	0	0.183	0

Table 5.23 (Nominal)					Table 5.23 (Real)				
Germany					Germany				
AR Roots	Real	Imag	Modulus	Period	**No Cointegration**				
1	-0.002	0.401	0.401	1.624					
2	-0.002	-0.401	0.401	0					
3	-0.2	-0.335	0.389	0					
4	-0.2	0.335	0.389	1.213					
5	0.187	0.337	0.386	2.402					
6	0.187	-0.337	0.386	0					
7	-0.386	0	0.386	0					
8	0.314	0.196	0.371	4.594					
9	0.314	-0.196	0.371	0					
10	-0.316	-0.185	0.365	0					
11	-0.316	0.185	0.365	0.98					
12	0.344	0	0.344	0					
-	-	-	-	-					
Japan					Japan				
No Cointegration					AR Roots	Real	Imag	Modulus	Period
					1	0.17	-0.284	0.331	0
					2	0.17	0.284	0.331	2.102
					3	0.003	-0.33	0.33	0
					4	0.003	0.33	0.33	1.392
					5	-0.326	0	0.326	0
					6	-0.169	0.278	0.325	1.027
					7	-0.169	-0.278	0.325	0
					8	-0.275	-0.165	0.321	0
					9	-0.275	0.165	0.321	0.836
					10	0.269	0.164	0.315	3.958
					11	0.269	-0.164	0.315	0
					12	0.287	0	0.287	0
					13	0.215	0	0.215	0
US					US				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	0.528	-0.265	0.591	0	1	0.449	-0.226	0.503	0
2	0.528	0.265	0.591	8.066	2	0.449	0.226	0.503	6.856
3	0.292	0.481	0.562	3.658	3	0.249	0.409	0.477	3.109
4	0.292	-0.481	0.562	0	4	0.249	-0.409	0.477	0
5	0.009	-0.559	0.559	0	5	0.008	-0.475	0.475	0
6	0.009	0.559	0.559	2.415	6	0.008	0.475	0.475	2.053
7	-0.552	0	0.552	0	7	-0.47	0	0.47	0
8	-0.289	0.461	0.546	1.761	8	-0.245	0.392	0.463	1.497
9	-0.289	-0.461	0.546	0	9	-0.245	-0.392	0.463	0
10	-0.459	0.263	0.53	1.431	10	-0.391	0.223	0.451	1.217
11	-0.459	-0.263	0.53	0	11	-0.391	-0.223	0.451	0
12	0.241	0	0.241	0	12	0.205	0	0.205	0
-	-	-	-	-	13	0.185	0	0.185	0

Table 5.24 (Nominal)					Table 5.24 (Real)				
Germany					Germany				
AR Roots	Real	Imag	Modulus	Period	**No Cointegration**				
1	-0.004	0.778	0.778	3.152					
2	-0.004	-0.778	0.778	0					
3	-0.388	-0.649	0.755	0					
4	-0.388	0.649	0.755	2.355					
5	0.363	0.654	0.748	4.665					
6	0.363	-0.654	0.748	0					
7	-0.748	0	0.748	0					
8	0.61	0.38	0.72	8.918					
9	0.61	-0.38	0.72	0					
10	-0.613	-0.359	0.71	0					
11	-0.613	0.359	0.71	1.902					
12	0.667	0	0.667	0					
-	-	-	-	-					
Japan					Japan				
No Cointegration					AR Roots	Real	Imag	Modulus	Period
					1	0.35	-0.586	0.683	0
					2	0.35	0.586	0.683	4.346
					3	0.008	-0.68	0.68	0
					4	0.008	0.68	0.68	2.878
					5	-0.672	0	0.672	0
					6	-0.352	0.572	0.671	2.115
					7	-0.352	-0.572	0.671	0
					8	-0.569	0.342	0.664	0
					9	-0.569	-0.342	0.664	0
					10	0.561	0.328	0.65	8.485
					11	0.561	-0.328	0.65	0
					12	0.617	0	0.617	0
					13	-0.149	0	0.149	0
US					US				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	0.632	-0.292	0.65	0	1	0.632	-0.249	0.553	0
2	0.581	0.292	0.65	8.873	2	0.494	0.249	0.553	7.542
3	0.321	0.529	0.618	4.024	3	0.274	0.45	0.525	3.42
4	0.321	-0.529	0.618	0	4	0.274	-0.45	0.525	0
5	0.01	-0.615	0.615	0	5	0.009	-0.523	0.523	0
6	0.01	0.615	0.615	2.657	6	0.009	0.523	0.523	2.258
7	-0.607	0	0.607	0	7	-0.517	0	0.517	0
8	-0.318	0.507	0.601	1.937	8	-0.27	0.431	0.509	1.647
9	-0.318	-0.507	0.601	0	9	-0.27	-0.431	0.509	0
10	-0.505	0.289	0.583	1.574	10	-0.43	0.245	0.496	1.339
11	-0.505	-0.289	0.583	0	11	-0.43	-0.245	0.496	0
12	0.265	0	0.265	0	12	0.226	0	0.226	0
-	-	-	-	-	13	0.203	0	0.203	0
-	-	-	-	-	14	0.183	0	0.183	0

Table 6.1 (Nominal)					Table 6.1 (Real)				
Brazil					Brazil				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.0055	0.82456	0.82456	3.3422	1	-0.005	0.701	0.701	2.841
2	-0.0055	-0.82456	0.82456	0	2	-0.005	-0.701	0.701	0
3	-0.5137	-0.68816	0.8008	0	3	-0.437	-0.585	0.681	0
4	-0.5137	0.68816	0.8008	2.4965	4	-0.437	0.585	0.681	2.122
5	0.4807	0.69344	0.79288	4.9456	5	0.409	0.589	0.674	4.204
6	0.4807	-0.69344	0.79288	0	6	0.409	-0.589	0.674	0
7	-0.98119	0	0.79288	0	7	-0.834	0	0.674	0
8	0.8085	0.40304	0.76296	9.4556	8	0.687	0.343	0.649	8.037
9	0.8085	-0.40304	0.76296	0	9	0.687	-0.343	0.649	0
10	-0.8118	-0.38016	0.7524	0	10	-0.69	-0.323	0.64	0
11	-0.8118	0.38016	0.7524	2.0160	11	-0.69	0.323	0.64	1.714
12	0.8844	0	0.70752	0	12	0.752	0	0.601	0
13	-0.4026	0	0.32208	0	13	-0.342	0	0.274	0
China					China				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.005	0.767	0.767	3.108	1	-0.004	0.652	0.652	2.642
2	-0.005	-0.767	0.767	0	2	-0.004	-0.652	0.652	0
3	-0.478	-0.64	0.745	0	3	-0.406	-0.544	0.633	0
4	-0.478	0.64	0.745	2.322	4	-0.406	0.544	0.633	1.974
5	0.447	0.645	0.737	4.599	5	0.38	0.548	0.626	3.909
6	0.447	-0.645	0.737	0	6	0.38	-0.548	0.626	0
7	-0.913	0	0.737	0	7	-0.776	0	0.626	0
8	0.752	0.375	0.71	8.794	8	0.639	0.319	0.604	7.475
9	0.752	-0.375	0.71	0	9	0.639	-0.319	0.604	0
10	-0.755	-0.354	0.7	0	10	-0.642	-0.301	0.595	0
11	-0.755	0.354	0.7	1.875	11	-0.642	0.301	0.595	1.594
12	0.822	0	0.658	0	12	0.699	0	0.559	0
13	-0.374	0	0.3	0	13	-0.318	0	0.255	0
South Africa					South Africa				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.005	0.713	0.713	2.89	1	0.842	-0.423	0.943	
2	-0.005	-0.713	0.713	0	2	0.842	0.423	0.943	12.859
3	-0.445	-0.595	0.693	0	3	0.464	0.767	0.896	5.83
4	-0.445	0.595	0.693	2.159	4	0.464	-0.767	0.896	
5	0.416	0.6	0.685	4.277	5	0.015	0.891	0.892	3.852
6	0.416	-0.6	0.685	0	6	0.015	-0.891	0.892	
7	-0.849	0	0.685	0	7	-0.88	0	0.88	
8	0.699	0.349	0.66	8.178	8	-0.461	0.736	0.869	2.809
9	0.699	-0.349	0.66	0	9	-0.461	-0.736	0.869	
10	-0.702	-0.329	0.651	0	10	-0.732	0.42	0.845	2.283
11	-0.702	0.329	0.651	1.744	11	-0.732	-0.42	0.845	
12	0.764	0	0.612	0	12	0.383	0	0.383	

Table 6.2 (Nominal)					Table 6.2 (Real)				
Brazil					Brazil				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.004	0.536	0.536	2.172	1	-0.003	0.456	0.456	1.846
2	-0.004	-0.536	0.536	0	2	-0.003	-0.456	0.456	0
3	-0.334	-0.447	0.521	0	3	-0.284	-0.38	0.443	0
4	-0.334	0.447	0.521	1.623	4	-0.284	0.38	0.443	1.38
5	0.312	0.451	0.515	3.215	5	0.265	0.383	0.438	2.733
6	0.312	-0.451	0.515	0	6	0.265	-0.383	0.438	0
7	-0.638	0	0.515	0	7	-0.542	0	0.438	0
8	0.526	0.262	0.496	6.146	8	0.447	0.223	0.422	5.224
9	0.526	-0.262	0.496	0	9	0.447	-0.223	0.422	0
10	-0.528	-0.247	0.489	0	10	-0.449	-0.21	0.416	0
11	-0.528	0.247	0.489	1.31	11	-0.449	0.21	0.416	1.114
12	0.575	0	0.46	0	12	0.489	0	0.391	0
13	-0.262	0	0.209	0	13	-0.223	0	0.178	0
China					China				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.005	0.729	0.729	2.953	1	-0.004	0.62	0.62	2.51
2	-0.005	-0.729	0.729	0	2	-0.004	-0.62	0.62	0
3	-0.454	-0.608	0.708	0	3	-0.386	-0.517	0.602	0
4	-0.454	0.608	0.708	2.206	4	-0.386	0.517	0.602	1.875
5	0.425	0.613	0.7	4.369	5	0.361	0.521	0.595	3.714
6	0.425	-0.613	0.7	0	6	0.361	-0.521	0.595	0
7	-0.867	0	0.7	0	7	-0.737	0	0.595	0
8	0.714	0.356	0.675	8.354	8	0.607	0.303	0.574	7.101
9	0.714	-0.356	0.675	0	9	0.607	-0.303	0.574	0
10	-0.717	-0.336	0.665	0	10	-0.609	-0.286	0.565	0
11	-0.717	0.336	0.665	1.781	11	-0.609	0.286	0.565	1.514
12	0.781	0	0.625	0	12	0.664	0	0.531	0
-	-0.355	0	0.285	0	13	-0.302	0	0.242	0
South Africa					South Africa				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.005	0.677	0.677	2.746	1	-0.004	0.575	0.575	2.334
2	-0.005	-0.677	0.677	0	2	-0.004	-0.575	0.575	0
3	-0.423	-0.565	0.658	0	3	-0.36	-0.48	0.559	0
4	-0.423	0.565	0.658	2.051	4	-0.36	0.48	0.559	1.743
5	0.395	0.57	0.651	4.063	5	0.336	0.485	0.553	3.454
6	0.395	-0.57	0.651	0	6	0.336	-0.485	0.553	0
7	-0.807	0	0.651	0	7	-0.686	0	0.553	0
8	0.664	0.332	0.627	7.769	8	0.564	0.282	0.533	6.604
9	0.664	-0.332	0.627	0	9	0.564	-0.282	0.533	0
10	-0.667	-0.313	0.618	0	10	-0.567	-0.266	0.525	0
11	-0.667	0.313	0.618	1.657	11	-0.567	0.266	0.525	1.408
12	0.726	0	0.581	0	12	0.617	0	0.494	0

Table 6.3 (Nominal)					Table 6.3 (Real)				
Brazil					Brazil				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.002	0.322	0.322	1.303	1	-0.002	0.274	0.274	1.108
2	-0.002	-0.322	0.322	0	2	-0.002	-0.274	0.274	0
3	-0.2	-0.268	0.313	0	3	-0.17	-0.228	0.266	0
4	-0.2	0.268	0.313	0.974	4	-0.17	0.228	0.266	0.828
5	0.187	0.271	0.309	1.929	5	0.159	0.23	0.263	1.64
6	0.187	-0.271	0.309	0	6	0.159	-0.23	0.263	0
7	-0.383	0	0.309	0	7	-0.326	0	0.263	0
8	0.316	0.157	0.298	3.688	8	0.269	0.133	0.253	3.135
9	0.316	-0.157	0.298	0	9	0.269	-0.133	0.253	0
10	-0.317	-0.148	0.293	0	10	-0.269	-0.126	0.249	0
11	-0.317	0.148	0.293	0.786	11	-0.269	0.126	0.249	0.668
12	0.345	0	0.276	0	12	0.293	0	0.235	0
13	-0.157	0	0.125	0	13	-0.133	0	0.106	0
China					China				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.003	0.437	0.437	1.772	1	-0.003	0.371	0.371	1.506
2	-0.003	-0.437	0.437	0	2	-0.003	-0.371	0.371	0
3	-0.272	-0.365	0.425	0	3	-0.231	-0.31	0.361	0
4	-0.272	0.365	0.425	1.324	4	-0.231	0.31	0.361	1.125
5	0.255	0.368	0.42	2.621	5	0.217	0.313	0.357	2.228
6	0.255	-0.368	0.42	0	6	0.217	-0.313	0.357	0
7	-0.52	0	0.42	0	7	-0.442	0	0.357	0
8	0.428	0.214	0.405	5.012	8	0.364	0.182	0.344	4.26
9	0.428	-0.214	0.405	0	9	0.364	-0.182	0.344	0
10	-0.43	-0.202	0.399	0	10	-0.366	-0.172	0.339	0
11	-0.43	0.202	0.399	1.069	11	-0.366	0.172	0.339	0.909
12	0.469	0	0.375	0	12	0.399	0	0.319	0
-	-	-	-	-	-	-	-	-	-
South Africa					South Africa				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.003	0.406	0.406	1.648	1	-0.002	0.345	0.345	1.4
2	-0.003	-0.406	0.406	0	2	-0.002	-0.345	0.345	0
3	-0.254	-0.339	0.395	0	3	-0.216	-0.288	0.335	0
4	-0.254	0.339	0.395	1.231	4	-0.216	0.288	0.335	1.046
5	0.237	0.342	0.391	2.438	5	0.202	0.291	0.332	2.072
6	0.237	-0.342	0.391	0	6	0.202	-0.291	0.332	0
7	-0.484	0	0.391	0	7	-0.412	0	0.332	0
8	0.398	0.199	0.376	4.661	8	0.338	0.169	0.32	3.962
9	0.398	-0.199	0.376	0	9	0.338	-0.169	0.32	0
10	-0.4	-0.188	0.371	0	10	-0.34	-0.16	0.315	0
11	-0.4	0.188	0.371	0.994	11	-0.34	0.16	0.315	0.845
12	0.436	0	0.349	0	12	0.37	0	0.296	0

Table 6.4 (Nominal)					Table 6.4 (Real)				
Brazil					Brazil				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.002	0.242	0.242	0.977	1	-0.002	0.206	0.206	0.83
2	-0.002	-0.242	0.242	0	2	-0.002	-0.206	0.206	0
3	-0.15	-0.201	0.235	0	3	-0.128	-0.171	0.2	0
4	-0.15	0.201	0.235	0.731	4	-0.128	0.171	0.2	0.621
5	0.14	0.203	0.232	1.447	5	0.119	0.173	0.197	1.23
6	0.14	-0.203	0.232	0	6	0.119	-0.173	0.197	0
7	-0.287	0	0.232	0	7	-0.244	0	0.197	0
8	0.237	0.118	0.224	2.766	8	0.201	0.1	0.19	2.351
9	0.237	-0.118	0.224	0	9	0.201	-0.1	0.19	0
10	-0.238	-0.111	0.22	0	10	-0.202	-0.094	0.187	0
11	-0.238	0.111	0.22	0.59	11	-0.202	0.094	0.187	0.502
12	0.259	0	0.207	0	12	0.22	0	0.176	0
-	-	-	-	-	13	#VALUE!	#VALUE!	#VALUE!	#VALUE!
China					China				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.002	0.328	0.328	1.329	1	-0.002	0.278	0.278	1.13
2	-0.002	-0.328	0.328	0	2	-0.002	-0.278	0.278	0
3	-0.204	-0.274	0.319	0	3	-0.173	-0.233	0.271	0
4	-0.204	0.274	0.319	0.993	4	-0.173	0.233	0.271	0.844
5	0.191	0.276	0.315	1.966	5	0.163	0.235	0.268	1.671
6	0.191	-0.276	0.315	0	6	0.163	-0.235	0.268	0
7	-0.39	0	0.315	0	7	-0.332	0	0.268	0
8	0.321	0.161	0.304	3.759	8	0.273	0.137	0.258	3.195
9	0.321	-0.161	0.304	0	9	0.273	-0.137	0.258	0
10	-0.323	-0.152	0.299	0	10	-0.275	-0.129	0.254	0
11	-0.323	0.152	0.299	0.802	11	-0.275	0.129	0.254	0.682
12	0.352	0	0.281	0	12	0.299	0	0.239	0
-	-	-	-	-	13	0.224	0	0.179	0
South Africa					South Africa				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.003	0.447	0.447	1.813	1	-0.002	0.38	0.38	1.54
2	-0.003	-0.447	0.447	0	2	-0.002	-0.38	0.38	0
3	-0.279	-0.373	0.435	0	3	-0.238	-0.317	0.369	0
4	-0.279	0.373	0.435	1.354	4	-0.238	0.317	0.369	1.151
5	0.261	0.376	0.43	2.682	5	0.222	0.32	0.365	2.279
6	0.261	-0.376	0.43	0	6	0.222	-0.32	0.365	0
7	-0.532	0	0.43	0	7	-0.453	0	0.365	0
8	0.438	0.219	0.414	5.127	8	0.372	0.186	0.352	4.358
9	0.438	-0.219	0.414	0	9	0.372	-0.186	0.352	0
10	-0.44	-0.207	0.408	0	10	-0.374	-0.176	0.347	0
11	-0.44	0.207	0.408	1.093	11	-0.374	0.176	0.347	0.93
12	0.48	0	0.384	0	12	0.407	0	0.326	0

Table 6.13 (Nominal)					Table 6.13 (Real)				
Brazil					Brazil				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.005	0.684	0.684	2.774	1	-0.004	0.582	0.582	2.358
2	-0.005	-0.684	0.684	0	2	-0.004	-0.582	0.582	0
3	-0.426	-0.571	0.665	0	3	-0.363	-0.486	0.565	0
4	-0.426	0.571	0.665	2.072	4	-0.363	0.486	0.565	1.761
5	0.399	0.576	0.658	4.105	5	0.339	0.489	0.559	3.489
6	0.399	-0.576	0.658	0	6	0.339	-0.489	0.559	0
7	-0.814	0	0.658	0	7	-0.692	0	0.559	0
8	0.671	0.335	0.633	7.848	8	0.57	0.285	0.539	6.671
9	0.671	-0.335	0.633	0	9	0.57	-0.285	0.539	0
10	-0.674	-0.316	0.624	0	10	-0.573	-0.268	0.531	0
11	-0.674	0.316	0.624	1.673	11	-0.573	0.268	0.531	1.423
12	0.734	0	0.587	0	12	0.624	0	0.499	0
-	-	-	-	-	-	-	-	-	-
China					China				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.004	0.637	0.637	2.58	1	-0.003	0.541	0.541	2.193
2	-0.004	-0.637	0.637	0	2	-0.003	-0.541	0.541	0
3	-0.397	-0.531	0.618	0	3	-0.337	-0.452	0.525	0
4	-0.397	0.531	0.618	1.927	4	-0.337	0.452	0.525	1.638
5	0.371	0.535	0.612	3.817	5	0.315	0.455	0.52	3.244
6	0.371	-0.535	0.612	0	6	0.315	-0.455	0.52	0
7	-0.758	0	0.612	0	7	-0.644	0	0.52	0
8	0.624	0.311	0.589	7.299	8	0.53	0.265	0.501	6.204
9	0.624	-0.311	0.589	0	9	0.53	-0.265	0.501	0
10	-0.627	-0.294	0.581	0	10	-0.533	-0.25	0.494	0
11	-0.627	0.294	0.581	1.556	11	-0.533	0.25	0.494	1.323
12	0.682	0	0.546	0	12	0.58	0	0.464	0
-	-	-	-	-	-	-	-	-	-
South Africa					South Africa				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.004	0.492	0.492	1.994	1	0.632	0.418	0.418	1.694
2	-0.003	-0.492	0.492	0	2	-0.002	-0.418	0.418	0
3	-0.307	-0.41	0.479	0	3	-0.262	-0.349	0.406	0
4	-0.307	0.41	0.479	1.489	4	-0.262	0.349	0.406	1.266
5	0.287	0.414	0.473	2.95	5	0.244	0.352	0.402	2.507
6	0.287	-0.414	0.473	0	6	0.244	-0.352	0.402	0
7	-0.585	0	0.473	0	7	-0.498	0	0.402	0
8	0.482	0.241	0.455	5.64	8	0.409	0.205	0.387	4.794
9	0.482	-0.241	0.455	0	9	0.409	-0.205	0.387	0
10	-0.484	-0.228	0.449	0	10	-0.411	-0.194	0.382	0
11	-0.484	0.228	0.449	1.202	11	-0.411	0.194	0.382	1.023
12	0.528	0	0.422	0	12	0.448	0	0.359	0

Table 6.14 (Nominal)					Table 6.14 (Real)				
Brazil					Brazil				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.003	0.445	0.445	1.803	1	-0.002	0.378	0.378	1.532
2	-0.003	-0.445	0.445	0	2	-0.002	-0.378	0.378	0
3	-0.277	-0.371	0.432	0	3	-0.236	-0.315	0.368	0
4	-0.277	0.371	0.432	1.347	4	-0.236	0.315	0.368	1.145
5	0.259	0.374	0.427	2.668	5	0.22	0.318	0.364	2.268
6	0.259	-0.374	0.427	0	6	0.22	-0.318	0.364	0
7	-0.53	0	0.427	0	7	-0.45	0	0.364	0
8	0.437	0.217	0.412	5.101	8	0.371	0.185	0.35	4.336
9	0.437	-0.217	0.412	0	9	0.371	-0.185	0.35	0
10	-0.438	-0.205	0.406	0	10	-0.373	-0.174	0.345	0
11	-0.438	0.205	0.406	1.087	11	-0.373	0.174	0.345	0.925
12	0.477	0	0.382	0	12	0.406	0	0.325	0
-	-	-	-	-	-	-	-	-	-
China					China				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.004	0.605	0.605	2.451	1	-0.003	0.515	0.515	2.083
2	-0.004	-0.605	0.605	0	2	-0.003	-0.515	0.515	0
3	-0.377	-0.505	0.588	0	3	-0.32	-0.429	0.5	0
4	-0.377	0.505	0.588	1.831	4	-0.32	0.429	0.5	1.556
5	0.353	0.509	0.581	3.626	5	0.3	0.432	0.494	3.083
6	0.353	-0.509	0.581	0	6	0.3	-0.432	0.494	0
7	-0.72	0	0.581	0	7	-0.612	0	0.494	0
8	0.593	0.295	0.56	6.934	8	0.504	0.251	0.476	5.894
9	0.593	-0.295	0.56	0	9	0.504	-0.251	0.476	0
10	-0.595	-0.279	0.552	0	10	-0.505	-0.237	0.469	0
11	-0.595	0.279	0.552	1.478	11	-0.505	0.237	0.469	1.257
12	0.648	0	0.519	0	12	0.551	0	0.441	0
-	-	-	-	-	-	-	-	-	-
South Africa					South Africa				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.004	0.541	0.541	2.193	1	-0.003	0.46	0.46	1.863
2	-0.003	-0.541	0.541	0	2	-0.002	-0.46	0.46	0
3	-0.338	-0.451	0.527	0	3	-0.288	-0.384	0.447	0
4	-0.338	0.451	0.527	1.638	4	-0.288	0.384	0.447	1.393
5	0.316	0.455	0.52	3.245	5	0.268	0.387	0.442	2.758
6	0.316	-0.455	0.52	0	6	0.268	-0.387	0.442	0
7	-0.644	0	0.52	0	7	-0.548	0	0.442	0
8	0.53	0.265	0.501	6.204	8	0.45	0.226	0.426	5.273
9	0.53	-0.265	0.501	0	9	0.45	-0.226	0.426	0
10	-0.532	-0.251	0.494	0	10	-0.452	-0.213	0.42	0
11	-0.532	0.251	0.494	1.322	11	-0.452	0.213	0.42	1.125
12	0.581	0	0.464	0	12	0.493	0	0.395	0

Table 6.15 (Nominal)					Table 6.15(Real)				
Brazil					Brazil				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.002	0.267	0.267	1.081	1	-0.002	0.227	0.227	0.92
2	-0.002	-0.267	0.267	0	2	-0.002	-0.227	0.227	0
3	-0.166	-0.222	0.26	0	3	-0.141	-0.189	0.221	0
4	-0.166	0.222	0.26	0.808	4	-0.141	0.189	0.221	0.687
5	0.155	0.225	0.256	1.601	5	0.132	0.191	0.218	1.361
6	0.155	-0.225	0.256	0	6	0.132	-0.191	0.218	0
7	-0.318	0	0.256	0	7	-0.271	0	0.218	0
8	0.262	0.13	0.247	3.061	8	0.223	0.11	0.21	2.602
9	0.262	-0.13	0.247	0	9	0.223	-0.11	0.21	0
10	-0.263	-0.123	0.243	0	10	-0.223	-0.105	0.207	0
11	-0.263	0.123	0.243	0.652	11	-0.223	0.105	0.207	0.554
12	0.286	0	0.229	0	12	0.243	0	0.195	0
-	-	-	-	-	-	-	-	-	-
China					China				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.002	0.363	0.363	1.471	1	-0.002	0.278	0.278	1.13
2	-0.002	-0.363	0.363	0	2	-0.002	-0.278	0.278	0
3	-0.226	-0.303	0.353	0	3	-0.173	-0.233	0.271	0
4	-0.226	0.303	0.353	1.099	4	-0.173	0.233	0.271	0.844
5	0.212	0.305	0.349	2.175	5	0.163	0.235	0.268	1.671
6	0.212	-0.305	0.349	0	6	0.163	-0.235	0.268	0
7	-0.432	0	0.349	0	7	-0.332	0	0.268	0
8	0.355	0.178	0.336	4.16	8	0.273	0.137	0.258	3.195
9	0.355	-0.178	0.336	0	9	0.273	-0.137	0.258	0
10	-0.357	-0.168	0.331	0	10	-0.275	-0.129	0.254	0
11	-0.357	0.168	0.331	0.887	11	-0.275	0.129	0.254	0.682
12	0.389	0	0.311	0	12	0.299	0	0.239	0
-	-	-	-	-	13	#VALUE!	#VALUE!	#VALUE!	#VALUE!
South Africa					South Africa				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.002	0.595	0.595	2.412	1	-0.002	0.506	0.506	2.049
2	-0.003	-0.595	0.595	0	2	-0.002	-0.506	0.506	0
3	-0.372	-0.496	0.58	0	3	-0.317	-0.422	0.492	0
4	-0.372	0.496	0.58	1.802	4	-0.317	0.422	0.492	1.532
5	0.348	0.501	0.572	3.57	5	0.295	0.426	0.486	3.034
6	0.348	-0.501	0.572	0	6	0.295	-0.426	0.486	0
7	-0.708	0	0.572	0	7	-0.603	0	0.486	0
8	0.583	0.292	0.551	6.824	8	0.495	0.249	0.469	5.8
9	0.583	-0.292	0.551	0	9	0.495	-0.249	0.469	0
10	-0.585	-0.276	0.543	0	10	-0.497	-0.234	0.462	0
11	-0.585	0.276	0.543	1.454	11	-0.497	0.234	0.462	1.238
12	0.639	0	0.51	0	12	0.542	0	0.435	0

Table 6.16 (Nominal)					Table 6.16 (Real)				
Brazil					Brazil				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.002	0.201	0.201	0.811	1	-0.002	0.171	0.171	0.689
2	-0.002	-0.201	0.201	0	2	-0.002	-0.171	0.171	0
3	-0.125	-0.167	0.195	0	3	-0.106	-0.142	0.166	0
4	-0.125	0.167	0.195	0.607	4	-0.106	0.142	0.166	0.515
5	0.116	0.168	0.193	1.201	5	0.099	0.144	0.164	1.021
6	0.116	-0.168	0.193	0	6	0.099	-0.144	0.164	0
7	-0.238	0	0.193	0	7	-0.203	0	0.164	0
8	0.197	0.098	0.186	2.296	8	0.167	0.083	0.158	1.951
9	0.197	-0.098	0.186	0	9	0.167	-0.083	0.158	0
10	-0.198	-0.092	0.183	0	10	-0.168	-0.078	0.155	0
11	-0.198	0.092	0.183	0.49	11	-0.168	0.078	0.155	0.417
12	0.215	0	0.172	0	12	0.183	0	0.146	0
-	-	-	-	-	-	-	-	-	-
China					China				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.002	0.272	0.272	1.103	1	-0.002	0.209	0.209	0.848
2	-0.002	-0.272	0.272	0	2	-0.002	-0.209	0.209	0
3	-0.169	-0.227	0.265	0	3	-0.13	-0.175	0.203	0
4	-0.169	0.227	0.265	0.824	4	-0.13	0.175	0.203	0.633
5	0.159	0.229	0.261	1.632	5	0.122	0.176	0.201	1.253
6	0.159	-0.229	0.261	0	6	0.122	-0.176	0.201	0
7	-0.324	0	0.261	0	7	-0.249	0	0.201	0
8	0.266	0.134	0.252	3.12	8	0.205	0.103	0.194	2.396
9	0.266	-0.134	0.252	0	9	0.205	-0.103	0.194	0
10	-0.268	-0.126	0.248	0	10	-0.206	-0.097	0.191	0
11	-0.268	0.126	0.248	0.666	11	-0.206	0.097	0.191	0.512
12	0.292	0	0.233	0	12	0.224	0	0.179	0
-	-	-	-	-	13	0.168	0	0.134	0
South Africa					South Africa				
AR Roots	Real	Imag	Modulus	Period	AR Roots	Real	Imag	Modulus	Period
1	-0.002	0.655	0.655	2.653	1	-0.002	0.557	0.557	2.254
2	-0.003	-0.655	0.655	0	2	-0.002	-0.557	0.557	0
3	-0.409	-0.546	0.638	0	3	-0.349	-0.464	0.541	0
4	-0.409	0.546	0.638	1.982	4	-0.349	0.464	0.541	1.685
5	0.383	0.551	0.629	3.927	5	0.325	0.469	0.535	3.337
6	0.383	-0.551	0.629	0	6	0.325	-0.469	0.535	0
7	-0.779	0	0.629	0	7	-0.663	0	0.535	0
8	0.641	0.321	0.606	7.506	8	0.545	0.274	0.516	6.38
9	0.641	-0.321	0.606	0	9	0.545	-0.274	0.516	0
10	-0.644	-0.304	0.597	0	10	-0.547	-0.257	0.508	0
11	-0.644	0.304	0.597	1.599	11	-0.547	0.257	0.508	1.362
12	0.703	0	0.561	0	12	0.596	0	0.479	0