EXCHANGE RATE VOLATILITY, PASS-THROUGH AND FOREIGN TRADE IN INDIA: 1998-2014

A Thesis Submitted to the University of Hyderabad in Partial Fulfillment of the Requirements for the Award of

DOCTOR OF PHILOSOPHY

IN

ECONOMICS

BY

YAZIR P

SCHOOL OF ECONOMICS

UNIVERSITY OF HYDERABAD

HYDERABAD-500046 (INDIA)

MAY-2017

CERTIFICATE

This is to certify that the thesis entitled **"Exchange Rate Volatility, Pass-through and Foreign Trade in India: 1998-2014"** submitted by **Yazir P** bearing Registration Number **12SEPH17** in partial fulfillment of the requirements for award of **Doctor of Philosoph**y in the School of Economics is a bonafide work carried out by him under my supervision and guidance.

This thesis is free from plagiarism and has not been submitted previously in part or in full to this or any other university or institution for award of any degree or diploma.

Papers related to this thesis have been:

A. Published in the following publication

1. The Empirical Economics Letters, 15(4): (April 2016) ISSN : 1681 8997

and

B. Presented in the following conferences:

1. International Conference on "Trade And Exchange Rate Policies in The Context of WTO and Preferential Trading Agreements (PTAS): Challenges before Emerging Economies" held at Institute of Public Enterprises, Hyderabad during 21- 22, September, 2015
2. 51st Annual Conference of the Indian Econometric Society (TIES) held at Punjabi University, Patiala, during 12-14, December, 2014.

Further, the student has passed the following coursework requirement for Ph.D. / was exempted from doing coursework (recommended by Doctoral Committee) on the basis of the following courses passed during his M.Phil. Program and the M.Phil. degree was awarded:

S.No.	Code	Name	Credits	Pass/Fail
1	SE-600	Research Methodology	4	PASS
2	SE-601	Social Accounting and Data Base	4	PASS
3	SE-602	Advanced Economics Theory	4	PASS
4	SE-620	Study Area	4	PASS
5	SE-680	Dissertation	16	PASS

Dean
School of Economics

(Prof. B. Kamaiah)
Research Supervisor

DECLARATION

I, **YAZIR P,** hereby declare that the work embodied in the present dissertation entitled **"Exchange Rate Volatility, Pass-through and Foreign Trade in India: 1998-2014"** submitted by me under the guidance and supervision of **Prof. Bandi Kamaiah** is a bonafide research work for the award of Doctor of Philosophy in Economics from the University of Hyderabad. I also declare to the best of my knowledge that it has not been submitted previously in part or in full to this University or any other university or institution for the award of any degree or diploma. I hereby agree that my thesis can be deposited in Shodganga/INFLIBNET.

Date: **YAZIR P**

Place-Hyderabad **Regn No. 12SEPH17**

I submit

Before the drops of my tears

Where the image of your love was mirrored.

I submit

Before the drops of my tears

Where the image of your ridicule was mirrored.

It has indeed given me breath.

It has indeed made me run.

It has indeed given me life.

****

My dream and your dream

Was a paradoxical conjecture.

I submit

Before your dreams.

Please let me be free forever

For my colorful dreams.

****

Unlike Rohith,

I travel from stars to shadows.

Where the life never ends.

But you may take a while to reach there.

I want to be the truth

The ultimate truth,

Where you and me are one.

Where various worlds are one.

****

Yazir

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AIC	Akaike Information Criterion
AIR	Accumulated Impulse Responses
ARDL	Autoregressive Distributed Lag
BEKK	Baba Engle Kraft and Kroner
BFGS	Broyden–Fletcher–Goldfarb–Shanno
CIS	Commonwealth of Independent States
CLRM	Classical Linear Regression Model
CPI	Consumer Price Index
CPI-AL	Consumer Price Index-Agricultural Labour
CPI-IW	Consumer price Index- Industrial Worker
CRR	Cash Reserve Ratio
DCC	Dynamic Conditional Correlation
DSGE	Dynamic Stochastic General Equilibrium
ERPT	Exchange Rate Pass-Through
FDI	Foreign Direct Investment
FII	Foreign Institutional Investment
FPEC	Final Prediction Error Criterion
GARCH	The Generalized Autoregressive Conditional Heteroskedasticity
GDP	Gross Domestic Product
HQC	Hannan-Quinn Information Criterion
ICSS	Iterated Cumulative Sum of Squares
IIP	The Index of Industrial Production
IMF	International Monetary Fund
IRF	Impulse Response Functions
LCB	Lower Critical Bound
LCP	Local Currency Pricing
LERMS	Liberalized Exchange Rate Management System
LOOP	Law of One Price
MGARCH	Multivariate Generalized Autoregressive Conditional Heteroskedasticity
MRTP	Monopolies and Restrictive Trade Practices
NEER	Nominal Effective Exchage Rate
NICs	Newly Industrialized Countries
NOEM	New Open Economy Macroeconomics
PCP	Producer Currency Pricing
PPI	Producer Price Index
PPP	Purchasing Power Parity
PTM	Pricing-to-Market
RBI	Reserve Bank of India
REER	Real Effective Exchage Rate
SC	Schwarz Information Criterion
SLR	Statutory Liquidity Ratio
SVAR	Structural Vector Auto Regressive
UCB	Upper Critical Bound
VAR	Vector Auto Regressive
VD	Variance Decompositions
WPI	Wholesale Price Index

Acknowledgement

Words fail to convey my profound gratitude to my supervisor Prof. Bandi Kamaiah for giving the opportunity to work with him and providing expert guidance and encouragement which acted as a constant motivating force throughout my career. His valuable suggestions and experience had helped me counter various difficulties while preparing this challenging dissertation. The confidence which he instilled in me at crucial juncture had helped me to complete this thesis to the satisfaction of my mentors.

I was also fortunate to get special guidance and knowledge from my other esteemed professors in the department. I am grateful to Dr. Phanindra Goyari Dr. G. Sridevi, Dr. V. Vamsicharan and Dr. G. Vijay who helped me in my academic pursuits in various ways.

I am thankful to the management, principal, colleagues and students of Farook college, Calicut where I am currently working, for their continuous motivation and inspiration which helped me to submit thesis by overcoming the obstacles through my academic career. My discussions with Mr. Rasheeed, Dr. Abdul Jabbar, Mr. Muhammad Kasim, Mr. Shihabudheen, Mr. Sahadudheen and Mrs. Shajitha had helped me to understand the intricacies of the subject in a better way.

I would like to extend special thanks to my friends Hafsal, Ganga, Avishek, Radeef, Anoop, Basheerka, Ashiq, Ayoob, Muhsina, Vineetha, Lydia, Jyothish, Sampath, Raju, Haneefa, Aswini, Salman, Najiya, Shamlan, Shihabka, and Negi who had helped me in all the possible ways to complete this dissertation. In fact, I would not have been able to complete this dissertation on time without their support.

I am very thankful to my better half, Faiza fathima who is consistently inspired me to get back to the research and finish this work very soon.

I extend special thanks for my umma, uppa, yoosuf kaaku, and my relatives for their moral support and love, standing by me in hard times during this work.

I would also like to thank my friends who helped me to be a politically conscious and socially committed human being during the most significant time of my life.

I never forget the cherished moments i enjoyed with my beloved friends in gops, shopcom and football ground. The lush green football ground was a motivating force to take me back to the campus life always.

Last but not the least; I thank the almighty Allah who had helped me to realise my potentials and made me what I am today.

Yazir Palathingal

Chapter 1

Introduction, Background and Objectives of the Study

1.1 Background and Introduction

With the advent of the Bretton Woods system, spanning from 1970s to late 80s, several countries across the globe experienced noticeable shifts in their exchange rate policies. These countries witnessed a transition from fixed exchange rate to floating or managed exchange rate system. This shift also turned exchange rates from being passive to a more dynamic macro variable which in turn began to influence other macro and financial variables as well. In fact, it became a key monetary policy tool which helped stabilize the internal or external economy and maintain equilibrium. Effective exchange rate management contributes to promoting of internal macro variables in a certain favourable position. In which case, instability and extreme volatility of exchange rate invite inflation and hampers investment, trade flow and economic growth (Frankel and Rose, 2002). In countries where managed floating exchange rate system prevails, the central banks are actively involved in purchasing and selling of foreign currencies to curb high-level of volatilities and channelise the exchange rate in a particular direction which is favorable for both internal as well as external economy. All these countries try to control the exchange rate in one way or the other to fulfill certain macro objectives and keep the economy in a good shape.

The post Bretton Woods era has seen the literature on exchange rate favouring on the relationship between inflation and exchange rate that identifies the need for inflation and exchange rate management. Inflation and exchange rate relationship is a double-edged sword. Lack of proper management of one variable will have an adverse impact on the other. During the period of fixed exchange rate system, managing inflation rate and setting a band level for inflation was easier since the exchange rate was totally controlled by the government or central bank of a country and the monetary authority had all autonomy to adopt independent monetary policies. In the floating or managed floating exchange rate system, the government or central bank needs multiple objective formulations where a mix of proper policies for exchange rate and inflation management has to be implemented according to the economic condition.

The waves of exchange rate shifts reached India in the 1990s. As a result of financial reforms, India witnessed a shift from the pegged exchange rate regime to a predominantly market determined and managed floating regime in 1993. From 1993 onwards, India has been following the managed floating exchange rate system where exchange rate determined mostly by market forces with intermittent intervention of RBI in the market to curtail high volatility whenever it is necessary.

The volatile nature of exchange rate has a tendency to influence trade flows of a nation and it is quite evident since many decades. However, a greater emphasis is laid on this subject in the last few decades. Almost all the nations have followed the liberal and globalised strategy and deeply integrated into the global markets. When the world economy witnessed structural changes brought about by a wide range of policies such as free labor, capital mobility, more flexible or managed exchange rate policy, the cross-border trade of goods and services became more attractive and profitable. So the studies related to the profitability of traders, various hedging strategies and the impact of exchange rate volatilities on trade were widely published in various economic and financial journals.

1.2 Exchange Rate Pass-through and Volatility

In the literature, "the expression 'exchange rate pass-through' is generally used to refer to the effects of exchange rate changes on one of the following: (1) import and export prices, (2) consumer prices, (3) investments and (4) trade volumes" (Darvas, 2001, p. 4). These four variables can also influence each other, which in turn will lead to the strengthening of exchange rate pass-through. The present study focuses on the second and fourth variables, namely, consumer price (domestic price) and trade volumes. The concept of 'exchange rate pass-through' was formulated as a result of the discursive debates and discussions among the economists during the post-Bretton Wood period, when the countries witnessed sweeping volatility shifts in exchange rates and policy changes. The pass-through can be formed through linear or non-linear relationship. Linear transmission mechanism is cited quite often in the literature. However, some of the recent works find that the volatility in the exchange rate has been transmitted to other variables in the nonlinear mechanism.

Though Darvas (2001) considers the broad view of exchange rate pass-through by including the impact of exchange rate on different variables, in literature, exchange rate pass-through is commonly confined to the impact of exchange rate on the domestic price level. Exchange rate pass-through (ERPT) is defined as the responsiveness of domestic consumer prices, producer prices or import price to the changes in exchange rate. It is the degree of changes in the domestic prices as a result of changes in the exchange rate.

The transmission mechanism of the exchange rate to inflation can be in many ways. Bhattacharya, Patnaik, and Shah (2008) analyse two stages of this transmission. When there is depreciation, the initial changes in exchange rate pass-through is reflected in the increase in prices of imported consumer and intermediary goods. These products become expensive in terms of home currency. Secondly, the increase in the prices of intermediary goods leads to an increase in the cost of production of the domestically-produced goods. Moreover, the demand will shift to the domestic goods when the imported goods become comparatively expensive. This increased demand for domestic goods will also attribute to an increase in the prices of domestically-produced goods. The pass-through might be complete or incomplete. Various studies across the world prove the existence of incomplete pass-through in various degrees. But complete pass-through is very rarely witnessed in an imperfectly competitive market due to the presence of market segmentation and product differentiation (Dholakia and Saradhi, 2000).

1.3 Significance of the Study

As far as developing countries are concerned, exchange rate management is very crucial while international financial transaction and cross-border trade take place either in dollar or any other dominant currency of the world. So for each transaction, all these countries need to exchange their own currencies with any other major dominant currency. Even small changes in the exchange rate can make a huge difference in the total volume of the transaction amount. Relative changes in the exchange rates of different developing countries may not make any differences in the transaction amount of the developed countries. Since, the lion’s share of the developing countries’ foreign trades or financial transactions are with these developed countries, the study of the exchange policies, volatility spillover and its impact on foreign trade are very relevant for the developing countries.

Moreover, the exchange rate has due importance as one among the monetary transmission channels. There is four key direct channels for monetary transmission: (1) interest rate channel, (2) quantum channel relating to credit, (3) asset price channel and (4) exchange rate channel (Bernanke and Gertler, 1995; Taylor, 1995; Boivin et.al. 2001). The interest rate channel is more prominent and is considered as a key monetary transmission channel regardless of the monetary system that prevails in a particular economy. The relative importance of each channel depends upon several inherited attributes of the economy such as "degree of monetisation of the economy, the extent to which households borrow from the formal financial system, the state of development of financial markets, the instruments available to monetary policy, the fiscal stance and the degree of openness" (Kapur and Behera, 2012, p. 4). In many emerging markets, exchange rate channel stands as the key monetary transmission channel and its impact on output and inflation is noteworthy where interest rate channel is comparatively weak (Norris and Floerkemeier, 2006; Catao and Pagan, 2009; Bhattacharya et.al. 2011). The study of Battacharya et al. (2011) found that the interest rate channel is found to be weak in the Indian context. The main cause for weak interest rate channel and increased transmission through exchange rate is due to the lack of a well-developed financial system in developing countries (Dorrucci et al., 2009).

The relationship among the economic variables may be linear or non-linear. In literature, the exchange rate pass-through is generally analysed on the assumption of linear and symmetric relationship. However, there is no guarantee that the relationship between exchange rate and inflation will be always linear. Quite a few recent works (for instance, Pollard and Coughlin, 2004; Frankel, Parsley and Wei, 2012; Bussiere, 2013; Nortey et.al, 2015) look at the presence of non-linearities and asymmetries in exchange rate pass-through in various ways. So the efforts to check both linear and non-linear relationship hold due importance.

India, which is one among the major developing and emerging economies, has a very long history of currency management and exchange rate. India has passed through different exchange rate regimes. After independence, India continued with more or less fixed exchange rate up to 1990s. The rupee was pegged to the pound sterling between the years 1947 and 1975 (except in1974), and it was pegged to a basket of currencies up to the 1990s (Bhattacharyya, 2004). 1993 witnessed a major transition in the exchange rate regime from a fixed exchange rate to a managed float.

While the exchange rate was kept free to be determined by the market forces, active interventions can be seen from the part of RBI for containing volatility and influencing exchange rate (Patnaik, 2007). Significant policy changes have been implemented in the forex market as a part of structural reforms in the foreign exchange market and liberalising the economy since the 1990s. Over the last two decades, the volatility in the exchange rate of Indian rupee has increased significantly, and the rupee has plunged to an all-time low against the US dollar. It should also be noted that this excessive volatility of Indian Rupee triggered its depreciation against major dominant currencies in the international market (Mirchandani, 2013). Within the span of last decade decade, the rupee showed a massive decline in value after the financial crisis and the exchange rate touched its all-time low point recently. So the high depreciation during this post-crisis period has questioned the stability of the forex market. During this period of instability, the economists or policy analysts were curious about the impact of the highly volatile exchange rate on other macro variables.

As per the Impossible Trinity hypothesis, it is impossible for a country to simultaneously have the three economic strategies, namely, stable exchange rate, free capital movements and an independent monetary policy (Obstfeld and Taylor, 1997). As far as the Impossible Trinity is concerned, the concurrent options are always hot potatoes. These dilemmas made the countries think of alternative options such as reducing currency volatility and stabilising monetary policy. So some countries select a mix of strategies through different kinds of rules and regulation as a barrier to the free flow of capital or exchange rate. In this context, exchange rate pass-through acts as a crucial monetary phenomenon which enables to understand the interlinkage between exchange rate and inflation particularly in an liberalised economic setup. So analysing the exchange rate pass-through in India, since it is one among developing countries who follows managed floating exchange rate is very important to know the exchange rate-inflation interaction and evaluate external pressure on the monetary mechanism in an open economy.

One among the most important aims of the exchange rate policy is to pull the trade balance in the direction which is favourable for the better performance of an economy by promoting higher production, export, and economic growth. The volatile nature of exchange rate also is expected to have a spillover effect on the trade balance. The rupee had been continuously depreciating throughout the last decade although we saw an appreciating tendency for very short span of time. So this kind of high-level depreciation of exchange rate is expected to be favourable for trade balance as the exports will become cheaper, and imports will become more expensive. When member countries approach IMF to correct the adverse situation of balance of payment or balance of trade, IMF also instructs the member countries to use the exchange rate as a control variable and to fix the rate accordingly to avoid disequilibrium in the external economy as part of structural reform packages. The time required for the transmission of exchange rate changes to domestic prices is also crucial to analyse the impact of exchange rate on the balance of trade. If the transmission takes a very long period, the impact on the balance of trade will be very marginal (Dholakia and Saradhi, 2000). Moreover, in a floating or managed exchange rate system, the exchange rate shifts will not be only in one direction. High positive or negative fluctuations and exchange rate overshooting are a common phenomenon. This kind of wide variations and fluctuations in the exchange rate which will have various effects on macro variables and this makes the study of exchange rate volatility and foreign trade very necessary.

1.4 Relevance of Analysis Using Non-linear Models

The presence of volatility in financial and currency markets has drawn the attention of scholars exploring various forms of non-linearities and chaotic behavior in the exchange markets (Adrangi and Allender, 2011). Bussiere (2013) shows potential possibilities of non-linearities and asymmetries in the exchange rate pass-through channel. According to him, the prices are found to be rigid downwards when quantities are rigid upwards, and the asymmetric impact can be summed up in Peltzamn’s (2000) words: “the prices rise faster than they fall." When the exporters face depreciation of the domestic currency, assuming *ceterisparibus*, they gain price competitiveness and market share if they keep the prices unchanged. Thus, the quantity can be increased as per increased demand at lower prices. However, if the firm is running at full capacity, generally it tends to raise the prices instead of increasing quantity. When the exporters face an appreciation, assuming *ceterisparibus*, they lose price competitiveness and market share, and this compels them to go with ‘pricing to market’ strategy by adjusting the prices. Due to downward price rigidity, the exporters will not reduce the price beyond a certain level since it will affect their profit margins badly. So the quantity will be moved downward. Hence, the exchange rate pass-through is expected to be more in the case of depreciation than in the case of appreciation.

The quality of products and productivity of the firm are also important factors which make significant changes in the exchange rate pass-through. The firms which have higher productivity can counterbalance the movement of the exchange rate by suitably using ‘pricing to market’ strategy when the low productivity fails to do so (Berman, Martin and Mayer, 2012). In the same way, higher quality goods always have higher markups and can accommodate changes in the exchange rate which leads to higher exchange rate pass-through. These types of microstructures of the products generate different forms of non-linear relationship between exchange rate and import or export prices and asymmetrically impacts exchange rate pass-through.

Another crucial factor which led to the exploration of non-linear pass-through is threshold-level effect of exchange rate movements. In the empirical study of developing countries, Frankel et al. (2012) found that the threshold effect works in the exchange rate pass-through. According to this, big devaluation is expected to have higher exchange rate pass-through whereas less pass-through impact is expected for a devaluation which is below a threshold level. The attempt of Pollard and Coughlin (2004) to study non-linearities and asymmetries in the exchange rate pass-through at the industrial level indicates that there is clear evidence for the asymmetries across the industry and that the asymmetric effect varies across the industries.

Volatility spillover and co-movements between the variables are other important points of focus of non-linear studies in the area of exchange rate and macro variables. The study of Nortey et al. (2015) made a significant contribution in checking volatility and the conditional relationship among inflation rates, exchange rates and interest rates using multivariate GARCH DCC and BEKK models in the context of Ghana.

Despite the possibility of a non-linear relationship in various forms, as we mentioned above, the focus of this study is limited to the checking of volatility or uncertainty spillover from exchange rate to inflation and foreign trade using Multivariate GARCH models following Nortey et al. (2015). The prime inspiration behind checking this relationship is derived from the preliminary analysis that the researcher carried out on the volatility trend of the exchange rate, inflation, and foreign trade. The volatility series of these variables shows almost similar trends and particularly high levels of volatility can be seen in the post-financial crisis period.

The volatility of exchange rate or inflation means the unexpected deviation from the mean of the variable. It is the indicator of the uncertainty in the expected values of a variable. The study of inflation uncertainty is relevant in several ways. Any sort of volatility is expected to get worse the prospects of a healthy economy. If volatility is high, investors will be reluctant to make more investment understanding the uncertainty in their future investments due to high inflation risk, as a result, demand a high return. At the same time, high volatility in inflation is expected to increase the cost of borrowing which has direct negative effect on investment and health of the economy to a large extent which leads to ineffective planning (Nortey et al., 2015). In the same way, the uncertainty in the exchange rate which is the indicator of the competitiveness of a country in the world market also reduces the confidence level of the investor. According to Berument et al. (2009), it is a widely accepted fact that any economic agent's decision in the uncertain economic situation will be different from the decision they would take otherwise. In this context, it will be interesting to study the volatility behaviour of exchange rate and inflation. In addition to this, the study also aims to analyse the volatility spillover between these two variables.

The interaction of exchange rate and foreign trade is an area which various studies has been produced across the world. In all these works, the major focus was to check the changes in trade flows according to the movements of exchange rate or its volatility shifts in linear framework. The uncertainty spillover between exchange rate and foreign trade and co- movements of volatility is an area which has been less researched. Baum and Caglayan (2009) investigated the role of exchange rate uncertainty in determining trade volatility in Eurozone countries. He found that one percent increase in exchange rate uncertainty led to eight percent increase in the trade volatility. Again, Baum and Caglayan (2010) studied the role of uncertainty considering broader set of industrial countries. The main conclusion of the work was that exchange rate uncertainty has a positive and significant impact in the determination of bilateral trade volatility. In the same manner, this thesis try to analyze the volatility spillover between the exchange rate and foreign trade and check whether the exchange uncertainty plays a crucial role in determining trade volatility. This is an unexplored area in the Indian context.

In this backdrop, the study tries to connect the three variables, namely, exchange rate, inflation and foreign trade, and examine the possible linear and non-linear interactions of inflation and trade with the exchange rate in the Indian context.

1.5 Objectives of the Study

Accordingly, the objectives of the study are formulated as follows:

1. To examine the nature and pattern of linear exchange rate pass-through in the Indian context and measure the strength of the pass-through.
2. To explore significant structural breaks in exchange rate volatility and analyze the changes of linear pass-through in different volatility regimes.
3. To analyze non-linear exchange rate pass-through and study non-linear dynamic interactions between exchange rate and inflation.
4. To analyze linear and non-linear dynamic interactions between exchange rate and foreign trade and empirically validate the Marshal Lerner condition and the J- Curve hypothesis.
5. To evaluate the linear and non-linear interactions of the exchange rate with inflation and foreign trade and recommend policy alternatives in Indian context for better exchange rate and monetary mechanism.

1.6 Hypothesis

1. Both external and internal factors from both demand and supply side play a role in the determination of exchange rate.

2. As any other devoloping country, India also uses exchange rate as a key monetary tool to achieve certain internal and external objectives.

3. Exchange rate pass-through to the inflation might be positive or negative as it is evident from other countries' experience.

4. Exchange rate depreciation helps to achieve favourable balance of trade as the theory suggests.

1.7 Data and Methodology

The present study is primarily an empirical one and relates to the Indian context for the period 1998-2014. The monthly and quarterly data series that was used in this study are sourced from the IMF Data Base, the US-Fed Reserve, the Reserve Bank of India, the Ministry of Commerce and Industry and Government of India. The study employs time series econometric methodology. More specifically, SVAR and VAR models have been applied to check the nature and strength of exchange rate pass-through to inflation. SVAR models are more efficient than other time series models in capturing exchange rate pass-through due to their ability to accommodate the contemporaneous interactions between the variables. The logic behind fitting separate Vector Autoregressive models is to make disaggregated analysis of exchange rate pass-through to different product groups and also evaluate the pass-through in different lag levels as only the joint significance level is considered in SVAR models. The non-linear pass-through between exchange rate and inflation is examined by using Multivariate GARCH-BEKK model. BEKK has several advantages in checking the volatility spillover compared to other multivariate GARCH models. The linear and non-linear relationship between exchange rate and foreign trade are investigated by using ARDL Cointegration Approach and Multivariate GARCH-BEKK model. ARDL model helps to examine the short-run and the long-run relationships between exchange rate and foreign trade irrespective of the variables being integrated of order I (0) or I (1).

The main intention behind scrutinizing the structural breaks as per different variance level is to understand jumps and peaks of the volatility and divide the period into different volatility regimes. Moreover, further analysis is possible confining to the data series of different variance blocks. The study has used ICSS algorithm test which is accepted to check the structural shifts in volatility. The most ranked model from the family of GARCH models is used to run the algorithm test. The standard GARCH approach is applied with the objective of producing the standardised errors that are used to identify the number of breakpoints in the volatility series.

1.8 Organization of the Study

The study is organized into seven chapters. Chapter 1 provides the background, objectives of the study and its scope and limitations. Chapter 2 is devoted to theoretical background and preliminary analysis of exchange rate, inflation and foreign trade in

India. Chapter 3 deals with the review of classified literature related to exchange rate pass-through and influence of the exchange rate fluctuations on foreign trade using linear or non-linear framework. The linear exchange rate pass-through is analysed in Chapter 4. Aggregate pass-through and disaggregated product group-wise pass-through is also analysed to check the extent of pass-through in various product groups. Chapter 5 deals with the volatility in the exchange rate and inflation, structural breaks in volatility and non-linear pass-through between exchange rate and inflation. Chapter 6 discusses the estimated model that finds the linear and non-linear relationship between exchange rate and foreign trade. In particular, the empirical work tests the validity of the Marshal Lerner condition and J-curve hypothesis in the Indian context. The last chapter presents the policy recommendations and identifies the scope for further research in this direction.

1.9 Limitations of the Study

The present study suffers from some limitations. Firstly, the strength of the exchange rate pass-through depends on several factors such as the amount of export-import operations, the openness of the economy, whether the country belongs to developed or underdeveloped category, the credibility of monetary policy and inflation level of the country. The country which has more export-import operations, more openness, less developed economic characteristics, less credible monetary policy and high level of inflation is expected to have more exchange rate pass-through as compared to the countries with opposite characteristics. Since the study is carried out within the framework of a single country analysis, the determinants of exchange rate pass-through in a multi-country scenario is out of the scope of this study.

Secondly, according to the methodology of McCarthy (2000), the study of exchange rate pass-through will be more comprehensive if we include the complete distribution chain of pass-through. Hence, using variables such as import price, wholesale price and consumer prices on a chain basis could have produced more insights. However, we could not use import price since monthly data was not available for the entire study period.

Thirdly, since the focus of this study was to draw a conclusion on exchange rate pass-through to the price level in general and to different products, in particular, using secondary data, a detailed pricing behavior of the firms are not taken care of. The pricing behavior of the firm such as PCP or LCP plays a vital role in determining the strength of the exchange rate pass-through.

Fourthly, the relative importance of different channels of the monetary mechanism has not been analysed in the thesis, considering plenty of works in this area, where the exchange rate channel has been identified as the most prominent in emerging economies.

Fifthly there is a possibility of various nonlinearities and asymmetries in the exchange rate pass-through channel. Despite the possibility of a non-linear relationship in various forms, the focus of the study is limited to examine the volatility or uncertainty spill over from exchange rate to inflation and foreign trade using Multivariate GARCH models following Nortey et al. (2015).

Sixthly, this study has limited the data period from 1998 to 2014 considering the availability of all the variables in monthly or quarterly basis.

Finally, despite several theories which connect exchange rate and foreign trade, this study tried to check the validity of Marshal Lerner condition and J-curve hypothesis.

------ xxx -------

Chapter 2

Theoretical Background and Preliminary Analysis

2.1 Introduction

The macroeconomic variables influence each other in linear or non-linear pattern. The theoretical underpinnings of linear transmission are very strong and widely discussed in the literature. The volatility transmission of macro variables in non linear set-up and analyzing the relationship according to different variance blocks after finding out structural breaks are new areas of economic research. The main intention behind scrutinising the structural breaks as per different variance level is to understand jumps and peaks of the volatility and divide the period into different volatility regimes. The study has used ICSS algorithm test and GARCH models to check the structural shifts in volatility. Before going to the detailed analysis of nonlinear relationships and volatility regimes, this chapter explains the theoretical background of exchange rate, inflation and foreign trade which are commonly discussed in standard macro textbooks on the assumption of linear relationship.

This chapter is divided into three major sections. The first Section gives the theoretical background of exchange rate pass-through. Monetary transmission and importance of exchange rate channel, the theoretical literature on exchange rate pass-through and its channels and the determinants are discussed in detail. The second section deals with theories of the exchange rate and foreign trade. An overview of Indian economic scenario and the nature and trends of study variables are given as a preliminary analysis in the final section.

2.2 Exchange Rate Pass-through: Theoretical Background

Considering the exchange rate as a macro dynamic variable which can influence and be influenced by other variables, the study of interrelationship between the exchange rate and other variables, particularly monetary variables such as inflation, stands significant. The concept of exchange rate pass-through has evolved over the time from various studies of exchange rate and other monetary variables. Thus the theoretical underpinnings of exchange rate pass-through lie in the theories of monetary transmission, its channels, other theories which connect exchange rate and inflation. Theoretical background of the exchange rate pass-through is explained in the following sections.

2.2.1 Monetary Transmission and Importance of Exchange Rate Channel

Monetary transmission explains how the changes in monetary instruments impact other macroeconomic variables such as inflation and output. Generally, the vehicles of monetary transmission can be categorised into financial market prices (eg, exchange rates, yields, interest rates, equity prices, asset prices) or financial market quantities (credit aggregates, supply of government bonds, money supply and foreign denominated assets) (Mohan, 2008). The monetary transmission mechanism is widely studied to evaluate the effectiveness of various policies in the economy, reframe the planning, and adopt alternative methods for effective transmission. Monetary transmission can take place through various channels. They include the interest rate channel, the credit channel, the asset pricing channel, the expectation channel, and exchange rate channel. Among these channels, interest rate channel is considered as prominent regardless of the monetary system prevailing in any economy due to its capacity to directly influence investment and overall growth and development of an economy. These channels work together to achieve certain monetary objectives.

The integration of the world market as a part of globalization and liberalization has led to a shift in the importance of different monetary transmission channels since the external pressure on fiscal and monetary policies is significant. Moreover, the relative importance of each channel depends upon several inherited attributes of the economy such as "degree of monetisation of the economy, the extent to which households borrow from the formal financial system, the state of development of financial markets, the instruments available to monetary policy, the fiscal stance and the degree of openness" (Kapur and Behera, 2012, p. 4). In many emerging markets, exchange rate channel stands as key monetary transmission channel and its impact on output and inflation is noteworthy in comparison to interest rate channel (Norris and Floerkemeier, 2006; Mashat and Billmeier, 2007; Catao and Pagan, 2009; Bhattacharya et.al, 2011). In the Indian case, Bhattacharya et.al (2011) found that the interest rate channel is weak and this is primarily due to lack of a well-developed financial system, especially in the case of developing countries (Dorrucci, Meyer-Cirkel and Santabarbara, 2009).

The fluctuation in the exchange rate will have an impact on the inflation level of a country either through a disciplinary effect or credibility effect. Disciplinary effect of money is one which happens as a part of restricting money supply for the adjustment of exchange rates. Credibility effect works through increasing demand for money and reducing the velocity of money (Mohanty and Bhanumurthy, 2014). When there exists a pegged exchange rate system, demand for money will be high due to less uncertainty about the monetary policy which in turn leads to decline nominal interest rates and inflation. This credibility effect is working out through demand side. It is widely accepted that when there is more stable or pegged exchange rate system there will be a low level of exchange rate pass-through to the inflation.

2.2.2 Exchange Rate Pass-through: Theories of Exchange Rate and Inflation

The origin of the study on the relation between exchange rate and inflation came from the theory of purchasing power parity from the works of Cassel (1918), popularized and expanded by eminent economists later on. Absolute Purchasing Power Parity and Relative Purchasing Power Parity theories are two versions of this theory. As per the Absolute Theory, "the purchasing power parity (PPP) exchange rate is the exchange rate between two currencies that would equate the two relevant national price levels if expressed in a common currency at that rate, so that the purchasing power of a unit of one currency would be the same in both economies" (Taylor, 2002, p. 65). According to the Relative Purchasing Power Parity theory definition, the changes in the exchange rate of two currencies are proportional to the changes in the inflation rate of two countries. When the PPP hold, the nominal exchange rate can deviate at various time points, but the real exchange rates are expected to be constant over time.

2.2.3 Purchasing Power Parity and Exchange Rate Pass-through

Purchasing Power Parity theory originated from the Law of One Price (LOP). The LOP can be written as

$$p_{i,t} = s_t p^*_{i,t} \qquad i=1,2,3\ldots..N \qquad \ldots\ldots. (2.1)$$

where $p_{i,t}$ stands for the price of good i in terms of the domestic currency at time t, $p^*_{i,t}$ denotes the price of good i in terms of the foreign currency at time t, and s_t is the nominal exchange rate expressed as the domestic price of the foreign currency at time t. The intuitive idea of Law of One Price is that the price of the same product in different countries will be same if we denote it in the same currency. This is the absolute version of the Law of One Price theory. The LOP in relative terms can be written as (see, Taylor, 2002)

$$\frac{P^*_{i,t+1}s_t}{p_{i,t+1}} = \frac{P^*_{i,t}s_t}{p_{i,t}} \quad \text{i=1,2,3.....N} \qquad \text{........ (2.2)}$$

If LOP exists in an absolute sense, it means that the LOP can exist in relative terms also, but not vice-versa. The LOP can exist only in the absence of any tariff, transport costs and other non-tariff barriers since it pushes the market to fix the price accordingly. The LOP also requires the perfect substitutability of a product which rarely exists if we take in a general case. The product differentiation is a common phenomenon in the real world. For the absolute version of the PPP hypothesis to hold good, it should satisfy the summation criteria of all the traded goods in each country:

$$\sum_{i=1}^{N} \alpha_i \; p_{i,t} = s_t \sum_{i=1}^{N} \alpha_i \; p^*_{i,t} \qquad \text{...... (2.3)}$$

Where the weights in the summation should be equal to one

$$\sum_{i=1}^{N} \alpha_i = 1 \qquad \text{...... (2.4)}$$

The weights α_i are based on a national price index. The PPP Condition can be derived from equation 2.3. If the national and foreign price levels are denoted as p_t and p^*_t:

$$S_t = p_t - p^*_t \qquad \text{..... (2.5)}$$

From equation (2.5) it is easily seen that the real exchange rate, defined here in logarithmic form:

$$q_t \equiv S_t - p_t - p^*_t$$

where q_t can be considered as a measure of the deviation from PPP.

According to Absolute Purchasing Power Parity, the exchange rate between two countries should be equal to the ratio of the price level of those two countries. Relative Purchasing Power Parity theory is the dynamic version of the absolute power parity, which says the changes in the exchange can be explained by the difference in the inflation rates between two countries. Purchasing Power Parity is also called ‘inflation theory of exchange rate’ since the theory tries to explain the exchange rate movements only with a single variable, changes in inflation (Dornbusch, 1985).

The traditional open macroeconomic models on the basis of Purchasing Power Parity assure immediate and complete exchange rate pass-through to domestic prices. This is because the theory was developed on the assumption of the existence of a perfect competitive market which is rarely found. However, in the practical world, the empirical studies of the Law of One Price and Purchasing Power Parity revealed that the exchange rate pass-through is not found to be complete and immediate. If there is a chance for complete pass-through, it is expected to be there in the case of small countries. A small country, cannot influence world market prices, may experience complete pass-through in one to one direction, whereas advanced countries, can affect the world market price, hence experience incomplete and less exchange rate pass-through as denoted by McCarthy (2000). However, the empirical studies show that both small countries and advanced countries experience only incomplete exchange rate pass-through.

2.2.4 Imperfect Competition, Pricing to Market and Exchange Rate Pass-through

Though Purchasing Power Parity theory holds good, most of the empirical works could not explain by this theory alone. Deviations of exchange rate beyond the Purchasing Power Parity theory led to the origin of the concept of exchange rate pass-through and to produce several empirical works on the determinants of exchange rate pass-through. The assumption of a perfect competitive market which is rare in the practical world was found to be a major drawback of Purchasing Power Parity theory. Comprehensive analysis of exchange rate pass-through with imperfect competition was firstly analysed by Krugman (1986) and Dornbusch (1987)

Krugman (1986) introduced the concept of ‘pricing to market’ and tried to explain exchange rate pass-through using this concept. Pricing to market is the pricing behavior of firms according to different markets, which will help to adjust prices incompletely to exchange rate movements and adjust the profit margin accordingly. He argued that pricing to market is a real phenomenon, but cannot be considered as a universal phenomenon. It was empirically evident on German export prices which suggested stickiness being confined to machinery and transport equipment prices. The study found out that the import price is not entirely reflected by the changes in the exchange rate. Moreover, 35 to 40 percent of the real appreciation of the dollar since1980 has been absorbed by foreign exporters which lessened the extent of import price rise in the US than in other markets. According to Krugman, dynamic models of imperfect competition are best in explaining exchange rate pass-through by using supply dynamics resulting from the costs of rapidly adjusting marketing, distribution infrastructure and the demand dynamics arising from the need for firms to invest in reputation.

Dornbusch (1987) investigated the determinants of relative price changes of different groups of products when pricing mechanism was threatened in the U.S as a result of a persistent real appreciation of the dollar. The author went beyond the existing reasons of explaining exchange rate pass-through such as trade barriers, transaction and transportation costs, market power and imperfect substitutability between domestic substitute and foreign products, and came up with a more reliable outcome. He explained the pass-through as a result of market concentration, product homogeneity and substitutability and relative market shares of domestic and foreign firms. The study using all these variables gives evidence for the declining price level as a result of the persistent appreciation of the currency, and changes in the price level depend on the competition for the products and number of domestic and foreign firms involved in producing same products.

Analysis of Exchange rate pass-through by Krugman (1986) and Dornbusch (1987) is based on the assumption of imperfect competition and pricing to market theory. According to Krugman, if the adjustment of services and distribution to the changes in the exchange rate is costly, the expected persistence of exchange rate changes will be a major determinant of exchange rate pass-through. So the firm will not be ready to make changes in the prices if they expect that variations in the exchange rate will be reversed soon. Dornbusch (1987) pointed out that the share of import and degree of competition stand as two key factors which determine the level of exchange rate pass-through. The countries with more imports are found to have more pass-through since the exchange rate shift marginal cost curve of the firms. Increased competition leads to less pass-through due to the inability of firms to change the prices by adjusting markups.

2.2.5 The Vicious Circle of Depreciation- Inflation

The debate on 'the vicious Circle of Depreciation- Inflation' became very popular during the 1970s and 1980s and several economists attempted to examine this issue empirically. "The depreciation –inflation vicious circle is a situation in which an exchange- rate depreciation causes a domestic price increase such as to prevent the hoped-for benefits of the depreciation from coming about and thus calling for a new depreciation and so on and so forth" (Gandolfo, 1987, p. 368). When exchange rate depreciation causes the domestic price to increase, a depreciation-inflation vicious circle is produced. An opposite vicious circle exists between exchange rate appreciation and price stability or deflation. The concept of 'depreciation –inflation circle' which originated from the works of 17th century economists, paved the way for the empirical study of this issue through two different approaches; causality tests and structural macroeconomic models.

De Cecco (1983) has reviewed and summarized the debates on the vicious circle in the twenties and the seventies. A study by Kawai (1980) reveals that the circle exists in Italy, Belgium, the Netherlands, Switzerland, and Japan. Unlike the previous study, Kawai finds no causality in the case of UK. Causality testing fails to tell us 1) about the transmission mechanism through which the bi-directional causality occurs and 2) whether the circle is vicious or not.

In the second approach of building structural macroeconomic models, the relation between the various macroeconomic variables is adequately modeled to explain the circle. As there are different schools of thought in economics, the idea regarding the transmission also differs from one school to another. Some writers like Bilson (1979) and Bond (1980) observe the wrong direction of monetary policies as a reason for the circle. Excessive increase in the money supply affects the exchange rate immediately and the real markets eventually. The exchange rate depreciation causes an increase in aggregate demand and inflation.

Other writers, Basevi, and Grauwe (1977) opine that downward price rigidity is the reason for the circle. The initial expansionary monetary shock results in the depreciation of exchange rate by an excessive amount with respect to its long-run equilibrium value. An inevitable price increase continues since the downward price rigidity frustrates subsequent monetary restriction. However, the policy initiatives along with the exchange rate appreciation are not followed by the price decrease. When price remains high, the balance of payment deficits will reappear as a result of which exchange rate depreciates again. Depreciation of exchange rate is followed by inflation. Appropriate intervention in the foreign exchange market is required to prevent exchange rate from deviating from its long-run equilibrium value.

Modigliani and Padoa-Schioppa (1978) created an entirely different model. They used a price formation mechanism by means of markup on production and a wage indexation. In this context, exchange rate depreciation results in an increase in production costs and hence in prices and wages. The balance of payment deficit due to increase in prices and deterioration in the current account eventually leads to new exchange rate depreciation.

Various theories using appropriate econometric model to analyse the data and to prove the validity of the hypothesis have been developed over the period. In this way, the study of Gandolfo and Padoan (1984) shows that the circle is slowly converging with relatively mean time-lags in the context of Italy.

By a given exchange rate depreciation, prices increase less than proportionally, depreciation and inflation converge to zero so that the circle will not be vicious. If the percentage change is increasing or decreasing, the circle is said to be vicious. A dynamic structural model is required to analyse the time lags and adjust the changes accordingly. The longer the adjustment lags, the more worrying is the circle. The parameters which determine the divergence and convergence of circle and the length of the adjustment lags cannot be fixed a priori but has to be determined econometrically.

2.2.6 Firms' Pricing Behaviour and Exchange Rate Pass-through

Recent studies focus on the pricing strategies of the firm and its impact on pass-through in the context of imperfect competition. Two different approaches are developed in this area, wherein first one is partial equilibrium analysis with flexible price and imperfect competition while the second one is general equilibrium analysis with more emphasis on price stickiness (Engel, 2004). When the prices are considered to be sticky in the short-run, the strength of the exchange rate pass-through depends on the pricing strategy of the firm, PCP (Producer Currency Pricing) or LCP (Local Currency Pricing). According to PCP, the prices are determined in producer's currency (domestic currency), while according to LCP the prices are determined in the currency of the foreign country to which the producer export.

It is very important to examine what kind of pricing strategy is followed by the firms. Few works are found in this direction dealing with the determinants of pricing strategy of the firms. In a two-country general equilibrium model, the efforts of Devereux and Engel (2001) were to connect monetary and financial stability and pricing strategy of the firm. The countries which have more financial stability fix the import price in their own currency (LPC), which leads to less exchange rate pass-through. At the same time, the countries which have less financial stability fix the import price in foreign currency (PCP), which attributes to more fluctuation in the price according to the exchange rate movements and high exchange rate pass-through (Devereux and Engel, 2001; Devereux, Engel and Storgaard, 2004). Chang and Lapan (2003) try to analyse the role of exchange rate volatility in determining the pricing strategy of the firms and nature of exchange rate pass-through in a particular pricing strategy. High volatility in the exchange rate leads to wide variations in prices over the time. So the firms prefer PCP strategy and change the prices accordingly. In this context, the exchange rate pass-through is found to be high since high price variation due to the exchange rate volatility (Chang and Lapan, 2003; Corsetti and Pesenti, 2004).

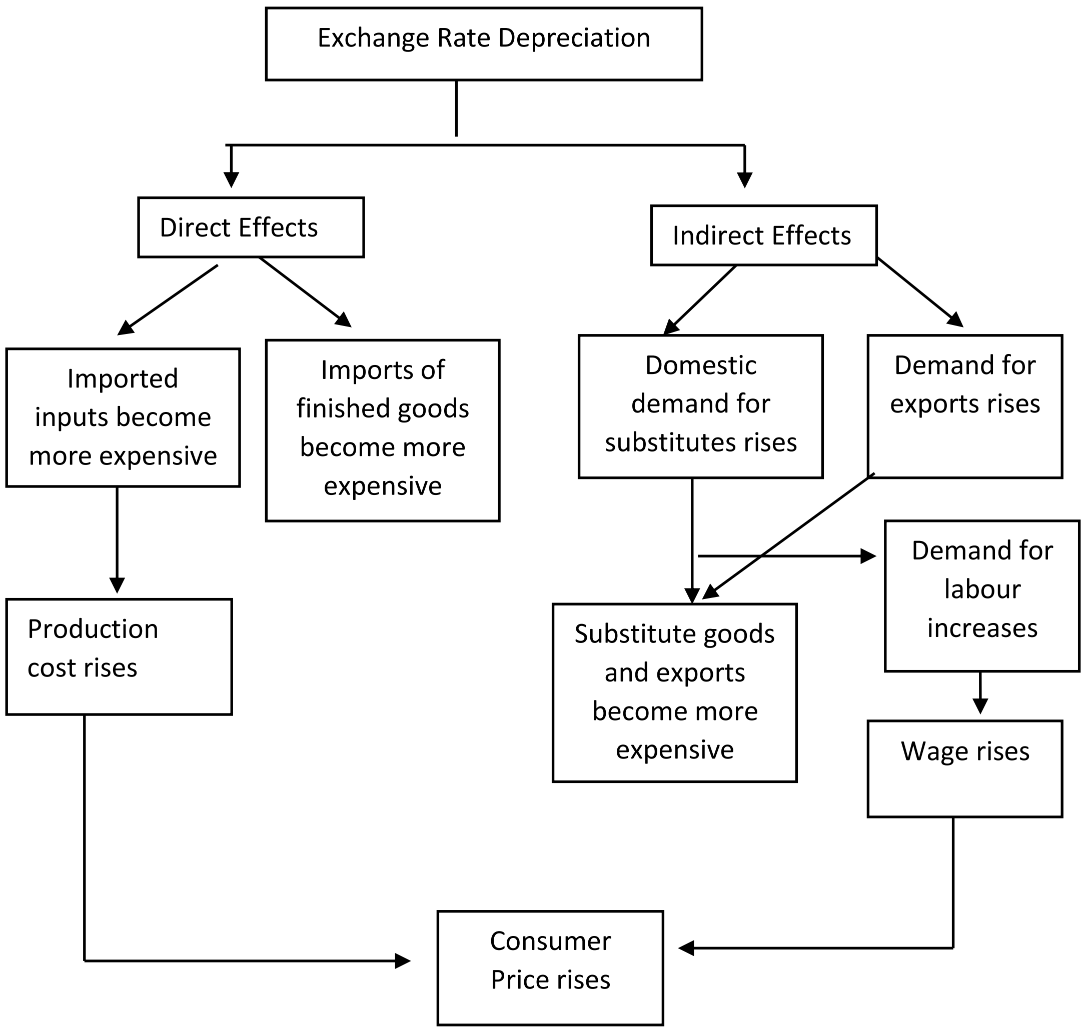
According to Bacchetta and Wincoop (2005), an international competition among the firms is one of the major influential factors of pricing strategy and exchange rate pass-through. The high market share for the foreign firms and high differentiation in products are the signs of low competition, which make the firms choose PCP and lead to high exchange rate pass-through.

There are other few studies which indicate that the exchange rate pass-through depends on the price indices used for the analysis. The coefficient of the pass-through varies to producer price index, wholesale price index or consumer price index. The exchange rate pass-through also differs to import prices and consumer prices. The incomplete pass-through to consumer price is due to the high distributional and transportation cost as well as the inclusion of tradable and non-tradable goods (Burstein, Eichenbaum and Rebelo, 2003, 2005). If the consumer price index includes more of non-tradable goods which are less affected by the changes in the exchange rate, the exchange rate pass-through to the CPI will be low. Bacchetta and Wincoop (2003) view that if the non-tradable goods cover a significant share of the total goods, the producers prefer PCP for the final goods and LCP for the intermediary goods. It leads to high exchange rate pass-through to import prices where pass-through to consumer prices is low. There is a chance that the firms might use a different strategy for different product and different market. By analysing the pricing strategy, Betts and Devereux (1996) and Engle (2002) argue that the exchange rate pass-through depends on the combination of the pricing strategy of the firms in a different context.

2.2.7 Exchange Rate Pass-through: Channels and Determinants

The strength of exchange rate pass-through depends on several macro variables which directly or indirectly influence exchange rate or inflation. Channels and determinants of exchange rate pass-through were the focus of some works, particularly in last three decades. The transmission channel of the exchange rate can be broadly classified into two, direct channel and indirect channel (Kahn, 1987; Menon, 1995; Lafleche, 1996; Goldberg and Knetter, 1997). The direct channel is measured by checking the impact of exchange rate on the import prices. When there is a depreciation or devaluation, it increases the price of imports which compel the importing country either to cut down the import or to pay more value for the same quantity of imports. Increased price of imports will have an impact on the domestic prices in two ways. If the imported item is finished goods, it directly attributes to an increase in the price level of the domestic currency. If it is an intermediary good which enters into the production of domestic consumption goods, it leads to an increase in the cost of production of domestic goods which in turn increases the price level of finished consumption goods. Moreover, there is the possibility of an increase in domestic prices on par with rising import prices by the domestic producers to take advantage of growing demand for domestic substitutes.

Fig. 2.1 Direct and Indirect Channels of Exchange Rate Pass-through



Source: Lafleche (1996)

The indirect channel works through the changes in the competitiveness of the goods in the international markets (Tandrayen-Ragoobur and Chicooree, 2013). According to Sachs (1985), the indirect channel effect of exchange rate movements can be divided into two effects, viz. competition effect, and the wage inflation effect. Competition effect captures the changes in commodity prices as a result of changes in demand for goods and services due to the direct impact of exchange rate on the price level. When there is an appreciation in the exchange rate, reduction in import price compels domestic producers to cut down the prices to compete with the lower price of imported goods which in turn leads to lower inflation level. Wage inflation effect occurs according to the changes in the exchange rate. When there is depreciation, domestic products become cheaper for foreign customers. It leads to an increase in export and total demand for the products. This increased demand attributes to an increase in the price level. Since the nominal wage contracts are fixed in the short-run, the real wage decreases for the labourers and the output will be increased. Over the period, the real wage increases and causes to increase the cost of production and price level accordingly.

The output level again comes down to the normal level. It means when the depreciation leads to a permanent increase in price level, the output is increased only for the short-run and later, the normal output level will be regained (Khan, 1987). Lafleche (1996) explain the indirect effect of depreciation as a result of changes in the demand for exported goods and substituted goods. It leads to an increase in the price level of such products and general price level ultimately. Theoretical explanation of Lafleche (1996) is given in figure 2.1.

The Large variation in the exchange rate pass-through can be seen in different countries and different macroeconomic conditions and regimes. The strength of exchange rate pass-through and its determinants vary author to author and context to context. Betts and Kehoe (2006) made an effort to explain the variation in the exchange rate pass-through using the law of one price which is the base of exchange rate pass-through studies. Pricing-to-Market (Krugman, 1986; Dorbushch, 1987) and the pricing strategy of the firm, whether firm follows PCP or LCP or its combination (Campa and Goldberg 2005, 2006) are another major determinants of the pass-through. High level of transportation and distribution cost reduces the effect of pass-through (Burstein et al., 2003, 2005; Corsetti and Dedola, 2005). The level of competition in the retail sector is the another determining factor of pass-through in which the higher competition compel the firms to adjust their markups according to the changes in the exchange rate instead of increasing the price. It reduces the strength of exchange rate pass-through (Feenstra, Gagnon and Knetter, 1996; Feinberg, 1989; Yang, 1997)

The inflationary situation of the country (Choudhri and Hakura, 2001) and volatility of exchange rate (Corsetti and Pesenti, 2004) also play a vital role in determining the extent of exchange rate pass-through. Normally, the countries with a higher cost of production would have a higher level of inflation. It is expected to have more impact of exchange rate pass-through on domestic price if the inflation level is high (Choudhri and Hakura, 2001). The volatility of exchange rate may lead either to increase or to decrease exchange rate pass-through since the profit margin may also be volatile as per the uncertainty exists in the exchange rate (Mann, 1986). If the exchange rate shocks are found to be transitory, the firm would not be ready to change the price. Instead, they adjust the markups for a short span of period. However, if it is found to be persistent for an extended period, they change the price accordingly. This results in zero exchange rate pass-through in the former, where the incomplete exchange rate pass-through can be expected in the second case. According to Mann (1986), the high volatility of demand for products also reduces the exchange rate pass-through.

The monetary policy environment (Devereux et al., 2004) and openness of the economy (McCarthy, 1999) also impact the exchange rate pass-through. Stabilized monetary policies help to reduce the volatility of money growth which in turn lessen the extent of exchange rate pass-through. This is because the low level of uncertainty in the monetary instruments encourages producers to use PCP (Producer Currency Pricing) instead of LCP (Local Currency Pricing). The price of goods and services are less affected by the changes in exchange rate when the firms use PCP strategy. The openness of the economy become important since more opened economy leads macro variables to be affected by the external shocks. So the economies which implement liberalized policies will face more exchange rate pass-through (Soto and Selaive, 2003; McCarthy, 1999)

2.3 Exchange Rate and Foreign Trade: Theories

One of the most important aims of the exchange rate policy is to pull the trade balance in a certain favourable direction that stimulates economic performance by promoting higher production, export, and economic growth. The volatile nature of the exchange rate is also expected to have spillover on the trade balance. Moreover, the pressure on the current account deficit can be eased by the devaluation or depreciation of the domestic currency. As a result of the depreciation of the domestic currency, the volume of exports increases as the foreigners receive more goods with the same value of the amount of their currency. The volume of imports that the domestic customers buy from abroad decrease as the value of the foreign currency has increased.

Various theories like absorption approach, elasticity approach, and monetary approach to the balance of payment talk about the effectiveness of the devaluation of currency. The Keynesian theory is divided into elasticity approach and absorption approach, while the monetarists deal the topic by the monetary theory of the balance of payments.

2.3.1 Elasticity Approach and Marshal-Lerner Condition

Favourable balance of trade play a crucial role in maintaining favourable position in the balance of payment and the disequilibrium of trade account impacts the balance of payment negatively. This has been theorized in two ways. Elasticity approach deals with the real exchange rate and flow of goods and services. Absorption approach extends the elasticity approach by including income effect.

Exchange rate adjusts the balance of payment as imports and exports depend on the exchange rate. Price change determines exchange rate and trade account position. This change can be quantitatively studied using elasticity measurement. Price elasticity of demand and supply shows a shift in the quantity of good with respect to changes in the prices. When the price elasticity is greater than one, the change in quantity is larger in proportion to that of change in price. When price elasticity is equal to one, the change in both price and quantity is proportional. Moreover, when elasticity is less than one, the change in quantity is much less than that of change in price. Depreciation in the domestic currency results in an increase in import price and a decrease in export price. This results in a decrease in import and increase in exports and an improvement in trade balance and current account. Improvement in trade balance due to depreciation in currency is not just because of change in the volume of imports and exports but also due to changes in prices.

The Marshall-Lerner condition explains how depreciation of exchange rate can result in improving or worsening the trade balance. It takes into consideration the sum of the price elasticities of the imports and the exports. If the sum of the elasticities is greater than one, then the devaluation of currency is favourable for trade. This is because the balance of payment is stable and narrows the disequilibrium. If the sum is equal to one, it is neither favourable nor unfavourable for trade. If the sum is less than one, then depreciation of the currency is not at all favourable for the trade balance. For trade balance to improve, the sum of the elasticities of import and export demand should be greater than one. In the short-run, price elasticities generally found to be significantly small. This is because, consumer preferences do not change in such a short period, hence, and the Marshall-Lerner condition talks about the long-run adjustment mechanism.

2.3.2 The J- Curve Hypothesis

The J-curve hypothesis suggests that the change in import and export demand due to exchange rate fluctuations occurs with a time lag (Magee, 1973). A devaluation of currency will not directly result in improvement in the trade balance. Devaluation initially results in the increase of import prices and fall in export prices. Changes in the import and export demand require time to change. When there is a weakening of domestic currency, the trade balance initially weakens and later improves making the curve in the shape of J. In the short-run, changes in the trade flow reflect the change in the relative prices due to exchange rate fluctuations. Depreciating domestic currency can boost export volume resulting in the high value of export earnings. However, variations in the quantity demanded will not change at the rate of change in prices because the trading partners might have been involved in some fixed binding contracts. Because of the contracts, the quantity remains fixed or change at a small marginal rate. Elasticities will adjust in the long-run which could lead to a recovery in the foreign demand for domestically produced goods. The benefit of depreciation depends on the openness of the economy and the size of the economy.

Both Marshall-Lerner condition and J-curve have failed to consider the difference in the application of the theories in various countries. The export and import vary from country to country according to its trade openness and size. A small country may export high, but its imports might be low as it is less in population. The exports and imports also depend on the restrictions imposed by the government.

2.3.3 Absorption Approach

Absorption approach highlights the change in real income and real expenditure as determinants of the country's balance of payment and exchange rate. This approach disregards the financial account. Absorption approach views trade balance as what is produced in the economy minus what is consumed in the economy. If domestic production exceeds domestic spending, then there is an excess of exports than imports and the current account runs a surplus. If the domestic production is less than domestic consumption, then the imports are greater than exports and current account runs a deficit. The volume of exports and imports depend on how much can be absorbed by the domestic economy. If the income exceeds expenditure, the rest is exported to the foreign consumer. If the income is less than expenditure, the domestic economy depends on imports to satiate its needs. When the income is greater than expenditure, the demand for local currency increases as there is an increased demand for exports. This will result in the appreciation of the local currency. Moreover, when the income is less than the expenditure, the currency depreciates.

2.3.4 Monetary Approach to Balance of Payments

Monetary approach to the balance of payments looks beyond the trade account and includes financial account also. This highlights the direct impact of demand and supply of money on the entire balance of payments. Money supply is the amount of money that is available in the economy while money demand is the amount of money that an individual decides to hold. According to the monetary theory of balance of payment, disequilibrium in the money market leads to balance of payment deficit rather than income or exchange rate as explained by elasticity or absorption approach. Humphrey and Keleher (1982) talks about the monetary forces that determine the exchange rate movements. The monetary approach considers balance of payment disequilibrium as a monetary phenomenon which arises as result of money market disequilibrium. In the case of fixed exchange rate system, the balance of payment surplus occurs only when demand is comparatively higher than the supply. Wherein the floating exchange rate system, the balance of payment is always balanced and changes in demand and supply lead to rise or fall the exchange rate value.

2.4 Impact of Exchange Rate on Inflation, and Foreign Trade in India: A Preliminary Analysis

This section is devoted to giving a preliminary analysis regarding the trends and policy changes in exchange rate, inflation, and foreign trade in the Indian context. In the last two or three decades, India has gone through different economic and financial system. The government policies and economic environment play a critical role in determining the impact of the external shock on the economy.

2.4.1 Exchange Rate: Trends and Regimes

Since India was under British rule, as one of their colonies for more than a century, the trade relationship was purely concentrated with Britishers while the relationship with other countries was nil or marginal. The Britishers used India for the raw materials and as the market for their finished products, and the exports and imports were constrained to this. This has led to Indian rupee being fixed to the pound sterling in the early 1960s. Indian exports were uncompetitive as there was no possibility of other export destinations and also rupee value appreciating over the time. A noteworthy depreciation of 36% happened only in 1966 which led to increase export volume and profit margin of the exporters tremendously (Bhagwati and Srinivasan, 1975). After that, there was no kind of appreciation or depreciation in the value of rupee till 1971.

The aftermath of Bretton Woods System, most of the countries adopted flexible or managed exchange rate system. At the same time, the share of Britain in India's trade reduced and trade relations and international transactions with other countries increased. Understanding the limitation of sticking into only one currency the Indian Rupee was de-linked from the Pound Sterling in September 1975 (RBI, 2016). Subsequently, the rupee value was determined with reference to daily exchange rate movements of some undisclosed currencies which led to broadening the view of exchange rate without limiting only to one currency. However, still Indian rupee could not capture the volatile movements of the major global currencies and it was more or less determined by the market forces in the currency market. In fact, it was the period of the crawling band around Pound Sterling.

Table 2. 1 History of India's Exchange Rate Arrangements

Time Period	Exchanage rate System- De Jure	Exchanage rate System- De facto
Nov. 1943- Oct. 1965	Peg to Pound Sterling	Peg to Pound Sterling
Oct. 1965- June.1966	Peg to Pound Sterling	Defacto band around Pound Sterling/ Parallel Market (Thre are multiple exchange rates; band width is +/- 5%
Jun. 1966- Aug. 1971	Peg to Pound Sterling	Peg to Pound Sterling
	There were two devaluations of the rupee during this period. First devaluation occurred on June 6, 1966 and the second devaluation occurred on May 28, 1971.	
Aug. 1971- Dec. 1971	Peg to U. S dollar	Peg to U. S dollar
Jan. 1972- Aug. 1975	Peg to Pound Sterling	Peg to Pound Sterling
Sep. 1975- Feb. 1979	Managed Float; Rupee's Effectvie rate linked to a basket of currencies of major trading partners	Defacto crawling band around Pound Sterling (band width is +/- 2%)
Mar. 1979- Jul. 1979	Managed Float	Managed Float
Aug. 1979- Jul. 1989	Pegged to Basket of Currencies	De facto crawling band around US Dollar (band width is +/- 2%)
Aug. 1989- Jul. 1991	Pegged to Basket of Currencies	De facto crawling peg to US Dollar
Aug. 1991- Feb. 1992	Pegged to Basket of Currencies	De facto peg to U.S dollar
Mar. 1992- Feb. 1993	Dual Rate Transition System (the dual rate was comprised of the effective rate and the inter- bank free rate)	De facto peg to U.S dollar
Mar. 1993- Jun. 1995	Managed Float	De facto peg to U.S dollar
Jul. 1995- Dec. 2001	Managed Float	De facto crawling peg to U.S dollar
Jan. 2002- Present	Managed Float	-

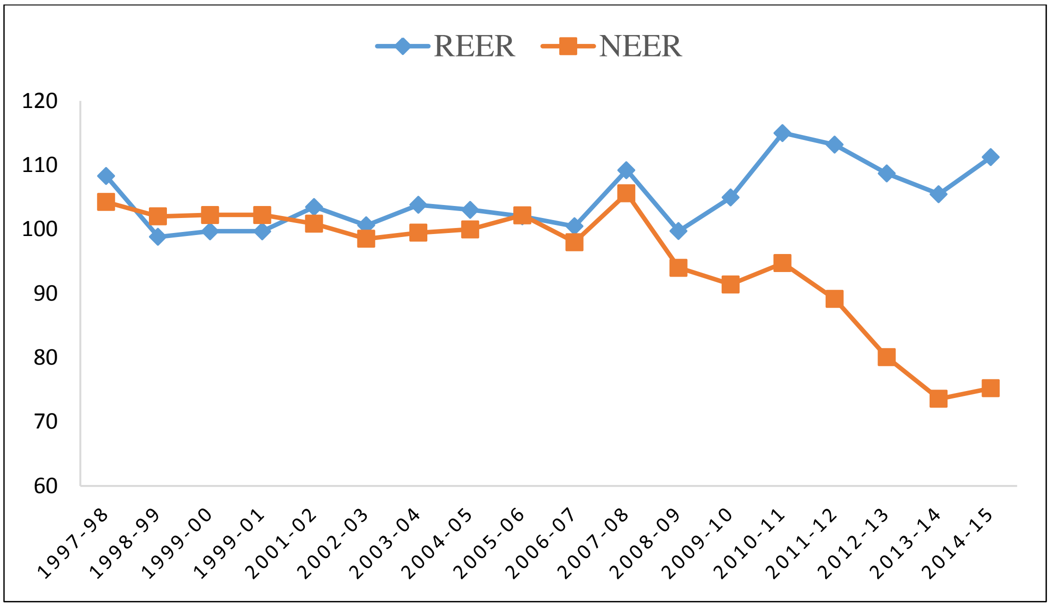
Source: International Economics at the Chinese University of Hong Kong (http:/ intl.econ.cuhk.edu.hk/exchaange_rate_regime), Reinhart and Rogoff (2002) and Jayakumar.et.al. (2006)

Later on during 1980s, Indian rupee was pegged to the dollar. As a result, rupee turned to be volatile due to short fluctuations in the dollar. In order to reduce the movement, RBI was doing frequent interventions in the value of currency adopting crawling peg system during 1983-84 and it continued till 1990 (Joshi and Little, 1994). Interventions of RBI under crawling peg regime were effective to capture the developments in the world forex market and exchange rate variations of dominant currencies. According to Reinhart and Rogoff (2002), the exchange rate in these periods was pegged to the U.S dollar, in such way that the variations in the dollar were correctly captured.

After the 1990s emerging countries and developing countries which followed soft peg or crawling peg system moved to hard peg or free float. These countries tactically have chosen constrained float or managed float regimes as they fear the consequence of pure float. (Mohanty and Bhanumurthy, 2014). In India, the Balance of payment crisis in 1991 brought drastic changes in exchange rate regimes and policies. Oil price hikes, and sharp fall in remittances from a large number of Gulf migrants have led to the crisis which in turn increased Indian external debt tremendously. Further export has gone down due to worldwide economic slowdown. This scenario compelled the government and monetary authority to think about more liberalized system in each and every segment of the financial sector. Accepting more exchange rate flexibility, downward adjustment of Indian rupee took place twice in July of 1991. This period was coined as the 'decisive end to the pegged exchange rate regime' (Dua and Ranjan, 2010). In March 1992, Indian forex market witnessed remarkable shift in the exchange rate system by introducing dual exchange rate system in which certain import payments, 40% of export and invisible receipts and official grants and IMF transactions were determined by the monetary authority whereas all other transactions were determined according to the market forces in inter- bank market. Through this, monitory authority started Liberalized Exchange Rate Management System (LERMS) which paved way for predominantly market-determined exchange rate system. Subsequently, on March 1, 1993, the unification of dual exchange rate system at market determined rate was officially announced. The exchange rate reform thus introduced has finally resulted in current account convertibility. Some of the writers argue that discrepancies could be found between the official or de jure exchange rate system and de facto or the existing system. Reinhart and Rogoff (2002) made a path-breaking work regarding exchange rate regimes in emerging markets including India. He concludes that the official exchange rate system in India is far away from the actual scene. Comparison of both de jure exchange rate system and a de facto system will help to understand the dynamics of exchange rate regimes. Table 3.1 gives the details of the exchange rate system.

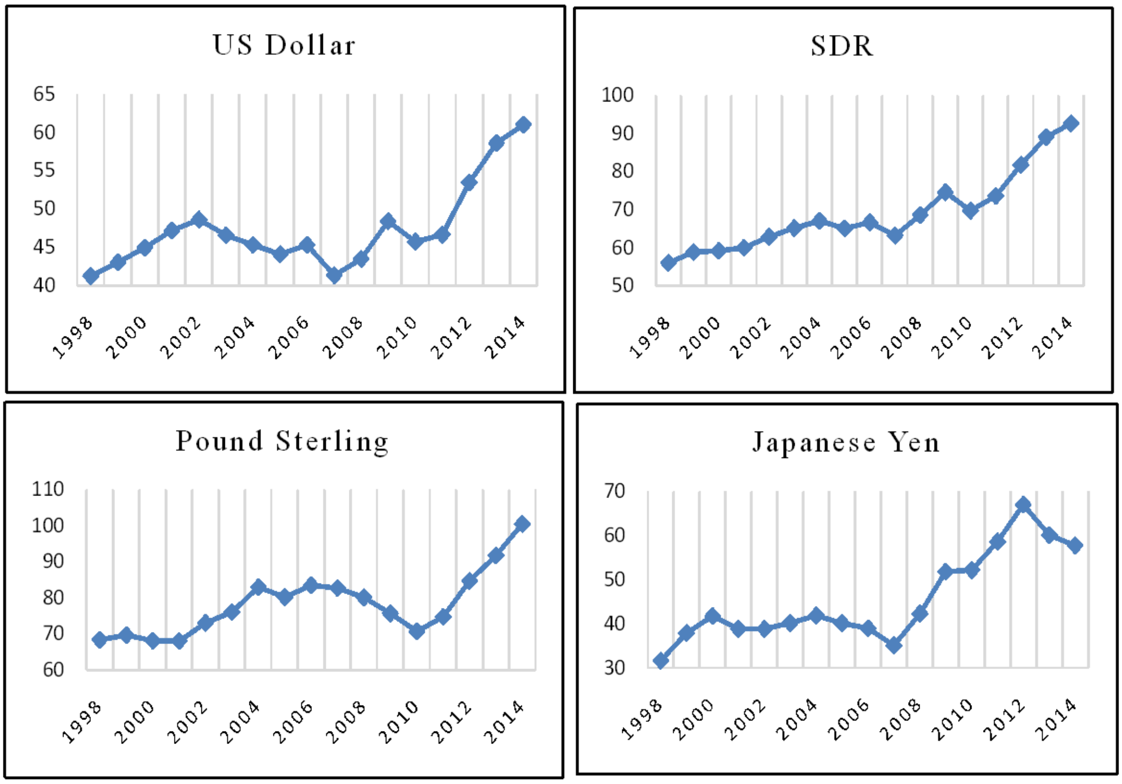
To overcome the limitation of the exchange rate management and improve the financial mechanism, various committees were established to look into suitable policy

Fig. 2.2 Trends in Indian Exchange Rate



Source: Handbook of Statistics on Indian Economy, RBI

Fig. 2.3 Exchange Rates from 1998 to 2014



Source: Reserve Bank of India

changes and reforms. Sodhani Committee (1994) was constituted to find out further possibilities of liberalization in the forex market. As per the recommendation of this committee, banks were permitted to initiate cross currency positions overseas on the basis of certain requirements. In due course, convertibility of capital account is being thought of. However, this has not been fully realized. But the effort has been taken in this direction as per the recommendation of Tarapore Committee (1997). For instance, on the investment front, FDI and FII policies have been liberalized. Recently government took decisive efforts for further liberalization of the capital market both in FDI (Foreign Direct Investment) side and FII (Foreign Institutional Investment) side. FDI front, more foreigners were allowed to participate by liberalizing the MRTP Act. Moreover, by liberalizing FII, equity, debt market, and overseas funds were permitted to hedge their entire foreign exchange exposure to promote more investment in Indian Equity market.

2.4.2 Exchange Rate Movements and Trends

Figure 2.2 and figure 2.3 shows movements in Nominal Effective Exchange Rate (NEER), Real Effective Exchange Rate (REER) based on 36 exporting countries and changes in the value of rupee against U.S dollar, SDR, Pound Sterling and Japanese Yen respectively. Overall trends show that the rupee has high volatility during the period (1997-2013). Up to 2007-08, NEER and REER have almost similar pattern, there is a great divergence between the two and REER started depreciating continuously which led to the loss of competitiveness of rupee in the international market. In the first half of 2008-09 NEER also showed a depreciating trend but the trend reversed again in 2009-10. The trend was however short lived and again there was sharp depreciation and continued till 2014-15.

As seen in figure 2.3, the value of rupee against U.S dollar, SDR, Pound Sterling and Japanese Yen were also volatile without showing a continuous trend. The appreciating trend of all exchange rate soon after the world financial crisis is noticeable. However, it was just a short-run phenomenon which existed only for two-quarters. The trend had reversed in the second half of 2008-09 when there were massive capital outflows as a result of capital withdraw by the foreign investors to replenish their foreign debt. After that, the rupee was depreciating against all currencies except in few quarters and the value of rupee against U.S dollar, SDR, Pound Sterling reached a maximum in 2014 while the value of rupee against Japanese Yen was declining 2012 onwards. The average annual depreciation or appreciation of NEER and REER which is sourced from Reserve Bank of India is given in table 2.2. Appreciation and depreciation considering both major exporting countries and trade partners are given separately with both the data series showing almost similar trends over the period.

Table 2.2 Annual Percentage Change in India's NEER and REER

	Export Based Weights		Trade Based Weights	
Year	REER	NEER	REER	NEER
1997-98	4.5	3.25	4.31	3.09
1998-99	-9.03	-1.99	-8.11	-3.41
1999-00	0.83	0.19	2.91	2.14
2000-01	3.58	-0.18	4.29	1.21
2001-02	0.04	-1.02	0.83	-0.59
2002-03	-2.74	-2.07	-2.68	-2.3
2003-04	3.04	0.82	1.31	-2.07
2004-05	-0.74	0.48	0.55	0.13
2005-06	-1.02	2.2	2.37	2.24
2006-07	-1.54	-4.2	-1.62	-4.61
2007-08	8.76	7.61	8.44	7.12
2008-09	-9.51	-11.61	-9.55	-11.41
2009-10	5.25	-2.58	4.23	-2.4
2010-11	10.05	3.32	8.8	2.6
2011-12	-1.84	-5.61	-2.41	-6.16
2012-13	-4.47	-9.08	-4.7	-9.06
2013-14	-3.23	-6.49	-2.3	-6
2014-15	5.76	1.65	5.66	1.76

Source: Reserve Bank of India

Note: Data for 2013-14 and 2014-15 are provisional

2.4.3 RBI's Intervention in Forex Market

In the managed exchange rate system, the apex bank of the country is expected to intervene in the forex market to curtail unprecedented volatility, whenever it is required. Unlike in fixed exchange rate system, the monetary authority does not have the power to fix the exchange rate directly but intervene the market by buying or selling of foreign currency to pull the exchange rate to desired direction same like any other economic agent who participates in the forex market. Bulk buy or selling of exchange rate and adjusting the demand and supply of foreign currency lead to determine the exchange rate accordingly. The monetary authority also takes proper measures to avoid wide variations in domestic money supply which occur as a result of forex market intervention.

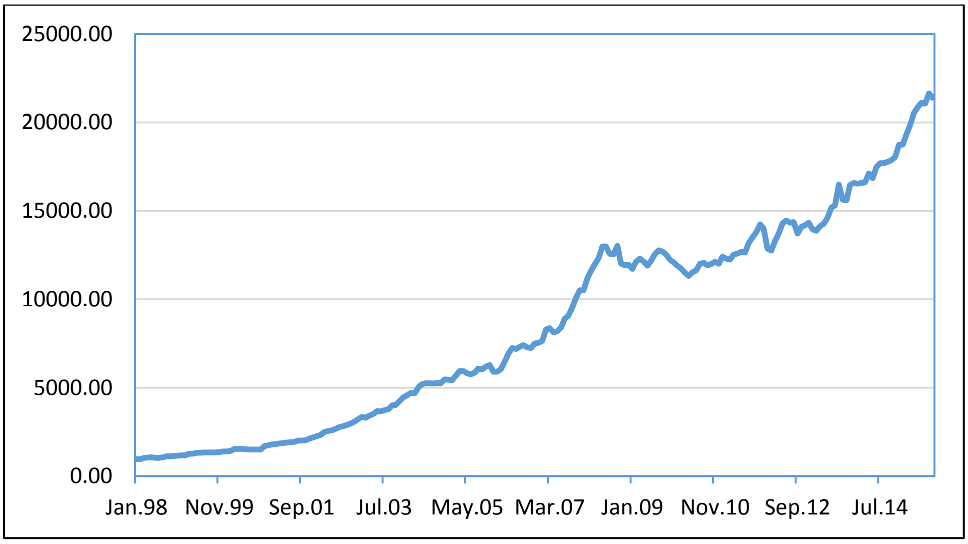
The market forces, demand and supply play a major role in determining the exchange rate. To curtail the volatility in exchange rate, the RBI is more dependent upon capital flows while India faces current account deficit always. In India, Reserve Bank of India has actively intervened in the forex market by buying and selling dollar. It can be considered as an indirect way to control the exchange rate and pull it to the desired direction. Table 2.3 shows the sale and purchase of U.S dollar and outstanding net forward sale or purchase by the Reserve Bank of India during 1995-96 to 2015-16. It can be seen that the purchase of the dollar has increased up to the crisis period and then declined. Finally, it reached the maximum level, $ 124.4 U.S billion in 2015-16. During the period from 2006-07 to 2011-12 the sales of the dollar were at a low level except in 2009-10. The net purchase or sale of the dollar is found mostly negative in the post-financial crisis period.

Table 2.3 Sale/ Purchase of U.S. Dollar by the Reserve Bank of India (US$ Billion)

Year	Purchase (+)	Sales (-)	Net Purchase/ Sale of Foreign Currency	Outstanding Net Forward Sales (-) /Purchase (+) at the end of month
1995-96	3.6	3.9	-0.3	-7.5
1996-97	11.2	3.4	7.8	-15.2
1997-98	15.1	11.2	3.8	-12.0
1999-00	28.7	26.9	1.8	-15.1
2000-01	24.1	20.8	3.2	-10.1
2001-02	28.2	25.8	2.4	-20.3
2002-03	22.8	15.8	7.1	-7.2
2003-04	30.6	14.9	15.7	10.3
2004-05	55.4	24.9	30.5	27.6
2005-06	31.4	10.6	20.8	0.8
2006-07	15.2	7.1	8.1	0.0
2007-08	26.8	0.0	26.8	0.0
2008-09	79.7	1.5	78.2	68.3
2009-10	26.6	61.5	-34.9	62.5
2010-11	4.0	6.6	-2.6	4.6
2011-12	2.5	0.8	1.7	2.0
2012-13	1.7	21.8	-20.1	-9.0
2013-14	13.6	16.2	-2.6	-147.5
2014-15	52.4	43.4	9.0	-216.1
2015-16	124.4	69.6	54.8	26.0

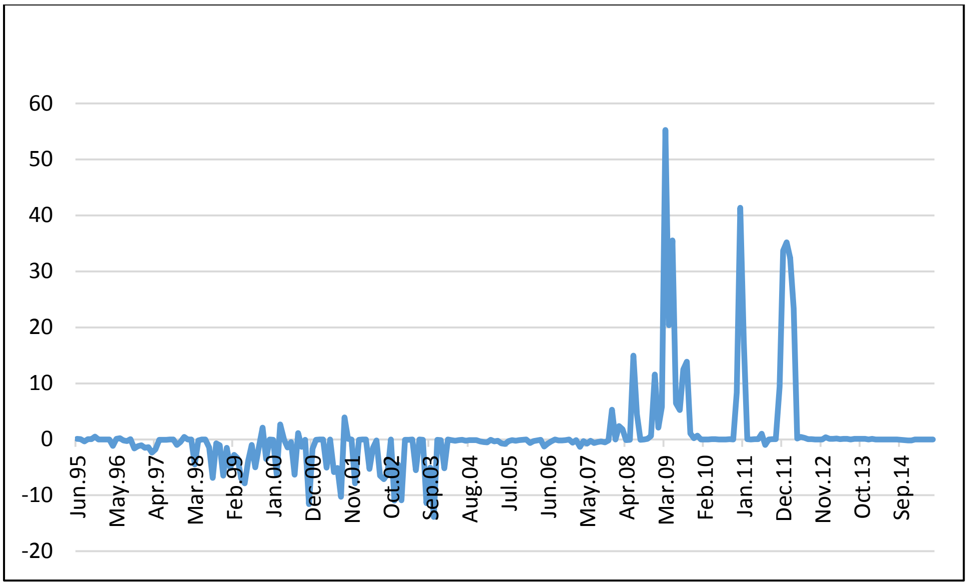
Source: Reserve Bank of India

Fig. 2.4 Net Foreign Currency Assets (Rupees Billion)



Source: Reserve Bank of India

Fig. 2.5 Open Market Operations (US$ Billion)



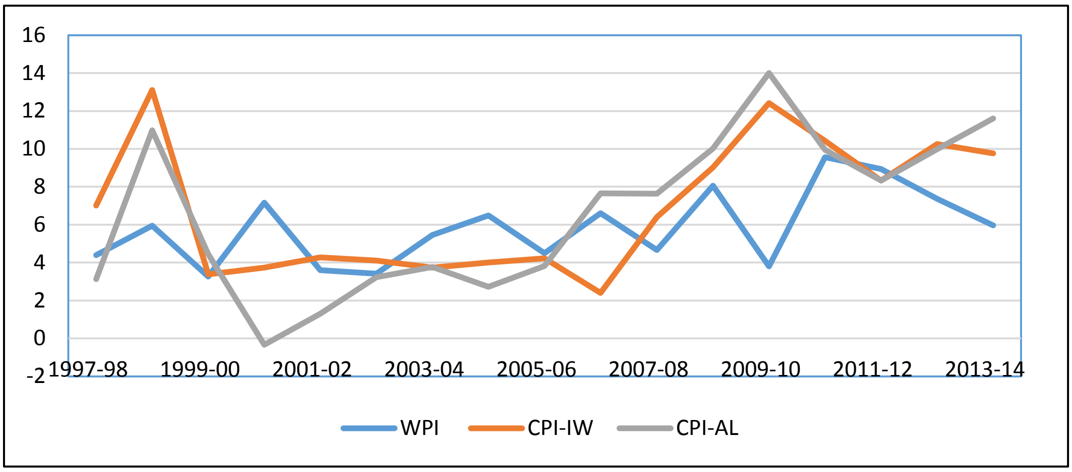
Source: Reserve Bank of India

The intervention of the Reserve bank in the forex market according to the foreign capital inflows through various channels leads to changes in foreign currency assets over the period. The foreign currency assets have tremendously increased in the 2007-08 period (see figure 2.4). The increase in foreign currency assets in the monetary base would lead to increase the domestic money supply in the economy. Reserve Bank of India has taken sterilization measures to counterbalance the increased money supply through open market operation. Figure 2.5 shows net purchase and sale of government securities by Reserve Bank of India to sterilize the impact of increasing foreign currency assets. Net purchase/ sale found to be positive and high during the financial crisis period since the sale of the securities was high during this time.

2.4.4 Inflation and Monetary Policies

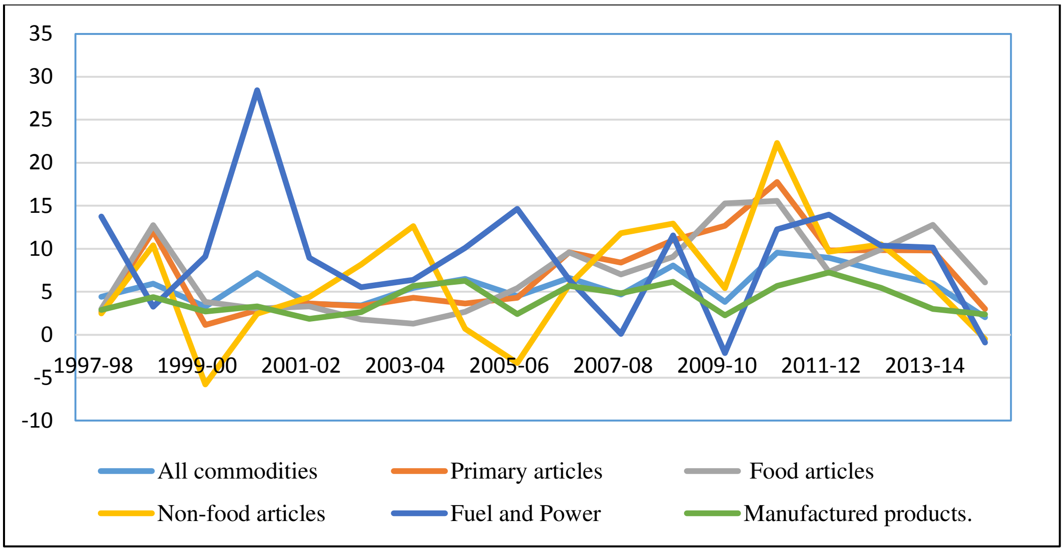
Inflation is defined as a sustained increase in the general price level of goods and services. It means that the purchasing power of the currency is coming down compared to previous time. It is the situation where "too much money chasing too few goods". Inflation is in India is calculated as the percentage change in WPI (Wholesale Price Index) and CPI (Consumer Price Index) in annual or monthly basis.

Fig. 2.6 WPI and CPI Inflation



Source: Office of the Economic Adviser, Ministry of Commerce and Industry, Government of India

Fig. 2.7 WPI Inflation- Disaggregated Level



Source: Office of the Economic Adviser, Ministry of Commerce and Industry, Government of India

WPI inflation is considered as an official measure of inflation used for policy purposes. The wholesale price index is available classified in product group wise such as all commodities, primary articles, foods articles, non-food articles, fuel and power, and manufactured products. Disaggregated data for each product is also available. Consumer Price Index is available based on occupational groups such as industrial workers and agricultural laborers. CPI-IW (Consumer Price Index for Industrial Workers) is commonly used wherever the consumer level inflation statistics is required.

Figure 2.6 shows the trend of WPI and CPI inflation from 1997-98 to 2013-14. Majorly there are two peaks in the inflation level, 1998-99 to 1999-00 and 2009-10 to 2010-11. The first peak is confined to only CPI- AL and CPI- IW, where WPI in general level (for all commodities) does not show high positive jump. However, the second peak indicates that all the inflation variables are getting high, though the WPI inflation is reaching its peak level only in 2010-11. Recently in 2012-14 both CPI-IW and CPI- AL show a positive trend while the WPI inflation started declining.

The WPI inflation level in major product groups is given in Figure 2.7. Contrary to the general trend of WPI inflation, variations can be seen in different product groups. Inflation in fuel and power get a high peak of 28% percentage in the 2000-01 period. Inflation level in all product was comparatively low up to 2008-09. During this period, food inflation, primary articles inflation, and non-food article inflation have shot up to more than 15%. The inflation level of manufactured goods seems to be marginal, and it did not cross more than 7% in the whole study period.

2.4.5 Monetary Policies

The monetary policies are mainly designed to control inflation and external economy and promote economic growth as per the need of the country. In India, the monetary mechanism is monitored by the Reserve Bank of India. Apart from long-term objectives, Reserve Bank of India take policy initiatives considering the short-term needs of the economy. The monetary policies play a crucial role in determining the growth and development of a country. In the pre-reform period, the emphasis was to use more direct monetary instruments such as CRR, SLR, and credit-enhancing in priority sectors. In post-reform period, along with specified direct instruments, the emphasis was given to several indirect instruments to achieve certain objectives.

Presently, Open market operations, repo and reverse repo rate, and bank rates are also used for effective monetary management. Various combinations of policy instruments were applied to the liquidity level of the economy into a certain direction to maintain an equilibrium level of demand and supply.

Table 2.4 Key Monetary Instruments (1998-99 to 2014-15)

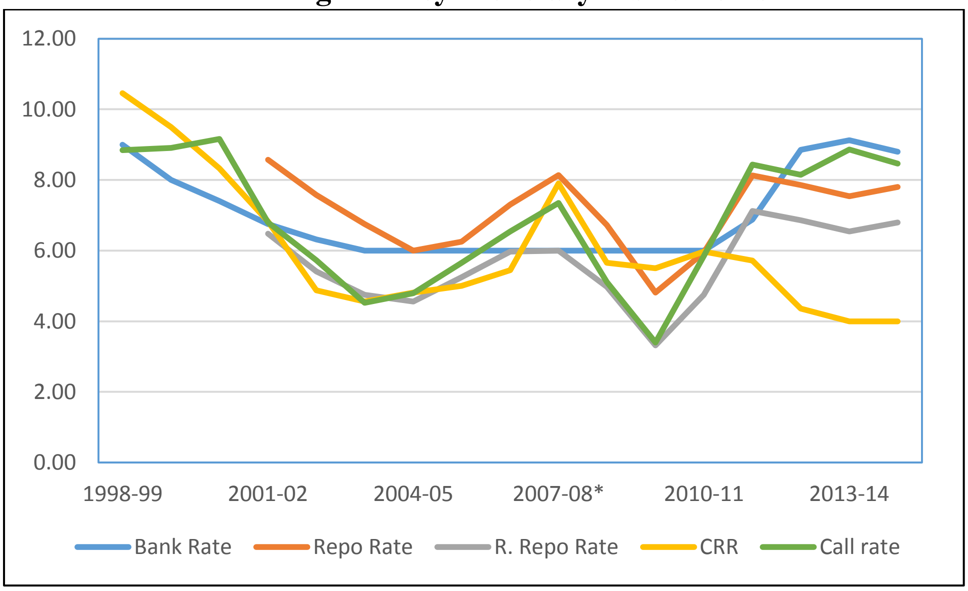
	Bank Rate	Repo Rate	R. Repo Rate	CRR	SLR	Call Money Rate
1998-99	9.00			10.46	25.00	8.8412
1999-00	8.00			9.50	25.00	8.9116
2000-01	7.40			8.33	25.00	9.1643
2001-02	6.75	8.58	6.48	6.83	25.00	6.7933
2002-03	6.31	7.58	5.41	4.88	25.00	5.7235
2003-04	6.00	6.75	4.75	4.56	25.00	4.5182
2004-05	6.00	6.00	4.56	4.81	25.00	4.7948
2005-06	6.00	6.25	5.25	5.00	25.00	5.6505
2006-07	6.00	7.31	5.97	5.44	25.00	6.5386
2007-08*	6.00	8.13	6.00	7.90	25.00	7.3528
2008-09**	6.00	6.73	4.98	5.65	24.40	5.1150
2009-10	6.00	4.81	3.31	5.50	25.00	3.4004
2010-11	6.00	5.94	4.75	5.97	24.67	5.8466
2011-12	6.88	8.13	7.13	5.72	24.00	8.4380
2012-13	8.86	7.86	6.86	4.36	23.14	8.1435
2013-14	9.13	7.54	6.54	4.00	23.00	8.8577
2014-15	8.80	7.80	6.80	4.00	21.90	8.4644

*2007 April - 2008 Septemper

** 2008 Octo- 2009April

Source: Reserve Bank of India

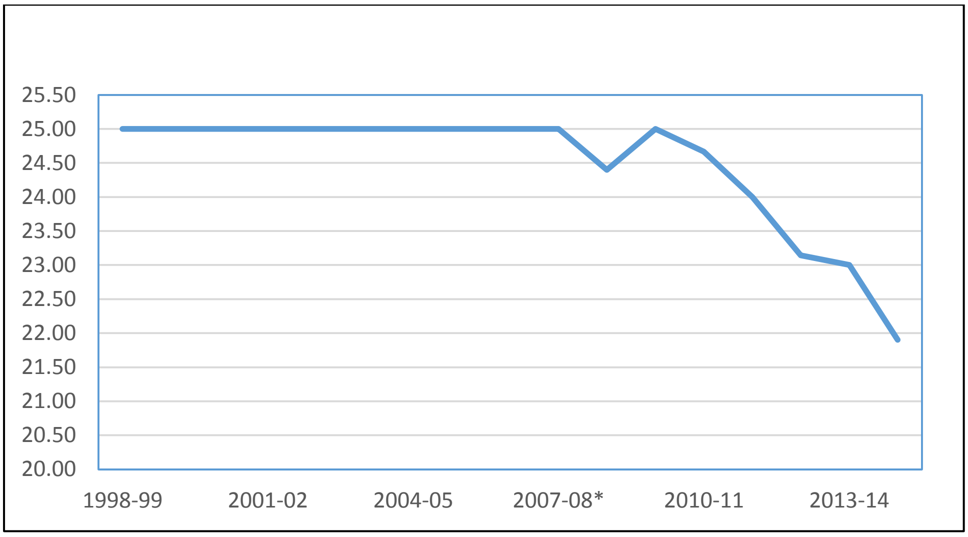
Fig. 2.8 Key Monetary Instruments



Source: Reserve Bank of India

Table 2.4 shows major monetary instruments which Reserve Bank of India adopted from 1998-99 to 2014-15. Changes in the bank rate, repo rate, reverse repo rate, CRR and SLR over the study period are given. The trend of open market operations has already been mentioned in the previous section. Dynamic nature of different policy instruments indicates that Reserve Bank of India has employed both expansionary and contractionary monetary policies according to the need of the economy. Post-crisis period witnessed high fluctuations in the monetary policies offset the external shocks on the exchange rate and inflation through capital flows. In 2007-08 and the first half of 2008-09 Reserve Bank of India was following more contractionary policies by increasing the rate of various instruments. However, in the second half of 2008-09 and 2009-10, more expansionary policies was adopted to recover from the negative impacts of the global financial crisis.

Fig. 2.9 Statutory Liquidity Ratio

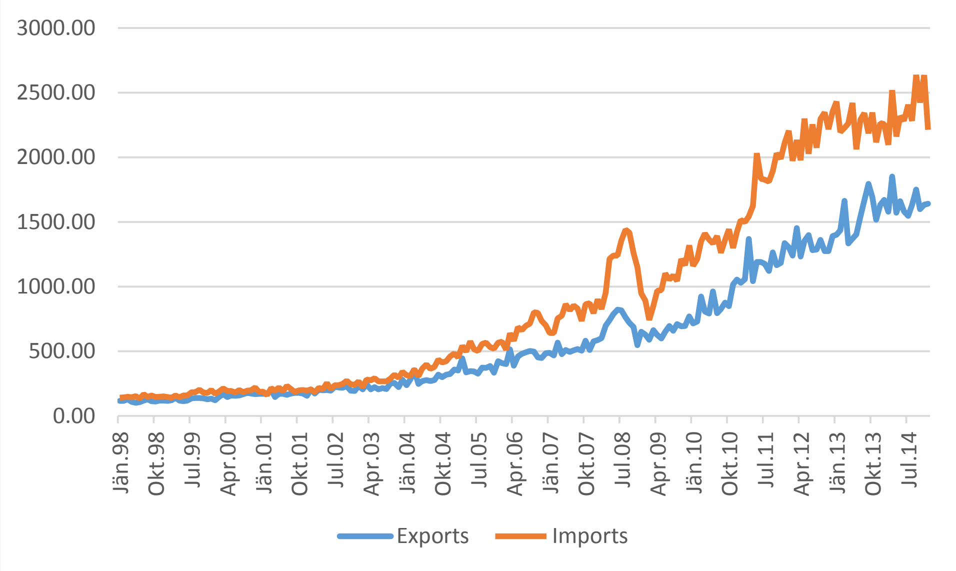


Source: Reserve Bank of India

2.4.6 Foreign Trade

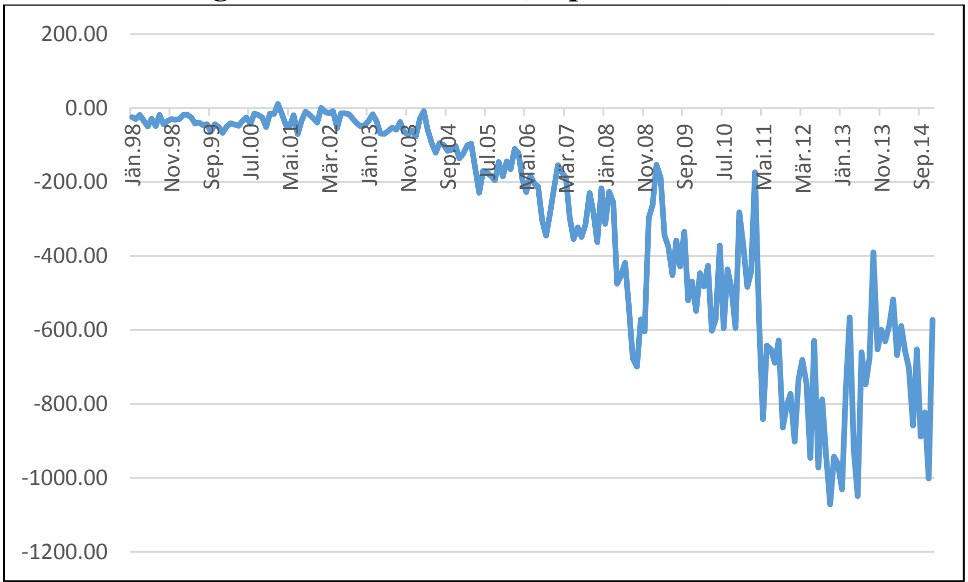
Cross-border trade has grown over the time as a result of increased integration of global market due to the removal of trade barriers between the countries and making several long terms and short term trade agreements among the countries. In the modern world, international trade is considered as the engine of economic growth. Increased specialization and mechanization led to production and export of particular goods and services instead of achieving self-sufficiency and independence in any given country.

Fig. 2.10 Export and Import (Rupees Billion)



Source: Reserve Bank of India

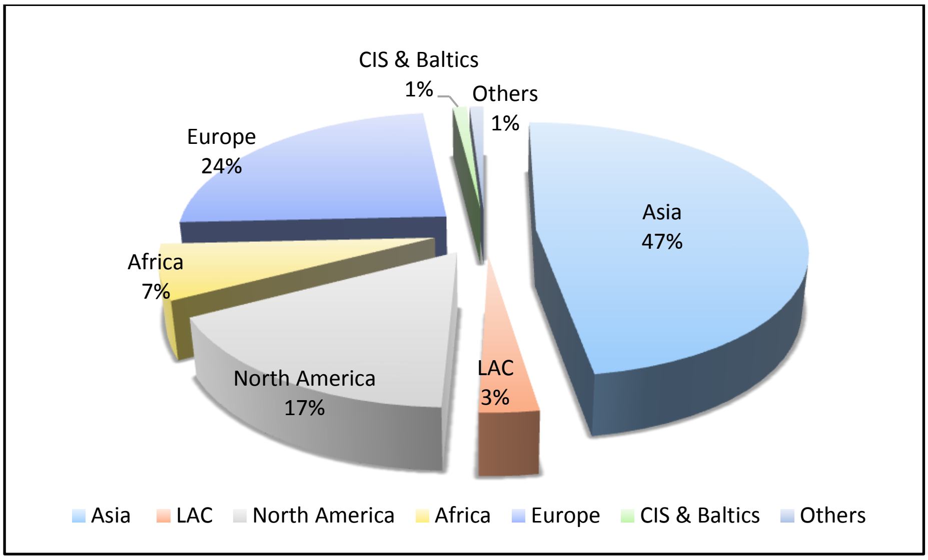
Fig. 2.11 Trade Balance (Rupees Billion)



Source: Reserve Bank of India

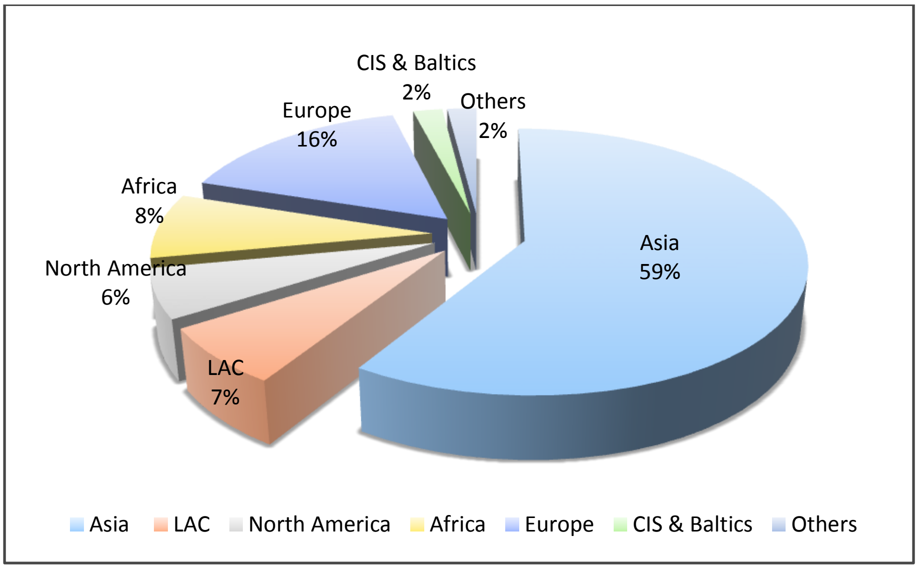
Trade between the countries increased, and all the countries try to increase the productivity of their specialized goods. In India, a remarkable change in foreign trade has occurred in the post-reform period as a result of financial reforms and liberalized policies in the external sector (Misra, et.al. 2011). Figure 2.10 shows the monthly trend of export and import of all goods and services from January 1998 to December 2014. Except for the initial few years, the export and import were increasing throughout the study period, and high growth of export and import could be found particularly after 2007 onwards.

Fig. 2.12 India's Export Destinations 2014-15



Source: Ministry of Commerce and Industry, Govt. of India

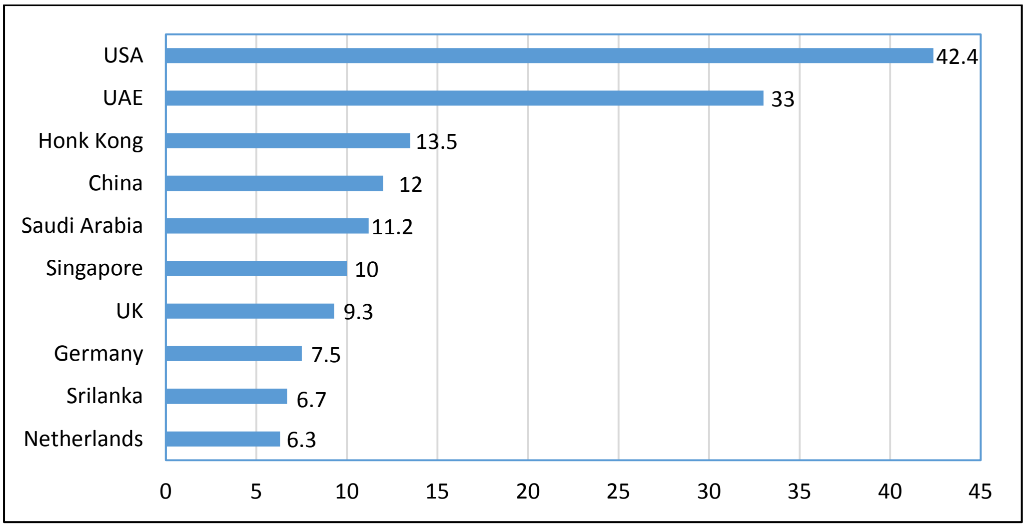
Fig. 2.13 India's Import Sources 2014-15



Source: Ministry of Commerce and Industry, Govt. of India

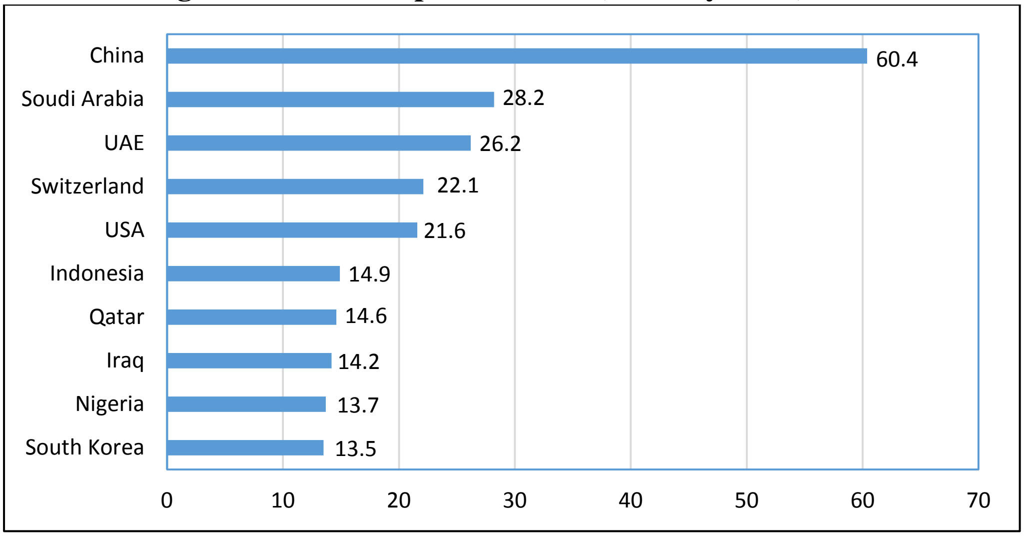
During the first half of 2008-09, the peak of the global financial crisis, import and export made a sudden positive jump, but the magnitude of the shift in import was very high compared to export which resulted in increasing the trade deficit. Throughout the study period, it can be seen that the divergence between export and import has increased. India's trade is mainly concentrated with its neighboring economy. As per the record of 2014-15, 47% of the export and 59% of import was to and from the Asian countries respectively. Major trading partners of India in terms of both export and import are shown in the figure 2.12 and figure 2.13.

Fig. 2.14 India's Export Destinations (Country Wise) 2014-15



Source: Ministry of Commerce and Industry, Govt. of India

Fig. 2.15 India's Import Sources (Country Wise) - 2014-15



Source: Ministry of Commerce and Industry, Govt. of India

Interestingly, after Asian countries, 41% of the total exports are to the European and Latin American Countries. Import share from Asian countries (59%) has been higher than the export share (47%) in 2015-16. Moreover, the share of import from European and Latin American Countries is only 23%. Combining export and import, Asia countries constitute the major trade parterres of India.

Country wise India's major export and import partners, are shown in the figure 2.14 and figure 2.15 respectively. If we consider 10 major export destinations of India, total export in dollar is 309.6 billion. From this, exports of 42.4 billion dollars were to the USA. UAE, Honk Kong, and China come after that, holding respective ranks after the USA. From imports of 447.5 billion, imports of 60.4 billion dollars were from China. Saudi Arabia, UAE, and Switzerland hold the second, third, and fourth ranks respectively. It should be noted that the import from USA (21.6 %) was considerably low. The analysis of export and import indicate that the major trading partners of India are USA, UAE, Honk Kong and China. So in the analysis of trade and exchange rate interactions in the final core chapter, combined GDP of all these four countries are used as world GDP along with world GDP statistics available from IMF.

2.5 Exchange Rate, Inflation and Foreign Trade

This section tries to make a preliminary analysis of the interaction between exchange rate and inflation as well as exchange rate and foreign trade. From the basis of various theoretical explanations which were discussed in the first part of this chapter, such as Purchasing Power Parity theory, the Vicious Circle of Depreciation- Inflation, the positive relationship between depreciation and inflation as well as a negative relationship between appreciation and inflation is expected. According to Marshal lerner condition, depreciation of the currency make favourable position in the balance of trade. The depreciation of rupee- dollar is expected to increase the import and reduce the export price for the foreign customers. It means that the demand for the export goes up where the demand for import will come down, and domestic customers will stick to more substituted goods. This leads to increase the export and decrease the import making the trade balance more favourable.

Figure 2.16 provides the trend of WPI inflation and annual depreciation or appreciation of Indian rupee against U.S dollar. The graph shows that the relationship between inflation and exchange rate is as expected most of the time. Particularly in Indian context, depreciation was severe in the post-financial crisis period and this coincided with inflationary spiral.

Fig. 2.16 Exchange rate and WPI inflation

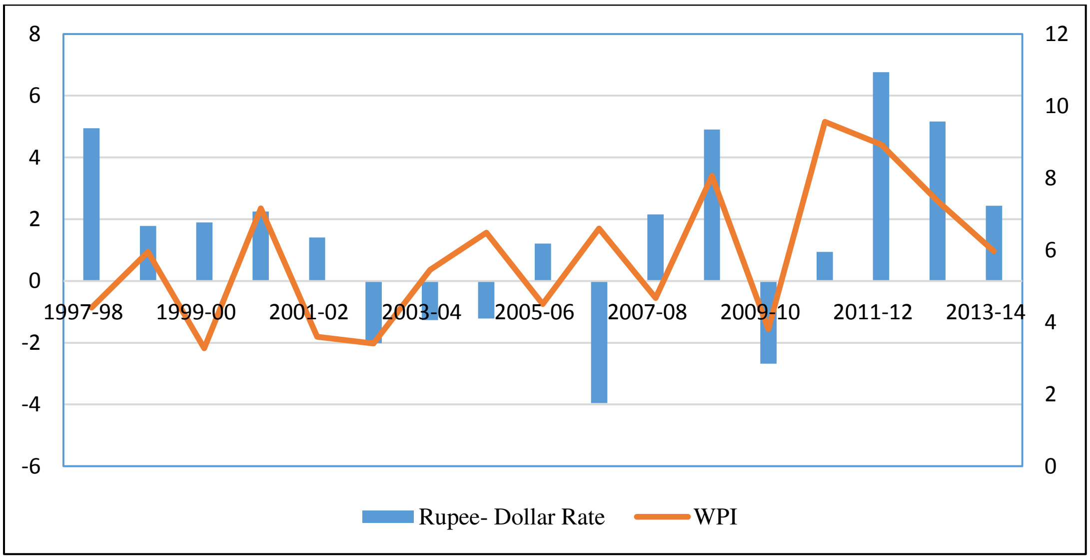


Fig. 2.17 Exchange rate and CPI inflation

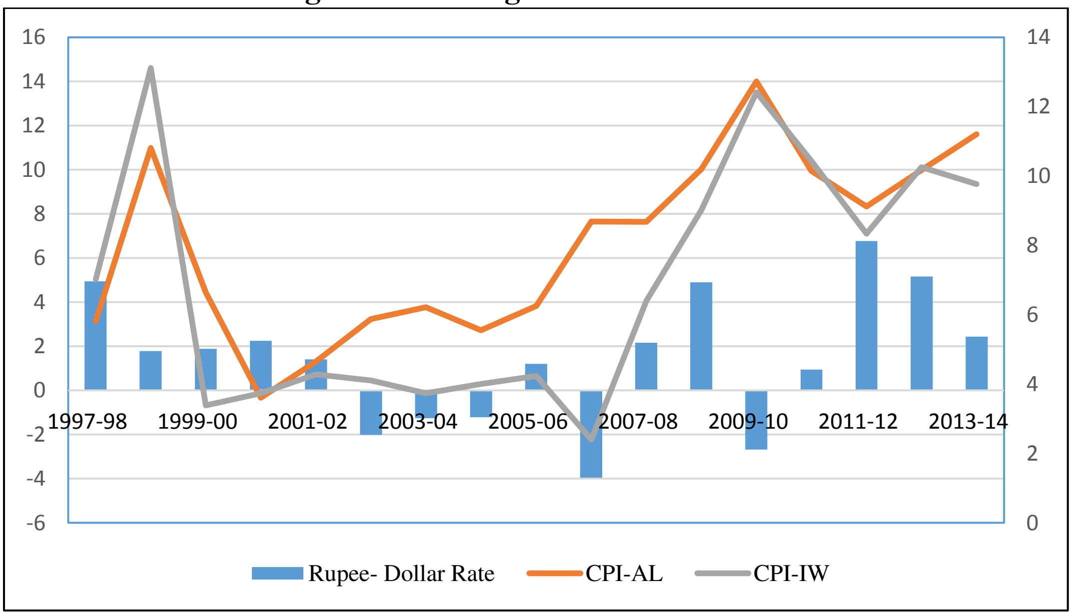
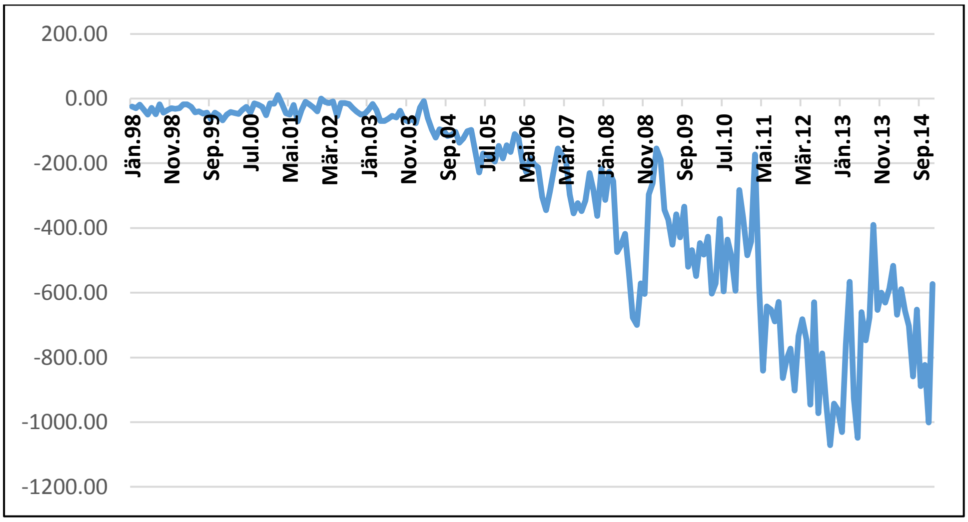


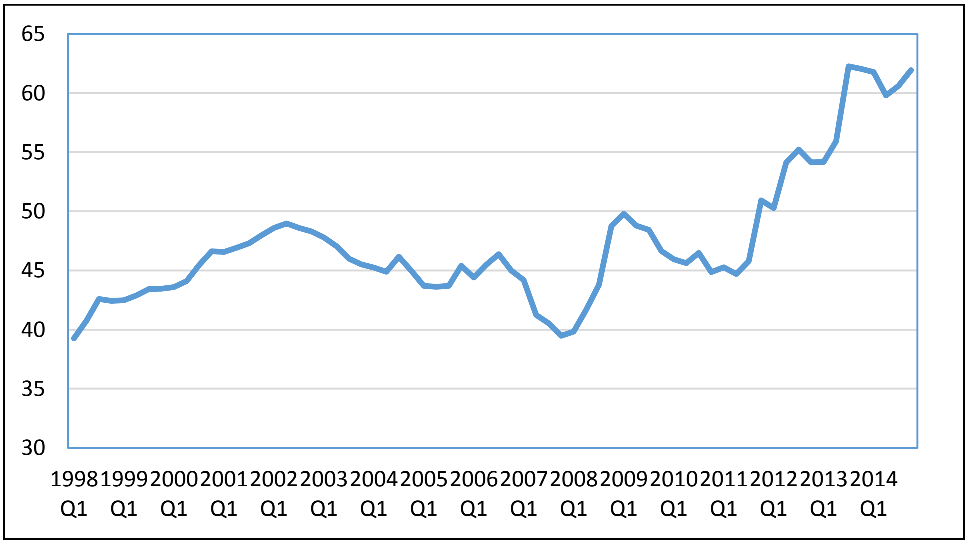
Figure 2.17 shows depreciation or appreciation of rupee against dollar, CPI-AL (Consumer Price Index-Agricultural labor) and CPI-IW (Consumer Price Index-Industrial Worker). A similar pattern of positive relationship between depreciation and inflation can be seen here also, though there is divergence from this at certain point of time.

Fig. 2.18 Trade Balance (Rupees Billion)



Source: Reserve Bank of India

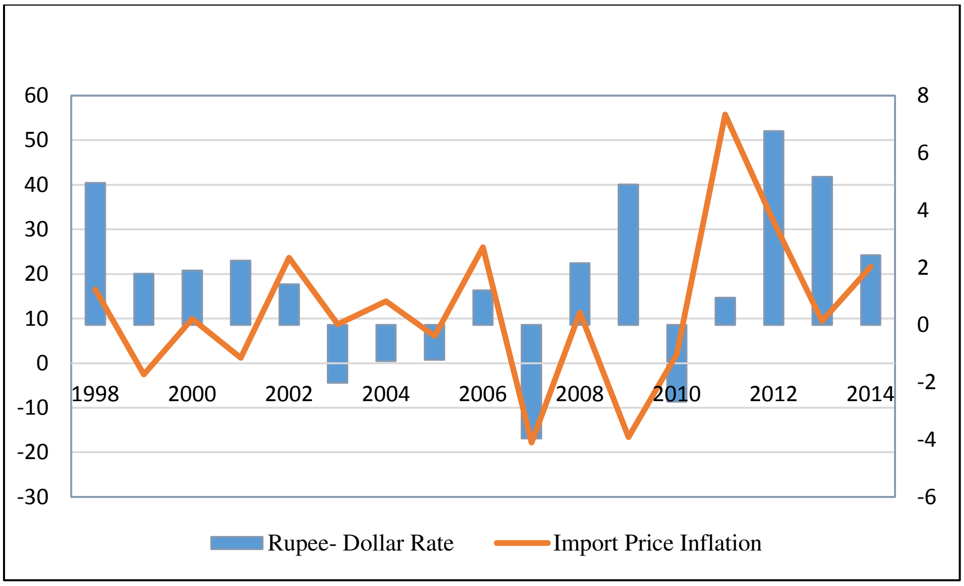
Fig. 2.19 Rupee-Dollar Exchange Rate



Source: Reserve Bank of India

In sum, it can be concluded from the graphical analysis that there is a positive relationship between inflation and depreciation. The exact relationship can be explored by using various econometric models. In the same way, the Figure 2.18 and figure 2.19 show the pattern of the rupee-dollar exchange rate and trade balance in the study period. Figure 2.20 shows the relationship of appreciation or depreciation of rupee and import price inflation. As we have seen the case of WPI and CPI inflation, in this case also the relationship shows a positive relationship between import price and depreciation as we expected. The interactions of the exchange rate and foreign trade variables, namely trade balance, export and import are discussed in the forthcoming chapter.

Fig. 2.20 Exchange Rate, Export and Import Price Inflation



2.6 Summary and Conclusion

This chapter gives a theoretical background to the study and analyses the Indian scenario focusing on the nature and trends of study variables. The theoretical base of this pass-through is found in works of many economists based on purchasing power parity, pricing-to-market, the Vicious Circle of Depreciation- Inflation, firms pricing behavior which strongly supports the existence of complete or incomplete exchange rate pass-through. The major theoretical base for the study of the exchange rate and trade balance are Elasticity approach and Marshal- Learner condition, J-curve hypothesis which shows short-run and the long-run relationship of trade balance with the exchange rate.

India has gone through different exchange rate regime and moved to managed floating exchange rate regime from the post-liberalization period. High volatility in the exchange rate could be found during this period. In the same way, the foreign trade and inflation were also fluctuating and showing similarity with movements of the exchange rate. The preliminary analysis of the variables, trade balance, inflation and exchange rate shows that the relationship between the variables are seen to be strong and directs towards the need for more econometric exploration to find out the extent of dynamic interactions.

----xxx----

Chapter 3

Review of Empirical Literature

3.1 Introduction

This chapter reviews the empirical works related to linear and nonlinear interactions between exchange rate and inflation, as well as exchange rate and foreign trade. The chapter has been divided into five sections. The first section deals with cross-country evidence of exchange rate volatility and pass-through. The second section reviews empirical studies on exchange pass-through in the Indian context. The third section deals with a short-run and long-run dynamics of the exchange rate and foreign trade across countries while Indian evidence is given in the fourth section. Finally, the fifth section reviews recent works on the exchange rate, inflation and foreign trade dynamics in the nonlinear framework.

3.2 Exchange Rate Volatility and Pass-through: Cross Country Evidences

The empirical literature on exchange rate pass-through can be stratified into four groups based on the chronology and the focus of the works[1]. The first generation works on the impact of exchange rate on inflation and is based on the Law of One Price (LOOP) and Purchasing Power Parity theory (for instance, Isard, 1977; Goldberg and Knetter, 1997). Based on the assumption of a perfect competitive market, these empirical works focused on the role of the price level in determining the movement of the exchange rate between two countries. The second generation studies emphasized on the lagged values of the exchange rate in determining domestic price level or inflation level of a country (for instance, Ohno, 1989). In the subsequent period, some of the

[1]Byrne et.al (2010) has classified into three groups, firstly literature based on LOOP, secondly works of exchange rate pass-through using lagged values and thirdly, works based on imperfect competition. Our classification to four categories is done by including the group of recent literature in New Open Macroeconomic (NOEM) framework.

researchers relaxed the assumption of perfect competitive markets and analyses the exchange rate phenomenon in an imperfect competitive environment. Dorbush's (1986) analysis of exchange rate pass-through by considering monopolistic competitive market and Krugman's (1987) Pricing-to-Market holds good in this scenario. Further, Studies of Knetter (1989) Marston, (1990) and Knetter (1993) have also extensively carried their empirical research on exchange rate pass-through in the monopolistic competitive environment. Goldberg and Knetter (1997) made an extensive study based on the theoretical background of Pricing-to-Market. The study shows that exchange rate pass-through is low in segmented markets which allow firms for price discrimination and high in imperfect competitive market.

The fourth generation empirical literature takes a step forward by interlinking the pricing strategy of firms and exchange rate pass-through using 'New Open Economy Macroeconomics' (NOEM) framework(for instance, Obstfeld and Roggoff, 1995; Bergin and Feenstra, 2001; Smets and Wouters, 2002; Bergin, 2003; Corsetti and Dedola, 2005; Gust and Sheets, 2006; Bergin, 2006). "NOEM is a class of optimising dynamic stochastic general equilibrium (DSGE) models for open economies with imperfect competition and nominal rigidities" (Bache, 2006, p. 2). Special focus is given to recent works that employed time series techniques such as unrestricted Vector Auto Regressive (VAR) or Structural Vector Auto Regressive (SVAR) models.

The Pricing-to-Market analysis explores various determinants of exchange rate pass-through which is contextual. Marston (1990) analysed the pricing strategies of exporting firms in Japan. By accepting the validity of pricing to market, the author found that there is significant evidence for fixing the price differently according to the market. The study also explored the presence of asymmetries in pricing strategies with appreciation and depreciation. Contrary to this result, Bach (2002) could not find any evidence for the Pricing-to-Market in his analysis of exchange rate pass-through in Norwegian import prices. However, the study could find the presence of complete exchange rate pass-through in the long-run.

Foundation stone for the New Open Economy Macroeconomics (NOEM) was laid by Obstfeld and Rogoff (1995). "The New Open Economy Macroeconomics refers to a vast body of literature embracing a new theoretical framework for policy analysis in open economy, with the goal of overcoming the limitations of the Mundell-Fleming model, while preserving the empirical wisdom and policy friendliness of traditional analysis.Starting in the early 1990s, NEOM contributions are developed general equilibrium models with imperfect competition and nominal rigidities….” (Corsetti, 2007, p. 6). Obstfeld and Rogoff (1995) developed a two-country model based on monopolistic competition and sticky nominal prices. According to him, under the assumption of sticky nominal prices, ‘the Law of One Price’ (LOOP) will hold in the economy since the firms employ Producer Currency Pricing (PCP) strategy. The local import price of the goods is expected to have one to one changes according to the exchange rate movements which show the evidence for the complete and immediate exchange rate pass-through.

Betts and Devereux (1996, 2000) extends the model of Obstfeld and Rogoff (1995) by incorporating the idea of market segmentation and short term rigid character of import prices. It is assumed that the import price of a country is pre-determined in the short-run. So the immediate changes in the domestic prices according to the exchange rate movements are not possible. This local currency price stickiness leads to zero exchange rate pass-through in the short-run. Contrary to the findings of Obstfeld and Rogoff (1995), the authors argue that the exchange rate pass-through will be complete only in the fully flexible price system.

The exchange rate pass- through analysis in 25 OECD countries by Campa and Goldberg (2002) shows significant role of exchange movements in the determination of domestic price level. The study has been done by using quarterly data from 1975 to 1999. Though the results across the countries differ, the average short-run pass-through is 46 percent in one-quarter, where the long-run coefficient is 60 percentage, which is comparatively high. According to the study, countries which have higher exchange rate volatility have higher level of pass-through. According to Campa, Goldberg and Minguez (2005), the exchange rate pass-through is found to be incomplete in the short-run, where it is close to complete in the long-run.

Corsetti and Dedola (2005) tried to analyse the exchange rate pass-through in NOEM framework with more realistic assumptions such as the requirement of non-traded goods and services for the distribution of traded goods to the consumers. He understands the relevance of distribution cost in creating significant difference in the imported consumer price of imports and import prices at the dock. This difference leads to lower level of exchange rate pass-through to import prices at the consumer level. Moreover, the gap between producer and consumer price allow price discrimination in the domestic and foreign market which implies that exchange rate pass-through will be incomplete to the import prices.

Bhattarai (2011) analyses the impact of exchange rate fluctuations and money supply on growth, inflation and interest rate in U. K. The study employed ILS, 2SLS and 3SLS for the estimation to show simultaneity among growth rates, inflation, interest rate and exchange rates in the UK. The study found that depreciation of sterling could increase the output growth of the economy by making the economy competitive in the global market. The study also indicates that interest rates have persistent and contractionary impact on domestic economy and money is found to be non-neutral in the short-run.

Recently a broad range of literature on exchange rate pass-through is produced using unrestricted vector autoregressive (VAR) or structural vector autoregressive (SVAR) models which are more empirical than theoretical. This includes McCarthy (2000, 2007), Korhonen and Wachtel (2005), Takatoshi and Kiyotaka (2007), Kim (2007), Doojav (2009), Sanusi (2010), Jiang (2012) and Tandrayen-Ragoobur and Chicooree (2013).

McCarthy (2000) made a remarkable contribution to the methodology of ERPT studies which become popular and widely cited in the literature thereafter. The study analyses the effect of exchange rates and import prices on the domestic PPI and CPI in few selected industrialized economies by using distribution chain of pricing. The distribution chain includes separate equations for import price, PPI, and CPI. The study has analysed ERPT by using oil price inflation as a supply shock, output gap as demand shock, and by including external supply and demand shock. The study found a significant impact of exchange rate changes on one group of countries like Japan, Belgium, France and Netherlands using multi-country panel regression. The study could not find significant impact in another group of developed countries such as Switzerland and Sweden. Using the same distribution chain, McCarthy (2007) again made an analysis, which showed a modest impact on exchange rate pass-through on domestic inflation, where the impact on import prices are comparatively high. The study also revealed that the exchange rate pass-through is more in the countries which have larger import share and more persistent exchange rates and import prices.

Assessing the extent and speed of exchange rate pass-through in the countries of the Commonwealth of Independent States (CIS) Korhonen and Wachtel (2005) estimated Vector autoregressive regressions, impulse response functions and variance decomposition methods for monthly data from 1999 onwards. The study reveals that there is clear evidence of exchange rate pass-through to domestic price, and the speed of this pass-through is fairly high where the full effect is seen to be transmitted to the domestic price in less than 12 months. The extent of exchange rate pass-through is found to be higher in CIS countries than other emerging market countries, but the impact of US price on domestic price is nil. The asymmetrical impact of pass-through is established in some countries though it is far from robust across the counties.

Large devaluation or depreciation as a result of currency crisis in any economy makes substantial changes in the macro variables, particularly in export and inflation. The study of Takatoshi and Kiyotaka (2007) try to empirically evaluate the impact of exchange rate changes on domestic price in crisis-hit countries, of East Asia and Latina America, to make a comparison of exchange rate pass-through across the countries. The study uses Structural Vector Autoregressive (SVAR) technique to examine exchange rate pass-through across these countries. Except in the case of Indonesia, the strength of the pass-through impact is found to be higher in Latin American countries and Turkey than in East Asian countries. When Argentina show a strong response of CPI to the exchange rate shock, Indonesia, Mexico, Turkey responded mildly. The study also reveals that the increase in base money during the period of currency crisis led to high level of inflation in Indonesia whereas price stability could be seen in other countries when they used credible monetary policies to curtail inflation. The way of transmission through different pricing chains also play a vital role in determining the inflation level. The high inflation of Indonesia, Mexico and Turkey is evident for this when the shock transmission from import prices or PPI to CPI is fairly high.

Kim (2007) tries to analyze exchange rate pass-through in Korean economy by using two country model incorporating macro variables of Korea and U.S since the U.S is prominent trade partner of Korea. The author talks about two measures of exchange rate pass-through, namely structural exchange rate pass-through and the shock-specific exchange rate pass-through. The analysis has been done using structural VAR model for the period 1988 to 2005 using monthly data with a pre-exogenous assumption of U. S macro variables with respect to Korean macro variables. The study considers Korean macro variables such as output, nominal interest rate, real money balances, the real exchange rate, the real export price, nominal money, while U. S. variables comprise output, nominal interest rate, real money balance and nominal money. A dummy for the year 1997 or 1998 has been introduced to test the significance of Korean currency crisis. The study indicates that structural exchange rate pass- through on Korean export price is trivial while the shock- specific pass-through shows positive and is significant irrespective of external shocks from the US or internal shocks. The findings also confirm that the exchange rate volatility affects the volume of export negatively but affects the exchange rate pass-through positively. The study also sheds light on the strong cross country liquidity effect and absence of within country liquidity effects by taking two countries' case specifically. By analyzing the strength of exchange rate pass-through, the study of Bandura (2010) showed 14 % and 9% of exchange rate pass-through to PPI and CPI indices respectively where most of the previous literature showed around 30 % of exchange rate pass-through in developing countries.

Doojav (2009) examines the impact of exchange rates on the domestic consumer prices in Mongolia using data from January 1998 to January 2008. Employing the methodology of McCarthy (2000) the author estimated a recursive VAR framework, Impulse responses and variance decompositions to measure the exchange rate pass-through to consumer price inflation. The study reveals that there is high pass-through of exchange rate to inflation in the country and low persistence and volatility in the exchange rate during the study period. The paper comes up with certain conclusions regarding the exchange rate pass-through- "(i) the impact of exchange rate on consumer prices is over after about a year months but is mostly felt in the 6-7 months. (ii) Exchange rate pass-through to consumer prices rises from about 10 percent in the fifth month of the shock to about 55 percent in ninth months. (iii) Exchange rate explains about 7-8 percent of the variation in consumer price inflation".

Sanusi (2010) employs Structural Vector Autoregressive framework to establish the relationship between exchange rate and domestic inflation in Ghana that is primarily dependent on foreign aid and exchange earnings. The author observes an incomplete but high level of exchange rate pass-through to the consumer prices.

However, the author finds that the monetary expansion determines the price level of the country since it strongly correlates with the inflation than the exchange rate depreciation. So, he suggests the adoption of more stable monetary policies for both exchange rate stability and lower level of inflation.

Naqvi and Rizvi (2011) attempts to a comparison of the Exchange rate pass-through between the inflation targeting and non-inflation targeting countries. They employed Structural VAR model by taking four Asian economies which have adopted IT during the period 1990-2010 and compare with a group of non-inflation targeters. Interestingly, the study finds that there is no evidence for ERPT in Asian IT or non-IT economies during the study period. From the analysis of the ERPT of IT economies before and after the adoption of inflation targeting, the author concludes that there are no significant changes in the exchange rate pass-through between these two periods. Unlike exchange rate changes, the foreign price level stands as a major determinant of the domestic inflation volatility.

Jiang (2012) analyses the exchange rate pass-through to inflation in the context of china. The question which the author tries to answer is whether exchange rate appreciation could reduce inflation through reducing prices of imports. The study uses SVAR model, following McCarthy (1999) with slight modification in the distribution chain due to limited availability of import price index in China. The study finds evidence for incomplete ERPT to the Producer Price Index (PPI) and Retail Price Index (RPI). The ERPT to Producer Price Index is found to be higher than to the Retail Price Index, which justifies the order of variables according to the distribution chain. The variance decompositions show that the exchange rate explains a modest proportion of the volatility in domestic prices, whereas the proportion of monetary policy is comparatively smaller. Finally, the pass-through to both PPI and RPI is more rapid and consistent in medium time period.

A similar study of Tandrayen-Ragoobur and Chicooree (2013) determines the extent and degree of exchange rate pass-through using distribution chain methodology of McCarthy (1999) in the Mauritian economy. Structural Vector Autoregressive (SVAR) model, impulse response and, forecast error variance decomposition are employed for the analysis of quarterly data from 1999 to 2010. Contrary to the earlier studies, the pass-through at different distribution levels namely from import price to producer price and consumer price is found to be very significant. The study reveals that exchange rate pass-through to consumer prices is highest and is followed by producer prices and import prices. The study gives evidence for the existence of bidirectional causality only between the nominal effective exchange rate and producer prices. Moreover, variance decomposition analysis shows that oil price shocks are the major determinants of import and producer prices, whereas the changes in consumer prices are majorly influenced by import price shocks.

3.3 Linear Exchange Rate Pass-through: Indian Scenario

A large number of works on exchange rate pass-through in Indian context have been produced in the post liberalisation period. The studies differ in its objectives, methodology and results. Most of the works are based on aggregate data series while few studies concentrate on exchange rate pass-through using industry-level data series.

Ranjan's (1995) paper appears to be the first one to test the exchange rate pass-through at sectoral level in India. He finds incomplete but high degree of exchange rate pass-through to export prices in India. His work emphasises at industry level pass-through and observes that pass-through coefficient differs across industries where low level of pass-through is found in the case of gems, jewellery, textile and in other manufacturing products and high pass-through in the case of leather, leather manufactures and chemical and related products.

Dholakia and Saradhi (2000) examine the impact of exchange rate and exchange rate volatility on export-import prices and quantities using quarterly data for the period 1980-96. The study attempts to check whether exchange rate pass-through is complete or incomplete during the study period. When complete exchange rate pass-through was seen in the case of import price throughout the period signaling price taking behavior, near complete and incomplete pass-through was seen before 1991 and after 1991 respectively. The study using structural equation model finds out that Indian export quantity is responsive to all the components of REER whereas neither the import quantities nor export – import price is sensitive to the components of REER. So the author concludes with the statement that "targeting REER in India may satisfactorily address the concern for the trade balance, though it may be useful for export promotion".

Khundrakpam (2007) studies the exchange rate pass-through to domestic prices during the post-economic reforms in India. Pass though is modeled by simple and rolling regression by using the monthly data from 1991:8 to 2005:3. Estimation results show that long-run and short-run coefficients of exchange pass-through are significant. The estimated pass-through coefficients are 0.063 and 0.09 respectively in the short-run and the long-run. These values appear to be small compared to other studies in the Indian context. The study also tries to check whether there is a declining trend in exchange rate pass-through when the wide range of cross-country data shows that exchange rate pass-through has declined over the year. It is found that there is no clear trend of a declining exchange rate pass-through to domestic prices in India during the post- reform period. The asymmetry effects in pass-through in terms of depreciation and appreciation, and between small and large exchange rate changes are also found to be significant. According to the author, important factors which contribute to the non-declining trend of pass-through are the openness of trade and import penetration, reducing import tariffs and elimination of trade restrictions, import composition by increasing the share of energy and food, inflation persistence.

Ghosh and Rajan (2007) estimated exchange rate pass-through to CPI for the period 1980Q1 to 2005Q3. By using simple regression, co-integration and VECM methods the study finds that in the long-run, the pass-through elasticity in India is 40 per cent for the entire study period, while the short-run pass-through is smaller. The test results show that the study could not find any significant pass-through by using the NEER data both in short-run and long-run. It indicates that the impacts of bilateral exchange rate with the US are very important than NEER in international transactions. The high exchange rate pass-through in post-reform period confirm the widely discussed fact that a more opened economic system leads to an increase in the strength of exchange rate pass-through.

Mallick and Marques (2006) make a comparison of exchange rate pass-through to import and export price between pre (1980–90) and post-reform (1991–2001) periods by using panel data. The study reveals that pass-through to import prices has declined whereas the pass-through to export prices has increased in the post-reform period. The study also evidences that number of sectors which have some degree of exchange rate pass-through has increased in the post-reform period. The study of

Mallick and Marques (2008) also confirm the existence of exchange rate pass-through to export price at the firm level. The increasing number of industries exhibiting incomplete exchange rate pass-through in post-reform period indicates the higher degree of pricing power for Indian industries during this period. Mallick and Marques (2010) made another attempt with monthly and annual data series to check the strength of exchange rate pass-through both in the short-run and long-run. The study concludes that the exchange pass-through to the export price is high only in the short. The comparison of exchange rate pass-through and the pricing behavior of Chinese and Indian exporters during 1994-2007 by the same authors (2013) shows that, with fixed exchange rate system, Chinese exporters adjust their prices, whereas in India with managed floating exchange rate there is the evidence for exchange rate pass-through. The idea of Pricing to Market (PTM) is developed by Krugman (1987). PTM is the practice of charging different prices in the domestic and foreign market; monopolistically competitive firms use this technique to take advantage of international pricing differences. The study of Mallick and Marques (2012) connecting Pricing to market (PTM) and exchange rate pass-through shed light on pricing behavior of Indian exporters in G3 countries and emerging markets. While Indian exporters practice 'Pricing to Market' by nullifying exchange rate pass-through in G3 countries, they depend upon pass-through in emerging markets where the competition is less.

Bhattacharya. et.al (2008) tried to explore the relationship between inflation and exchange rate in the post-reform period in India. The main focus of the study was to estimate the impact of nominal exchange rate changes on the wholesale and consumer price indices. The study employed recursive VAR and VEC model for the monthly data from September 1997 to October 2007. The variables, viz. oil prices, Output IIP gap were also included as control variables along with exchange rate, CPI and WPI. The author analysed the impact of changes in oil prices and world commodity prices on inflation to capture the influence of external shocks by following the methodology of McCarthy (1999). The study concludes that there is significant but incomplete, exchange rate pass-through in India during this period.

Roy and Pyne (2011) estimated exchange rate pass-through to India's export prices during 1960-2000. The study used simultaneous equation model using both aggregated and disaggregated manufactured export data series. The author could find the presence of incomplete, but high-level exchange rate pass-through to India's export prices. Moreover, it is also seen that the pass-through significantly differed across various product groups with near complete pass-through for export prices of chemicals and incomplete and low pass-through for prices of engineering goods.

Kapur and Behera (2012) attempts to examine the monetary transmission in India by using quarterly data by considering various channels such as quantum channel relating to credit, asset price channel, interest rate channel and exchange rate channel. The study shows that the exchange rate pass-through coefficient using NEER is found to be statistically significant in non-food manufactured products inflation. Short-run and long-run pass-through coefficients are 0.03 and 0.08 respectively which indicates that ten per cent depreciation of the NEER led to an increase of thirty bps in the WPI-NFMP inflation in the same quarter and eighty bps in the long-run. In the analysis of exchange rate pass-through, the authors argue that nominal exchange rate influences inflationary conditions, while the real effective exchange rate impacts the level of demand and output. Considering the nominal and the real effective exchange rate (NEER and REER) as exogenous variables in the model, it is found that the nominal exchange rate impacts the real exchange rate in real life. The study shows that higher demand from real depreciation increases inflationary pressures indirectly. It leads to the tightening of monetary policy which ultimately leads to policy rate returns to the baseline.

Mohanty and Bhanumurthy (2014) tried to analyse the impact of exchange rate regime on inflation. Since the stable exchange rate is expected to reduce the inflation, they tried to find out whether exchange rate stability in the managed floating regime leads to lower inflation. They used monthly data for the following variables: reserve money, 91 days treasury bill rate, WPI, Index of Industrial Production, net foreign exchange assets, RBI credit to government, exports and imports, RBI credit to commercial sector, Government’s currency liability to the public, Net non-monetary liabilities of the RBI and RBI's gross claims on banks. The empirical work is carried for the period April 1994 to June 2011 by classifying the period according to volatility of exchange rate and net foreign Exchange Asserts (NFA). The study uses ARDL bound test to check the long-run and short-run relations between inflation and other variables including exchange rate volatility. The cointegration test results show that the impact of exchange rate volatility on inflation is not significant. The author argues that it could be a result of the offsetting sterilization policies which RBI has undertaken to curtail the negative impact of exchange rate volatility on inflation.

Kumar (2014) studies exchange rate pass-through from 1995 M6 to 2013 M2 using SVAR framework. The study used variables, viz. oil prices proxied by energy price index, index of industrial production, exchange rate Rupee/USD, CPI and call money rate (MMR). The finding reveals that the energy prices have greater influence on domestic prices and are quite significant rather than the exchange rate pass-through is not significant. The study also reveals that global commodity prices have significant impact on domestic price level through wholesale price inflation. Contrary to the expectation, positive shock in exchange rate leads to negative impact on Index of industrial production. IIP also shows a positive jump for the energy price shock.

Ranadive and Burange (2015) examine the degree of exchange rate transmission to domestic prices for the post-reform period in the Indian context. The study provides more reliable outcome due to the incorporation of distribution price chain of exchange rate pass with the aid of unrestricted vector autoregressive (VAR) model, innovation accounting tools such as impulse response functions (IRFs) and variance decomposition. The data series from April 2009 to May 2013 is taken for the analysis with eight variables namely- oil prices, output gap, exchange rate, interest rate, money supply, import prices, wholesale prices and consumer prices. The study reveals that there is clear evidence for the incomplete pass-through to inflation in India where the ERPT elasticity is high and positive for import prices and it is quite low for wholesale prices. Unlike other previous literature, the paper comes up with an interesting conclusion of negative ERPT in the case of consumer prices which indicates that consumer prices are not much affected by the exchange rate fluctuations in India.

3.4 Exchange Rate and Foreign Trade: Short-run and Long-run Dynamics across Countries

In the decades of 1970s and 1980s, few economists made a notable contribution to the area of exchange rate and trade balance which paved way for further studies in this area. Laffer (1973), Salent (1974) and Miles (1978) tried to check whether devaluation could improve the trade balance. Laffer (1973) could not find any significant impact of devaluation on the trade balance instead; he argued that the trade balance was negative in the period after the devaluation. Salent (1974) expanded and re-examined the same but the conclusion was not much different from Laffer. The study revealed that although devaluation could make favourable position in the balance of payment, the trade balance was affected neither positively nor negatively. Miles (1978) made an effort to check the impact of devaluation on trade balance and balance of payment on 17 countries using t-test hypothesis. The author has used the ratio of export and import as trade balance variable where export minus import is used widely. The conclusion of this study was also not different from the previous studies. The impact of devaluation on balance of payment was found where there was no evidence for impact of devaluation on trade balance. Himarios (1985) tried to differentiate the long-run and short-run impact of exchange rate and test the validity of J-Curve hypothesis. But he could not find any evidence for J- curve hypothesis. But contrary to the findings of Miles (1979), he claimed that the devaluation does affect the trade balance in a traditionally predicted way.

The attempt of Bahamani (1985) to check the validity of J- Curve hypothesis and Marshal- Lerner Condition in four developing countries is remarkable in the literature of exchange rate- trade balance interactions. The study used econometric models by including the variables such as world income and domestic money supply. Quarterly data for the period 1973-80 is used for the analysis. By accepting the validity of J-Curve hypothesis, the study finds that trade balance doesn't improve immediately with currency devaluation. In U.S case, it is found that trade balance deteriorated after a significant devaluation of the dollar in 1971. The J-Curve hypothesis is validated since the adjustment process of trade balance according to the changes in exchange rate works in the long-run. The analysis of domestic and external sector's economic performance in the developing countries was the focus of Kamin (1988). He studied the major devaluation of the currency during 1953- 1983 and its impact on the trade balance, current account, and capital flows. Analysing the impact of devaluation, the study reveals that devaluation could improve the trade balance initially, but slowly it vanishes and turn to negative impact. The study also confirmed the significant positive impact of devaluation on current balance whereas the capital flows were less affected by the changes in exchange rate. Contrary to the previous studies, the author found that both short and long-run impact of devaluation on the balance of trade is positive and significant. The export is also found to be positively affected by devaluation which means that exporters could take advantage of devaluation to increase export volume and price.

Bahmani-Oskooee and Alse (1994) made some methodological improvements in the analysis of exchange rate and foreign trade compared to previous studies and took the ratio of export and import instead of export minus import as the trade balance variable. The study investigated the validity of J-Curve Hypothesis in 41 developed and less developed countries employing the Engle-Granger two-step procedure. By using the quarterly data from 1971 to 1990, the study found that while the long-run impact of devaluation on trade balance was positive in case of Costa Rica, Brazil, and Turkey; it was negative in Ireland. The long-run effect was not found in Canada, Denmark, Germany, Portugal, Spain, Sri Lanka, UK and the USA. The results of error correction model showed that J-Curve Hypothesis is validated in the case of Costa Rica, Ireland, Netherlands, and Turkey. The study also revealed that trade balance and real effective exchange rate are co-integrated for only fourteen countries.

Overcoming the methodological limitation of previous works such as stationarity, Bahmani-Oskooee and Brooks (1999) empirically analyse the relationship between exchange rate and foreign trade using bilateral trade data in the context of U.S with respect to 6 trading partners, Canada, France, Germany, Italy, Japan and the UK. Considering the advantage, the ratio of export and import is taken as the trade balance variable the period 1973Q1 to 1996Q2. The ARDL model is used to estimate the short and long-run relationship accommodating other control variables such as domestic GDP and foreign country GDP. The study could not find the presence of J- curve pattern indicating an unfavourable balance of trade in the short-run.But in the long-run, depreciation could pull trade balance in favourable condition. While Bahmani-Oskooee and Ratha (2004) expanded this study by including all trading partners and all industrial countries, the results were almost similar to the study of Bahmani-OskooeeandBrooks (1999).

Wilson (2001) tested the validity of J-Curve Hypothesis in the context of 3 countries- Singapore, Malaysia, and Korea. Trade balance with USA and Japan is considered to test the hypothesis in a bilateral way. The study used VAR approach since the long-run relationship was not established by using cointegration methods. The author could not find any evidence for J- curve except in the case of Korea. Contrary to the results of major empirical works across these countries, the study found that the impact of real exchange rate on trade balance was not significant in Singapore and Malaysia.

Onafowora (2003) employed Generalized Impulse response function and cointegration models respectively to test the short-run and long-run dynamics of trade balance of Thailand, Malaysia, and Indonesia with USA and Japan. Following commonly used method, the author considers the trade balance as a function of domestic income, foreign income, and real exchange rate. The study finds evidence for the presence of J-Curve Hypothesis. Moreover, the cointegration models show improvement of the trade balance in the long-run.

The aim of Bahmani-Oskooee and Kutan (2007) was to test the short-run and long-run relationship between exchange rate and balance of trade in Bulgaria, Croatia, Cyprus, Czech Republic, Hungary, Poland, Romania, Russia, Slovakia, Turkey, and Ukraine. The study employed ARDL cointegration approach and ARDL error correction model. J-curve hypothesis was validated in three countries, Bulgaria, Croatia, and Russia. When the exchange rate depreciation made a negative impact in the short-run, it turned positive in the long-run.

Bahmani-Oskooee and Ratha (2007) studied short-run and long-run dynamics of trade balance taking 14 out of 17 of Sweden's trade partners. Although negative impact of exchange rate on trade balance could be seen with many partners in the short-run, indicating devaluation become unfavourable for the trade balance in the short-run, J- curve hypothesis is validated only in the case of Norway where the negative short-run impact and positive long-run impact of exchange rate was observed on its trade. Bahmani-Oskooee, Goswami, and Talukdar's (2008) study on Canadian trade flows find the presence of J-Curve pattern with five out of 20 partners. A similar study conducted by Bahmani-Oskooee and Cheema (2009) using trade Pakistan's trade data again produced a mixed result. Subsequently, in 2009, the same authors found similar results when the model was carried for transition economies. Out of it, only 3 of these countries have justified the J-curve pattern. The positive long-run impact effect was found with only five partners and the rest of 8 established reverse patterns.

Recently, Mustafa, Rahman, and Guru-Gharana (2016) analysed the dynamics of Brazil-Us trade balance and dollar exchange rate by using monthly data from January 1999 to December 2013. Johansen-Juselius cointegration test is used to check the long-run relationship since all the variables are integrated of order one. From the study, it is evident that there exists a bi-directional causal relationship between the variables in the short-run. The J-curve pattern in trade balance was found as a result of exchange rate depreciation in the impulse response analysis. As far the author is concerned, contrary to the short-run impact of exchange rate, improvement in the trade balance during the long-run rests on monetary and fiscal policy initiatives of Brazilian economy by enhancing modern technology and labour productivity.

3.5 Interactions of Exchange Rate and Foreign Trade: Indian Scenario

Bahmani-Oskooee (1985) made an analysis of exchange rate and trade balance in the context of four countries namely, Greece, India, Korea, and Thailand. The author made a unique contribution to the empirical analysis wherein he uses multiplier based methodology following Kruger (1983). The author could validate the J- Curve hypothesis in all four countries but the length of deterioration period as a result of devaluation or depreciation differs from country to country. The long-run positive relationship between devaluation and trade balance as indicated by Marshal- Lerner condition was found only in the case of Thailand. Bahmani-Oskooee (1989) re-estimated the impact by making little modification in the methodology used earlier. The exchange rate was re-defined as the number of units of domestic currency per unit of foreign currency instead of units of foreign currency per unit of domestic currency. Moreover, the foreign country's price level was also included as a variable to determine the real exchange rate. Contrary to the previous study, the analysis shows that there is the presence of inverse J-curve during the study period. However, the long-run results produced the same results confirming long-run relationship only in Thailand.

Bahmani-Oskooee and Malixi (1992) attempted to find out the short and long-run impacts of exchange rate on trade balance by using linear regression model. Apart from real exchange rate, the study has considered other control variables such as real domestic output, real world output, domestic high powered money and world high powered money. The empirical analysis was carried for 13 LDCs, namely Brazil, Dominican Republic, Egypt, Greece, India, Korea, Mexico, Pakistan, Peru, Philippines, Portugal, Thailand, and Turkey. The authors could find evidence for the validation of J-Curve Hypothesis in Brazil, Greece, Korea, and India. Contrary to the standard pattern, the study also finds some shapes such as N, M, and I Curves. The long-run effects are seen to be positive in most of the cases, although few countries, Dominican Republic, Greece, India, Korea, and Mexico witnessed opposite results.

Buluswar, Thompson, and Upadhyaya (1996) produce different results that not in line in analysing the impact of exchange rate on the trade balance. The study could not find J- Curve pattern of trade balance as a result of depreciation in the Indian context instead holds M- Curve pattern. A long-run relationship was also not established between exchange rate and trade balance since the cointegration models could not give statistically significant results. Kulkarni (1996) also found similar results to Buluswar et al. (1996), in which he could not find any evidence to validate J-Curve Hypothesis in the Indian context.

Unlike the previous studies in the Indian context, Bahmani Oskooee M. and Mitra R. (2009) tested the short-run and long-run dynamics of the trade balance using disaggregated trade data between India and the rest of the world. For this purpose, the study used bilateral trade data between India and her seven major trading partners. The study could not find any significant relation between exchange rate and trade balance when the major trade partner -the U.S- was considered for the analysis. Industrial level results show that out of 38 industries, only 22 industries reacted significantly to the changes in the real exchange rate in the short-run and the J- curve pattern was supported by only eight industries.

The previous literature analysed the short and long-run dynamics of the exchange rate and trade balance by using aggregate level data of foreign trade. Recently, efforts were made to use bilateral trade data. Arora et al. (2010) and Dash's (2013) study finds more superior than others for estimating the model with the usage of bilateral trade as they produce more reliable results. Arora et al. (2010) employed ARDL model to check the bilateral trade balance of India with countries like Australia, France, Italy, US, UK, Japan, and Germany from 1977 to 1998. The study finds a significant relationship with any country in the short-run, while significant positive relationship could be seen only with Japan. Dash (2013) uses Vector Error Correction model for a longer period (1991 to 2006) taking trade balance of India with US, UK, Japan, and Germany. The short-run relationship between exchange rate and trade balance could be seen only in the case of Japan and Germany while the positive long-run relationship could be established in the case of Japan, Germany and UK.

3.6 Exchange Rate, Inflation and Foreign Trade: Non-linear Dynamics

So far the review on the exchange rate dynamics and its influence on inflation and trade centered around the linear framework. Subsequent to the discussion, the focus now shifts towards non-linear framework that captured greater attention in recent times. It is not guaranteed that the economic relationship will be always linear. Recently, non-linearities and chaotic behaviour in the exchange markets are widely studied (Adrangi and Allender, 2011). The presence of nonlinear relations among economic variables occurs as result of various factors such as variations in direction and size of change, downward price rigidity, the Asymmetric impact of different variables, presence of uncertainty and volatility spillover. Thus combining both linear and non-linear analysis helps to examine the all the possible ways of economic relationship.

Pollard and Coughlin (2004) examined asymmetries and non-linearities of exchange rate pass-through in U.S import prices for 29 industries. The main motive of the study was to find whether the direction of the exchange rate change and the size of the change play a crucial role in determining the pass-through impact. The study found that half of the industries react asymmetrically to the direction of the changes, appreciation, and depreciation, although the direction of asymmetry differs across the industries. Moreover, by showing a positive relationship between pass-through and size of the change, the industries react asymmetrically to the large and small changes in the exchange rate. Finally, the study concludes that the asymmetry in the size of the change dominates the asymmetry in the direction of the changes.

Berman, Martin and Mayer (2012) investigated the heterogeneous response of exporters to changes in real exchange rate. The study uses a very rich French firm-level data set with destination specific export values and volumes for the period 1995–2005. The study sheds light on the strategies of exporting firms according to the changes in the exchange rate. When there is depreciation in the currency, the firm which performs better in the market increase their markup than increasing volume of export.It means that the optimally high performing firms partially prefer to absorb the exchange rate changes in their markups. The study indicates that this heterogeneity of pricing to market differs by performance, samples and other econometric specifications. The study concludes that the weak impact of exchange rate pass-through to aggregate exports is due to the concentration of aggregate exports in high productivity firms which absorb the changes in the exchange rate in their markups and also due to heterogeneous pricing-to-market strategy.

The efforts of Frankel et al. (2012) using the base line empirical test to accommodate the nonlinear and asymmetric impact of exchange rate pass-through shows that significant devaluation in the exchange rate beyond a threshold level has a significant impact on the domestic prices. The author shows that developing countries witness more rapid exchange rate pass-through than high-income countries. The study also finds that there is an asymmetric exchange rate pass-through impact of depreciation and appreciation which resulted due to downward price rigidity. Further, an attempt is made to find out major determinants of exchange rate pass-through viz. per capita income, bilateral distance, tariffs, country size, wages, long-term inflation, and long-term exchange rate variability. The author suspects that the Balassa-Samuelson-Baumol effect could lead to decline in the pass-through coefficient in some developing countries

Bussiere (2013) attempted to go beyond the standard assumption of linear and symmetric exchange rate pass-through and analysed the relationship between exchange rate and inflation using the nonlinear framework. The empirical analysis was done by taking the data of export and import prices of the G7 economies. The main focus of the study is to understand the reactions of profit margins to the changes in the exchange rate which may occur as a result of price rigidities and switching costs. The study used standard linear equation model and tried to capture nonlinear relationship by adding terms of polynomial functions and interactive dummy variables to the same model. The study shows that larger appreciation has more than the proportional impact on the export prices. The major contribution of the work is the exploration of the nonlinear relationship in the exchange rate pass-through and plotting the magnitude of the relationship which differs across the countries in the context of G7.

Nortey, Ngoh, Doku-Amponsah and Ofori-Boateng (2015) examine the volatility and conditional relationship among inflation rates, exchange rates and interest rates using multivariate GARCH DCC and BEKK models during the period January 1990 to December 2013 in Ghanian economy. The study points out that if inflation rate is stable, it does not mean that exchange rates and interest rates are expected to be stable. Instead, inflation rates and interest rates respond positively to the movements in the exchange rate (cedi), though these variables are stable in the long-run. The mean equation of the DCC model is found to be robust to forecast inflation rates in Ghana. By forecasting the inflation volatility for the year 2014, the results reveal that the inflation is expected to react to the expected volatility of the exchange rate.

The works which check the impact of exchange rate uncertainty on the volume of international trade in a linear framework are plenty. The literature differs in its conclusion about the impact direction of exchange rate uncertainty on trade volume. Numerous theoretical works (for instance, Clark, 1973; Baron, 1976; Arize et al., 2000; Sauer and Bohara, 2001) have exposed adverse effect of exchange rate uncertainty on the foreign trade. A large number of works (for instance, Franke, 1991; Sercu and Vanhulle, 1992, Gagnon, 1993) conclude that the impact of exchange rate uncertainty on foreign trade is positive but ambiguous. Despite the efforts to check the volatility spillover or co-movements between exchange rate and foreign trade has been done, the exchange rate uncertainty impact on foreign trade volatility still needs a further investigation. Some of the works in this direction are reviewed here.

To begin with, Zimmermann's (1999) work appears significant in the analysis of volatility spillover from exchange rate to foreign trade. He uses business cycle model to make comprehensive analysis using components of GDP and trade flow volatility. Employing a three-country business cycle model the findings on spillover correlate with that of Engel and Wang (2007). Barkoulas, Baum and Caglayan (2002)examines the impact of exchange rate uncertainty on trade volume and volatility by using a signal extraction framework. Interestingly the study has found that the direction and magnitude of importers' and exporters' optimal trading activities are determined by the uncertainty formed from "general microstructure shocks, fundamental factors driving the exchange rate process, or a noisy signal of policy innovations". Like the previous studies, Barkoulas et al. (2002) conclude that exchange rate uncertainty impacts the volume of trade flows and variability of trade flows. Engel and Wang (2007) made a contribution to the analysis of volatility transmission by using a two-country-two-sector model to understand the dynamics of international real business cycles. The empirical study has been done by using quarterly data of 25 OECD countries. The major conclusion of the paper is that the high volatility in the international market is formed majorly as a result of volatility spillover from the exchange rate.

Baum and Caglayan (2009) analysed the volatility of international trade flows and exchange rate uncertainty in the context of Eurozone countries, other industrialized countries, and newly industrialized countries (NICs) from 1980 to 2006. To overcome the methodological limitation of previous studies, the proxies for uncertainty or volatility of trade and exchange rate is calculated using a bivariate GARCH-in-mean (GARCH-M) model.The GARCH-M could capture the volatility transmission from exchange rate to trade contemporaneously and by its lag values. The study found that the role of exchange rate uncertainty in determining the volatility of bilateral trade flows is significant. According to GARCH results, one standard deviation increase in exchange rate uncertainty results in eight per cent increase in trade volatility. Unlike the previous studies, the study advocates that exchange rate uncertainty does not impact the volume of trade flows of either industrialized countries or NICs.

Again, Baum and Caglayan (2010) made an empirical investigation in the same way to check the impact of exchange rate uncertainty on both trade volume and variability for 13 countries: US, UK, Canada, Germany, France, Italy, Japan, Finland, Netherlands, Norway, Spain, Sweden, and Switzerland.The study is done by using bivariate GARCH model considering the monthly data series from 1980 to 1998. Majorly the study put forward two conclusions. Firstly, the study could not find a significant impact of exchange rate volatility on trade flows, and significant results are produced only in few number of models. Secondly, there is clear evidence to show the volatility transmission from exchange rate to foreign trade in most of the models. The study found that for 81 out of 143 potential GARCH models, exchange rate volatility shows a positive impact on the volatility of trade flows.

3.7 Summary, Conclusion and Literature Gap

The empirical literature on exchange rate pass-through can be stratified into four groups based on chronology and the focus of the works. The first generation works on the impact of exchange rate on inflation and is based on the Law of One Price

(LOOP) and Purchasing Power Parity. The second generation of works is characterised by analysing the significance of the lagged values of the exchange rate in determining domestic price level or inflation level of a country. The third generation of the literature relaxes the assumption of perfect competitive markets and analyses the exchange rate phenomenon in an imperfectly competitive environment. The fourth generation empirical literature moves a step forward by interlinking the pricing strategy of firms and exchange rate pass-through using 'new open economy macroeconomics' (NOEM) framework. The presence of complete or incomplete exchange rate pass-through is evident from the empirical literature of all these generations. The Recent research employs unrestricted autoregressive or structural autoregressive models, which are more empirical than theoretical, thus shows enough evidence for the existence of incomplete exchange rate pass-through across the countries.

Studies on exchange rate pass-through in the Indian context differ from other works in explaining the strength and significance of exchange rate pass-through. A large number of works reveal that the exchange rate pass-through is significant, though the strength of the pass-through differs from author to author. However, some of the studies could not find significant exchange rate pass-through to inflation. Moreover, the studies point out that the long-run pass-through coefficients are highly significant compared to to short-run coefficients when cointegration methods are used for the analysis. Few other studies which made a comparison of pass-through between pre and post reform period reveal that pass-through are near complete and high in the post-reform period.

Quite a number of studies in the literature laid emphasis on the validity of J-Curve Hypothesis or Marshal-Lerner condition which in turn explores the short-run and long-run dynamics of the trade balance. The study can be broadly classified into works using aggregate trade balance data and works using bilateral trade balance data. These kinds of works across the globe could not produce a unanimous conclusion, i.e., the results are inconclusive in nature. There are works which could validate J-Curve Hypothesis and Marshal-Lerner condition, whereas other works could not find significant favourable results. Indian case is also not different from this global scenario. Several works have been published in Indian context which is inconclusive in nature.

The past studies which try to explore the nonlinear relationship between exchange rate and inflation, as well as exchange rate and foreign trade, show that there is the possibility of a nonlinear and asymmetric impact of exchange rate on inflation and foreign trade. The literature analysed different types of nonlinearities. The volatility co-movement or spillover became a very fertile area which some of the authors tried to explore the nonlinear relationship in this regard. The empirical studies across various countries show that there the exchange rate uncertainty plays a crucial role in determining the volume and variability of international trade flows.

Compared to other developed or developing countries, works dealing with exchange rate pass-through is very limited in the Indian context. Comprehensive analysis of ERPT in a product wise manner to understand what kinds of products are more influenced by changes in the exchange rate is not at all discussed in any literature so far. Apart from that, most of the works in this area are based on pre-assumption of a linear relationship between exchange rate and domestic price level. The nonlinear relationship, particularly checking the volatility spillover and modeling the variance equation is a new step in the study of exchange rate and inflation interaction in the Indian context.

The inconclusive results of exchange rate and foreign trade studies particularly in validating Marshal Lerner condition and J-curve hypothesis prompt to re-look the short and long-run relationship between the exchange rate and foreign trade in the Indian context. Further, an attempt to study the nonlinear relationship will widen the analysis and give a comprehensive view of the relationship.

Hence, the present study focuses on the linear and nonlinear pass-through of the exchange rate in general and at the disaggregated level in particular and explores the inter-linkages between exchange rate and foreign trade in the short-run and long-run.

----xxx----

Chapter 4

Exchange Rate and Inflation: Linear Pass-through

4.1 Introduction

Literature across the countries used various time series econometric techniques to analyze exchange rate pass-through. Commonly exchange rate pass-through is estimated by checking the response in return series of the exchange rate and inflation. While majority literature has focused on establishing a linear relationship using time series models such as simple regression, VAR, SVAR or Cointegration models in this returns series of data, few works tried to establish non-linear relationship between the exchange rate and inflation using univariate or multivariate GARH models. The second category works concentrated on the spillover effects through modeling variance equation. It should be noted that both of these two types of analysis ultimately tells about co-movements and inter-response of two or more macro or financial variables. When the first types of works portray the pass-through in a linear setup, second kinds of analysis shows the nonlinear pass-through.

This chapter examines the linear relationship in the data series by using structural VAR modeling. It has many advantages compared to other models. The structural modeling considers a system as a whole by including all possible variables and factors and estimates the parameters in a macroeconomic framework. The ordering and selections of variables are based on theoretical background. So the analysis is expected to give more reliable result in exchange rate pass-through. Moreover, only few works have been produced in Indian context by using pricing chain as used here.

The aim of this chapter is twofold. First, to evaluate exchange rate pass-through in India by estimating its extent and speed, in general, using the log series of the study variables. Secondly to check the extent of exchange rate pass-through at a disaggregated level by classifying inflation level into different product groups. Accordingly, 4.2 includes the description of data and empirical models are discussed under the methodology. VAR and SVAR models are estimated and the findings are discussed there on.

4.2 Data and Methodology

The study used monthly data starting from January 1998 up to December 2014. Since the recent financial crisis (2007) had shown a greater impact on the volatility of exchange rate of Indian rupee, exchange rate pass-through effect is observed in the both pre and post crisis period. As a reason, May 2008 is taken as period of structural shift considering high variations in volatility of the exchange rate between these two periods. The structural shift is detected by ICSS algorithm in the volatility series.

All the data series used for the study are taken from various sources. Percentage change in the crude oil (petroleum) price index (base year=2005) is used as the proxy for Oil price inflation. It is the simple averages of the spot prices of Dated Brent, West Texas Intermediate, and Dubai Fateh. This data is made available from IMF's international financial statistics database. World Price Inflation is calculated from the world commodity price index, (base year=2005) which includes both fuel and non-fuel price indices. It is also collected from international financial statistics database. M3 which is collected from RBI's database on Indian economy is used as a proxy for money supply. Index of Industrial Production Gap (IIP Gap) is used as a proxy for output gap since the GDP monthly data is not available and considering the high correlation between the GDP and IIP. IIP data from reserve bank of India is used to for the study. Hodrick and Prescott Filter is used to filter the IIP data and find out the IIP gap from the series, which is commonly used for the exchange rate pass-through studies (McCarthy, 2000,2007). The exchange rate is defined as the monthly average of rupees per dollar and Nominal Effective Exchange Rate (NEER) (36 countries Average). Rupee- dollar exchange rate data is collected from the database of International Monetary Fund while NEER data is made available from Bank of International Settlement (BIS), with the base of 2010. Finally, WPI and CPI indices wich is published by Reserve Bank of India refers to inflation. General level pass-through to both WPI and CPI is estimated using SVAR and VAR models. Further commodity wise pass-through effect is estimated using classified groups of WPI inflation data series. All the data series used here is differenced form of log series or simple log series. The differenced data is taken to make the data series stationary, where it is required except in the case of IIP gap, where it was already stationary in level series. SVAR and Simple VAR are the two-time series technique used in this chapter. A detailed description of the models and stationarity order of the variables are discussed in the following sections.

4.2.1 Introduction to Structural Vector Auto Regressive (SVAR) Models

Rather than mere empirical estimation thorough Vector Auto regressive models (VAR), Structural VAR use economic theory to recover structural innovations from residuals of a reduced form of VAR. An example of bivariate structural VAR model, which has a contemporaneous effect on other variables, is given below. (Enders, 2004)

$$\begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix} \begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix} + \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \begin{bmatrix} y_t \\ z_t \end{bmatrix} + \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix} \qquad \text{..... (4.1)}$$

Which can be written in reduced form as:

$$Bx_t = \Gamma_0 + \Gamma_1 x_{t-1} + \varepsilon_t \qquad \text{..... (4.2)}$$

Where,

$$B = \begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix}, \quad x_t = \begin{bmatrix} y_t \\ z_t \end{bmatrix}, \Gamma_0 = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix}, \quad \Gamma_1 = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix}, \quad \varepsilon_t = \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix}$$

The reduced- form of the structural can be written as:

$$\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ z_{t-1} \end{bmatrix} + \begin{bmatrix} e_{yt} \\ e_{zt} \end{bmatrix} \qquad \text{..... (4.3)}$$

or

$$x_t = A_0 + A_1 x_{t-1} + e_t \qquad \text{..... (4.4)}$$

Where:

$$A_0 = \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix} A_1 = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} e_t = \begin{bmatrix} e_{yt} \\ e_{zt} \end{bmatrix}$$

Equation 4.4 is derived from Equation 4.2 and the errors in the reduced-form VAR e_{yt} and e_{zt} are composites of the underlying structural shocks e_{yt} and e_{zt}since:

$$A_0 = B^{-1}\Gamma_0; A_1 = B^{-1}\Gamma_1;\ e_t = B^{-1}\varepsilon_t \qquad \text{…… (4.5)}$$

So the structural shocks can be written as:

$$\begin{bmatrix} e_{yt} \\ e_{zt} \end{bmatrix} = \begin{bmatrix} \frac{1}{1-b_{12}b_{21}} \end{bmatrix} \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix} \qquad \text{….. (4.6)}$$

Although e_t denotes one-step-ahead forecast errors in x_t, it does not capture content of any structural shocks where ε_t denotes the autonomous changes in x_t in model 4.2. The impulse response functions (IRF) or Variance decompositions (VD) can be derived from structural shocks ε_t to decompose influence of various factors in a structural framework.

The structural decomposition works with use of error term e_t by fitting an empirical VAR and to restrict the system so as to recover ε_t as $\varepsilon_t = Be_t$. The restriction should happen in such a way that we need to recover various ε_{ij} by preserving the assumption of independence among various ε_{ij}.

The number of equations and unknowns is very crucial to solving the identification problem in SVAR. The OLS can obtain the variance-covariance matrix $\sum$ is as follows.

$$\sum = \begin{vmatrix} \sigma_1^2 & \sigma_{12} & .. & \sigma_{14} \\ \sigma_{21} & \sigma_{22}^2 & .. & \sigma_{24} \\ . & . & . & . \\ \sigma_{n1} & \sigma_{n2} & .. & \sigma_{nn}^2 \end{vmatrix}$$

Where each element of $\sum$ is constrained as the sum: $\sigma_{ij} = (1/\mathrm{T})\sum_{t=1} e_{it}\ e_{jt}$.

The above $\sum$ contains contain $\frac{n^2+n}{2}$ distinct elements and need to focus only on lower or upper triangle because σ_{ij}=σ_{ji}. Now in the matrix B, diagonal elements are equal to one and only $n^2 - n$ off-diagonal elements are unknowns. Apart from that, there are n number of other unknowns. Therefore $n^2 - n + n = n$unknowns are to be identified from known $\frac{n^2+n}{2}$ from the empirical VAR. Therefore it is necessary to impose at least $n^2 - \left(\frac{n^2+n}{2}\right) = \left(\frac{n^2+n}{2}\right)$ restrictions on the structural model.

4.2.2 Structural VAR Model for Exchange Rate Pass-through

McCarthy (2000) made a path-breaking contribution in the area of multivariate exchange rate pass-through analysis using SVAR methodology. By using a distribution chain that follows import prices to producers and consumer prices, he analysed ERPT by a recursive VAR model. Subsequently, many others across the globe used the same procedure (Bhundia, 2002; Leigh and Rossi, 2002; Belaisch, 2003; Zorzi, Hahn and Sanchez, 2007; Bhattacharya, et.al 2008).

The empirical analysis carried here is based on the McCarthy's model (2000,2007 which is based on pricing distribution chain of import price and producer price and consumer price respectively. However, the import price could not be included in equations due to lack of data for the entire study period. This novel framework differs from others due to its inclusiveness of all possible variables and shocks. It considers demand, supply and exchange rate shocks and the reactions of the variables according to the monetary policies of the central bank.

The model considers oil price inflation as the supply shocks (ε_t^s) calculated from oil price index. We have taken IIP gap for the demand shock (ε_t^y) after accounting for contemporaneous supply side shocks, where McCarthy (2006) has taken the output gap. Moreover, monetary shocks (ε_t^m) are added to the model by incorporating M3 variable. Lastly, the Exchange rate shocks (ε_t^e) are considered after taking into account the contemporaneous effect of demand, supply and monetary shocks. The model has specified major determinants of inflation at each stage of wholesale and consumer price inflation, at period *t,* where the first determinant is the expected inflation at that stage based on available information at the end of the period *t-1*. Effects of domestic supply and demand shocks in period *t* on inflation at that stage are the next two determinants. The fourth and fifth components are the effects of monetary shocks and exchange rate shocks on inflation at that stage. Changes in M3 is proxied for the monetary policy shocks to account for the shocks of monetary policy on exchange and inflation. Subsequently, the shocks of the preceding stages of the chain are incorporated and finally, current stages shock also added to the model. The shocks at each stage can be referred as the impacts in the pricing power and markups of firms at each stage. The model can be drawn as follows:

$$\pi_t^{oil} = E_{t-1}(\pi_t^{oil}) + \varepsilon_t^s \qquad \ldots\ldots (4.7)$$

$$\pi_t^w = E_{t-1}(\pi_t^w) + \alpha\varepsilon_t^s + \varepsilon_t^w \qquad \ldots\ldots. (4.8)$$

$$\Delta m_t = E_{t-1}(\Delta m_t) + \Gamma_1\varepsilon_t^s + \Gamma_2\varepsilon_t^w + \varepsilon_t^m \qquad \ldots\ldots. (4.9)$$

$$\bar{y}_t = E_{t-1}(\bar{y}_t) + b_1\varepsilon_t^s + b_2\varepsilon_t^w + b_3\varepsilon_t^m + \varepsilon_t^y \qquad \ldots.. (4.10)$$

$$\Delta e_t = E_{t-1}(\Delta e_t) + \alpha_1\varepsilon_t^s + \alpha_2\varepsilon_t^w + \alpha_3\varepsilon_t^m + \alpha_4\varepsilon_t^y + \varepsilon_t^e \qquad \ldots.. (4.11)$$

$$\pi_t^{wpi} = E_{t-1}(\pi_t^{wpi}) + \lambda_1\varepsilon_t^s + \lambda_2\varepsilon_t^w + \lambda_3\varepsilon_t^m + \lambda_4\varepsilon_t^y + \lambda_5\varepsilon_t^e + \varepsilon_t^{wpi}. (4.12)$$

$$\pi_t^{cpi} = E_{t-1}(\pi_t^{cpi}) + \beta_1\varepsilon_t^s + \beta_2\varepsilon_t^w + \beta_3\varepsilon_t^m + \beta_4\varepsilon_t^y + \beta_5\varepsilon_t^e + \beta_6\varepsilon_t^{wpi} + \varepsilon_t^{cpi} \qquad \ldots.. (4.13)$$

Where π_t^{oil}, π_t^w and Δm_t denotes oil price inflation, world price inflation and Changes in the money supply (M3) respectively. $\bar{y}_t$ represents the IIP gap. While Δe_t stands for changes in the exchange rate, π_t^{wpi} and π_t^{cpi} are the CPI inflation and CPI inflation respectively. All the variables are taken in log form. ε_t^s, ε_t^w, ε_t^m, ε_t^y, ε_t^e are the oil price (supply side), world price, monetary, IIP Gap (demand side) and exchange rate structural shocks respectively. ε_t^{wpi} and ε_t^{cpi} are WPI and CPI inflation shocks. *E (t-1)* is the expectation of the variable based on the past information set available at the end of the period *t-1*.

4.2.3 SVAR Estimation Technique

The estimation of these above mentioned seven equations (4.7 to 4.13) are based on the assumption that the conditional expectations *E(.)* in these models can be substituted by linear projection on lags of the seven variables in the whole system. So the estimation can be made as a VAR with a Cholesky decomposition technique to identify the shocks.

The structural VAR model used here is represented as follows:

$$A_0 X_t = A\,(L)\,X_{t-1} + \varepsilon_t \qquad \text{...... (7.14)}$$

where X_t is the $Nx1$ vector of contemporaneous endogenous variables namely, oil price inflation, world price inflation, changes in money supply, IIP gap, exchange rate changes (Dollar/NEER), WPI, CPI. The matrix A_0 is of order *NxN* and explains the contemporaneous relationships between the variables of the model. *A(L)* is the lag polynomial matrix of order infinity where as e_t is the unobserved vector of structural shocks of order *N x 1*. The study used four models with a combination of the variables. The details of the four models are given below.

> **Model 1**: 7 Variables X= (oil price inflation, world price inflation, money supply (M3), IIP gap, exchange rate(Dollar), WPI, CPI) for the entire study period.
>
> **Model 2**: 7 Variables X= (oil price inflation, world price inflation, money supply (M3), IIP gap, exchange rate(Dollar), WPI, CPI) for pre- crisis period
>
> **Model 3**: 7 Variables X= (oil price inflation, world price inflation, money supply (M3), IIP gap, exchange rate(Dollar), WPI, CPI) post-crisis period.
>
> **Model 4**: 7 Variables X= (oil price inflation, world price inflation, money supply (M3), IIP gap, exchange rate(NEER), WPI, CPI)

When equation (4.1) is multiplied by an inverse matrix A_0^{-1}, we get the VAR model in its reduced form. Thus, these adjustments are essential because the model given in equation (4.1) is cannot be taken directly and structural shocks cannot be correctly recognized. Hence,

$$X_t = A_0^{-1}(L)X_{t-1} + e_t \qquad \text{.....(4.15)}$$

e_t refers to a N×1 vector of serially uncorrelated structural errors (disturbances) of the model and it is explaine as follows:

$$A_0 e_t = \varepsilon_t \text{ or } e_t = A^{-1}\varepsilon_t \qquad \text{......(4.16)}$$

$n(n-1)/2$ number of restrictions are levied on the matrix A_0 using the Cholesky decomposition of the residual variance-covariance matrix by describing A as a lower triangular matrix. The lower triangular matrix indicates a recursive scheme among variables assuming the absence of contemporaneous effect for some structural shocks on some endogenous variables given the ordering of the endogenous variables. Following the identification scheme, equation (4.16) can be written as:

$$\begin{pmatrix} \varepsilon_t^{oil} \\ \varepsilon_t^{w} \\ \varepsilon_t^{m} \\ \varepsilon_t^{y} \\ \varepsilon_t^{e} \\ \varepsilon_t^{wpi} \\ \varepsilon_t^{cpi} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ \alpha & 1 & 0 & 0 & 0 & 0 & 0 \\ \Gamma_1 & \Gamma_2 & 1 & 0 & 0 & 0 & 0 \\ b_1 & b_2 & b_3 & 1 & 0 & 0 & 0 \\ \alpha_1 & \alpha_2 & \alpha_3 & \alpha_4 & 1 & 0 & 0 \\ \lambda_1 & \lambda_2 & \lambda_3 & \lambda_4 & \lambda_5 & 1 & 0 \\ \beta_1 & \beta_2 & \beta_3 & \beta_4 & \beta_5 & \beta_6 & 1 \end{pmatrix} \begin{pmatrix} e_t^{oil} \\ e_t^{w} \\ e_t^{m} \\ e_t^{y} \\ e_t^{e} \\ e_t^{wpi} \\ e_t^{cpi} \end{pmatrix} \quad \ldots\ldots (17)$$

where ε_t is the reduced form of VAR residuals. Determining the order of variables is very significant to identify structural shocks. As given in equation 4.17, oil prices are given first order priority considering the fact that the reduced form residuals of oil prices are not expected to be influenced contemporaneously by any other shocks except the oil prices shock itself, at the same time oil price shocks influence all the variables in the system contemporaneously. World price inflation is ordered next considering the fact that it also affects other variables and it is affected by the oil price inflation. The monetary variable (log difference of M3) and IIP gap as a proxy for output gap is ordered respectively before exchange rate variable since it plays a vital role in determining the exchange rate. Then fifthly the nominal effective exchange rate is ordered. World price index and Consumer price index are followed respectively considering the price chain distribution (McCarthy, 2006). Effect of shocks in all other variables to inflation can be captured properly since the inflation variables are given at the end.

The wholesale price inflation is directly affected by the oil price shocks, world inflation shocks, monetary shocks, output shocks and exchange rate shocks. In Addition, the shocks of the wholesale price index are added as determining factors of consumer price index considering the pricing chain.

The exchange rate pass-through to the respective domestic prices is derived from the impulse response function and the pass-through elasticity at t is given by:

$$\text{Dynamic Pass} - \text{through elasticity at t} = \frac{Per\ cent\ change\ in\ the\ price\ level\ t\ quarters\ after\ the\ shock}{Per\ cent\ change\ in\ the\ exchange\ rate\ t\ quarters\ after\ the\ shock}$$

$$PT_{t,t+j} = \frac{\sum_{j=1}^{T} \hat{P}_{t,t+j}}{\sum_{j=1}^{T} \hat{E}_{t,t+j}} \qquad \text{........ (18)}$$

In the equation 18, the numerator denotes the percentage change in the level of the respective price indices between the period zero, while the initial exchange rate shock hits, at time t. The denominator indicates the percentage change in the nominal effective exchange rate at time t.

4.2.4 VAR Modeling

Secondly, an attempt is made to fit a VAR model (Bodrug, 2011) using CPI inflation and various product groups of WPI inflation to get a more concrete idea about the strength and degree of exchange rate pass-through to different products. Sometimes the pass-through impact might be weak when we are considering the total strength of all lagged values as in SVAR modeling. However, some specific lagged values will have more impact on other variables. Therefore, analysing the pass-through impact of different lagged variable of exchange rate using simple VAR model helps to extract more information from exchange rate pass-through. The model used for the study is as follows:

$$\Delta\pi_t = \alpha_1 + \sum_{i=1}^{m} \beta_{1i}\,(i)\Delta X_{t-i} + \sum_{i=1}^{m} \Pi_{1i}\,(i)\Delta m_{t-i} + \sum_{i=1}^{m} \phi_{1i}\,(i)\Delta e_{t-i} + \sum_{i=1}^{m} \theta_{1i}\,(i)\Delta\pi_{t-i} + \varepsilon_{1t}^{\pi} \qquad \text{... ... (4.19)}$$

$$\Delta e_t = \alpha_2 + \sum_{i=1}^{m} \beta_{2i}\,(i)\Delta X_{t-i} + \sum_{i=1}^{m} \Pi_{2i}\,(i)\Delta m_{t-i} + \sum_{i=1}^{m} \phi_{2i}\,(i)\Delta e_{t-i} + \sum_{i=1}^{m} \theta_{2i}\,(i)\Delta \pi_{t-i} + \varepsilon_{2t}^{e} \quad \ldots\ldots(4.20)$$

Where π- inflation level, e - exchange rate, m- money supply, X- control variables (oil price, output gap). $\alpha's$ are constants, $\beta's$, $\Pi's$, $\phi's$ and $\theta's$ are the parameters.

4.3 Empirical Results

Descriptive statistics and empirical results of the two model, VAR and SVAR are given in detail in the following sections. When the SVAR models emphasized on pre and post-crisis period comparison of exchange rate pass-through, the disaggregated analysis in product wise is given priority in simple VAR models.

4.3.1 Descriptive Statistics and Unit Root Testing

Table 4.1 Discriptive Statistics

	DLOI	DLWI	DLM3	LIIPGAP	DLD	DLNEER	DLWPII	DLCPII
Mean	0.003	0.002	0.006	0.006	0.001	0.010	0.002	0.003
Median	0.008	0.005	0.005	-0.006	0.000	0.000	0.002	0.003
Maximum	0.088	0.048	0.025	0.059	0.028	1.968	0.011	0.019
Minimum	-0.137	-0.103	-0.002	-0.033	-0.018	-0.022	-0.008	-0.011
Std. Dev.	0.037	0.021	0.004	0.018	0.007	0.138	0.003	0.004
Skewness	-0.920	-1.251	1.247	0.921	0.835	14.128	-0.272	-0.141
Kurtosis	4.713	6.480	5.670	3.287	5.459	201.079	4.534	4.636
Jarque-Bera	53.735	156.138	113.441	29.552	75.116	340288.200	22.509	23.422
Probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sum Sq. Dev.	0.274	0.090	0.004	0.069	0.011	3.862	0.002	0.004
Observations	204	204	204	204	204	204	204	204

The descriptive statistics of the study variables are given in Table 4.1. Since all the variables are taken in log form, the mean values are close to zero. There are 204 number of observations in each series. The descriptive statistics of the variables shows nature and pattern of the data series. Checking stationarity is another important deal which should be confirmed before going for further time series or econometric treatment. Non- stationary data series leads spurious regression results. Well known and widely used three tests, Dicky-Fuller, Phillips- Perron and KPSS, are used to check the stationarity of the series. All the series except IIP GAP, which is taken in log form are found to be stationary in its first any chance of doubt. Table 4.3 shows correlations matrix of the variables. From the matrix, it is clear that the correlation remains low except in the case of oil price inflation and world commodity price inflation. In this case, the correlations are high (0.9501), but all other cases correlations are less than 50%.

Table 4.2. Unit Root Test Statistics

Variables	Dicky- Fuller		Philllips- Perron		KPSS	
	Test Statistic	P- Value	Test Statistic	P- Value	Test Statistic	Critical Value (5%)
DLOI (Oil Price Inflation)	-10.423	0.0000	-10.498	0.0000	0.124799	0.4630
DLWI (World Inflation)	-9.544	0.0000	-9.701	0.0000	0.102295	0.4630
DLM3 (Money Supply)	-3.196	0.0202	-2.997	0.0352	0.268583	0.4630
LIIPGAP (IIP Gap)	-23.008	0.0000	-12.143	0.0000	0.010865	0.4630
DLD (Exch. rate, $)	-9.843	0.0000	-9.676	0.0000	0.190202	0.4630
DLNEER (Exch. rate, NEER)	-296.861	0.0000	-279.943	0.0000	0.332602	0.4630
DLWP (WPI Inflation)	-8.943	0.0000	-8.982	0.0000	0.100122	0.4630
DLCPI (CPI Inflation)	-12.069	0.0000	-12.12	0.0000	0.364038	0.4630

4.3 Correlation Matrix of Study Variables

	DLOI	DLWI	LIIPGAP	DLM3	DLNEER	DLD	DLWPI	DLCPI
DLOI	1							
DLWI	0.9501	1						
LIIPGAP	0.0987	0.1642	1					
DLM3	0.0533	0.037	0.1813	1				
DLNEER	-0.1146	-0.0944	0.0793	0.0031	1			
DLD	-0.2148	-0.3147	-0.0833	-0.003	-0.0874	1		
DLWPI	0.2684	0.3036	-0.2028	0.023	0.0792	0.0382	1	
DLCPI	-0.0347	-0.0425	-0.3414	-0.0439	0.1907	0.0896	0.4199	1

4.3.2 SVAR Results

Since all the variables are stationary, we move forward to fit the Recursive Structural VAR model which is explained in methodology part. The lag length four is determined as per the traditional lag selection criteria tests, namely, LR, FPE, AIC, SC and HQ and also considering the autocorrelation in the models after fitting unrestricted VAR models. Table 4.3 shows the estimated coefficients of SVAR model. The second part shows that the autocorrelation in the different lag structure after fitting the model. It is very clear from this part that the model could catch maximum information when we select four lag, where there is no sign of autocorrelations in any model. After series of trial and error model with different lags, model with lag 4 shows high log likelihood and give robust results compared to other lag models. From table 4.3, one can find that contemporaneous relationships between the variables and the coefficients are statistically significant and having expected sign except in few cases.

Table 4.4 Estimates of Coefficients in the Contemporaneous Impact Matrix of SVAR

		Model 1		Model 2		Model 3		Model 4	
		(7- Var, $, 98-2014)		(7- Var, $, 98-2007)		(7- Var, $, 2007-2014)		(7-Var, NEER, 98-2014)	
	Coefficient	Estimate	P- Value	Estimate	P- Value	Estimate	P- Value	Estimate	P- Value
World Inflation	α	-0.5231	0.000	-0.465	0.000	-0.6294	0.000	-0.5281	0.000
M3	Γ1	-0.0663	0.000	-0.533	0.000	-0.2801	0.035	-0.3317	0.000
	Γ2	0.1159	0.000	0.9684	0.000	0.213	0.058	0.4167	0.000
IIP Gap	b1	0.1078	0.195	0.1305	0.237	0.093	0.496	0.094	0.255
	b2	-0.2378	0.000	-0.2687	0.032	-0.2544	0.027	-0.2105	0.006
	b3	-0.0084	0.084	-0.001	0.985	0.0129	0.908	0.008	0.905
Exchange rate ($/Neer)	α1	0.063	0.041	-0.0171	0.877	0.0827	0.539	0.025	0.763
	α2	0.1789	0.025	0.0388	0.761	0.2784	0.019	-0.0591	0.445
	α3	-0.012	0.096	-0.017	0.850	-0.0013	0.990	-0.0006	0.992
	α4	-0.0179	0.798	0.0071	0.937	-0.0281	0.802	0.0478	0.496
WPI Inflation	λ1	0.0206	0.068	-0.0006	0.995	-0.0527	0.701	0.0117	0.888
	λ2	0.0302	0.709	0.0035	0.978	0.0438	0.721	-0.0535	0.490
	λ3	0.0032	0.964	-0.0062	0.945	0.00861	0.939	0.006	0.931
	λ4	0.0317	0.651	0.0447	0.620	0.0284	0.800	0.0565	0.421
	λ5	0.3366	0.000	0.3999	0.000	0.2182	0.052	-0.4153	0.000
CPI Inflation	β1	0.024	0.098	-0.0056	0.959	-0.0106	0.939	0.0111	0.894
	β2	-0.025	0.758	-0.00199	0.988	-0.0439	0.720	-0.0523	0.500
	β3	0.0097	0.889	0.0029	0.974	0.0227	0.840	0.0144	0.837
	β4	0.985	0.161	0.1088	0.228	0.0885	0.432	0.1064	0.131
	β5	0.1169	0.104	0.04301	0.078	0.0762	0.092	-0.1553	0.041
	β6	0.7832	0.000	0.6033	0.000	0.7928	0.000	0.8058	0.000
	Lagrange- Multiplier Test for Auto- Correlation								
	lag	chi2	Prob	chi2	Prob	chi2	Prob	chi2	Prob
	1	85.7709	0.00091	74.9679	0.0099	54.8242	0.26327	69.6428	0.02783
	2	64.8985	0.06363	48.7926	0.48147	60.0866	0.13321	59.3252	0.14826
	3	79.684	0.00365	72.9616	0.0148	44.5629	0.65342	75.9325	0.00812
	4	58.428	0.16759	37.702	0.87986	42.0838	0.74739	60.4101	0.12718
	5	65.2606	0.05994	43.7742	0.68435	38.9739	0.84682	64.5281	0.06761

Of the special interest is the equations of WPI and CPI inflation. The pass-through coefficients, λ_5 and β_5 are significant with expected sign in all four models either at 1%, 5% or 10% significance level. The coefficient is positive in all first three models which imply that the dollar depreciation has a positive impact on inflation. The positive relationship between the depreciation and inflation is as we expected. It should be noted that both λ_5 and β_5 have a negative sign in the case of the NEER. The opposite sign in the case of NEER is expected because the decreasing (increasing) value of NEER denotes depreciation (appreciation).

Table 4.5 Granger Causality Wald Test ($)

Equation	Excluded	chi2	Prob
dloi	dlwi	19.704	0.001
dloi	dlm3	7.852	0.158
dloi	liipg	4.124	0.572
dloi	dld	3.424	0.672
dloi	dlwpii	7.457	0.189
dloi	dlcpii	3.514	0.692
dlwi	dloi	14.677	0.012
dlwi	dlm3	7.882	0.163
dlwi	liipg	7.336	0.197
dlwi	dld	21.321	0.001
dlwi	dlwpii	8.154	0.148
dlwi	dlcpii	9.408	0.094
dlm3	dloi	13.269	0.021
dlm3	dlwi	11.211	0.047
dlm3	liipg	16.706	0.005
dlm3	dld	4.195	0.522
dlm3	dlwpii	8.879	0.114
dlm3	dlcpii	3.314	0.652
liipg	dloi	22.538	0.000
liipg	dlwi	23.209	0.000
liipg	dlm3	19.700	0.001
liipg	dld	12.151	0.033
liipg	dlwpii	6.683	0.245
liipg	dlcpii	29.433	0.000
dld	dloi	5.735	0.333
dld	dlwi	7.980	0.157
dld	dlm3	6.844	0.233
dld	liipg	17.208	0.004
dld	dlwpii	12.038	0.034
dld	dlcpii	9.478	0.094
dlwpii	dloi	6.197	0.283
dlwpii	dlwi	11.294	0.046
dlwpii	dlm3	17.400	0.004
dlwpii	liipg	10.203	0.070
dlwpii	dld	20.221	0.002
dlwpii	dlcpii	3.305	0.653
dlcpii	dloi	3.522	0.620
dlcpii	dlwi	2.064	0.840
dlcpii	dlm3	17.472	0.004
dlcpii	liipg	6.137	0.293
dlcpii	dld	18.610	0.003
dlcpii	dlwpii	17.025	0.004

Table 4.6 Granger Causality Wald Test (NEER)

Equation	Excluded	chi2	Prob
dloi	dlwi	15.861	0.007
dloi	dlm3	6.266	0.281
dloi	liipg	7.607	0.179
dloi	dlneer	8.451	0.133
dloi	dlwpii	6.089	0.250
dloi	dlcpii	7.436	0.187
dlwi	dloi	11.262	0.046
dlwi	dlm3	5.179	0.394
dlwi	liipg	8.473	0.132
dlwi	dlneer	7.422	0.191
dlwi	dlwpii	3.491	0.625
dlwi	dlcpii	7.156	0.209
dlm3	dloi	14.336	0.014
dlm3	dlwi	13.203	0.022
dlm3	liipg	14.764	0.011
dlm3	dlneer	2.139	0.830
dlm3	dlwpii	10.089	0.073
dlm3	dlcpii	3.244	0.662
liipg	dloi	19.076	0.002
liipg	dlwi	20.824	0.001
liipg	dlm3	21.025	0.001
liipg	dlneer	12.040	0.034
liipg	dlwpii	8.568	0.128
liipg	dlcpii	33.146	0.000
dlneer	dloi	8.227	0.144
dlneer	dlwi	11.220	0.047
dlneer	dlm3	2.319	0.803
dlneer	liipg	19.106	0.002
dlneer	dlwpii	13.303	0.029
dlneer	dlcpii	1.638	0.897
dlwpii	dloi	12.825	0.025
dlwpii	dlwi	10.777	0.056
dlwpii	dlm3	19.272	0.002
dlwpii	liipg	13.117	0.022
dlwpii	dlneer	10.997	0.050
dlwpii	dlcpii	3.253	0.661
dlcpii	dloi	6.177	0.289
dlcpii	dlwi	4.565	0.471
dlcpii	dlm3	14.264	0.014
dlcpii	liipg	15.480	0.008
dlcpii	dlneer	9.458	0.095
dlcpii	dlwpii	19.352	0.002

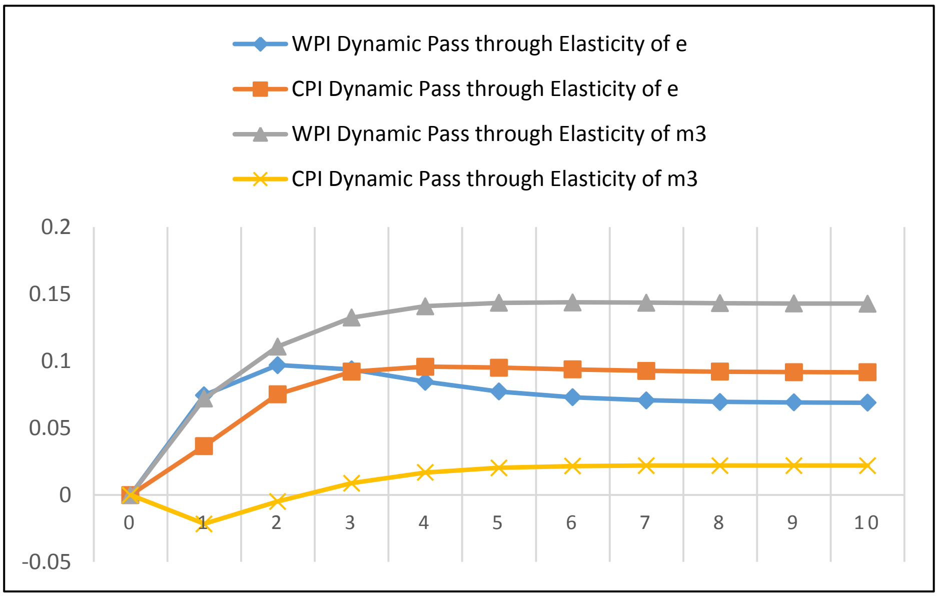
Moreover, the positive impact of the WPI inflation on CPI inflation can also be seen from these four models. β_6 is significant at 1% level and positive in all four models which give more evidence for the justification for the variables' order and putting the WPI inflation in first in the order. It implies that when there is a shock in the WPI inflation, the retail price inflation is positively affected.

Tables 4.5 and 4.6 show the results of Ganger Causality Wald test which is derived from SVAR model as a diagnostic check to the reliability of the model using rupees- dollar and NEER exchange rate. Here the focus is on the relationship of the exchange rate vis-à-vis money supply and inflation. Bi-directional causality can be seen between rupee – dollar exchange rate (dld) and WPI inflation and rupee – dollar exchange rate (dld) and CPI inflation at 5% and 10% significance level. However, only unidirectional causality can be seen from Money supply (dlm3) to WPI inflation and CPI inflation at a significant level, not vice versa. Secondly, the causality analysis using NEER reveals the same bidirectional causality between NEER vis-a-vis CPI and WPI inflation and unidirectional relationship between money supply and inflation except in the case of WPI inflation which has a bidirectional relationship at 10% significance level.

Table 4.7 Accumulated Impulse Responses (AIR) of Domestics Price Levels to Structural One SD Shocks and Dynamic Pass through Elasticity (1998- 2014)

Months	Estimated Response of e one SDA shock to e (e1)	Estimated Response of w one SDA shock to e (w1)	WPI Dynamic Pass through Elasticity of e (w1/e1)	Estimated Response of c one SDA shock to e (C1)	CPI Dynamic Pass through Elasticity of e (C1/e1)	Estimated Response of m one SDA shock to m (m1)	Estimated Response of w one SDA shock to m (w2)	WPI Dynamic Pass through Elasticity of m3 (w2/m1)	Estimated Response of c one SDA shock to m3 (C2)	CPI Dynamic Pass through Elasticity of m3 (C2/m1)
0	1	0	0	0	0	1	0	0	0	0
1	1.353	0.101	0.075	0.049	0.037	0.981	0.071	0.072	-0.021	-0.022
2	1.465	0.142	0.097	0.110	0.075	0.968	0.107	0.111	-0.005	-0.005
3	1.518	0.142	0.094	0.140	0.092	0.966	0.128	0.132	0.009	0.009
4	1.548	0.131	0.084	0.148	0.096	0.961	0.135	0.141	0.016	0.017
5	1.562	0.121	0.077	0.148	0.095	0.959	0.137	0.143	0.019	0.020
6	1.569	0.114	0.073	0.147	0.094	0.958	0.138	0.144	0.021	0.022
7	1.571	0.111	0.071	0.145	0.093	0.957	0.137	0.143	0.021	0.022
8	1.571	0.109	0.069	0.145	0.092	0.957	0.137	0.143	0.021	0.022
9	1.571	0.108	0.069	0.144	0.092	0.957	0.137	0.143	0.021	0.022
10	1.571	0.108	0.069	0.144	0.092	0.957	0.137	0.143	0.021	0.022

Fig. 4.1 Dynamic Pass through Elasticity ($,1998-2014)



4.3.3 SVAR Dynamic Pass-through Elasticity

This section compares the dynamic pass-through elasticity of exchange rate and money supply to WPI and CPI inflation during the pre and post financial crisis period.

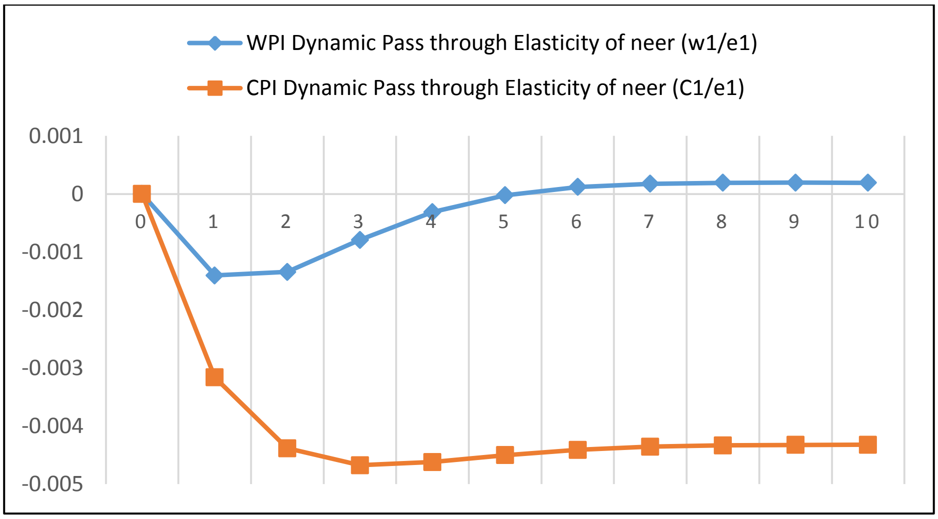
Table 4.8 Accumulated Impulse Responses (AIR) of Domestics Price Levels to Structural One SD Shocks and Dynamic Pass through Elasticity (1998- 2014)

Months	Estimated Response of neer one SDA shock to neer (e1)	Estimated Response of w one SDA shock to neer (w1)	WPI Dynamic Pass through Elasticity of neer (w1/e1)	Estimated Response of c one SDA shock to neer (C1)	CPI Dynamic Pass through Elasticity of neer (C1/e1)
0	1	0	0	0	0
1	0.997	-0.001	-0.001	-0.003	-0.003
2	0.999	-0.001	-0.001	-0.004	-0.004
3	1.000	-0.001	-0.001	-0.005	-0.005
4	1.000	0.000	0.000	-0.005	-0.005
5	1.000	0.000	0.000	-0.005	-0.005
6	1.000	0.000	0.000	-0.004	-0.004
7	1.000	0.000	0.000	-0.004	-0.004
8	1.000	0.000	0.000	-0.004	-0.004
9	1.000	0.000	0.000	-0.004	-0.004
10	1.000	0.000	0.000	-0.004	-0.004

Though we have made the comparison separately for rupee- dollar exchange rate and NEER by classifying pre and post-crisis period, the analysis of NEER avoided since it yields the same results.

Table 4.7 shows Accumulated Impulse Responses (AIR) of domestic inflation to structural one SD shocks and dynamic pass-through elasticity of exchange rate and money supply using rupee- dollar exchange rate for the entire study period (1998-2014). Considering the short time analysis, we have taken ten months period to check the impact of various structural shocks. The response of exchange rate to its own shock always has a positive impact, and the response is getting peak with ten months. As a result of exchange rate shock WPI inflation also getting increased and reaching to the peak level within four months.

Fig. 4.2 Dynamic Pass through Elasticity (NEER, 1998-2014)



CPI inflation is reaching its peak in 5 months. In the same way, the response of WPI to the positive shock in money supply is positive and reaching at peak with six months, while it shows negative impact in CPI for two months and it turns positive. The WPI and CPI dynamic elasticity of exchange rate are lesser than the WPI elasticity of money supply but still, it is higher than the CPI elasticity of money supply. (see table 4.6 and fig. 4.1). While using NEER also, the same changes can be seen. One positive SD shock to NEER means the exchange rate is appreciation. So the negative impact should be expected in inflation level. WPI and CPI Dynamic pass-through elasticity of NEER show a declining trend. Though the negative impact persists only for five months in WPI inflation, it is continuously getting down in CPI for whole ten months.

The comparison of exchange rate pass-through in pre and post financial period reveals that dynamic pass-through and response functions are entirely different in two periods. Table 4.9 shows that the exchange rate has high positive changes (173% in the 10^{th} month) as a result of one SD shock in exchange rate itself in the pre-crisis period. However, the response of CPI and WPI response as a result of exchange rate shock is also very high and touches its peak level in the 7^{th} month. This leads to high level of WPI and CPI dynamic pass-through elasticity of exchange rate over this period. This high pass-through effect is a result of the consistent depreciation of the rupee without any major trend of appreciation in between. At the same time, CPI inflation and WPI inflation seems to be less responsive to the shocks in money supply in this period. So when we analyse the dynamic pass-through elasticity of exchange rate and money supply, WPI and CPI dynamic pass-through elasticity of exchange rate is comparatively higher than that of money supply (see fig.4.3).

Table 4.9 Accumulated Impulse Responses (AIR) of Domestics Price Levels to Structural One SD Shocks and Dynamic Pass through Elasticity (1998- 2008)

Months	Estimated Response of e one SDA shock to e (e1)	Estimated Response of w one SDA shock to e (w1)	WPI Dynamic Pass through Elasticity of e (w1/e1)	Estimated Response of c one SDA shock to e (C1)	CPI Dynamic Pass through Elasticity of e (C1/e1)	Estimated Response of m one SDA shock to m (m1)	Estimated Response of w one SDA shock to m (w2)	WPI Dynamic Pass through Elasticity of m3 (w2/m1)	Estimated Response of c one SDA shock to m3 (C2)	CPI Dynamic Pass through Elasticity of m3 (C2/m1)
0	1	0	0	0	0	1	0	0	0	0
1	1.392	0.160	0.115	0.097	0.070	0.979	0.068	0.069	0.044	0.045
2	1.559	0.263	0.168	0.232	0.149	0.966	0.090	0.094	0.072	0.074
3	1.639	0.294	0.180	0.315	0.192	0.966	0.100	0.104	0.079	0.082
4	1.677	0.290	0.173	0.346	0.206	0.965	0.104	0.107	0.083	0.086
5	1.694	0.279	0.165	0.351	0.207	0.965	0.105	0.109	0.085	0.088
6	1.701	0.271	0.159	0.349	0.205	0.965	0.105	0.109	0.085	0.089
7	1.703	0.267	0.157	0.346	0.203	0.965	0.105	0.109	0.086	0.089
8	1.703	0.265	0.156	0.344	0.202	0.965	0.105	0.109	0.086	0.089
9	1.703	0.265	0.155	0.344	0.202	0.964	0.105	0.109	0.086	0.089
10	1.703	0.265	0.155	0.344	0.202	0.964	0.105	0.109	0.086	0.089

Fig. 4.3 Dynamic Pass through Elasticity ($,1998-2008)

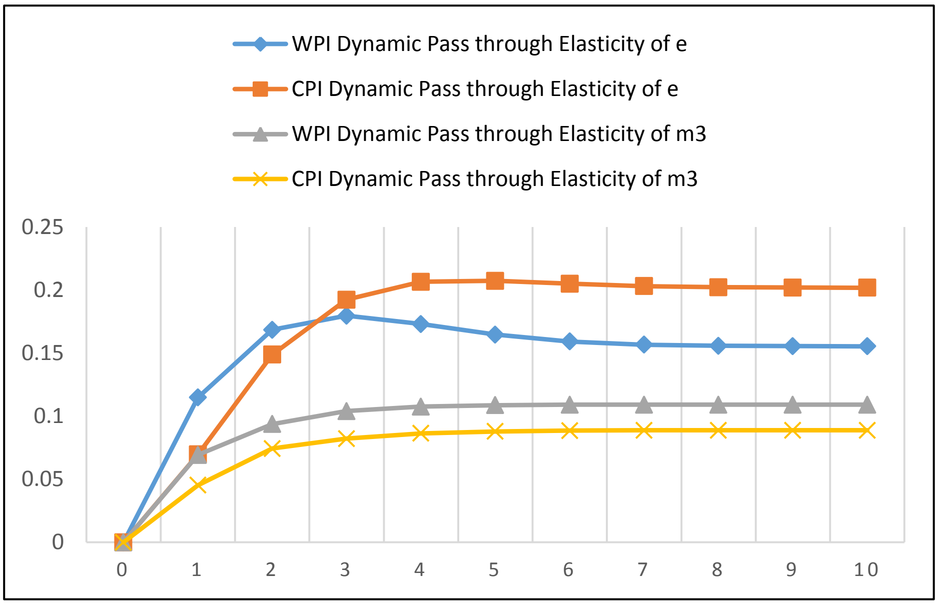


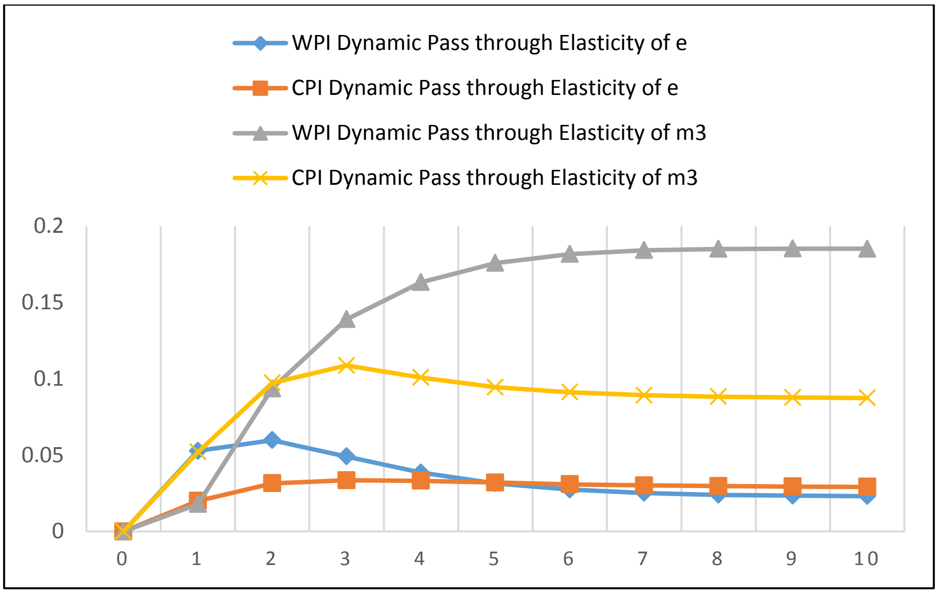
Table 4.10 Accumulated Impulse Responses (AIR) of Domestics Price Levels to Structural One SD Shocks and Dynamic Pass through Elasticity (2008- 2014)

Months	Estimated Response of e one SDA shock to e (e1)	Estimated Response of w one SDA shock to e (w1)	WPI Dynamic Pass through Elasticity of e (w1/e1)	Estimated Response of c one SDA shock to e (C1)	CPI Dynamic Pass through Elasticity of e (C1/e1)	Estimated Response of m one SDA shock to m (m1)	Estimated Response of w one SDA shock to m (w2)	WPI Dynamic Pass through Elasticity of m3 (w2/m1)	Estimated Response of c one SDA shock to m3 (C2)	CPI Dynamic Pass through Elasticity of m3 (C2/m1)
0	1	0	0	0	0	1	0	0	0	0
1	1.388	0.073	0.053	0.028	0.020	0.905	0.016	0.018	0.047	0.052
2	1.470	0.088	0.060	0.046	0.032	0.918	0.086	0.094	0.089	0.097
3	1.499	0.074	0.049	0.050	0.033	0.915	0.127	0.139	0.099	0.109
4	1.518	0.059	0.039	0.050	0.033	0.908	0.148	0.163	0.091	0.101
5	1.531	0.048	0.032	0.049	0.032	0.906	0.159	0.176	0.085	0.094
6	1.538	0.042	0.027	0.048	0.031	0.904	0.164	0.182	0.082	0.091
7	1.542	0.039	0.025	0.046	0.030	0.903	0.166	0.184	0.081	0.089
8	1.544	0.037	0.024	0.046	0.030	0.903	0.167	0.185	0.080	0.088
9	1.544	0.036	0.023	0.045	0.029	0.902	0.167	0.185	0.079	0.088
10	1.545	0.036	0.023	0.045	0.029	0.902	0.167	0.185	0.079	0.087

Table 4.10 and figure 4.4 shows the situations during post financial period. The exchange rate is not much positively responsive for its own shock during this period. This may be due to high volatility during this period and the directions of the changes were only on one side. The WPI and CPI also found to be not much responsive to this high volatile position of the exchange rate since changes in the exchange rate in this

period was very high. However, both have responded well for the domestic monetary policies. That led higher level of WPI and CPI dynamic pass-through elasticity of money supply than that of the exchange rate in the post-financial period. It can be seen from figure 4.4 that WPI elasticity of money supply is higher than the CPI elasticity, whereas the WPI and CPI elasticity of exchange rate is almost same and stagnant over the period.

Fig. 4.4 Dynamic Pass through Elasticity ($,2008-2014)

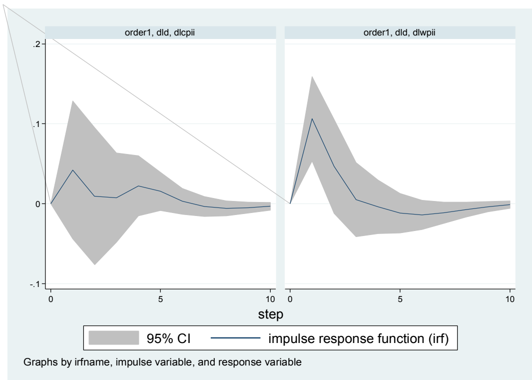


4.3.4 SVAR Impulse Response Functions

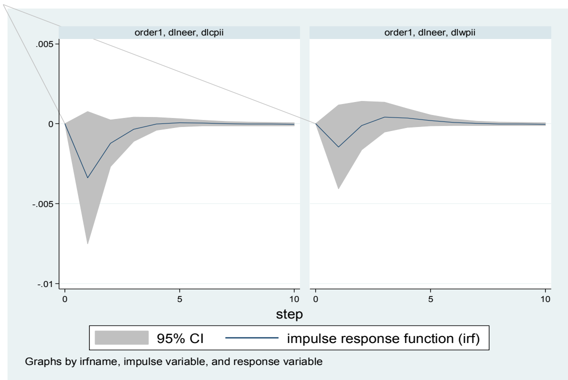
Impulse Response Function helps us understand the magnitude of the changes in one variable when the shock is given to other variables. Since our prime concentration is on the relationship between exchange rate and money supply vis-a-vis WPI and CPI inflation, here we give response function of inflation variables to one SD shock to the exchange rate, money supply. Pre and post- financial crisis periods are also being considered to confirm the pass-through elasticity results.

Fig. 4.5 Impulse Response of Domestic Inflation to one SD Structural Shock to other Variables for the Entire Study Period

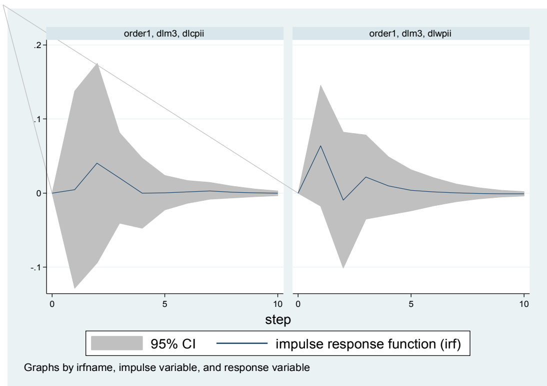
Dollar => CPI and WPI



NEER => CPI and WPI



MS => CPI and WPI



WPI => CPI and WPI

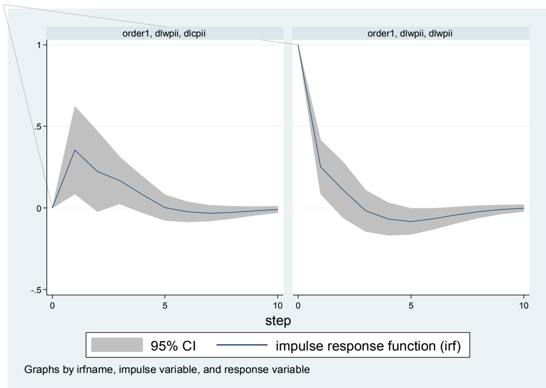
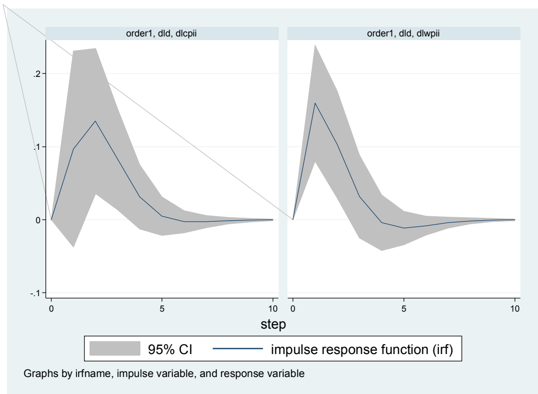


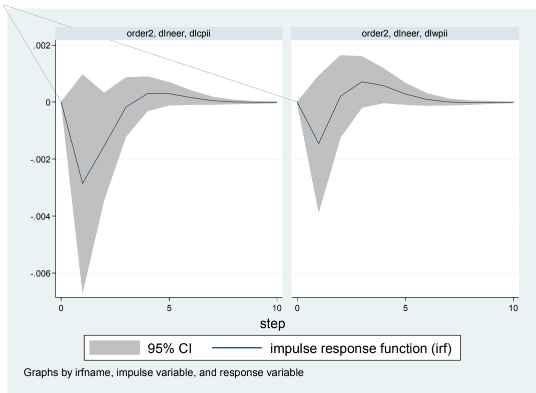
Figure 4.5 shows the impulse response functions of CPI and WPI to the shock in the exchange rate, money supply and WPI inflation respectively for the entire study period. The positive impact of one SD shock in the rupee-dollar exchange rate to WPI and CPI getting its peak before five months and response of WPI is higher than CPI as expected. It is because the possibility of external impact is higher in WPI due to its high weight for oil price inflation where the food inflation is given high weight is CPI inflation. Positive shocks in NEER (appreciation) lead to a negative impact in CPI and WPI inflation. It means, if there is a negative shock (depreciation) obviously there will positive impact in the inflation level. Though money supply has a positive impact on inflation, it is not as much as there in exchange rate shock. The positive impact of WPI inflation on CPI inflation justifies our ordering and the logic to put the WPI inflation before CPI inflation.

Fig. 4.6 Impulse Response of Domestic Inflation to one SD Structural Shock to other Variables for the Period of 1998-2008

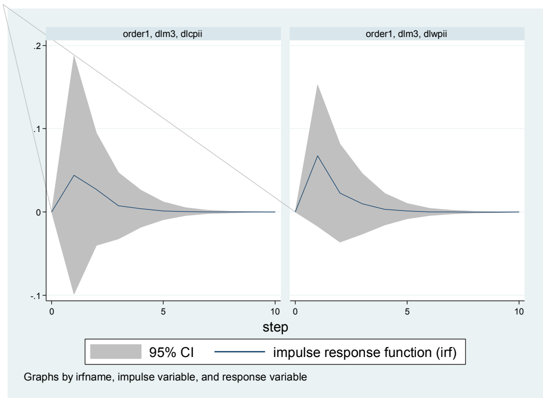
Dollar => CPI and WPI



NEER => CPI and WPI



MS => CPI and WPI



WPI => CPI and WPI

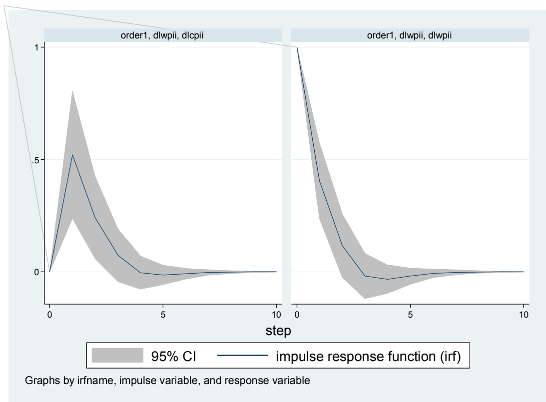
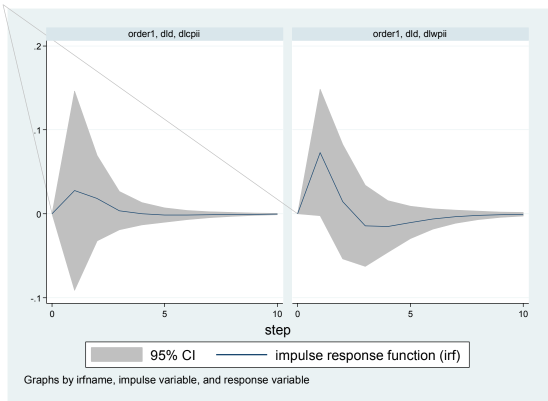


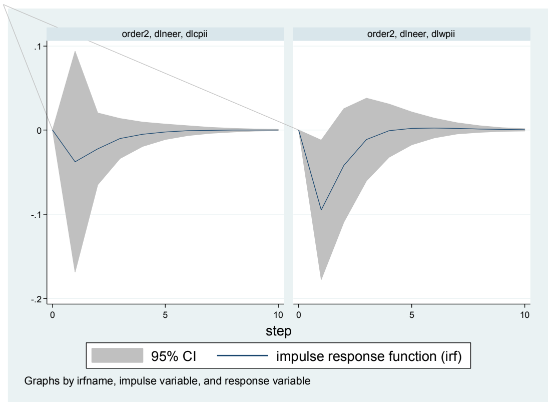
Figure 4.7 and 4.8 make a comparison of impulse response functions between the pre and post financial period. As per the result of SVAR, during both period the exchange rate and money supply have a significant impact on WPI and CPI inflation. However, the strength and impact differ according to the period. The impact of exchange rate shock has a lesser impact in post-crisis period comparing to the pre-crisis period. This is true in both cases of Rupee- dollar and NEER exchange rate. However, it evident that the WPI is getting more affected by the exchange rate shocks in both periods. Contrary to this, money supply had greater impact in the post-crisis period, which confirms the results of dynamic pass-through elasticity. The response of CPI inflation as a result of shocks in the WPI inflation is even lesser in the post-financial crisis period.

Fig. 4.7 Impulse Response of Domestic Inflation to one SD Structural Shock to Other Variables for the Period of 2008-2014

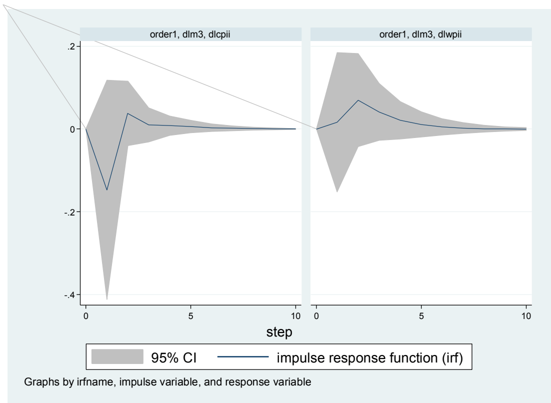
Dollar => CPI and WPI



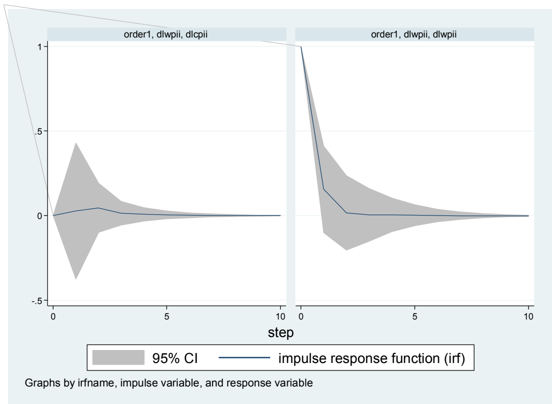
NEER => CPI and WPI



MS => CPI and WPI



WPI => CPI and WPI



4.3.5 Exchange Rate Pass-through: A Disaggregated Analysis Using VAR Model

The logic behind fitting separate unrestricted Vector Auto Regressive models, after fitting the SVAR model is to make disaggregated analysis of exchange rate pass-through to different product groups and also evaluate the pass-through effect in a different lag level where only the joint significance level of all lags is taken together in SVAR models. So it is quite possible that the exchange rate pass-through will be significant in some lags where joint significance in SVAR is not found. Tables 4.11, 4.12, 4.13 and 4.14 show the results of VAR model using rupee- dollar exchange rate and NEER respectively. Three lags are selected as per LR, FPE, AIC, SC and HQ information criteria and also considering the log likelihood and autocorrelation in the models.

The results of product wise VAR estimation using rupee- dollar exchange rate (Table 4.11) reveal that the pass-through coefficient in total WPI is positive and significant at 1% level using lag one, while the lag 2 and 3 are not significant. In the primary article also the lag one coefficient is positive and significant at 5% significance level. While there is a significant and positive relationship in the case of food items, a significant relationship was not found in nonfood articles. Fuel and mineral oil products are also positively affected by the changes in the exchange rate. The study could not find any significant impact exchange rate fluctuations on the price level of manufactured products, beverages, and tobacco products wood and wood products leather and leather products metal and metal products transport and transport equipment. However, the positive coefficient in the case of chemical and chemical products are significant at 5% in lag one.

The estimation result using NEER (table 4.13) even reveal similar results. The exchange rate pass-through coefficient is negative and significant in lag one and lag three at 1% and 5% significance level respectively in the case of total WPI. This negative sign is expected since increasing value of NEER indicates an appreciation of the exchange rate and vice versa. The results displays that pass-through coefficient is significant at various lag levels in the case of primary article, food articles, fuel, power and lubricants, whereas no evidence of pass-through in nonfood articles and mineral oils using NEER is found. It is evident from table 4.14 that the impact of changes in the exchange rate (NEER) does make any significant influence in manufactured products, beverages and tobacco products, wood and wood products, leather and leather products, and transport and its equipment, though all the coefficients carry negative sign as expected. The pass-through coefficient in chemical and chemical products and metal and metal products are significant at 5% in lag one.

In sum, it may concluded that primary articles, food articles are more affected by the drastic volatility in the exchange rate whereas nonfood items and manufactured products are not much affected.

4.4 Summary and Concluding Remarks

The aim of this chapter was two. Firstly, to evaluate exchange rate pass-through by estimating its extent and speed, in general level, which is done by using SVAR Modes following McCarthy (2000,2007). Secondly, to check the extent of exchange rate pass-through in disaggregated level by classifying inflation level according to different product groups which are done by unrestricted VAR models. SVAR results show that during the whole study period, the exchange rate pass-through coefficient is significant both in WPI and CPI inflation. The pass-through is found to be higher to the CPI inflation than to WPI inflation. Moreover, a pass-through impact is higher in the pre-crisis period compared to post-crisis period. It is because of the high volatile position of exchange rate during the post-crisis period. Estimation of Pass-through using Rupee- Dollar exchange rate with disaggregated WPI data reveals that Pass-through is significant in the primary articles, food items, Fuel and mineral oil products, Chemical and chemical products. Nonfood items, viz. manufactured products Beverages and tobacco products wood and wood products leather and leather products metal and metal products transport and transport equipment are not much affected by the changes in Exchange rate. Using NEER, the pass-through coefficient is significant at various lag levels in the case of the primary article, food articles, fuel, power and lubricants, whereas no evidence of pass-through is seen in the case of nonfood articles and mineral oils manufactured products beverages and tobacco products wood and wood products leather and leather products and transport and its equipment. In sum, we can conclude that primary articles, food articles are more affected by the drastic volatility in the exchange rate whereas nonfood items and manufactured products are not much affected.

----xxx----

Table 4.11 Product Wise VAR Estimation for WPI (Dollar)

	Total WPI		Primary Articles		Food		Non- Food		Fuel, Power & Lubricants		Mineral Oils	
Variable	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.
OIL_INFLATION(-1)	0.027	0.000	0.031	0.014	0.032	0.040	0.015	0.299	0.087	0.000	0.138	0.000
OIL_INFLATION(-2)	0.002	0.716	-0.003	0.803	-0.009	0.585	0.025	0.098	0.021	0.123	0.071	0.002
OIL_INFLATION(-3)	0.009	0.085	0.010	0.412	0.019	0.235	-0.011	0.430	0.037	0.006	0.045	0.051
M3(-1)	0.010	0.005	0.020	0.021	0.023	0.046	0.010	0.336	0.015	0.096	0.029	0.055
M3(-2)	0.005	0.223	-0.010	0.349	0.003	0.844	0.030	0.016	0.009	0.406	0.020	0.262
M3(-3)	0.006	0.116	0.012	0.162	0.022	0.053	0.020	0.059	0.004	0.666	0.006	0.698
IIPGAP(-1)	0.021	0.035	0.013	0.610	0.008	0.818	0.000	0.997	0.023	0.318	0.041	0.301
IIPGAP(-2)	0.019	0.068	0.060	0.019	0.063	0.060	0.026	0.368	0.004	0.859	-0.037	0.371
IIPGAP(-3)	0.022	0.032	0.069	0.007	0.068	0.040	0.022	0.449	-0.016	0.515	-0.041	0.312
DOLLAR(-1)	0.086	0.001	0.124	0.045	0.124	0.072	0.002	0.974	0.201	0.001	0.260	0.014
DOLLAR(-2)	0.003	0.909	0.033	0.612	0.019	0.817	0.058	0.460	-0.063	0.340	-0.113	0.310
DOLLAR(-3)	-0.017	0.505	-0.086	0.162	-0.093	0.239	-0.016	0.830	0.089	0.162	0.110	0.300
WPI_ INFLATION(-1)	0.264	0.000	0.155	0.038	0.199	0.009	0.252	0.000	0.192	0.005	0.048	0.485
WPI_ INFLATION(-2)	-0.008	0.916	-0.027	0.716	-0.096	0.217	-0.039	0.585	-0.046	0.524	-0.007	0.918
WPI_ INFLATION(-3)	0.086	0.187	0.184	0.010	0.170	0.024	0.028	0.688	0.120	0.059	0.149	0.017
Const	0.002	0.146	0.003	0.256	0.003	0.355	0.002	0.627	-0.001	0.796	-0.001	0.783
N of Obs.	201		201		201		201		201		201	

Table 4.12 Product Wise VAR Estimation for WPI (Dollar)

	Manufactored Prod		Bevarage and Tobaco		Wood and pro		Leather and Pro		Chemical and Pro		Metal and Pro		Transport and Equts	
Variable	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.
OIL_INFLATION(-1)	0.004	0.393	0.010	0.532	0.002	0.934	-0.008	0.635	0.015	0.000	0.019	0.087	-0.004	0.404
OIL_INFLATION(-2)	0.006	0.183	0.027	0.113	-0.012	0.558	-0.004	0.804	0.004	0.417	0.004	0.753	0.005	0.262
OIL_INFLATION(-3)	0.003	0.559	-0.035	0.034	-0.006	0.741	-0.006	0.703	0.006	0.136	0.018	0.105	0.002	0.691
M3(-1)	0.001	0.849	0.001	0.901	0.027	0.059	0.011	0.367	0.002	0.566	0.002	0.812	0.002	0.624
M3(-2)	0.002	0.625	0.002	0.890	0.032	0.054	0.008	0.549	0.005	0.189	0.001	0.896	0.003	0.511
M3(-3)	-0.002	0.460	0.007	0.579	-0.014	0.329	0.016	0.183	0.004	0.164	-0.003	0.749	0.001	0.771
IIPGAP(-1)	0.027	0.002	-0.022	0.478	0.013	0.734	-0.007	0.825	0.019	0.016	0.051	0.015	0.028	0.002
IIPGAP(-2)	0.001	0.905	-0.016	0.628	-0.046	0.230	0.022	0.498	0.011	0.182	-0.012	0.593	-0.016	0.093
IIPGAP(-3)	0.003	0.711	-0.002	0.956	0.018	0.638	0.013	0.691	-0.008	0.328	0.026	0.227	-0.016	0.086
DOLLAR(-1)	0.017	0.482	0.012	0.884	-0.033	0.735	0.065	0.436	0.058	0.005	0.032	0.563	0.012	0.627
DOLLAR(-2)	0.015	0.551	0.096	0.275	0.035	0.738	-0.073	0.403	-0.015	0.498	-0.053	0.363	0.032	0.195
DOLLAR(-3)	-0.017	0.478	-0.067	0.419	-0.147	0.135	0.039	0.643	0.000	0.984	-0.070	0.203	0.018	0.462
WPI_ INFLATION(-1)	0.123	0.083	0.569	0.000	0.525	0.000	0.109	0.122	0.174	0.014	0.209	0.003	0.068	0.334
WPI_ INFLATION(-2)	0.119	0.092	0.217	0.006	0.384	0.000	0.281	0.000	0.038	0.596	0.019	0.786	0.019	0.791
WPI_ INFLATION(-3)	-0.017	0.807	-0.087	0.213	-0.038	0.577	0.031	0.661	-0.011	0.871	0.069	0.308	0.094	0.180
Const	0.002	0.040	-0.002	0.656	0.008	0.104	0.004	0.303	-0.001	0.330	0.004	0.101	0.001	0.408
N of Obs.	201		201		201		201		201		201		201	

Table 4.13 Product Wise VAR Estimation for WPI (NEER)

	Total WPI		Primary Articles		Food		Non- Food		Fuel, Power & Lubricants		Mineral Oils	
Variable	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.
OIL_INFLATION(-1)	0.024	0.000	0.026	0.030	0.030	0.048	0.014	0.323	0.080	0.000	0.131	0.000
OIL_INFLATION(-2)	0.001	0.862	-0.003	0.781	-0.009	0.550	0.023	0.121	0.018	0.188	0.071	0.002
OIL_INFLATION(-3)	0.013	0.015	0.019	0.136	0.029	0.067	-0.009	0.545	0.032	0.017	0.039	0.091
M3(-1)	0.011	0.002	0.021	0.020	0.024	0.037	0.011	0.308	0.016	0.073	0.030	0.051
M3(-2)	0.005	0.276	0.008	0.456	0.000	0.978	0.027	0.025	0.010	0.345	0.024	0.185
M3(-3)	0.007	0.040	0.015	0.093	0.026	0.021	0.017	0.108	0.004	0.684	0.003	0.849
IIPGAP(-1)	0.016	0.103	0.010	0.692	0.006	0.861	0.005	0.859	0.012	0.619	0.030	0.458
IIPGAP(-2)	0.024	0.018	0.067	0.009	0.071	0.034	0.038	0.201	0.006	0.802	-0.048	0.263
IIPGAP(-3)	0.024	0.021	0.063	0.016	0.054	0.110	0.026	0.372	-0.003	0.895	-0.029	0.492
NEER(-1)	-0.112	0.000	-0.139	0.036	-0.127	0.048	-0.107	0.177	-0.193	0.005	-0.121	0.294
NEER(-2)	-0.010	0.708	-0.002	0.971	0.026	0.753	-0.038	0.627	-0.016	0.817	-0.012	0.915
NEER(-3)	0.002	0.063	0.005	0.088	0.009	0.015	-0.001	0.875	-0.002	0.572	0.000	0.967
WPI_ INFLATION(-1)	0.320	0.000	0.200	0.007	0.241	0.001	0.247	0.000	0.225	0.001	0.061	0.378
WPI_ INFLATION(-2)	-0.018	0.805	-0.033	0.658	-0.085	0.271	-0.031	0.663	-0.020	0.786	0.001	0.985
WPI_ INFLATION(-3)	0.073	0.257	0.160	0.027	0.138	0.066	0.025	0.719	0.129	0.043	0.160	0.011
Const	0.002	0.134	0.003	0.218	0.004	0.252	0.001	0.680	-0.001	0.762	-0.001	0.808
N of Obs.	201		201		201		201		201		201	

Table 4.14 Product Wise VAR Estimation for WPI (NEER)

	Manufactored Prod		Bevarage and Tobaco		Wood and pro		Leather and Pro		Chemical and Pro		Metal and Pro		Transport and Equts	
Variable	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.
OIL_INFLATION(-1)	0.004	0.445	0.009	0.568	0.003	0.864	-0.009	0.575	0.014	0.001	0.019	0.081	-0.005	0.251
OIL_INFLATION(-2)	0.006	0.172	0.026	0.114	-0.010	0.593	-0.004	0.824	0.004	0.348	0.006	0.573	0.004	0.422
OIL_INFLATION(-3)	0.004	0.375	-0.030	0.068	0.003	0.864	-0.007	0.668	0.007	0.092	0.021	0.054	0.001	0.753
M3(-1)	0.000	0.911	0.000	0.997	0.027	0.061	0.011	0.354	0.002	0.531	-0.003	0.706	0.002	0.648
M3(-2)	0.002	0.564	0.002	0.884	0.040	0.016	0.007	0.608	0.005	0.183	0.005	0.622	0.002	0.536
M3(-3)	0.003	0.370	0.005	0.663	-0.021	0.146	0.015	0.214	0.004	0.152	0.005	0.563	0.001	0.780
IIPGAP(-1)	0.026	0.003	-0.025	0.431	0.012	0.744	-0.011	0.733	0.017	0.037	0.053	0.011	0.025	0.006
IIPGAP(-2)	0.002	0.806	-0.019	0.568	-0.013	0.735	0.033	0.332	0.012	0.160	0.002	0.912	-0.015	0.131
IIPGAP(-3)	0.006	0.566	0.006	0.852	0.021	0.592	0.011	0.738	-0.005	0.565	0.024	0.287	-0.016	0.089
NEER(-1)	-0.022	0.396	0.006	0.947	-0.195	0.065	-0.117	0.199	-0.051	0.028	-0.096	0.106	-0.028	0.275
NEER(-2)	-0.025	0.319	-0.144	0.101	0.016	0.880	0.096	0.281	-0.008	0.724	0.084	0.147	-0.002	0.943
NEER(-3)	0.001	0.596	0.003	0.496	0.001	0.781	-0.001	0.821	0.000	0.744	0.000	0.942	0.000	0.747
WPI_ INFLATION(-1)	0.122	0.086	0.560	0.000	0.532	0.000	0.099	0.160	0.185	0.009	0.216	0.002	0.088	0.210
WPI_ INFLATION(-2)	0.120	0.088	0.217	0.006	0.390	0.000	0.284	0.000	0.025	0.735	0.012	0.871	0.022	0.757
WPI_ INFLATION(-3)	-0.015	0.831	-0.079	0.256	-0.043	0.540	0.042	0.553	-0.003	0.966	0.079	0.239	0.111	0.113
Const	0.002	0.043	-0.002	0.655	0.007	0.155	0.004	0.310	-0.001	0.326	0.004	0.123	0.001	0.415
N of Obs.	201		201		201		201		201		201		201	

Chapter 5

Exchange Rate and Inflation: Volatility Pass-Through and Structural Breaks

5.1 Introduction

The presence of volatility in financial and currency markets has drawn the attention of scholars exploring various forms of non-linearities and chaotic behavior in the exchange markets (Adrangi and Allender, 2011). Bussiere (2013) shows potential possibilities of non-linearities and asymmetries in the exchange rate pass-through channel. According to him, the prices are found to be rigid downwards when quantities are rigid upwards, and the asymmetric impact can be summed up in Peltzamn's (2000) words: "the prices rise faster than they fall." When the exporters face depreciation of the domestic currency, assuming *ceterisparibus*, they gain price competitiveness and market share if they keep the prices unchanged. These kinds of asymmetric and non-linear pattern of relationship between exchange rate and inflation encourage researchers to go beyond the linear relationship of the variables and get more intuitive implication from various nonlinear models developed recently.

Among these non-linear patterns, modeling exchange rate volatility and its pass-through or spillover to other macro or financial variables become a fertile research area for economist and policy makers. In the empirical economic literature, there are several studies which used various linear equation models, however, the studies which examined nonlinear relationship are limited in general and in developing countries in particular. Classical linear regression model (CLRM) draw only the linear average mean relationship of the variable based on the assumption that the variance of the errors is constant (which is known as homoscedasticity). If the variance of the errors is not constant, it is known as heteroscedasticity. It is very likely to have a varying variance for errors, especially in financial variables such as stock reruns or exchange rate returns. When CLRM tries to model the average relationship, it does not try to model the volatility of the series. The focus of the heteroscedastic models is to employ various tools and techniques to model the volatility of the series. It may be either univariate or multivariate. Before going to the nonlinear relationship, we should check the possibility of nonlinear dependence between the variables using various statistical tests.

In addition to the previous chapter's linear equation models, the focus of this chapter is to model the volatility of exchange rate and inflation and to examine the volatility pass-through from exchange rate to the domestic inflation in a nonlinear setup. This chapter has three objectives. Firstly, to fit univariate heteroscedastic model for the exchange rate and inflation variables to check whether the volatility of the series is determined according to past shocks and past volatility. Secondly, to check the structural shifts in the volatility series after drawing it from the best univariate model. Thirdly to check the strength and degree of volatility pass-through between exchange rate and inflation. Accordingly, detailed methodology and data source are discussed here. The empirical analysis is carried through univariate models, structural breaks, and multivariate GARCH models and findings are discussed.

5.2 Data and Methodology

This chapter uses same monthly data from January 1998 to December 2014, which was used in the last chapter. The detailed description and justification of period, etc. are given in the previous chapter. All the data series used for the study are taken from various sources. A period average of rupees per dollar on a monthly basis (henceforth dollar) and Nominal Effective Exchange Rate considering 36 countries (henceforth NEER) are taken as the variables of the exchange rate.

Table 5.1 Discriptive Statistics

	Exch. Rate ($)	Exch. Rate (NEER)	WPI Inflation	CPI Inflation
Mean	0.000989	-0.001062	0.001903	0.002525
Median	0.000379	-0.000666	0.001851	0.002893
Maximum	0.028477	0.014505	0.011057	0.019429
Minimum	-0.017979	-0.026243	-0.00838	-0.010792
Std. Dev.	0.007335	0.006643	0.002995	0.004241
Skewness	0.831736	-0.551154	-0.271841	-0.140674
Kurtosis	5.477096	4.01735	4.533804	4.636014
Jarque-Bera	75.67675	19.12572	22.50924	23.42345
Sum Sq. Dev.	0.010922	0.008957	0.001821	0.003651
Observations	204	204	204	204

Rupee- dollar exchange rate data is collected from the database of International Monetary Fund, while NEER data is made available from the Bank of International

Settlement (BIS) with the base year of 2010. Finally, the WPI and CPI inflation is calculated from the WPI and CPI indices published by Reserve Bank of India.

5.2.1 Introduction to GARCH Models

The heteroscedastic econometric models are used to capture the time varying nature of the variance of the data series, which is very common in the financial variables. In this direction, the new models, viz. the Autoregressive Conditional Heteroskedasticity (ARCH) model formulated by Engle (1982) and its extension, Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model formulated by Bollerslev (1986), and Taylor (1986) occupies the central place in the economic and financial literature. Hence, the same conditional heteroskedasticity framework has been adopted here to analyze the nature of volatility of exchange rate and inflation in India. EGARCH is also used along with simple univariate GARCH model to check asymmetric impact in the volatility series.

The ARCH model, however, had some major technical drawbacks often raising doubts on its reliability of the model, such as difficulty to decide the number of lags, violation of non-negativity constraints. By overcoming all these issues, Bollerslev (1986) proposed the generalized ARCH (GARCH) model. The GARCH model studies conditional variance to be a linear combination between squared residual and a part of lagged conditional variance. A GARCH (p, q) model can be summarized as follows:

$$r_t = \mu + a_t \qquad \text{…. (5.1)}$$

$$a_t = \sigma_t \varepsilon_t, \qquad \varepsilon_t \sim iidn\ (0,1) \qquad \text{…. (5.2)}$$

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i a_{t-i}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 \qquad \text{…. (5.3)}$$

Where, ${\sigma_t}^2$ is the conditional variance of a_t and $\alpha_0 > 0$, $\alpha \geq 0$, $\beta \geq 0$. Equation (5.3) demonstrates that the conditional variance is described by past shocks or volatility (ARCH term) and past variances (the GARCH term). If the sum of these coefficients is close to unity, it implies that shocks to the conditional variance will be highly persistent, and there is a presence of quite long memory behavior, but being less than unity it is still mean reverting. As the sum of α and β becomes close to unity, shocks die out rather slowly (Bollerslev, 1986).

The GARCH model has a distinguishing advantage that it can trace out the volatility clustering phenomenon very efficiently in any series. The assumption of normality for the error term in the equation (5.2) is applied for ARCH. However, other distributional assumptions such as Student's *t*-distribution and General error distribution can also be assumed. In Equation (5.3), if the sum of α and β is equal to 1, then shocks to volatility persist forever, and the unconditional variance is not determined by the model.

Though the GARCH model can capture the volatility presence in the series, it could not incorporate the leverage effect, which is one among common characteristics of financial data series. Leverage effect means conditional variance reacts asymmetrically to positive and negative shocks. The negative returns may have more impact on volatility than positive returns. Considering this fact, Nelson proposed an exponential GARCH (EGARCH) model in 1991, which can incorporate the asymmetric effects in returns. This model is called asymmetric volatility model.

According to Bollerslev and Mikkelsen (1996), the EGARCH model can be expressed:

$$\log(\sigma_t^2) = \omega + [1-\beta(L)]^{-1}\,[1+\alpha(L)]\,g(z_{t-1}) \qquad \text{....(5.4)}$$

Where ω is a constant, $\beta(L)$ and $\alpha(L)$ are the polynomials in L (backshift operator), and $g(z_t)$ is the formula of several elements. In Nelson's (1991) words: "To accommodate the asymmetric relation between stock returns and volatility changes (…) the value of $g(z_t)$ must be a function of both the magnitude and the sign of z_t". Thus, he introduced the function g(.) as:

$$g(z_t) = \gamma_1 z_t + \gamma_2 [\,|z_t| - E|z_t|\,] \qquad \text{.... (5.5)}$$

Where the first part of the equation denotes the sign effect and the second part denotes the magnitude effect. Applying variance targeting to the EGARCH model implies replacing ω by $\log(\sigma^2)$, where σ^2 is the unconditional variance of ε_t, which can be consistently estimated by its sample counterpart.

Apart from Univariate GARCH models, multivariate GARCH models are used to check the volatility spillover between the variables and co-movements in the market. It helps to understand how the volatility in one market affects the other market volatility and how the volatility in one market spread in another market which in turn impacts the economy as a whole. Among various models of multivariate GARCH models, the study employs the BEKK model.

5.2.2 ICSS Algorithm for Volatility Structural Break

This study used ICSS methodology proposed by Inclan and Tiao (1994) to identify breakpoint (or jump) in the variance. It helps to identify the multiple breakpoints in data via iteration over sub-samples till no new points are identified in the total sample. This approach is criticised due to overstating of some actual breaks (Fernandez 2004) and lack of reliability in the presence of conditional heteroskedasticity (Fernandez 2007; Sanso, Arago, and Carrion-i-Silvestre, 2004). Usually, the limitations are resolved by filtering the return series by GeneralizedAutoregressive Conditional Heteroskedasticity Models. It is assumed that initial data points of the variables are stationary and continued to be stationary until next break. Likewise, the data is divided into different stationary sub-data where the variance of each sub-data may be different.

To identify the breakpoint, the cumulative sum of squared (standardized) residual obtained from GARCH is used.

$$C_k = \sum_{t=1}^{k} \varepsilon \qquad \text{..... (5.6)}$$

"Where k=1,.....T,and $\{\varepsilon_t\}$ is a series of uncorrelated random variables with zero mean and unconditional variance σ. The variance in each interval is denoted by σ, with j=0, 1…NT, where NT is the total number of variance changes in T observations. By letting$1 < K_1 < K_2 < \dots < K_{NT} < T$, be the set of breakpoints". The variance is then defined as:

$$\sigma_t = \tau_0^2 , \quad 1 < t < K_1 \qquad \text{.....(5.7)}$$

$$= \tau_1^2 \quad k < t < K_2$$

$$\dots\dots\dots$$

$$= \tau_{NT}^2 \quad K_{NT} < t < T$$

The statistic D_k is defined as follows:

$$D_k = \frac{C_k}{C_t} - \frac{k}{T} \; with \; D_0 - D_0 = 0 \qquad \text{….. (5.8)}$$

where C_k is the sum of the square residuals.

The significance of D_k is examined using the upper and lower critical value provided. If the maximum of the absolute value of the statistic D_k is greater than the critical value, the null hypotheses of no sudden changes are rejected. If $\max k = \sqrt{(T/2) * |D_k|}$ exceeds the critical values, then k* is taken as an estimate of the change point. The term $\sqrt{(T/2)}$ is used to standardize the distribution. The critical value of 1.358 is the 95th percentile of the asymptotic distribution of $\max k = \sqrt{(T/2) * |D_k|}$. Therefore, upper and lower boundaries can be set at ±1.358 in the D_k plot (Kang et.al, 2011).

5.2.3 BEKK- GARCH Model for Volatility Pass-Through

Multivariate BEKK GARCH model is used to check the spillover between the exchange rates and inflation. BEKK-GARCH Model is an extension of the multivariate GARCH model which enables us to show the volatility transmission from one series to another, as well as the persistence of volatility within each series. Since the parameterization of BEKK is in quadratic form, there are no restrictions needed to ensure positive definiteness of the H-matrix. In the present study, we have used bivariate VAR-BEKK (Baba-Engle-Kraft-Kroner) to examine the volatility transmission i.e. spillover effects within and between exchange rates and inflation. Here VAR (1, 1) is used to define the conditional mean of the returns. It accommodates each variable's own returns and the returns of other variables lagged by one period.

$$Y_t = \mu_t + \phi Y_{t-1} + \varepsilon_t \qquad \text{……. (5.9)}$$

$$\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} + \begin{bmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{bmatrix} \begin{bmatrix} Y_{1t-1} \\ Y_{2t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \qquad \text{……. (5.10)}$$

$$\varepsilon_t | \Omega_{t-1} \sim N(0, H_{t)} \qquad \text{……. (5.11)}$$

Where the own market mean spillovers and cross-market mean spillovers are measured by the estimates of 'ϕ' elements, the parameters of the autoregressive term.

The BEKK parameterization for the bivariate GARCH (1, 1) model is given by:

$$H_t = \acute{C}_1 C_1 + \sum_{i=1}^{p} \acute{A}_{11} \varepsilon_{t-1} \varepsilon_{t-1}^{\prime} A_{11} + \sum_{i=1}^{p} \acute{B}_{11} H_{t-1} B_{11} \quad \text{...... (5.12)}$$

Where the parameter matrices for the variance equation are defined as ***C***, which is restricted to be lower triangular, and two unrestricted matrices ***A*** and ***B***. Thus, the second moment can be represented by,

$$H_t = \grave{C}_0 C_0 + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}' \begin{bmatrix} e_{c,t-1}^2 & e_{c,t-1} e_{th,t-1} \\ e_{th,t-1} e_{c,t-1} & e_{th,t-1}^2 \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} + \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}' H_{t-1} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \quad \text{.... (5.13)}$$

The diagonal element a_{11} and a_{22} show conditional variances are correlated with past residual terms of own series, b_{11} and b_{22} measures the relationship between current and past conditional variances. The off-diagonal parameters, a_{21} and a_{12} measure the degree of market shocks from market 1 to market 2 and vice versa, b_{21} and b_{12} persistence in conditional volatility between market 1 and market 2. The number of parameters in the BEKK model is N (5N+ 1)/2, hence, in this model, the number of parameters is 11. The BFGS algorithm is used to produce the maximum likelihood parameter estimates and their corresponding asymptotic standard errors.

5.3 Empirical Results

The results of univariate and multivariate GARCH models and structural breaks in the volatility series are discussed here. Accordingly, estimated volatility series of the best univariate model is used to check out the structural breaks. Lastly, BEKK- GARCH is used to analyse the spillover effect.

5.3.1 GARCH Results

5.3.1.1 Exchange Rate GARCH Models

The study used a family of GARCH models including asymmetric models to explain the volatility and understand the dynamics of the volatility series from various models. Mainly GARCH (1, 1) GARCH (1,2) GARCH (2,1) GARCH (2,2) and EGARCH (1,1) are estimated, and only significant results are produced in the table. Before fitting GARCH models, preliminary tests are done to check whether there is a presence of heteroscedasticity in the data series and to understand the nature of the distribution of the data series.

Table 5.3, table 5.4, table 5.5 and table 5.6 show the results of normality test, ARCH-LM test, Box- Pierce Q static test and Run test of the dollar and NEER respectively. Testing for the normality shows both the variables, i.e., changes in rupee-dollar values and NEER are normally distributed since skewness, and excess kurtosis is not closer to zero. The high value of Jarque- Bera test confirms that the joint null hypothesis of the skewness being and the excess kurtosis being zero is rejected with small probabilistic value. Secondly, the ARCH test rejects the null hypothesis that there is no ARCH or GARCH effect, which means the alternative hypothesis of the presence of ARCH, and GARCH effect is accepted for both the case of dollar and NEER. The Box-Pierce Q test also confirms this result by rejecting the null hypothesis of no autocorrelation in raw return series and squared data. Finally, run test is used to check whether the sequence of the series is produced in a random manner or not. The results show that the null hypothesis of the random sequence is rejected. Since it is clear from the preliminary tests that there is the presence of ARCH effect in the model from both ARCH-LM and Box-Pierce Q statistics, we can move to fit VAR-GARCH models for rupee- dollar exchange rate and NEER.

Table 5.6 shows that the list of statistically significant results of GARCH models for rupee- dollar exchange rate. A trial and error method by using a family of GARCH models, specifically GARCH (1, 1), GARCH (1, 2), GARCH (2, 1), GARCH (2, 2), and EGARCH (1, 1) are fitted by using various lags of ARMA models.

Table 5.2 Normality Test

	Statistic	t-Test	P-Value
DOLLAR			
Skewness	0.83174	4.8852	0.000
Excess Kurtosis	2.4771	7.309	0.000
Jarque-Bera	75.677		0.000
NEER			
Skewness	-0.55115	7.7845	0.000
Excess Kurtosis	1.01735	6.129	0.000
Jarque-Bera	19.12572		0.008

Table 5.3 LM ARCH Test Results

Lags	F-Stat	Prob.
DOLLAR		
ARCH 1-2 TEST: F(2,199)	9.5463	[0.0001]**
ARCH 1-5 TEST: F(5,193)	5.9916	[0.0000]**
ARCH 1-10 TEST: F(10,183)	3.6979	[0.0002]**
ARCH 1-15 TEST: F(15,173)	2.8578	[0.0005]**
ARCH 1-20 TEST: F(20,163)	2.2826	[0.0025]**
NEER		
ARCH 1-2 TEST: F(2,199)	8.7742	[0.0002]**
ARCH 1-5 TEST: F(5,193)	3.5637	[0.0042]**
ARCH 1-10 TEST: F(10,183)	2.4542	[0.0090]**
ARCH 1-15 TEST: F(15,173)	2.1012	[0.0119]*
ARCH 1-20 TEST: F(20,163)	1.7025	[0.0375]*

Table 5.4 Box- Pierce -Q –Statistic Test Results on Raw and Squared Data

At Lags		Q-Stat	P-Value
DOLLAR			
Q	(5)	29.5038	[0.0000185]**
Q	(10)	35.5299	[0.0001014]**
Q	(20)	63.6703	[0.0000019]**
Q	(50)	87.0892	[0.0009040]**
Q^2	(5)	35.6606	[0.0000011]**
Q^2	(10)	40.3257	[0.0000148]**
Q^2	(20)	69.8713	[0.0000002]**
Q^2	(50)	112.648	[0.0000010]**
NEER			
Q	(5)	17.1234	[0.0042717]**
Q	(10)	21.9275	[0.0154782]*
Q	(20)	44.8449	[0.0011582]**
Q	(50)	65.8673	[0.0655798]
Q^2	(5)	18.805	[0.0020896]**
Q^2	(10)	20.994	[0.0211352]*
Q^2	(20)	27.4027	[0.1243101]
Q^2	(50)	46.7281	[0.6054626]

Table 5.5 Runs Test Result

Runs Test Statistic	P-Value
DOLLAR	
-4.36689	[0.0000126]**
NEER	
-3.35083	[0.0008057]**

The estimation is done by assuming different distribution such as Gaussian normal distribution, t- distribution and GED distribution.As expected, all the models are not significant.The models in which the ARCH and GARCH term are insignificant, they are avoided from the results. After analysing the correctly specified models, it is observed that the Models ARMA (1,0)- GARCH(1,2)[Normal-distribution] have higher α value than the β coefficient, which means that past shocks are more important in determining the current volatility. At the same time, Models, ARMA (0,0)-GARCH(1,1) [Normal-distribution], ARMA(0,0)-EGARCH (1,1) [Normal-distribution], ARMA(1, 1)-GARCH (1, 1) [Student - t distribution] and ARMA(0, 0)-EGARCH(1, 1) [Normal distribution] are having high β coefficient which indicates that, not the shocks but past volatility is more important in determining the present volatility. But here the last model is not considered for the analysis since it could not satisfy non-negativity constraints which are necessary for convergence.

Table 5.6 Statistically Significant Estimates (Dollar)

Model	**Variables**							**Distribution**
	α_0	α_1	α_2	β_1	β_2	θ_1	α+β	
ARMA(0,0) GARCH(1,1)	0.374075 (0.490)	0.152975 (0.000)		0.846553 (0.000)			0.999528	Normal
ARMA(1,0) GARCH(1,2)		0.7074 (0.154)		0.451692 (0.002)	0.243654 (0.074)		1.402746	Student
ARMA(0,0) EGARCH(1,1)	0.039598 (0.858)	0.152407 (0.091)		0.975843 (0.000)		-0.12805 (0.067)	1.12825	Normal
ARMA(1,1) GARCH(1,1)	0.832706 0.261	0.542975 0.1415		0.710352 0			1.253327	Student
ARMA(0,0) EGARCH(1,2)		0.020562 (0.107)	0.091817 (0.039)	0.870923 (0.000)		-0.08413 (0.027)	0.983302	Normal
ARMA(1,0) GARCH(2,1)	0.469791 (0.292)	0.962325 (0.102)	-0.571 (0.228)	0.796258 (0.000)				Student

(Note: P-Values are given in Parenthesis)

Table 5.7 Residual Based Hetroskedasticity Test (Dollar)

MODEL	RBD(2)	RBD(5)	RBD(10)	LM ARCH (1-2)	LM ARCH (1-5)	LM ARCH (1-10)	DISTRIBUTION
ARMA(0,0) GARCH(1,1)	17.1434 0.0001894	-3.8889 1	-0.310495 1	1.0192 [0.3628]	0.5868 [0.7101]	0.52215 [0.8731]	Normal
ARMA(1,0) GARCH(1,2)	-4.18943 [1.0000000]	-0.121762 [1.0000000]	2.71341 [0.9873877]	0.30532 [0.7372]	0.2693 [0.9295]	0.47664 [0.9036]	Student
ARMA(0,0) EGARCH(1,1)	4.11973 [0.1274714]	7.62227 [0.1783184]	9.05832 [0.5265780]	1.0982 [0.3355]	0.85562 [0.5121]	0.7974 [0.6314]	Normal
ARMA(1,1) GARCH(1,1)	3.93985 [0.1394671]	-0.755492 [1.0000000]	1.58369 [0.9986502]	0.33889 [0.7130]	0.30141 [0.9116]	0.39003 [0.9499]	Student
ARMA(0,0) EGARCH(1,2)	2.66971 [0.2631965]	5.90691 [0.3153830]	8.91761 [0.5399405]	0.45495 [0.6352]	0.45 [0.8129]	0.66481 [0.7560]	Normal
ARMA(1,0) GARCH(2,1)	4.44319 [0.1084360]	1.89335 [0.8636961]	4.64057 [0.9138601]	0.37559 [0.6874]	0.38753 [0.8570]	0.45688 [0.9156]	Student

(Note : P-Values are given in Parenthesis)

The sum of α and β is close to one in the models, ARMA (0, 0)-GARCH (1, 1) [Normal-distribution], and ARMA (0, 0)-EGARCH (1, 1) [Student t distribution]. So these models are stationary in variance. These estimated models support the claim of volatility persistence in exchange rates. However, other three models give the sum value of α and β higher than one which shows a clear sign of explosive trends in the volatility. So the mean reverting trend is not visible in these models. Asymmetry in volatility refers to a situation in which a negative (or positive) shock to financial time series is likely to cause volatility to rise by more than a positive (or negative) shock of the same magnitude.

Table 5.8 Ranking of the Models Based on Information Criterion (Dollar)

Model	Akaike	Shibata	Schwarz	Hannan-Quinn	Ranking	Distribution
ARMA(0,0) GARCH(1,1)	-7.251707	-7.25401	-7.18665	-7.225389	3	Normal
ARMA(1,0) GARCH(1,2)	-7.575766	7.57693	-7.49444	-7.542868	5	Student
ARMA(0,0) EGARCH(1,1)	-6.852953	-6.854618	-6.755361	-6.813475	2	Normal
ARMA(1,1) GARCH(1,1)	-7.574275	-7.57594	-7.476683	-7.534798	4	Student
ARMA(0,0) EGARCH(1,2)	-6.750387	-6.752052	-6.652795	-6.71091	1	Normal
ARMA(1,0) GARCH(2,1)	-7.586184	-7.587849	-7.488592	-7.546707	6	Student

It means that the good and bad news (positive and negative shocks) have different impact on future volatility. Black (1876) Christie (1982) Pyndyck (1984) and French, et.al (1987) have contributed to the theoretical background of asymmetry in financial variables and analysed two types of effects, leverage effect, and volatility feedback effect. According to this, the volatility depends on the sign of the past return. Negative returns are connected with increased volatility. This is known as leverage effect. The "volatility feedback" was the concentration of the last two authors. The main crux of this argument is reverse causality which says that changes in volatility have an impact on the return of the variables. It should also be noticed that large negative returns are common in financial variables where large positive returns are a rare case. So this large negative news is followed by other negative news which causes an increase in the volatility. So a negative relationship between the returns and volatility is highly expected. Asymmetric nature of volatility is examined by using EGARCH models. In this model, we try to explain differential effect of good news and bad news on conditional variance. If $\theta < 0$, we say that the leverage effect exists. If θ not equal to 0 the news impact is asymmetric. If the θ is not at all significant, it means that there is no asymmetric impact. The models ARMA (0, 0)-EGARCH (1, 1) [Normal-distribution], and ARMA (0, 0)-EGARCH (1, 2) [Normal-distribution], confirms the presence of asymmetry. In both ARMA (0, 0)-EGARCH (1, 1) and ARMA (0, 0)-EGARCH (1, 2), the parameter for asymmetry, θ is negative and statistically significant. It means that there is a negative relationship between return and volatility, and volatility seems to be highly responsive to past negative shocks.

Table 5.7 shows Residual Based Heteroskedasticity test (RBD) as a post estimation diagnostic test to confirm the reliability of the model. It involves calculating artificial regressions and testing for the statistical significance of the regression parameters. These tests are used to overcome several limitations of classical diagnostic tests (see Tse, 2002). The null hypothesis of the RBD test is the correct specification of the model. This null hypothesis is accepted in cases with a high probability value, which means the model could squeeze maximum information from the data by selecting appropriate lags. So now there is no more presence of heteroscedasticity in the residuals.

To rank the models, two set of criterion are used. The first, the minimisation of the Information Criterion viz. Akaike Information Criteria (AIC), Bayes Information Criteria (BIC), Hannan-Quinn Criteria (HQC) and Shibata Information Criteria (SIC), is used to order the models as per the goodness of fit. The ordering of the models as per the criterion is shown in Table 5.8. Here we have ranked the model and confirmed that ARMA (0, 0)-EGARCH (1, 2) [Normal-distribution] and ARMA (0, 0)-EGARCH (1, 1) [Normal-distribution] are the most suitable models. The residual series of the ARMA (0, 0)-EGARCH (1, 2) [Normal-distribution] is taken to calculate the volatility series and find out the structural breaks in the volatility. The analysis of structural breaks for rupee- dollar exchange rate, NEER and inflation variables using ICSS algorithm are given in the next section.

Table 5.9 Statistically Significant Estimates (NEER)

Model	Variables							Distribution
	α_0	α_1	α_2	β_1	β_2	θ_1	α+β	
ARMA(0,0) GARCH(1,1)	22.43437 (0.022)	0.218345 (0.107)		0.281688 (0.278)			0.500033	Normal
ARMA(1,0) GARCH(1,1)	3.098303 0.5026	0.071939 0.1969		0.853897 0			0.925836	Normal
ARMA(0,0) EGARCH(1,1)		0.082352 (0.508)		0.83824 (0.000)		0.16751 (0.407)	0.920592	Normal
ARMA(0,1) GARCH(1,1)	5.877054 (0.156)	0.089793 (0.159)		0.766146 (0.000)			0.855939	Student
ARMA(0,0) EGARCH(1,2)		0.83123 (0.000)		0.025888 (0.009)	0.942261 (0.000)	0.125714 (0.422)	1.799379	Normal

(Note: P-Values are given in Parenthesis)

Table 5.10 Residual Based Heteroskedasticity Test Stats (NEER)

MODEL	RBD(2)	RBD(5)	RBD(10)	LM ARCH (1-2)	LM ARCH (1-5)	LM ARCH (1-10)	DISTRIBUTION
ARMA(0,0) GARCH(1,1)	-44.353 [1.0000000]	-37.0828 [1.0000000]	-20.2952 [1.0000000]	1.0735 [0.3438]	0.68508 [0.6353]	0.6703 [0.7511]	Normal
ARMA(1,0) GARCH(1,1)	15.6605 [0.0003975]	302.949 [0.0000000]	6.24649 [0.7941461]	0.89693 [0.5373]	1.0472 [0.3913]	0.89693 [0.5373]	Normal
ARMA(0,0) EGARCH(1,1)	1.87025 [0.3925368]	4.42042 [0.4906009]	6.01546 [0.8139629]	0.18059 [0.8349]	0.3324 [0.8929]	0.26723 [0.9874]	Normal
ARMA(0,1) GARCH(1,1)	-44.353 [1.0000000]	-37.0828 [1.0000000]	-20.2952 [1.0000000]	1.9411 [0.1463]	1.141 [0.3402]	1.0802 [0.3796]	Student
ARMA(0,0) EGARCH(1,2)	4.20333 [0.1222525]	9.04778 [0.1071736]	28.7336 [0.0013759]	0.46084 [0.6314]	1.0118 [0.4120]	0.73361 [0.6921]	Normal

(Note: P-Values are given in Parenthesis)

Table 5.9 shows that the list of statistically significant results of GARCH models for Nominal Effective Exchange Rate (NEER). We have made a trial and error method by using a family of GARCH models, specifically GARCH (1, 1), GARCH (1, 2), GARCH (2,1), GARCH (2,2), and EGARCH (1,1) by employing various lags of ARMA models same as in the previous case. From the models, it is observed that no other models have higher α value than the β coefficient, which means that past shocks are least important in determining the current volatility.

At the same time, all models: ARMA (0,0)- GARCH(1,1) [Normal-distribution], ARMA (1,0)-GARCH(1,1) [Normal distribution],ARMA(0,0)-EGARCH(1,1) [Normal-distribution], ARMA(0,1)-GARCH(1,1) [Student-t distribution] and ARMA(0,0)-EGARCH(1,2)[Normal Distribution], are having a high β coefficient which indicates that not the shocks, but the past volatility is more important in determining the present volatility.

Table 5. 11 Ranking of the Models Based on Information Criterion (NEER)

Model	Akaike	Shibata	Schwarz	Hannan-Quinn	Ranking	Distribution
ARMA(0,0) GARCH(1,1)	-7.187242	-7.18767	-7.13845	-7.167503	3	Normal
ARMA(1,0) GARCH(1,1)	-7.260674	-7.261424	-7.195613	-7.234356	4	Normal
ARMA(0,0) EGARCH(1,1)	-6.590456	-6.591205	-6.525395	-6.564138	1	Normal
ARMA(0,1) GARCH(1,1)	-7.264588	-7.265752	7.183262	7.23169	5	Student
ARMA(0,0) EGARCH(1,2)	-6.641941	-6.643105	-6.560615	-6.609043	2	Normal

The sum of α and β is close to one in the models, ARMA (1,0)-GARCH(1,1) [Normal-distribution], ARMA(0,0)-EGARCH(1,1) [Normal-distribution] and ARMA(0,1)-GARCH(1,1) [Student-t distribution]. When the sum of α and β is only 0.50 in the first model, in the last model it is more than one. So these models which have less than one are stationary in variance which indicates that volatility is highly persistent and will take time to die out except where it is very less as in the first model. These estimated models support the claim of volatility persistence in exchange rates. The last model gives a sum value of α and β higher than one which shows a clear sign of explosive trends in the volatility. So mean reverting trend is not visible in this model.

EGARCH models to check the asymmetric impacts reveals that both the models ARMA (0, 0)-EGARCH (1, 1) [Normal-distribution] and ARMA (0, 0)-EGARCH (1, 2) [Normal-distribution], could not find the presence of asymmetry. In both ARMA (0, 0)-EGARCH (1, 1) and ARMA (0, 0)-EGARCH (1, 2), the parameter for asymmetry, θ is statistically insignificant.

Table 5.10 shows the results of Residual Based Heteroskedasticity test (RBD). The null hypothesis, the model, is correctly specified is accepted with a high probability value, which means the model could squeeze maximum information from the data by selecting appropriate lags. So now there is no more presence of heteroscedasticity in the residuals.

The ordering of the Models as per the criterion is shown in Table 5.8. Here we have ranked the model and confirmed that ARMA (1, 0)-GARCH (1, 1) [Normal-distribution] and ARMA (0, 0)-EGARCH (1, 2) [Normal-distribution] are the most suitable models. The residual series of the ARMA (1, 0)-EGARCH (1, 2) [Normal-distribution] is taken as the volatility series and finds out the structural breaks in the volatility.

5.3.1.2 Inflation GARCH Models

As we have done before, we have used a family of GARCH models including asymmetric models to model the volatility of inflation variables namely WPI inflation and CPI inflation. Mainly GARCH (1, 1) GARCH (1,2) GARCH (2,1) GARCH (2,2) and EGARCH (1,1) are estimated, and only significant results are given in the table. Before the GARCH models, preliminary tests are done.

Table 5.12 Normality Test

	Statistic	t-Test	P-Value
WPI			
Skewness	-0.14908	0.87562	0.38124
Excess Kurtosis	-0.42658	1.2587	0.20815
Jarque-Bera	2.3024		0.31626
CPI			
Skewness	0.65798	3.8647	0.00011
Excess Kurtosis	0.24098	0.71104	0.47706
Jarque-Bera	15.214		0.0005

Table 5.13 LM ARCH Test Results

Lags	F-stat	Prob
WPI		
ARCH 1-2 TEST: F(2,199)	934.29	[0.0000]**
ARCH 1-5 TEST: F(5,193)	392.22	[0.0000]**
ARCH 1-10 TEST: F(10,183)	191.1	[0.0000]**
ARCH 1-15 TEST: F(15,173)	139.11	[0.0000]**
ARCH 1-20 TEST: F(20,163)	98.776	[0.0000]**
CPI		
ARCH 1-2 TEST: F(2,199)	629.62	[0.0000]**
ARCH 1-5 TEST: F(5,193)	253.48	[0.0000]**
ARCH 1-10 TEST: F(10,183)	114.58	[0.0000]**
ARCH 1-15 TEST: F(15,173)	110.8	[0.0000]**
ARCH 1-20 TEST: F(20,163)	81.648	[0.0000]**

Table 5.14 Box- Pierce -Q –Statistic Test Results on Raw and Squared Data

At Lags	Q-Stat	P-Value
WPI		
Q (5)	506.526	[0.0000000]**
Q (10)	530.019	[0.0000000]**
Q (20)	581.744	[0.0000000]**
Q (50)	631.343	[0.0000000]**
Q^2 (5)	518.678	[0.0000000]**
Q^2 (10)	547.091	[0.0000000]**
Q^2 (20)	602.612	[0.0000000]**
Q^2 (50)	685.816	[0.0000000]**
CPI		
Q (5)	710.453	[0.0000000]**
Q (10)	1019.41	[0.0000000]**
Q (20)	1252.94	[0.0000000]**
Q (50)	1547.77	[0.0000000]**
Q^2 (5)	601.027	[0.0000000]**
Q^2 (10)	766.275	[0.0000000]**
Q^2 (20)	841.297	[0.0000000]**
Q^2 (50)	940.675	[0.0000000]**

Table 5.15 Runs Test Results

Runs Test Statistic	P-Value
WPI	
-10.6942	[0.0000000]**
CPI	
-10.682	[0.0000000]**

Table 5.11, Table 5.12, Table 5.13 and Table 5.14 show the results of normality test, ARCH-LM test, Box- Pierce Q static test and Run test of WPI and CPI inflation respectively. Testing for the normality shows that WPI inflation is normally distributed since skewness, and excess kurtosis is closer to zero. In the case of CPI inflation, the high value of Jarque- Bera test static confirms that the null joint hypothesis of the skewness and the excess kurtosis being zero is rejected with a small probabilistic value which indicates that CPI inflation is not normally distributed. Secondly, the ARCH test rejects the null hypothesis that there is no ARCH or GARCH effect which means the alternative hypothesis of the presence of ARCH and GARCH effect are accepted both in the case of WPI and CPI inflation. The Box-Pierce Q test also confirms this result by rejecting that the null hypothesis of no autocorrelation in raw return series and squared data. Finally, run test is used to check whether the sequence of the series is produced in a random manner or not. The results show the null hypothesis of a random sequence is rejected. Since it is clear from the preliminary tests that there is a presence of ARCH effect in the model from both ARCH-LM and Box-Pierce Q statistics, we moved to fit univariate GARCH models for WPI and CPI inflation.

Table 5.16 Statistically Significant Estimates - WPI

Model	**Variables**							**Distribution**
	α_0	α_1	α_2	β_1	β_2	θ_1	$\alpha+\beta$	
ARMA(1,1)	0.02475	0.07264		0.65012	0.16293		0.88569	Normal
GARCH(2,1	(0.038)	(0.146)		(0.007)	(0.000)			
ARMA(2,1)	0.0119	0.01925		-0.85626				Normal
GARCH(1,1	0.064	0.7652		0				
ARMA(0,0)	0.03896	0.06414		0.83151		-0.044	0.89566	Normal
EGARCH(1,	(0.995)	(0.076)		(0.000)		(0.691)		
ARMA(1,1)	0.0123	0.07046		0.8187			0.88916	Student
GARCH(1,1	(0.060)	(0.166)		(0.000)				
ARMA(1,0)	0.05503	0.42464		0.18972	0.43223		1.04658	Student
GARCH(2,1	(0.022)	(0.046)		(0.028)	(0.000)			

(Note: P-Values are given in Parenthesis)

Table 5.17 Residual based Heteroskedasticity Test Stats - WPI

MODEL	RBD(2)	RBD(5)	RBD(10)	LM ARCH (1-2)	LM ARCH (1-5)	LM ARCH (1-10)	Distribution
ARMA(1,1) GARCH(2,1)	1.36082 [0.5064086]	-1.59767 [1.0000000]	1.55412 [0.9987567]	0.53429 [0.5869]	0.88476 [0.4924]	0.87596 [0.5568]	Normal
ARMA(2,1) GARCH(1,1)	1.37588 [0.5026104]	27.3604 [0.0000485]	0.975941 [0.9998461]	0.51106 [0.6007]	0.65157 [0.6606]	0.63739 [0.7805]	Normal
ARMA(0,0) EGARCH(1,1)	-12.041 [1.0000000]	9.91011 [0.0778228]	4.50015 [0.9219774]	0.57092 [0.5659]	1.0084 [0.4140]	1.0718 [0.3862]	Normal
ARMA(1,1) GARCH(1,1)	3.41475 [0.1813409]	4.03378 [0.5445625]	5.89206 [0.8242485]	1.2471 [0.2896]	0.90046 [0.4819]	0.96068 [0.4794]	Student
ARMA(1,0) GARCH(2,1)	2.3267 [0.3124385]	13.3488 [0.0203206]	4.9239 [0.8962032]	0.49693 [0.6092]	0.38578 [0.8582]	0.3999 [0.9454]	Student

(Note: P-Values are given in Parenthesis)

Table 5.18 Ranking of the Models based on Information Criterion - WPI

Model	Akaike	Shibata	Schwarz	Hannan-Quinn	Ranking	Distribution
ARMA(1,1) GARCH(2,1)	-8.675153	-8.67741	-8.5613	-8.629096	4	Normal
ARMA(2,1) GARCH(1,1)	-8.674846	-8.677099	-8.560989	-8.628789	3	Normal
ARMA(0,0) EGARCH(1,1)	-6.463021	-6.464686	-6.365429	-6.423543	1	Normal
ARMA(1,1) GARCH(1,1)	-8.701917	-8.704169	-8.58806	-8.65586	5	Student
ARMA(1,0) GARCH(2,1)	-8.562549	-8.564802	-8.448692	-8.516492	2	Student

Table 5.16 shows the list of statistically significant results of GARCH models for WPI inflation. From the models, it is observed that not many models have higher α value than the β coefficient, which means that past shocks are least important in determining the current volatility. At the same time, all models ARMA (1,1)-GARCH(2,1) [Normal-distribution], ARMA (2,1)-GARCH(1,1) [Normal-distribution], ARMA(0,0)-EGARCH(1,1) [Normal-distribution], ARMA(1,1)-GARCH(1,1) [Student-t distribution], and ARMA(1,0)-EGARCH(2,1) [Student-t distribution], are having a high β coefficient which indicates that, not the shocks but past volatility is more important in determining the present volatility.

The sum of α and β is close to one in the models ARMA (1,1)-GARCH (2,1),

ARMA(0,0)-EGARCH(1,1) [Normal-distribution], ARMA(1,1)-GARCH(1,1) [Student-t distribution]. So these models which have a sum of less than one are stationary in variance which indicates that volatility is highly persistent and will take time to die out. These estimated models support the claim of volatility persistence in WPI inflation. The last model gives the sum value of α and β higher than one which shows a clear sign of explosive trends in the volatility. So mean reverting trend is not visible in this model.

EGARCH models to check the asymmetric impacts reveals that the model ARMA (0, 0)-EGARCH (1, 1) [Normal-distribution] could not find the presence of asymmetry since the parameter for asymmetry, θ is statistically insignificant in ARMA (0, 0)-EGARCH (1, 1)

Table 5.19 Statistically Significant Estimates - CPI

Model	**Variables**							**Distribution**
	α_0	α_1	α_2	β_1	β_2	θ_1	$\alpha+\beta$	
ARMA(0,0) GARCH(1,1	0.26003 (0.000)	0.9509 (0.000)		-0.0901 (0.000)				Normal
ARMA(0,0) GARCH(1,2	0.01676 (0.488)	0.15337 (0.000)	0.186965 (0.000)	0.62212 (0.000)			0.96245	Normal
ARMA(1,0) EGARCH(1,	0.10764 (0.000)	0.71286 (0.005)		-0.2487 (0.005)		-0.175 (0.126)		Normal
ARMA(1,0) GARCH(1,1	0.01294 (0.103)	0.05339 (0.029)		0.48633 (0.000)			0.53973	Normal
ARMA(0,1) GARCH(1,2	0.06159 (0.003)	0.00755 (0.916)	0.796876 (0.000)	0.14485 (0.104)			0.94927	Normal

(Note:P-Values are in Parenthesis)

Table 5.17 shows Residual Based Heteroskedasticity test (RBD). The null hypothesis of the RBD test that the model is correctly specified and accepted with high probability value except in very few cases, which means the model could squeeze maximum information from the data by selecting appropriate lags. So now there is no more presence of heteroscedasticity in the residuals.

The ordering of the Models as per the criterion is shown in Table 5.18. Here we have ranked the model and confirmed that ARMA (0, 0)-GARCH (1, 1) [Normal-distribution] and ARMA (1, 0)-GARCH (2, 1) [Normal-distribution] are the most suitable models. The residual series of the ARMA (0, 0)-EGARCH (1, 1) [Student-t distribution] is taken as the measure of the volatility series and to find out the structural breaks in the volatility.

Table 5.20 Residual based Heteroskedasticity Test Stats - CPI

MODEL	RBD(2)	RBD(5)	RBD(10)	LM ARCH (1-2)	LM ARCH (1-5)	LM ARCH (1-10)	Distribution
ARMA(0,0) GARCH(1,1)	0.0493066 [0.9756481]	-137.411 [1.0000000]	11.2406 [0.3390842]	0.024083 [0.9762]	2.0939 [0.0679]	1.5016 [0.1418]	Normal
ARMA(0,0) GARCH(1,2)	0.127064 [0.9384441]	-7.41068 [1.0000000]	-241.404 [1.0000000]	0.06315 [0.9388]	1.5131 [0.1875]	1.2049 [0.2905]	Normal
ARMA(1,0) EGARCH(1,1)	-2.74249 [1.0000000]	35.0299 [0.0000015]	-38.0442 [1.0000000]	0.43931 [0.6451]	4.6136 [0.0005]	2.6651 [0.0046]	Normal
ARMA(1,0) GARCH(1,1)	-59.3979 [1.0000000]	3.0901 [0.6860966]	5.78925 [0.8326476]	0.10858 [0.8972]	1.2966 [0.2670]	0.9889 [0.4547]	Normal
ARMA(0,1) GARCH(1,2)	0.94656 [0.6229558]	6.4251 [0.2670233]	8.59316 [0.5710996]	0.2611 [0.7705]	0.98619 [0.4274]	0.77406 [0.6537]	Normal

(Note:P-Values are in Parenthesis)

Table 5.21 Ranking of the Models based on Information Criterion - CPI

Model	Akaike	Shibata	Schwarz	Hannan-Quinn	Ranking	Distribution
ARMA(0,0) GARCH(1,1)	-6.181884	-6.18263	-6.11682	-6.155566	2	Normal
ARMA(0,0) GARCH(1,2)	-6.172559	6.173723	-6.091232	-6.139661	1	Normal
ARMA(1,0) EGARCH(1,1)	-7.931309	-7.933561	-7.817452	-7.885252	3	Normal
ARMA(1,0) GARCH(1,1)	-7.98503	-7.986194	-7.903704	-7.952132	4	Normal
ARMA(0,1) GARCH(1,2)	-6.998096	-6.999762	-6.900505	-6.958619	5	Normal

Table 5.19 shows the list of statistically significant results of GARCH models for CPI inflation. From models, it is observed that the only one model, ARMA (0, 1)-GARCH(1,2) [Normal-distribution] have higher α value than the β coefficient, which shows the past shocks are more important in determining the current volatility. At the same time, other models, ARMA (0,0)- GARCH(1,2) [Normal-distribution], ARMA(1,0)-GARCH(1,1)-[Normal-distribution], are having a high β coefficient. ARMA(0,0)-GARCH(1,1)-[Normal-distribution] and ARMA(1,0)-EGARCH(1,1)-[Normal-distribution] fail to converge and fail to fulfill non-negativity constraints. The sum of α and β is close to one in the models, ARMA (0,0)- GARCH(1,2) [Normal-

distribution], ARMA(1,0)-GARCH(1,1)-[Normal-distribution] and ARMA(0,1)-GARCH(1,2)-[Normal-distribution] . So these models which have less than one are stationary in variance which indicates that volatility is highly persistent and will take time to die out except where it is very less. These estimated models support the claim of volatility persistence. There is no model which gives the sum value of α and β higher than one.

EGARCH models to check the asymmetric impacts reveals that both the models ARMA (0, 0)-EGARCH (1, 1) [Normal-distribution], and ARMA (0, 0)-EGARCH (1, 2) [Normal-distribution], could not find the presence of asymmetry. In both ARMA (0, 0)-EGARCH (1, 1) and ARMA (0, 0)-EGARCH (1, 2), the parameter for asymmetry, θ is statistically insignificant.

EGARCH models to check the asymmetric impacts reveals that the model ARMA (0, 0)-EGARCH (1, 1) [Normal-distribution] could not find the presence of asymmetry since the parameter for asymmetry, θ is statistically insignificant in ARMA (0, 0)-EGARCH (1, 1)

Table 5.21 shows Residual Based Heteroskedasticity test (RBD). The null hypothesis of the RBD test that the model is correctly specified, is accepted in cases with high probability value except in very few cases.

The ordering of the Models as per the criterion is shown in Table 5.22. Here we have ranked the model and confirmed that ARMA (0, 0)-GARCH (1, 2) [Normal-distribution] and ARMA (0, 0)-GARCH (1, 1) [Normal-distribution] are the most suitable models. The residual series of the ARMA (0, 0)-EGARCH (1, 2) [Normal-distribution] is used as the measure of volatility and to find out the structural breaks in the volatility.

5.3.2 Volatility Structural Breaks

The main intention behind scrutinising the structural breaks as per different variance level is to understand jumps and peaks of the volatility and divide the period into different volatility regimes. Moreover, further analysis is possible confining to the data series of different variance blocks.

Fig. 5.1 Daily Dollar Volatility

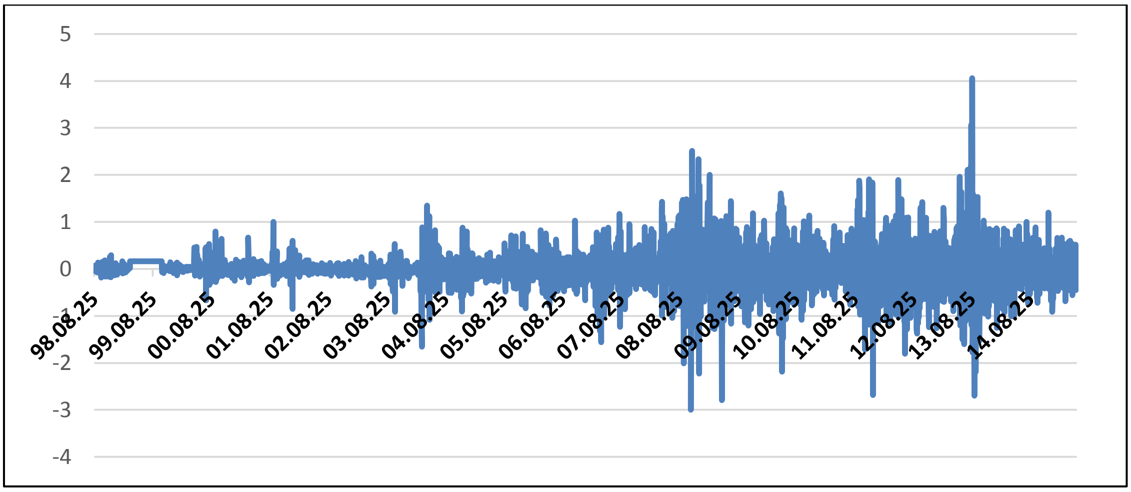


Fig. 5.2 Daily Pound volatility

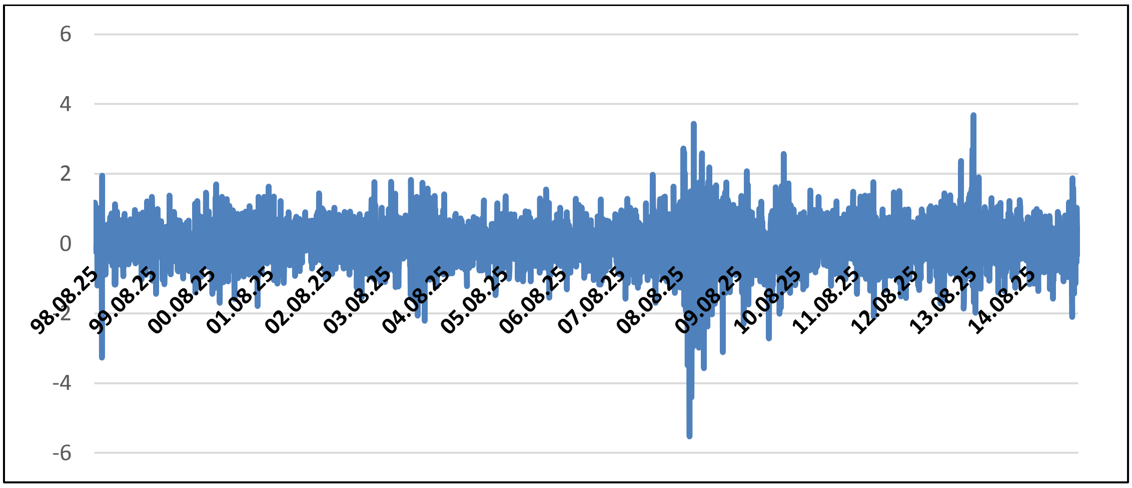


Fig. 5.3 Daily Euro Volatiliy

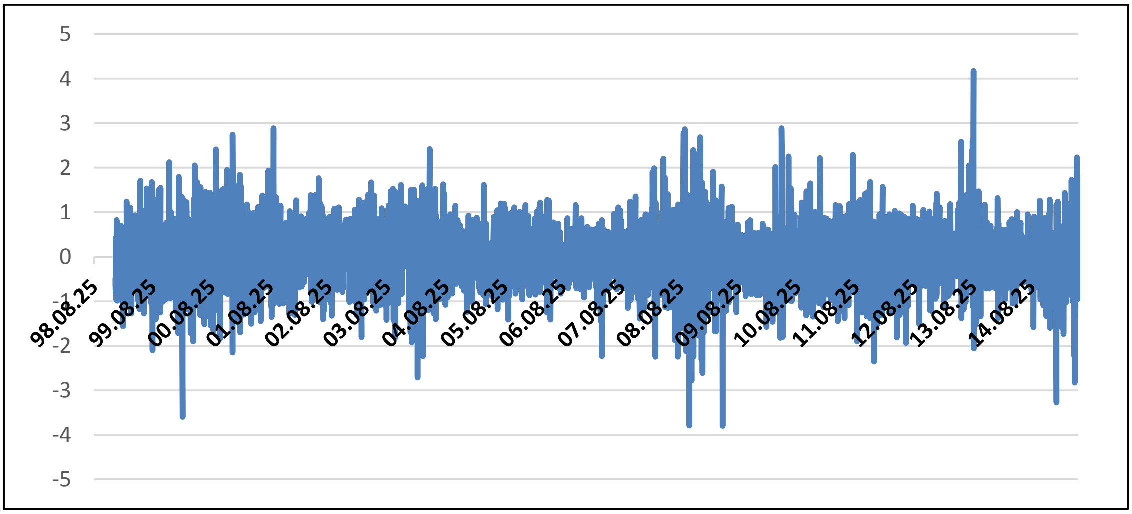


Fig. 5.4 Daily Japanees Yen Volatility

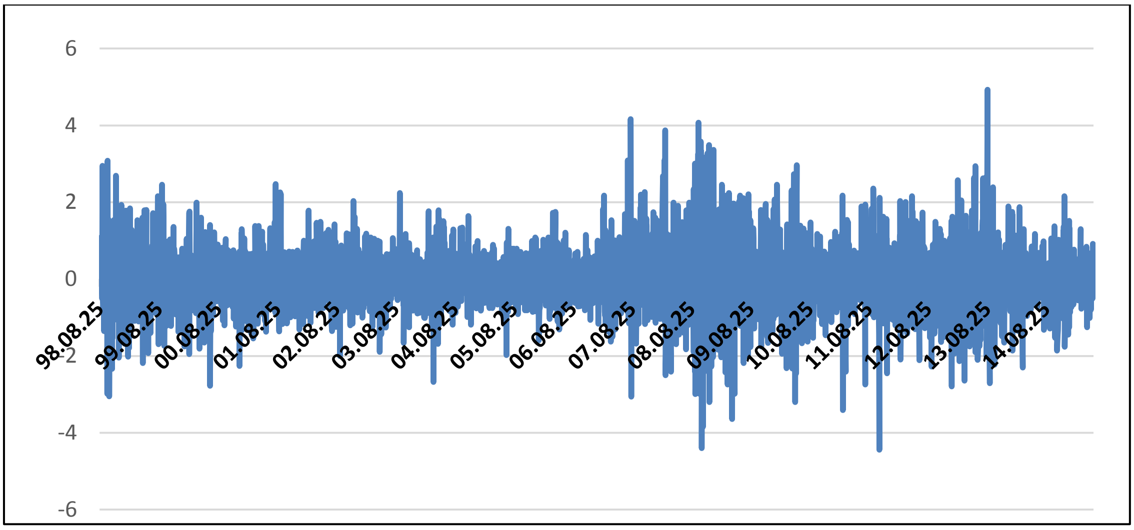


Fig. 5.5 Monthly Dollar Volatility

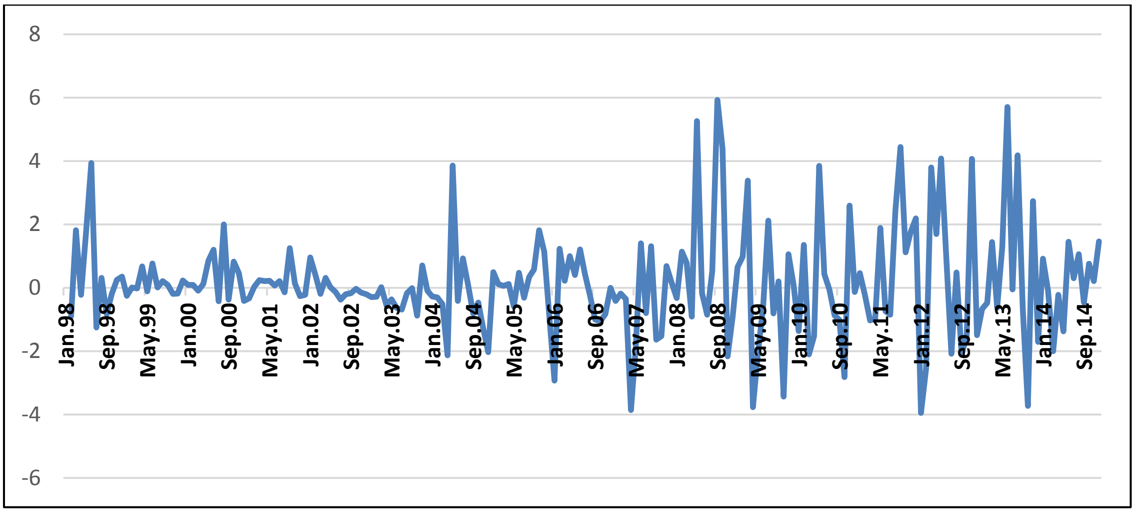


Fig. 5.6 Monthly NEER Volatility

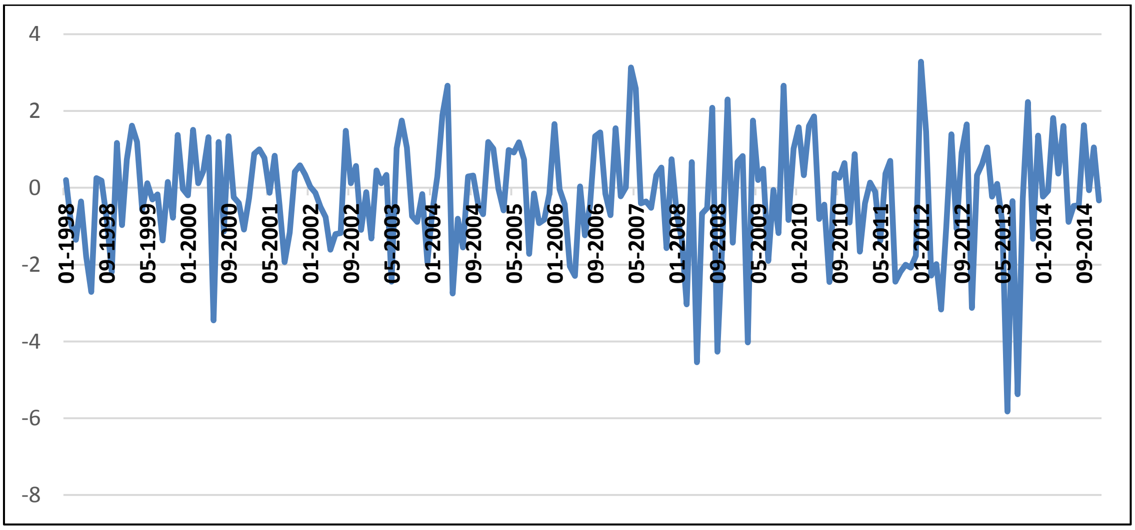


Fig. 5.7 Monthly WPI Inflation Volatility

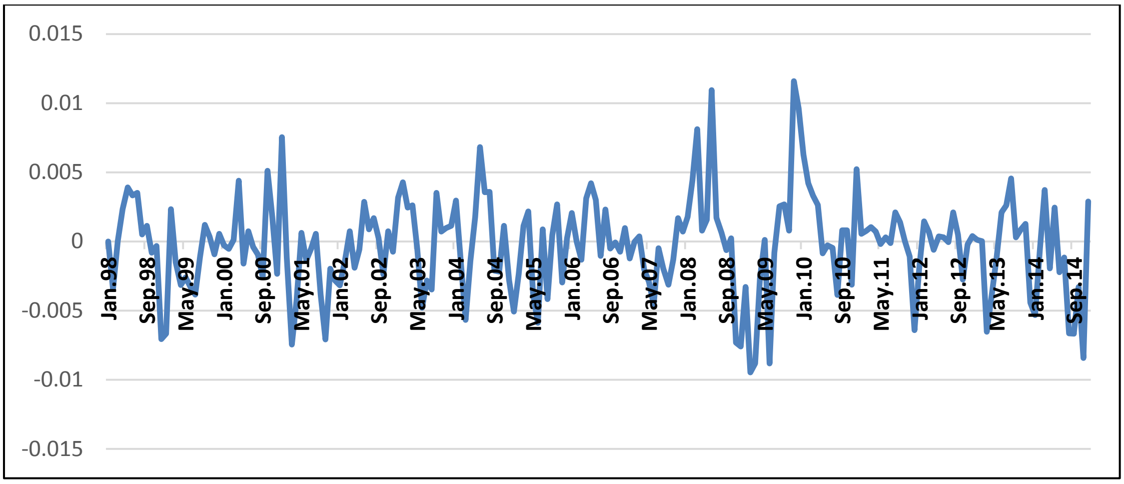
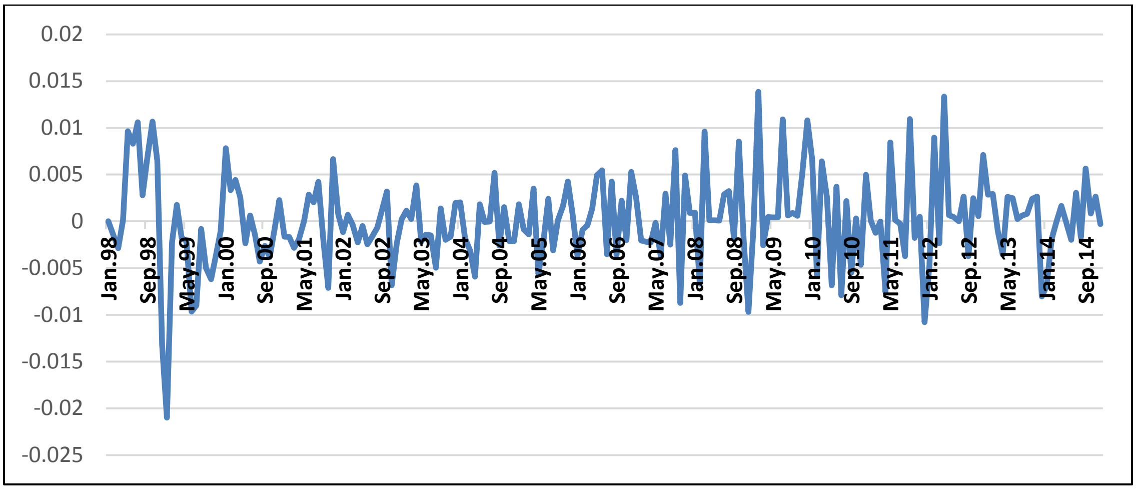


Fig. 5.8 Monthly CPI Inflation Volatility



The study has used ICSS algorithm test which is accepted to check the structural shifts in volatility. The most ranked model from the family of GARCH models is used to run the algorithm test. The standard GARCH approach is applied with the objective of producing the standardised errors that are used to identify the number of breakpoints in the volatility series.

The time periods of shifts in volatility of exchange rate and inflation as identified by ICSS algorithm are shown in below tables: 5.22 to 5.26. In table 5.22 the variance of each period also given separately to understand the strength of volatility in each time period. There are eight structural breaks in series of the rupee-dollar exchange rate data which produce eight short sub-sample periods of volatility regime. According to the variance of sub-sample period, the significant structural change can be found in April/May – 2008. The high variance (0.097) can be seen during May 2008-August 2011. It can be read as the major structural shift happened in post-financial crisis. The period September 2011 – December 2014 also followed a high level of variance (0.107), continuing the same trend of the previous period. These structural shifts are confirmed using daily dollar- rupee exchange rate data in Table 5.23 which shows around 12 major structural shifts which lead to 13 time periods of different variance. The increasing level of the variance in the post-financial crisis period is clearly seen from the table. After May 2008 the variance raised from 0.139 to 0.343 and 0.370 in the following two periods. However, in the case of NEER (see Table 5.24), though it can be considered as an increase in the post-crisis period, it is not that much mention worthy since the magnitude of changes in variance is very marginal.

Table 5.22 Structural Breaks in Monthly Dollar Volatility

	Breaks	Variance
1	Jan 98- May 98	0.0257
2	June 98- Apr 2000	0.0184
3	May 2000- Oct 2003	0.0179
4	Nov 2003 - March 2004	0.0659
5	Apr 2004- March 2007	0.0331
6	May 2007- April 2008	0.0532
7	May 2008- Aug 2011	0.0978
8	Sep 2011- Dec 2014	0.1071

Table 5.23 Structural Breaks in Daily Dollar Volatility

	Breaks	Variance
1	25/08/98- 25/09/98	0.0032
2	26/09/98-28/10/98	0.0107
3	29/10/08-24/11/98	0.0099
4	25/11/98-07/12/98	0.0068
5	08/12/98-31/03/99	0.0037
6	01/04/99-20/10/99	0.0148
7	21/10/99-08/05/00	0.0018
8	09/05/00-19/03/04	0.0178
9	20/03/04-28/04/08	0.0952
10	29/04/08-05/05/08	0.1395
11	06/05/08-06/08/08	0.2772
12	07/08/08-08/09/11	0.3439
13	09/09/11- 12/06/15	0.3703

Table 5. 24 Structural Breaks in NEER Volatility

	Breaks	Variance
1	Jan 98- Oct 98	0.0437
2	Nov 98- Jan 99	0.0174
3	Feb 99- Apr 2000	0.0222
4	May 2000-Apr 2003	0.0288
5	May 2003- Oct 2003	0.0472
6	Nov 2003- Mar 2007	0.0323
7	Apr 2007- Feb 2008	0.0498
8	Mar 2008- July 2011	0.0540
9	Aug 2011- Dec 2014	0.0690

Table 5.25 Structural Breaks in WPI Volatility

	Breaks	Variance
1	Jan 98- Oct 2001	0.0130
2	Nov 2001- Dec 2003	0.0079
3	June 2004- Jan 2008	0.0127
4	Feb 2008- July 20014	0.0159
5	Aug 2014- Dec 2014	0.0207

Table 5.26 Structural Breaks in CPI Volatility

	Breaks	Variance
1	Jan 98- Jan 99	0.0927
2	Feb 99- May 99	0.0230
3	June 99- Jan 2000	0.0163
4	Feb 2000- July 2001	0.0088
5	Aug 2001- Oct 2003	0.0092
6	Nov 2003- Apr 2006	0.0075
7	May 2006- Aug 2007	0.0124
8	Sep 2007 -Dec 2014	0.0260

The structural breaks in inflation volatility are also detected using the same ICSS algorithm. Table 5. 25 shows the structural shifts and variance of at different time periods in CPI inflation volatility. There are eight structural shifts in the series which give eight short sub-sample periods. According to the variance of different time spans, the period is split into two, viz. pre and post financial periods. The variance seems to be getting up and down throughout the period without showing a common trend over the period. Variance is high (0.092) in the first sub-sample period, whereas it is comparatively low in other periods. When we analyse structural breaks of WPI inflation volatility (Table 5.26), the same kinds of trend can be seen. The variance has an upward or downward trend over the period without a common trend altogether. Then also the variance is high in the last span of period August 2014- December 2014. The Daily volatility series which derived from the residuals of GARCH models dollar, pound, euro and Japanese exchange rate shown in figures 5.1 5.2, 5.3, and 5.4 respectively. In all figures, the high level of volatility in post-crisis period can be seen. Figures 5.6 and 5.7 show monthly volatility series dollar and NEER, which gives a clear distinction in the strength of the volatility in pre and post financial crisis period.

5.3.3 Volatility Pass-Through: Multivariate GARCH – BEKK Modeling

Table 5.27 Volatility Spillovers between Exchange Rate and Inflation Estimated from Bivariate GARCH(1, 1)-BEKK Model

	Dollar-WPI Inflation			Dollar- CPI Inflation	
Parameters	Coef.	SE	Parameters	Coef.	SE
DOLLAR{1}	0.374***	0.063	DOLLAR{1}	0.410***	0.062
WPIINF{1}	0.143	0.117	CPIINFL{1}	0.146**	0.072
Constant	0.000	0.000	Constant	0.000	0.000
DOLLAR{1}	0.071***	0.023	DOLLAR{1}	0.059	0.041
WPIINF{1}	0.346***	0.071	CPIINFL{1}	0.191***	0.064
Constant	0.001***	0.000	Constant	0.001***	0.000
C(1,1)	0.003	0.001	C(1,1)	0.002	0.001
C(2,1)	-0.002***	0.000	C(2,1)	-0.002***	0.001
C(2,2)	0.018	0.012	C(2,2)	-0.004	0.008
A(1,1)	0.447***	0.089	A(1,1)	0.597***	0.130
A(1,2)	-0.017	0.040	A(1,2)	0.163***	0.060
A(2,1)	-0.374*	0.207	A(2,1)	0.198**	0.105
A(2,2)	0.314***	0.113	A(2,2)	-0.259***	0.099
B(1,1)	0.813***	0.071	B(1,1)	-0.846***	0.053
B(1,2)	0.139***	0.056	B(1,2)	0.014	0.099
B(2,1)	0.890***	0.293	B(2,1)	0.167	0.234
B(2,2)	-0.461***	0.18	B(2,2)	0.677***	0.142
Diagnostic Checks					
Log likelihood	1665.273			1332.547	
LB-Q (0-4)	17.724	0.340		1588.371	0.130
LB-Q (0-8)	44.136	0.075		22.432	0.015
LB-Q (0-12)	72.426	0.013		51.871	0.000
LB-Q^2 (0-4)	7.907	0.952		51.871	0.693
LB-Q^2 (0-8)	21.053	0.931		29.212	0.608
LB-Q^2 (0-12)	41.290	0.732		76.141	0.006

Tables 5.27 and 5.28 show the Multivariate GARCH BEKK results. The diagonal parameters a_{11} and a_{22} captures own ARCH effect, which is statistically

significant implying the presence of ARCH in all variables. It means the volatility of exchange rate and inflation is significantly determined by its past shocks. The estimated coefficients of b_{11} and b_{22} are all statistically significant at 1% level, indicating a strong GARCH (1, 1) effect in all GARCH models. This implies that as we have seen in the univariate models of each variable, the own past volatility play a crucial role in determining the present volatility of the series. But our focus in the multivariate GARCH models is not on checking the importance of variable's past shocks or volatility; rather we try to explore the volatility transmission between the variables.

The off-diagonal elements of matrix *Aij* and *Bij* capture the cross-variables effects such as shock spillover and volatility spillover between the variables of the exchange rate and inflation. Analysis of volatility transmission from dollar-rupee exchange rate to WPI inflation reveals that when A_{12} (ARCH) is not significant, B_{12}(GARCH) is seen to be significant which means that the impact of past volatility from the dollar is transmitted to WPI inflation whereas the past shocks dollar is not transmitted to WPI inflation. As contrary to this, both the impact of past volatility and past shocks from WPI inflation are transmitted to the dollar since the coefficient A_{21} (ARCH) and B_{21} (GARCH) are significant. As a whole, we can say that the relationship is bidirectional except in the case of ARCH term from the dollar to WPI inflation. However, in the case of transmission between the CPI inflation and the dollar exchange rate, both ARCH terms A_{12} and A_{21} are significant, whereas both the GARCH terms B_{12} and *B21* are not significant. It means that there is a past shocks transmission in a bidirectional way between the CPI inflation and Dollar exchange rate whereas there is no past volatility transmission in any direction.

Secondly, we have made this analysis using Nominal Effective Exchange Rate to make more general conclusions regarding exchange rate and inflation volatility transmission mechanism. Analysis of volatility transmission from NEER to WPI inflation reveals that when A_{12} (ARCH) is not significant, A_{21} is seen to be not significant which means that the impact of past shocks from NEER is transmitted to WPI inflation whereas the past shocks of WPI are not transmitted NEER. As contrary to this, the impact of past volatility of both NEER and WPI inflation are transmitted to each since the coefficient B_{12} and B_{21} (GARCH) are significant. As a whole, we can say that the relationship is bidirectional except in the case of ARCH term from WPI inflation to NEER. However, in the case of transmission between the NEER and CPI inflation, both the ARCH terms, A_{12} and A_{21} are significant, whereas both the GARCH terms B_{12} and B_{21} are not significant. It means that there is past shocks transmission in a bidirectional way between the CPI inflation and NEER whereas there is no past volatility transmission in any direction.

Table 5.28 Volatility Spillovers between Exchange Rate and Inflation Estimated from Bivariate GARCH(1, 1)-BEKK Model

	NEER- WPI Inflation			NEER- CPI Inflation	
Parameters	Coef.	SE	Parameters	Coef.	SE
NEER{1}	0.247***	0.065	NEER{1}	0.278***	0.063
WPIINF{1}	-0.302**	0.144	CPIINFL{1}	-0.253***	0.092
Constant	-0.003	0.000	Constant	-0.001	0.000
NEER{1}	-0.071***	0.027	NEER{1}	-0.070*	0.043
WPIINF{1}	0.414***	0.068	CPIINFL{1}	0.176***	0.065
Constant	0.001***	0.000	Constant	0.001***	0.000
C(1,1)	0.001	0.001	C(1,1)	-0.012*	0.001
C(2,1)	0.004	0.000	C(2,1)	-0.005	0.000
C(2,2)	0.004	0.001	C(2,2)	0.011	0.001
A(1,1)	-0.195**	0.096	A(1,1)	0.297***	0.063
A(1,2)	0.115**	0.025	A(1,2)	0.044	0.044
A(2,1)	0.091	0.168	A(2,1)	0.178*	0.100
A(2,2)	0.232**	0.076	A(2,2)	-0.134**	0.060
B(1,1)	0.828***	0.044	B(1,1)	0.928***	0.035
B(1,2)	0.167***	0.023	B(1,2)	-0.059***	0.019
B(2,1)	-0.914***	0.141	B(2,1)	0.078***	0.031
B(2,2)	0.882***	0.042	B(2,2)	0.970***	0.021
Diagnostic Checks					
Log likelihood	1664.806			1585.962	
LB-Q (4)	16.656	0.408		18.782	0.280
LB-Q (8)	44.444	0.071		48.915	0.028
LB-Q (12)	84.453	0.001		94.074	0.000
LB-Q^2 (4)	8.237	0.941		15.613	0.480
LB-Q^2 (8)	25.158	0.800		28.410	0.649
LB-Q^2 (12)	36.283	0.893		44.275	0.626

Panel B of tables 5.27 and 5.28, presents the multivariate Q-statistic used to test the null hypothesis that the model is correctly specified or to check the presence of random noise. Multivariate Q statistic for both standardised and standardised squared residuals up to lag 12 for each pair are reported here. Results show no serial dependence in the standardized residual and squared standardised residuals, validating the appropriateness of the MGARCH-BEKK model.

5.4 Indian Scenario and Exchange Rate Pass-Through: A Discussion

The impact of exchange rate on domestic price has been tested using a linear and nonlinear framework in the Indian context. Linear Vector Autoregressive models show enough evidence of the pass-through impact to CPI as well as WPI inflation. Moreover, the pass-through impact is found to be higher in the pre-crisis period compared to post-crisis period. The low pass-through in post-financial crisis period could be because of the increased volatility of exchange rate as we have seen in this chapter. According to Dixit (1989) and Albuquerque and Portugal (2005), the high uncertainty in the exchange rate as a result of high volatility leads to smaller effects in the price level. The results of nonlinear models reveal that there is evidence of bidirectional volatility spillover between exchange rate and inflation. Spillover seems to be higher in the case of WPI inflation than CPI inflation. From both linear and nonlinear models, the impact of exchange rate on domestic price level is very clear. The study could not focus on the determinants of exchange rate pass-through or the variability of exchange rate pass-through in different firms. However, based on the previous literature the possible reasons of high pass-through in the Indian context are as follows:

1. High depreciation of Indian rupee especially in the post-crisis period has led to an increase in the price level in different ways.

    a. When Imports become more expensive, the price level of the products which uses the imported raw materials shoots up.
    b. Rising oil prices as a result of depreciation lead to increase the transportation cost of all products which in turn increases the general price level.
    c. When import price increases, the price of domestic import substituted products also gets high due to increased demand for substitutes.

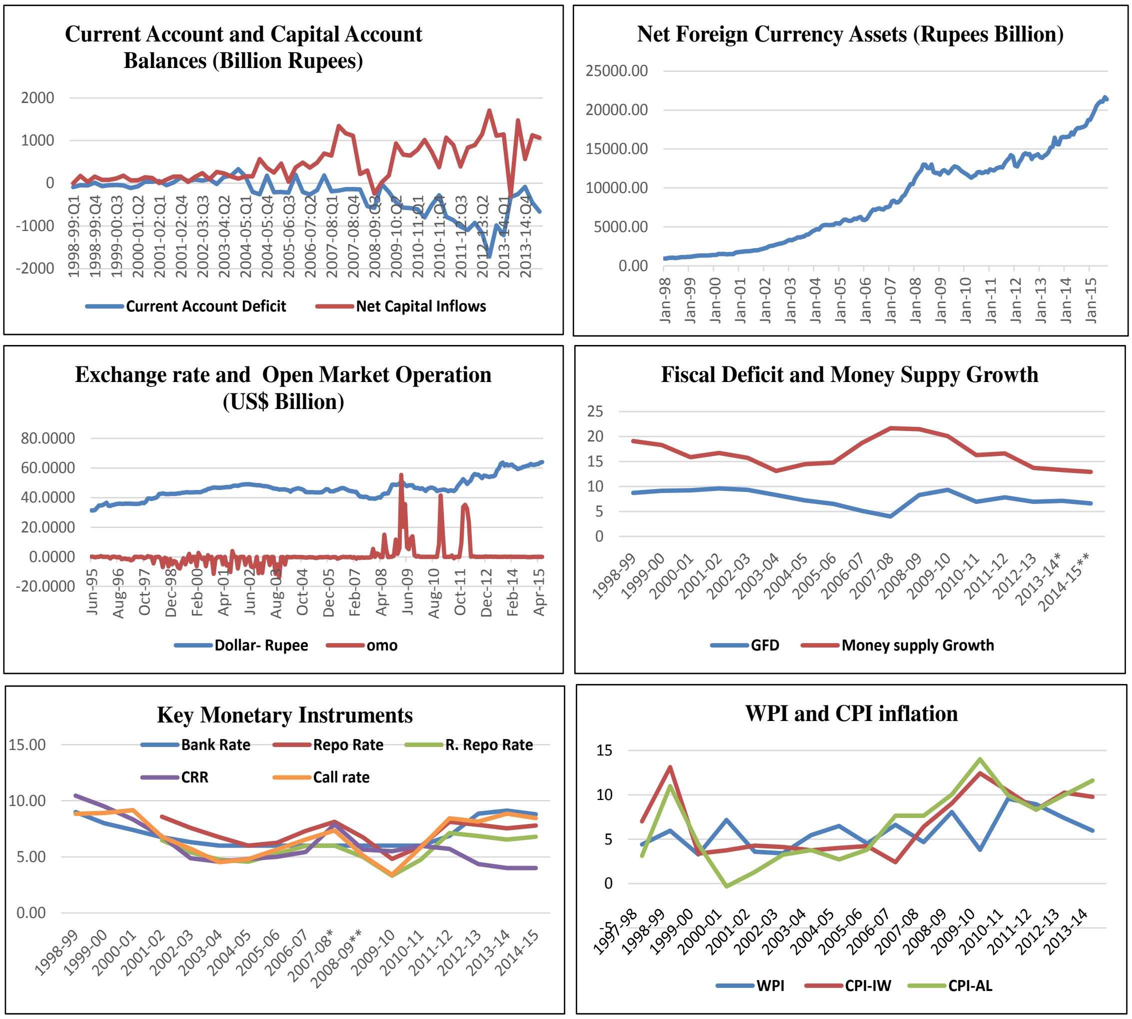
2. Since India faces competition from the developing countries in exporting to advanced countries, India tries to keep the rupee depreciated by attracting more capital flows. The increase of the foreign reserves accordingly leads to an increase in domestic money supply. In this context, failure of appropriate sterilization policies leads to an increase in inflation.

5.4.1 Indian Monetary System and Exchange Rate Pass-Through

The widespread negative impact of inflation in various sectors persuades government and monetary authorities to keep inflation under control. However, it is not guaranteed that the policies which are adopted will have the desired results. During the study period, the high peaks of inflation could be found in 1998-99 and 2009-10. From the analysis of the inflation level in 1998-99, a double digit CPI inflation can be observed while the WPI inflation is only 6%. As we know, oil price inflation and food price inflation are the two major determinants of inflation level in India. The weight of food prices is higher in the CPI basket, while the weight of oil price is more in the WPI. So, the changes in the oil prices due to changes in the exchange rate lead to an increase in WPI inflation than CPI inflation. Thus, the WPI inflation witnesses high changes by the external shocks and exchange rate fluctuations. In the first peak of inflation, the food price inflation was high whereas the oil price inflation was marginal (Mishra and Roy, 2011). Therefore, CPI is found to be high in this period whereas the WPI inflation is low. It means that internal shocks were more crucial in deciding the inflation peak in 1998-99 than external shocks through exchange rate and oil price inflation. There was no much capital flows or much depreciation in the exchange rate during this period. The second peak of inflation was mostly driven by the external shocks such as exchange rate depreciation and oil price changes. Hence, the dynamics of this exchange rate driven-peak, of both WPI and CPI inflation which started in the post-crisis period, is more important for the analysis of pass-through.

Most of the developing countries which have the lion share of their export to the developed or developing countries will always be much concerned about the appreciations of their currency than depreciation. It is mainly due to the fear of losing their share of export to the advanced countries, which will be a great threat to the domestic growth and development. The destination of India’s lion’s share of export also being the advanced economies, the Indian government always takes monetary or foreign exchange policies by considering the domestic exporters. At the same time, the developing countries also try to attract more foreign investment and capital flows to their countries since most of the developing countries face the problem of insufficient domestic investment and high population. However, the increasing capital inflows leads to the appreciation of the domestic currency due to the increased increasing demand for domestic currency. After the global financial crisis, Indian assets became more attractive and reliable than the assets of advanced countries which experienced the repercussions of the crisis. In this context, India could attract more foreign capitals which recorded highest flows in the Indian history. As a developing country, which faces the problem of supply bottleneck, it was a good sign for the domestic growth and development. However, when there is only current account convertibility, the Reserve Bank of India should sell the required Indian rupee by purchasing the foreign currency. It led to an increase in the foreign reserve assets of the reserve bank and injected more domestic currency to the economy, which in turn impacted the inflation level of the country. Figure 5.9 shows external and internal monetary scenario of Indian economy along with CPI and WPI inflation during the study period.

Figure 5.9 Indian Economic Indicators, Exchange Rate and Domestic Inflation



Source: Reserve Bank of India

The initial impact of the subprime crisis was very positive for India, which led to more capital flows and foreign reserves. To curb the negative impact of increasing capital flows in the domestic economy, India has taken sterilization measures during this period. Open market operations were comparatively higher than any other period in the post-liberalization period. At the same time, all monetary instruments were used to reduce the money supply in the economy. The Repo rate increased from 7.75% in April to 9% in August 2008. CRR also increased from 7.5% in April 2008 to 9% in August 2008. These policy measures were carried out only when WPI inflation reached its peak level in August 2008 due to increasing oil price and increased the money supply as a consequence of sterilization process. Although RBI adopted more expansionary policies in the second half of 2008-09, after 2010-11, continuous contractionary policies were followed. Nevertheless, the contractionary policies were not up to the mark to rein in inflation. Therefore, the CPI and WPI inflation continued to be high during this period.

In sum, the monetary policies were not effective in containing inflation during the study period while the focus of the authority was to maintain desirable exchange rate. RBI could not use sterilization policies to bring inflation under control. The concentration of the monetary policy especially after the subprime crisis was to avoid the appreciation of the rupee and neutralizes the impact of foreign capital inflows. As a result, the exchange rate was continuously depreciating during this period. When the RBI took measures of sterilization and kept the rupee depreciating most of the period, the high level of the inflation was a great threat to the economy. In line with the results of Rashid and Husain (2010) in the context of Pakistan, our results also indicate that the inflationary impact of capital flows was significant in India.

As we have seen, RBI responds to the capital flows by increasing the foreign reserves accordingly to keep the rupee depreciated to avoid the chance of appreciation. Whenever there was a tendency of appreciation, the economy has been badly hit by mounting up the current account deficit. So the prime focus of RBI was managing exchange rate than controlling the inflation. As far as the managed floating is concerned, it is more flexible rather than fixed or controlled. So the attempt to maintain the floating exchange rate always required the sacrifice of the monetary autonomy in one way or another. Considering the fact that India is a developing country, which has the problem of supply bottleneck needs high capital flows and investment for the domestic development and growth. Crawling peg with the broader band is more suitable for effective sterilization and to avoid the high volatility of capital flows and control the exchange rate in the desired direction. The adoption of this alternative will help to retain more autonomy on monetary policy. Secondly, sterilization policies which India adopts could not provide desired results. So the sterilization policies should be improved in such a way that the excess domestic money supply pumped to the economy as a result of increasing foreign reserves should not lead to an increase in inflation.

5.5 Summary and Conclusion

The aim of this chapter was to portray the nonlinear relationship between exchange rate and inflation by checking volatility spillover using univariate and multivariate GARCH models. Firstly, we have used a family of univariate GARCH models to estimate the volatility series. An ample number of models show significant ARCH and GARCH effect in the volatility. EGARCH models to capture the asymmetric impacts of shocks reveals that there is leverage effect in the case of dollar whereas the effect was not seen in NEER, CPI and WPI inflation. ICSS algorithm was run to check the structural shifts in volatility by taking volatility series of the best model from GARCH and EGARCH models. Though we could find multiple break points in volatility, a clear distinction between pre and post financial crisis period can be seen only when we analyse the variance in various sub-sample time periods. Finally, the non-linear pass-through is tested by using Multivariate GARCH- BEKK models. The results reveal that there is evidence of bidirectional volatility spillover between exchange rate and inflation in India. Spillover seems to be higher in the case of WPI inflation than CPI inflation.

The analysis of the inflation and monetary scenario of Indian economy reveals that the monetary policies were not effective in containing inflation during the study period while the focus of the authority was to maintain desirable exchange rate. RBI could not use effective sterilization policies to bring inflation under control. The concentration of the monetary policy especially after the subprime crisis was to avoid the appreciation of the rupee and neutralizes the impact of foreign capital inflows. As a result, the exchange rate was continuously depreciating during this period. When the RBI took measures of sterilization and kept the rupee depreciating most of the period, the high level of the inflation was a great threat to the economy. In line with the results of Rashid and Husain (2010) in the context of Pakistan, our results also indicate that the inflationary impact of capital flows was significant in India.

----xxx----

Chapter 6

Exchange Rate and Foreign Trade: Linear and Nonlinear Dynamic Interaction

6.1 Introduction

The traders who involve in cross country trade activities are much concerned about the variations in the exchange rate as well as the global price and demand for the product since these are all crucial determinants of their profit margins. Future uncertainties in the exchange rate also matter as it compels the traders to go with some hedging strategies or speculating strategies depending upon the risk-bearing capacity of the trader. Exchange rate volatility or uncertainty leads to uncertainty in effective price and cost of the products which will ultimately affect the profit margin of the trader (Dholakia and Saradhi, 2000). The study of exchange rate impact on foreign trade or its volatility holds due importance, since the changes in exchange rate and its uncertainty about the future values matter for cross-border trading activities of a trader. This chapter tries to examine linear as well as the non-linear relationship between the exchange rate and foreign trade in Indian.

The rest of the chapter is set forth as follows. Section 6.2 deals with data and methodology used in the study. Interactions between exchange rate and trade balance are discussed thereafter. Subsequently, the interactions of exchange rate export and import, and nonlinear interactions or volatility transmission of the variables using multivariate GARCH- BEKK framework are analysed. The final section gives the conclusions of the study.

6.2 Data and Methodology

Monthly data from January 1998 to until November or December 2014 and quarterly data of the same period is used for this time series analysis. All the data series used for the study are taken from various sources. Export, Import balance data is taken from IMF's international financial statistics database. Trade balance data is calculated from export and import as explained in the forthcoming sections in detail. A period average of rupees per dollar in monthly basis and Real Effective Exchange Rate (REER - 36 countries Average) are taken as the variables of the exchange rate. Rupee- dollar exchange rate data is collected from the database of International Monetary Fund while NEER data is made available from Bank of International Settlement (BIS), with the base of 2010. Finally, the WPI and CPI inflation is calculated from the WPI and CPI indices wich is published by Reserve Bank of India. The reason behind using two types of data series, quarterly and monthly, is due to unavailability of GDP data series on a monthly basis. Considering GDP as a strong determinant of foreign trade, GDP data is expected to be added as an independent variable. In the absence of monthly GDP data series, quarterly data is used to estimate ARDL model with 68 observations. Further, understanding the need of adequate number of observations in GARCH modeling to give reliable results, monthly data series are used for this purpose. Thus, Instead of GDP, monthly Index of Industrial Production (IIP) collected from Reserve Bank of India is considered for the model. Two proxies are used for world GDP. The first one is world GDP, (GDP*) collected from the database of International Monetary Fund. The second one (GDP**) is calculated by combining the GDP of India's four major trade partners- USA, China, Hongkong and Singapore.

Table 6.1 Discriptive Statistics -Quarterly Data Series

	LTB	DLX	DLM	DLREER	DLDOLLAR	DLGDP	DLGDP*	DLGDP**	DLIIP
Mean	-0.144	0.019	0.017	0.000	0.003	0.013	3.322	0.005	0.006
Median	-0.140	0.019	0.012	0.000	0.001	0.014	3.366	0.005	0.011
Maximum	-0.015	0.096	0.140	0.027	0.047	0.031	5.827	0.011	0.034
Minimum	-0.263	-0.057	-0.131	-0.030	-0.030	-0.010	-1.812	-0.009	-0.046
Std. Dev.	0.060	0.035	0.035	0.011	0.014	0.007	1.534	0.003	0.021
Skewness	0.146	-0.003	-0.165	-0.174	1.142	-0.668	-0.983	-1.437	-0.581
Kurtosis	2.243	2.498	8.358	3.952	5.320	5.128	4.608	6.813	2.144
Jarque-Bera	1.868	0.715	81.656	2.909	30.035	17.891	18.275	64.602	5.906
J. B. Prob	0.393	0.699	0.000	0.234	0.000	0.000	0.000	0.000	0.052
Sum Sq. Dev.	0.238	0.081	0.082	0.007	0.013	0.003	157.597	0.001	0.029
Observations	68	68	68	68	68	68	68	68	68

The descriptive statistics of quarterly and monthly variables are given in Table 6.1 and 6.2 respectively. Since all the variables are taken in the log form, the mean values are closer to zero. The descriptive statistics of the variables help us to understand the nature and pattern of the data series. When the trade balance and dollar exchange is positively skewed all other variables in the quarterly series are negatively skewed, though it is not far away from zero. Trade balance Export, REER and IIP seems to be mesokurtic since the kurtosis value is near 3, while other variables diverge from 3. The monthly data series also has a mean value closer to zero as we have seen in the quarterly data series. When the export and REER is positively skewed, trade balance, import and dollar exchange rate seems to negatively skewed. Except in dollar exchange rate, all other cases, the kurtosis value stands around 3.

Table 6.2 Discriptive Statistics- Monthly Data Series

	LTB	DLX	DLM	DLREER	DLDOLLAR
Mean	0.000	0.006	0.006	-0.001	0.001
Median	-0.003	0.006	0.006	-0.001	0.000
Maximum	0.160	0.121	0.127	0.015	0.028
Minimum	-0.141	-0.155	-0.086	-0.026	-0.018
Std. Dev.	0.047	0.048	0.044	0.007	0.007
Skewness	0.081	-0.333	0.113	-0.551	0.832
Kurtosis	3.307	3.667	2.441	4.017	5.477
Jarque-Bera	1.024	7.544	3.093	19.126	75.677
J. B. Prob	0.599	0.023	0.213	0.000	0.000
Sum Sq. Dev.	0.455	0.475	0.395	0.009	0.011
Observations	204	204	204	204	204

6.2.1 Cointegration Approach

The traditional classical linear regression models cannot be fitted using non-stationary data series. As per this classical approach, the regression of non-stationary data series may produce spurious regression. In the practical world, most of the financial and macroeconomic variables are found to be non-stationary data series. So the limitation of the classical regression models inspired to explore new models which are suitable for modeling the nonstationarity series. The introduction of Cointegration approach holds due importance in this regard. The concept of cointegration drew the attention of econometricians by the path-breaking works of Granger (1981) and Engel and Granger (1987) which accommodates non-stationary variables sharing a common stochastic trend. They viewed that though the variables are not stationary and move arbitrarily, there might be a chance of having a relationship between the variables in the long-run. This idea of Granger and Engel opened a new door for modeling nonstationary variables, which was later on expanded and popularized by so many other econometricians. Since the Engel- Granger Cointegration test is limited only with two variables, the expanded form with multivariate variables is used widely. Among these, Johansen Cointegration test and ARDL Bound test hold due importance. The detailed explanation of Johansen Cointegration test and ARDL Bound test are given below, though the second one is used for the analysis.

6.2.1.1 Johansen Maximum Likelihood Cointegration Approach

Johansen (1991), and Johansen and Juselius (1990) multivariate cointegration technique is widely used if the variables are integrated of order one, I (1). A long-run relationship means that the variables tend to move together over time, so disturbances which may arise in short-run will be corrected in long-run (Manning and Andrianacos, 1993). Johansen and Juselius (1990) modeled cointegrating vector of time series as reduced rank regression with the Gaussian Errors. The Error Correction method of this model can be represented by:

$$\boldsymbol{\Delta} Z_t = \mu + \sum_{i=1}^{p-1} \Gamma_i \boldsymbol{\Delta} Z_{t-k} + \prod Z_{t-1} + \varepsilon_t \qquad \ldots (6.1)$$

Where Z_t is a (*nx1*) column vector of *p* variables, μ is a (*nx1*) vector the of constant term; ***Δ*** is a difference operator. *K* denotes the lag length and $\varepsilon_t \sim N(0, \Sigma)$.The coefficient matrix ∏ is known as the co-integrating matrix which is a (*NxN*) matrix, and it contains information about the long-run relationships including the number of co-integrating vectors *(r)* between the variables in Z. Here, *r* is the rank of ∏.This method requires that variables entering the cointegration relationship to be integrated of the same order and yields two likelihood statistics known as trace and maximum Eigen value statistics which are given by;

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \lambda_i) \qquad \ldots. (6.2)$$

$$\lambda_{max}(r, r+1) = -T \ln(1 - \lambda_{i+1}) \qquad \ldots. (6.3)$$

Both Trace Test, and Maximum Eigenvalue Test are used to check the cointegrating relations. The trace statistic tests the null hypothesis of at most *r* cointegrating relations against a general alternative whereas, in Maximum Eigenvalue Test, the null hypothesis is exactly *r* number of cointegrating relations against alternative of *r+1*cointegrating relations. Further, the optimum lag length used in the estimation is obtained by sequentially modified LR test and Schwarz information criterion.

6.2.1.2 ARDL Bound Testing and Cointegration Approach

Co-integration tests such as the Johansen maximum likelihood limit its applicability due to its requirement of strict I (1) stationary variables. It is quite possible to have some I (1) variable and some I (0) variables. In Johansen and Juselius (1990) model, the reason for sticking to only I (1) variables is considering the possibility of I (0) stationary variable from the linear combination of I (1) variables. However, the requirement of I(1) variables often leads to biases since whether the variables are stationary or not also depends on which unit root test is used and which lag is selected for the analysis. Some variables which are stationary in Dickey-Fuller test might not be stationary in Philips Parron test. In this regard, ARDL Bound Test overcome this limitation and accommodates both I (0) and I(1) variables, where most of economic or financial variables will be either of them. Therefore, to get robust finding and reliable results, ARDL Cointegration approach is used in the study. More than the stationarity order of the variable, the model holds many advantages compared to the traditional approaches. Firstly, it is asymptotically efficient and can be run even with small samples and endogenous variables. In addition, it also helps to select optimum lag as per various information criteria which will be good to capture the long-run relationship.

In ARDL bound test, we use F-test to examine the existence of a long-run relationship between the variables instead of trace and maximum eigenvalue value by Johnsen. The null hypothesis of F bound test is that all the long-run parameters are equal to zero against an alternative hypothesis of significant log run parameters different from zero, which is an indication of co-integration among the variables (Pesaran et al., 2001).However, these critical values generated by Pesaran et. al (2001) are suitable only for large samples such as 20,000 and 40,000. According to Narayan (2004), these high critical values cannot be used for small sample sizes. In this study, we have compared the F-statistic computed from the model with critical bounds generated by Lower critical Bound (LCB) and Upper Critical Bound (UCB) developed by Narayan (2005). The cointegration among the variables can be confirmed if the computed F-statistic is more than Upper Critical Bound (UCB). However, the result becomes inconclusive if the F-statistic lies between LCB and UCB.

6.2.1.3 ARDL Model

Most of the studies which try to empirically validate Marshal – Learner Condition or J-Curve Hypothesis used export minus import as trade balance while some others had analysed it by using the ratio of export to import. Here, the latter methodology is adopted by taking the ratio of export to import which has many advantages compared to the traditional approach. Mainly it is not sensitive to units of measurement, and not sensitive to whether export or import calculated in real or nominal terms. Another very important advantage of this approach is the easy calculation in log form without any difficulty. Since the import is higher than the export, mostly the trade balance will be negative which is not able to directly convert to log form. Moreover, it helps to check the Marshal Lerner condition exactly in the logarithmic model. (Khan and Hossain, 2010)

The model we used here for the analysis is the same reduced model employed by Krugman Baldwin (1987), Rose and Yellen (1989), Rose (1991) Bahmani- Oskooee (1991), Brada et al. (1993) and Panda and Reddy (2015) for the analysis of trade balance and exchange rate.This is a simple macroeconomic model which uses few variables such as domestic, Global GDP, exchange rate and trade variables.

The trade balance ratio of export to import used in this analysis can be written as:

$$TB_t = \frac{P_t X_t}{P_t^* S_t M_t} \quad \text{.....(6.4)}$$

Where TB_t is the trade balance in nominal terms. $P_t X_t$ denotes volume of total export multiplied by the domestic price of the export. $P_t^* S_t M_t$ is the total volume of imports multiplied by the foreign country's price, from where the product is imported, and the nominal exchange rate of the country with respect to particular currency. Here, increase in the value of trade balance is considered as favourable where decreasing trend is considered as unfavourable. If we consider the above-mentioned equation in logarithmic form, it is as follows:

$$\ln B_t = \ln X_t - \ln M_t - (\ln S_t - \ln P_t - \ln P_t^*) \quad \text{......(6.5)}$$

Where the nominal export and import can be written as:

$$X_t = P^* \text{ x } X_t \; and \; M_t = P \text{ x} M_t$$

In the second equation $\ln S_t - \ln P_t - \ln P_t^*$ is the Real Effective Exchange Rate which can be written without the logarithmic form:

$$E = S \text{ x} \frac{P^*}{P} \quad .....(6.6)$$

Where E is the Real Effective Exchange Rate if we write without log form, S is the spot exchange rate, P domestic price level or inflation and P^* foreign price level or inflation. By putting the equation 6.6 into 6.5, we can re write the equation 6.5 as follows:

$$\ln B_t = \ln X_t - \ln M_t - (\ln E_t) \quad .... (6.7)$$

Now if we consider the export and import equations separately, export can equation can be written as:

$$\ln X_t = \alpha_x + \beta^* \ln Y_t^* + \gamma_x \ln E_t + \varepsilon_x \quad .... (6.8)$$

And the import long-run equation can be written as:

$$\ln M_t = \alpha_m + \beta \ln Y_t + \gamma_m \ln E_t + \varepsilon_m \quad ..... (6.9)$$

Now if we combine both the equation of export (6.8) and import (6.9) to the trade balance equation we can rearrange the trade balance equation as follows:

$$\ln B_t = (\alpha_x + \alpha_m) + \beta^* \ln Y_t^* - \beta \ln Y_t - (\gamma_x + \gamma_m - 1) \ln E_t + (\varepsilon_x + \varepsilon_m) \quad .... (6.10)$$

The Marshal Learner condition says that any depreciation or devaluation will lead to trade balance improvement if the sum of export elasticity and import elasticity is greater than one. If we want to evaluate empirically, the validity of Marshal- Learner condition from the above equation can be analysed by checking the sign of$\gamma_x + \gamma_m - 1$. Now we can re arrange the equation as below in reduced form for the simplicity.

$$\ln B_t = \alpha + \beta^* \ln Y_t^* - \beta \ln Y_t - \gamma \ln E_t + \theta_t + \varepsilon \quad \text{.....(6.11)}$$

Where, $\alpha_x - \alpha_m = \alpha, \ \gamma_x + \gamma_m - 1 = \gamma, \ \theta_x - \theta_m = \theta, \varepsilon_x - \varepsilon_m = \varepsilon$

Now the parameter of world GDP is expected to have positive sign since the increase of global GDP will lead to increase in the export from our country to other countries. At the same time, the parameter of domestic GDP is expected to have negative sign since the increase in the domestic GDP will lead to an increase in the purchasing power of the customer which in turn leads to a higher import demand from other countries. Finally, the parameter exchange rate is expected to have a negative sign in the case of REER because decreasing value of REER indicates depreciation. So if the hypothesis is that the depreciation has a positive impact on the trade balance, then this parameter will be negative in the case of REER and positive in the case of the Rupee- dollar exchange rate.

Based on this theoretical background we have estimated three separate equations for trade balance, export and import integrating short-run and long-run dynamics of the variables

6.2.2 BEKK- GARCH Model for Volatility Spillover

Multivariate BEKK GARCH model is used to check the spillover between the exchange rates. BEKK-GARCH Model is an extension of the multivariate GARCH model which enables us to show the volatility transmission from one series to another, as well as the persistence of volatility within each series. Since the parameterization of BEKK is in quadratic form, there are no restrictions needed to ensure positive definiteness of the H matrix. In the present study, we have used bivariate VAR-BEKK (Baba-Engle-Kraft-Kroner) to examine the volatility transmission i.e. spillover effects within and between exchange rates. Here we have used VAR (1, 1) to define the conditional mean of the returns. It accommodates each market's returns and the returns of other markets lagged by one period.

$$Y_t = \mu_t + \phi Y_{t-1} + \varepsilon_t \quad \text{....... (6.12)}$$

$$\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} + \begin{bmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{bmatrix} \begin{bmatrix} Y_{1t-1} \\ Y_{2t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \quad \text{....... (6.13)}$$

$$\varepsilon_t | \Omega_{t-1} \sim N(0, H_{t)} \quad \text{....... (6.14)}$$

Where the own market mean spillovers and cross-market mean spillovers are measured by the estimates of 'ϕ' elements, the parameters of the autoregressive term.

The BEKK parameterization for the bivariate GARCH (1, 1) model is given by:

$$H_t = \acute{C_1} C_1 + \sum_{i=1}^{p} \acute{A}_{11} \varepsilon_{t-1} \varepsilon_{t-1}' A_{11} + \sum_{i=1}^{p} \acute{B}_{11} H_{t-1} B_{11} \quad \text{...... (6.15)}$$

Where the parameter matrices for the variance equation are defined as ***C***, which is restricted to be lower triangular, and two unrestricted matrices ***A*** and ***B***. Thus, the second moment can be represented by,

$$H_t = \grave{C_0} C_0 + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}' \begin{bmatrix} e_{c,t-1}^2 & e_{c,t-1} e_{th,t-1} \\ e_{th,t-1} e_{c,t-1} & e_{th,t-1}^2 \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} +$$
$$\begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}' H_{t-1} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \quad \text{..... (6.16)}$$

The diagonal element a11 and a22 show the relationship between conditional variances and past shocks of own series, whereas b11 and b22 measures the relationship between current and past conditional variances. The off-diagonal parameters, a21 and a12 measure the degree of market shocks from market 1 to market 2 and vice versa. The parameters b21 and b12 measure the persistence in conditional volatility between market 1 and market 2.The number of parameters in the BEKK model is N (5N+ 1)/2, hence, in this model the number of parameters is 11. The BFGS algorithm is used to produce the maximum likelihood parameter estimates and their corresponding asymptotic standard errors.

6.3 Empirical Results

Firstly, checking stationarity is important to be confirmed before going for further time series or econometric treatment. Three kinds of stationarity tests are used for this purpose, Dicky-Fuller, Phillips- Perron and KPSS tests. Table 6.3 give results of these tests for quarterly series in the first part and monthly series in the second part. As we have mentioned in the methodology part, the data series should be either I (0) or I (1) to go for ARDL model. However, it should not be I(2) in any case. The variables in levels and differenced form are tested for stationarity to have a proper understanding of the stationarity nature of the data. Test static value and p-value is given in the first two tests whereas static value and critical value at 5% significance level is given in the KPSS test. Firstly, only trade balance and export variables exhibit stationarity in levels in all three tests. In all other variables namely import, REER, Dollar, GDP and GDP** and IIP are stationary at first differenced form as per three tests, though in some cases few variables differ in one test.

Table 6.3 Unit Root Test Statistics

Quaterly data Series						
Variables	Dicky- Fuller		Philllips- Perron		KPSS	
	Test Statistic	P- Value	Test Statistic	P- Value	Test Statistic	Critical Value (5%)
LTB	-3.713	0.0341	-4.575421	0.0025	0.091663	0.1460
DLTB	-8.544	0.0000	-21.82218	0.0001	0.119464	0.1460
LX	-4.620814	0.0021	-4.605818	0.0022	0.094896	0.1460
DLX	-6.741513	0.0000	-14.98554	0.0001	0.128344	0.1460
LM	-2.593136	0.2848	-2.682225	0.2472	0.179026	0.1460
DLM	-8.92302	0.0000	-9.308181	0.0000	0.125143	0.1460
LREER	-1.629035	0.7709	-1.786203	0.7005	0.21184	0.1460
DLREER	-6.909773	0.0000	-6.897835	0.0000	0.041639	0.1460
LDOLLLAR	-1.084591	0.9238	-1.483444	0.8257	0.18049	0.1460
DLDOLLAR	-6.229934	0.0000	-6.201987	0.0000	0.109936	0.1460
LGDP	-1.701225	0.7399	-1.736017	0.7241	0.233074	0.1460
DLGDP	-6.441766	0.0000	-6.456338	0.0000	0.121248	0.1460
DLGDP*	-3.677504	0.0309	-2.891486	0.1719	0.064303	0.1460
LGDP**	-1.821726	0.6830	-1.748076	0.7186	0.211823	0.1460
DLGDP**	-5.195402	0.0003	-5.273973	0.0003	0.075184	0.1460
LIIP	-1.602653	0.7809	-3.865357	0.0190	0.169992	0.1460
DLIIP	-1.293079	0.1790	-9.806881	0.0000	0.080711	0.1460
Monthly data Series						
DLDOLLAR	-9.841605	0	-9.802534	0.0000	0.187754	0.4630
DLREER	-11.12179	0.0000	-11.00649	0.0000	0.102978	0.4630
LTB	-10.30638	0.0000	-48.45577	0.0001	0.396327	0.4630
DLX	-5.178741	0.0000	-47.32895	0.0001	0.172607	0.4630
DLM	-24.44929	0.0000	-24.88623	0.0000	0.081929	0.4630

Note: GDP* denotes World GDP Collected from IMF data base
GDP** denotes calculated World GDP

The world GDP growth (GDP*) is taken from IMF database. So we could not check whether it is stationary in levels or not. In monthly series, since we have considered only differenced log variables, all variables are stationary in first differenced form. So in the next sections, we have tried to model various ARDL models for trade balance, export and import.

6.3.1 Exchange Rate and Trade Balance

As we have discussed in the theoretical framework, Elasticity approach and J-curve hypothesis deals with both short-run and long-run relationship between exchange rate and trade balance. Only the cointegration models can capture both the short-run and long-run relationship in the same model. ARDL model holds its superiority than other cointegration models through its accommodating capacity of I (0) or I (1) variables. Table 6.4 shows ARDL Error Correction Model, which establishes a short-run relationship. We have fitted several models and selected four models which are most suitable and shows significant long-run relationships in ARDL bound test. In Model 1 we have considered only three variables including its past values of trade balance. We can see significant negative relationship between domestic GDP growth and dollar exchange rate and positive relationship between world GDP growth and dollar exchange rate. It is as expected since increasing growth of domestic GDP will lead to more imports as increasing growth of world GDP leads to more export. The relationship between dollar exchange rate and the trade balance is our main focus. The significant positive relationship, in this case, rejects the J – curve hypothesis that depreciation will be unfavourable for short-run as is explained through the J- curve pattern. In the second model using the REER as an independent variable, the relationship between the variables is as expected. The significant negative relationship between REER and trade balance also rejects the validity of J- curve hypothesis.

Table 6.4 ARDL Error Correction Model for Trade Balance

	Model 1		Model 2			Model 3			Model 4		
	Coeff.	Std. Error		Coeff.	Std. Error		Coeff.	Std. Error		Coeff.	Std. Error
D(LTB(-1))	-0.188	0.158	D(LTB(-1))	-0.357**	0.150	D(LTB(-1))	-0.265*	0.149	D(LGIIP)	0.251	0.422
D(LTB(-2))	-0.106*	0.147	D(LTB(-2))	-0.153	0.143	D(LTB(-2))	-0.161	0.141	D(LIIP(-1))	-0.252	0.275
D(LTB(-3))	-0.314	0.120	D(LTB(-3))	-0.339***	0.120	D(LTB(-3))	-0.321***	0.120	D(LIIP(-2))	0.902***	0.000
D(LGDP)	-0.651**	0.284	D(LGDP)	0.092	0.077	D(LGDP)	-0.220***	0.068	D(LIIP(-3))	-1.366***	0.000
D(LGDP**)	0.909	0.564	D(LGDP**)	-0.807	1.786	D(GDP*)	-0.007	0.005	D(LGDP**)	1.212	0.401
D(LDOLLAR)	0.313***	0.114	D(LGDP**(-1))	-6.849**	2.856	D(LDOLLAR)	0.160***	0.053	D(LGDP**(-1))	-5.911***	0.012
CointEq(-1)	-0.545***	0.171	D(LGDP**(-2))	2.960*	1.620	CointEq(-1)	-0.432***	0.154	D(LGDP**(-2))	2.346*	0.081
			D(LREER)	-1.156***	0.472				D(LREER)	-0.85**	0.047
			D(LREER(-1))	-0.570	0.674				D(LREER(-1))	-0.290	0.597
			D(LREER(-2))	-0.571	0.722				D(LREER(-2))	0.121	0.831
			D(LREER(-3))	-1.398***	0.545				D(LREER(-3))	0.957**	0.028
			CointEq(-1)	-0.296**	0.146				CointEq(-1)	-0.397***	0.000

Unlike dollar exchange rate, the negative sign is expected since negative sign in REER means depreciation. In third and fourth models also there is a significant positive sign in the case of dollar exchange rate and negative sign in the case of REER, which shows that depreciation leads to a more favourable position in the trade balance in the short-run also as against the theoretical view of J- Curve hypothesis. The results of long-run equations and diagnostic checks for both short-run and long-run equations are given in table 6.5.

In all models, the domestic GDP growth has both positive and negative relationship. It is because of various levels of influence of GDP on import and export. In the fourth model, we have considered IIP instead of GDP but it does not seem to be a major determinant of the trade balance in the long-run. Global GDP is found to be significant only in the first model. Finally, the relationship between the exchange rate and balance of trade is as expected. In the first and third model, where we have used rupee- dollar rate as a proxy for the exchange rate, the coefficient of the exchange rate is positive means that the depreciation has led to having a more favourable balance of trade in the long-run.

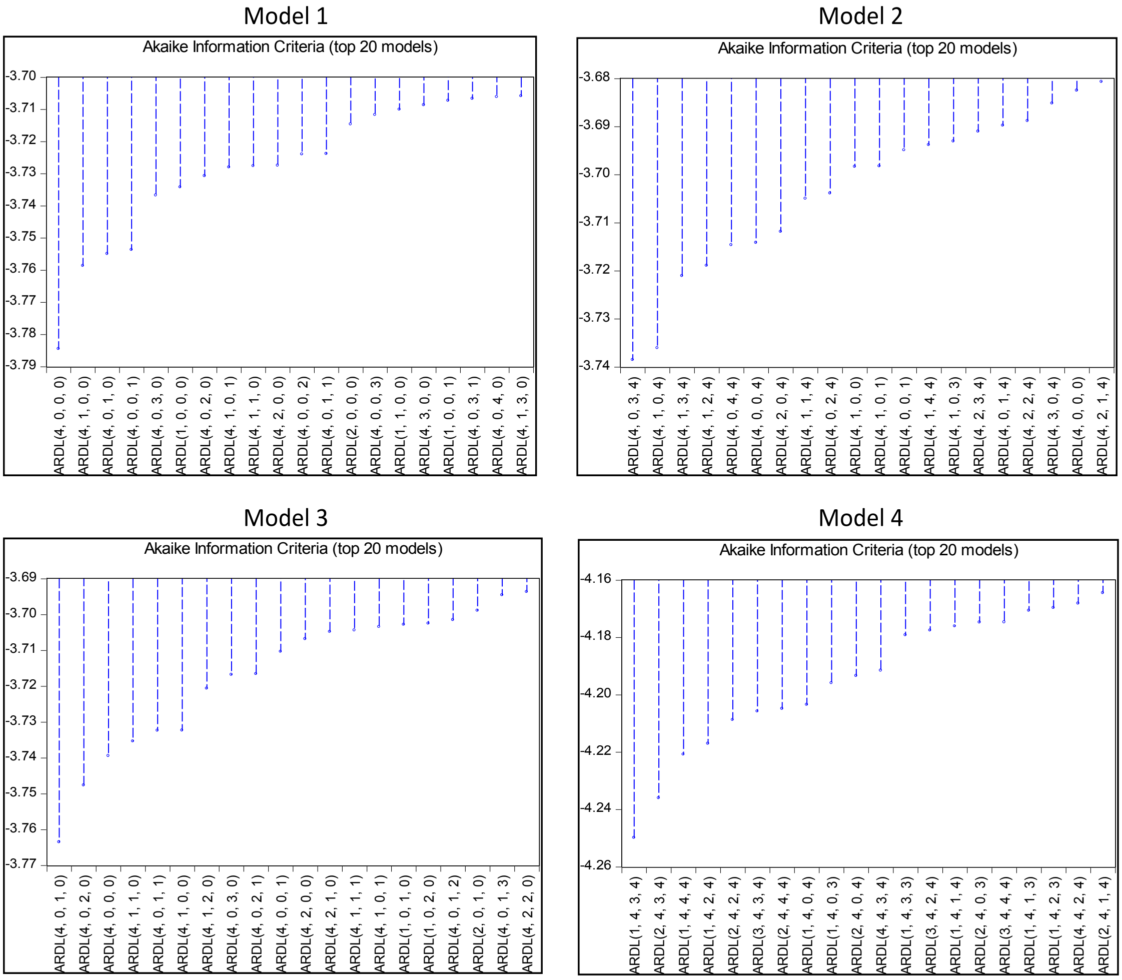
Table 6.5 ARDL Longrun Equation for Trade Balance

	Model 1		Model 2		Model 3		Model 4	
	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error
LGDP	-1.194***	0.425	0.308	0.326	-0.509***	0.133		
LIIP							-0.182	0.369
LGDP*					0.004	0.007		
LGDP**	1.667*	0.916	-1.285	1.043			-0.081	0.568
LDOLLAR	0.5751***	0.180			0.370***	0.134		
LREER			-2.834*	1.612			-1.518*	0.737
C	-17.174*	10.039	20.217	12.718	1.206***	0.304	4.324	6.675
Diagnostic Checks								
ARDL Bound Test								
Narayan (2005) Critical Values at 5% significance level if k=3 I(0)= 3.37, I(1)= 4.545; if k=2 I(0)= 3.947, I(1)= 5.02								
	Value	k	Value	k	Value	k	Value	k
F static	3.792	3	3.410	3	2.894	3	4.946	3
Breusch- Godfrey Serial Correlation LM Test								
	Value	Prob. F(2,54)	Value	Prob. F(2,47)	Value	Prob. F(2,53)	Value	Prob F(2,46)
F static	0.437	0.649	0.981	0.382	0.377	0.688	0.465	0.631
Breusch- Pagan- Godfrey Hetroskedasticity Test								
	Value	Prob. F(14,49)	Value	Prob F(7,56)	Value	Prob F(8,55)	Value	Prob F(15,48)
F static	0.801	0.664	0.699	0.673	0.721	0.672	0.571	0.883

In the same way, the coefficients of REER in the second and fourth equation shows significant positive value which also shows that depreciation leads to a more favourable balance of trade. The negative sign in REER and NEER represents the depreciation of exchange rate. Opposite signs expected in dollar exchange rate and REER.

Long-run cointegration model would be valid and reliable only if the long-run relationship is proved through ARDL Bound Test. Therefore it has been considered Narayan (2005)- Critical values rather than Pesaran et al. (2001) to overcome the limitation of small sample frequency. Now the long-run relationship can be established only if the F static value is higher than the critical value. The null hypothesis of ARDL bound test is ‘no long-run relationship between the variables’. Here, the F static value of ARDL bound test is higher than the critical value in models except in third one. Thus, the null hypothesis is rejected at 5% significance level.

Fig. 6.1 Ranking of the Models as per Akaike Information Criteria (Top 20 Models)



It means there is long-run relationship between trade balance and independent variables. In the first and third model, the coefficient of domestic GDP is -1.94 [0.425] and -0.509 [0.133] which shows a significant and negative relationship between domestic GDP and trade balance. The coefficient of world GDP (1.667 [0.916]) is significant and positive only in the first model. The coefficients of rupee- dollar exchange rate are respectively 0.5751 [0.180] and 0.370 [0.134] in the first and third model. REER coefficients (-2.834 and -1.518) are negative and significant in the both second and fourth model. It clearly shows that the depreciation has always led to make favourable balance of trade in the long-run.

Secondly, we have made Breusch – Godfrey Serial Correlation LM test to check the autocorrelation in the residual series. The null hypothesis of no autocorrelation is accepted with high probabilistic value in all four models. Breusch– Pagan- Godfrey Heteroskedasticity test reveals that there is no issue of heteroscedasticity in the residuals in any model. Figure 6.1 shows the ranking of 20 models as per Akaike Information Criteria to select lags for each model. As per the criteria, the models are selected which have highest values. In the first model, lag of 4,0,0,0 is selected while lag of 4,0,3,4 is selected for the second model. 4,0,1,0 and 1,4,3,4 are selected for the third and fourth models respectively.

6.3.2 Exchange Rate and Export and Import

The relationship between exchange rate and trade balance exist since the export and import of country heavily depends on the variations in exchange rate. Moreover, whether trade balance becomes favourable or not rest on the sensitivity of export or import to the exchange rate changes. Table 6.6 and 6.7 shows ARDL Error Correction Model, which establishes the short-run and long-run relationship of Indian export. After fitting several models, four models which are most suitable and show significant long-run relationships in ARDL bound test were selected.

The results of Error Correction Model and long-run models are given separately. In Model 1, only three variables including its past values of export were considered. There is significant positive relationship between Domestic GDP and dollar exchange rate (In model 1, the value 3.132 [1.323], in model 2, the value 5.201 [1.14] in model 3, the value 2.991 [1.097] in model 4 the value 6.800 [1.17]) as well as world

GDP growth and rupee - dollar exchange rate. It is as expected that the increasing growth of world GDP will lead to more export when the relationship between domestic GDP and export may be positive or negative. The relationship between dollar exchange rate and export is positive as the depreciation helps to earn more profit for the exporters. In model 1, the coefficient of dollar is 0.073 and in model 2, it is 0.164. In the third and four models, when REER was used instead of dollar respectively the estimates are -0.494 and –1.134. In the second model, we have used IIP data instead of GDP, where it is found to be statistically significant. The significant negative relationship between REER and export can be seen indicating the depreciation leads to more exports. Unlike rupee-dollar exchange rate, the negative sign is expected since negative sign in REER means depreciation.

Table 6.6 ARDL Error Correction Model for Export

	Model 1		Model 2			Model 3			Model 4		
	Coeff.	Std. Error		Coeff.	Std. Error		Coeff.	Std. Error		Coeff.	Std. Error
D(LX(-1))	-0.135	0.151	D(LX(-1))	0.308**	0.12967	D(LX(-1))	0.220**	0.112	D(LX(-1))	0.214	0.143954
D(LX(-2))	0.056	0.135	D(LX(-2))	0.257**	0.108737	D(LX(-2))	0.353***	0.089	D(LX(-2))	0.197*	0.115349
D(LX(-3))	-0.321***	0.119	D(LIIP)	-0.056	0.318308	D(LGDP)	1.200***	0.149	D(LIIP)	-0.121	0.401236
D(LGDP**)	3.132**	1.323	D(LIIP(-1))	-0.423*	0.227647	D(LGDP**)	2.991***	1.097	D(LIIP(-1))	-0.508**	0.240442
D(LDOLLAR)	0.073	0.069	D(LIIP(-2))	0.241279	0.215136	D(LREER)	-0.494	0.310	D(LIIP(-2))	0.184702	0.239986
CointEq(-1)	-0.277*	0.158	D(LIIP(-3))	-1.324***	0.346119	D(LREER(-1))	-0.499	0.426	D(LIIP(-3))	-1.460**	0.433108
			D(LGDP**)	5.201***	1.134609	D(LREER(-2))	-0.912***	0.349	D(LGDP**)	6.800***	1.171227
			D(LDOLLAR)	0.164***	0.050581	CointEq(-1)	-1.218***	0.142	D(LREER)	-1.134***	0.371345
			CointEq(-1)	-0.872***	0.155484				CointEq(-1)	-0.699***	0.169937

The results of long-run equations and diagnostic checks for both short-run and long-run equations are given in table 6.7. It is very surprising to see that all the variables used in the model are significant at 1% significant level.

In all the models, the domestic GDP, IIP, and Global GDP are found to have significant positive impact on export from all these four models in the long-run. As expected, dollar rate and export have a positive relationship while it is negative with REER. It is very clear that increase in the rate of dollar (depreciation) promotes more export while the increasing rate of REER (Appreciation) leads to a reduction in the export level of the country.

Table 6.7 ARDL Long-Run Equation for Export

	Model 1		Model 2		Model 3		Model 4	
	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error
LGDP					0.985***	0.040		
LIIP			1.238***	0.183817			2.045***	0.186106
LGDP*								
LGDP**	3.847***	0.456	1.995***	0.236766	1.261***	0.136	1.338***	0.293067
LDOLLAR	0.264**	0.124	0.188***	0.039454				
LREER					-0.593***	0.174	-0.878***	0.282623
C	-45.745***	5.454	-25.499***	2.580213	-18.236***	1.464	-17.134***	3.303056
Diognostic Checks								
ARDL Bound Test								
Narayan (2005) Critical Values at 5% significance level if k=3 I(0)= 3.37, I(1)= 4.545; if k=2 I(0)= 3.947, I(1)= 5.02								
	Value	k	Value	k	Value	k	Value	k
F static	7.600	2	9.544	3	18.699	3	6.357	3
Breusch- Godfrey Serial Correlation LM Test								
	Value	Prob. F(2,54)	Value	Prob. F(2,50)	Value	Prob. F(2,52)	Value	Prob. F(2,49)
F static	1.906796	0.1584	3.724	0.031	3.486	0.038	1.270	0.29
Breusch- Pagan- Godfrey Hetroskedasticity Test								
	Value	Prob. F(7,56)	Value	Prob. F(11,52)	Value	Prob. F(10,54)	Value	Prob. F(12,51)
F static	0.999237	0.4416	1.913	0.059	0.830	0.602	1.564	0.1327

Fig 6.2 Ranking of the Models ass per Akaike Information Criteria (Top 20 Models)

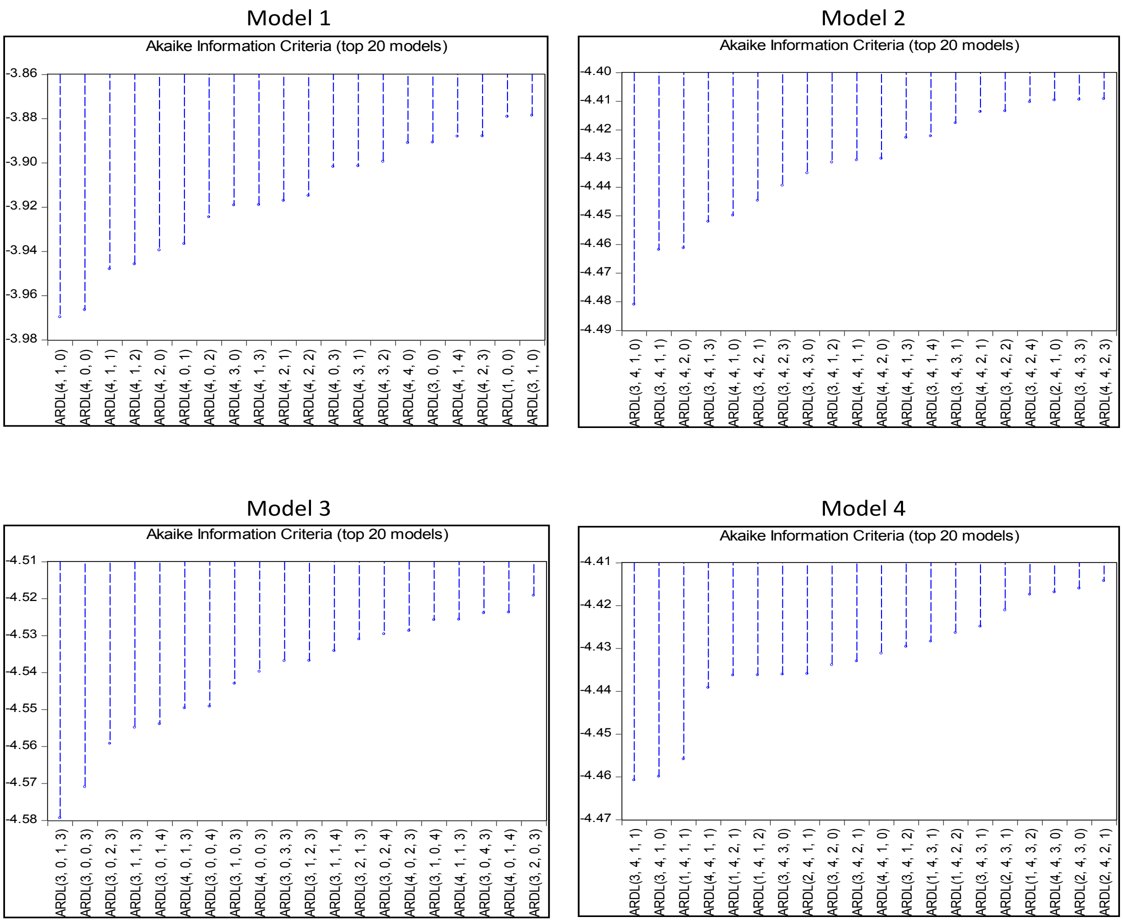


Table 6.8 ARDL Error Correction Model for Import

	Model 1		Model 2		
	Coeff.	Std. Error		Coeff.	Std. Error
D(LM(-1))	0.1341	0.101158	D(LGDP)	2.753***	0.625866
D(LGDP)	2.710***	0.618681	D(LGDP(-1))	0.934	0.637169
D(LGDP**)	-0.283	0.479768	D(LGDP**)	3.013**	1.453773
D(LDOLLAR)	-0.260**	0.123694	D(LREER)	0.150	0.409894
CointEq(-1)	-0.450***	0.112285	D(LREER(-1))	0.215	0.53769
			D(LREER(-2))	-0.273	0.551051
			D(LREER(-3))	-0.715*	0.424709
			CointEq(-1)	-0.368***	0.094589

As we have pointed out earlier, the long-run cointegration model will be valid and reliable only if the long-run relationship is proved through ARDL Bound test. The F static value of ARDL bound test is higher than the critical value in models. Secondly, in Breusch – Godfrey Serial Correlation LM test which checks the autocorrelation in the residual series, the null hypothesis of no autocorrelation is accepted with high probabilistic value in all four models. Breusch – Pagan- Godfrey Heteroskedasticity test reveals that there is no issue of heteroscedasticity in the residuals in any model. Figure 6.2 shows the ranking of 20 models as per Akaike Information Criteria to select lags for each model. As per the criteria, the models which have highest values are selected. In the first model, lags of 4,1,0 are selected while lags of 3,4,1,0 are selected for the second model. 3,0,1,3 and 3,4,1,1 are selected for the third and fourth models respectively.

Tables 6.8 and 6.9 show ARDL Error Correction and Cointegration Model, which establish the short-run and long-run relationship of Indian imports. After fitting several models in a trial and error method, only two models which are most suitable and shows significant long-run relationships in ARDL bound test were selected. In the first model, we can see a significant positive relationship between Domestic GDP growth and imports with coefficient value of 2.710 [0.618] and negative relationship between world GDP and imports with coefficient value of -0.283 [0.479]. It is as expected that the increasing domestic GDP leads to more import when the relationship between world GDP and import may be positive or negative.

Table 6.9 ARDL Long-Run Equation for Import

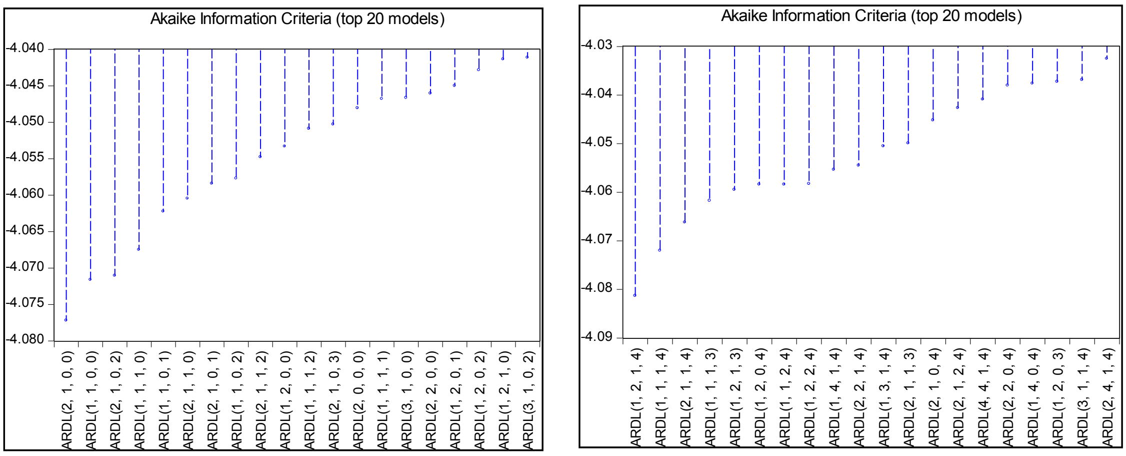
	Model 1			
	Coeff.	Std. Error	Coeff.	Std. Error
LGDP	2.240***	0.496592	0.970***	0.170453
LIIP				
LGDP*				
LGDP**	-0.629	1.019148	1.443***	0.60012
LDOLLAR	-0.578***	0.207964		
LREER			2.508***	0.828095
C	2.630733	11.094068	-24.156***	6.477538
Diognostic Checks				
ARDL Bound Test				
Crtical Value Bounds: I(0) Bounds- 3.23 (5% Significance), I(1) Bounds- 4.35 (5% Significance)				
	Value	k	Value	k
F static	4.646	3	5.021	3
Breusch- Godfrey Serial Correlation LM Test				
	Value	Prob. F(2,57)	Value	Prob. F(2,50)
F static	0.129559	0.879	0.464	0.6317
Breusch- Pagan- Godfrey Hetroskedasticity Test				
	Value	Prob. F(6,59)	Value	Prob. F(11,52)
F static	0.626171	0.709	0.452	0.9236

The relationship between rupee-dollar exchange rate and import is negative with coefficient value of -0.260 [0.123] as the increasing rupee-dollar exchange rate leads to increase the price of imports in terms of domestic currency which in turn leads to less imports. In the second model when REER is used as an independent variable, the relationship is positive with coefficient value of 0.150 [0.409] which again confirm that the depreciation leads lower the quantity of imports and appreciation leads to increase the quantity of imports. The significant negative relationship between REER and import can be seen which indicates that depreciation (decreasing REER) leads to more imports. It may be because in the short-run, as in J- Curve hypothesis, it quite possible that the consumers may continue using the same quantities of imports which may end up with a negative relationship in the short-run but not in long-run.

The results of long-run equations and diagnostic checks for both short-run and long-run equations are given in Table 6.9. It can be seen that all the variables except calculated global GDP are significant at 1% significant level. In the models, the domestic GDP is found to have significant positive impact on import in both in the long-run. As contrary to export equation, dollar rate, and export have a negative relationship while it is positive with REER. It is very clear that increasing the rate of the dollar (depreciation) leads to reduce the imports when imports become expensive, while the increasing rate of REER (Appreciation) leads to increase the import when the imports become comparatively cheaper. The negative sign in REER and NEER represents the depreciation of exchange rate. So an opposite sign is expected in the case of rupee-dollar exchange rate and REER.

Fig. 6.3 Ranking of the Models as per Akaike Information Criteria (Top 20 Models)

Model 1 | Model 2



In both models, the F static value of ARDL bound test is higher than the critical value. Moreover, the null hypothesis of no autocorrelation is accepted with high probabilistic value in all four models. Breusch – Pagan- Godfrey Hetroskedasticity test reveals that there is no issue of hetroskedasticity in the residuals in any model. Figure 6.3 shows the ranking of 20 models as per Akaike Information Criteria to select lags for each model. As per the criteria, the models which have highest values are selected. In the first model, lags of 2,1,0 are selected while lags of 1,2,1,4 are selected for the second model.

6.3.3 Nonlinear Interactions Using Multivariate GARCH- BEKK Model

Tables 6.10, 6.11 and 6.12 show the Multivariate GARCH BEKK results which are modeled, to check the nonlinear interactions between exchange rate and foreign trade variables. The volatility transmission between the variables captures nonlinear relationship.

Table 6.10 Volatility Spillovers between Exchange Rate and Foreign Trade Estimated from Bivariate GARCH(1, 1)-BEKK Model

	Dollar -Trade Balance			Dollar- Export	
Parameters	Coef.	SE	Parameters	Coef.	SE
GDOLLAR{1}	-0.284***	0.063	GDOLLAR{1}	-0.503***	0.058
R_TB{1}	0.0734	0.480	R_X{1}	0.245	0.355
Constant	-0.001	0.003	Constant	0.008***	0.003
GDOLLAR{1}	-0.028***	0.008	GDOLLAR{1}	-0.019	0.004
R_TB{1}	0.485***	0.072	R_X{1}	0.410***	0.066
Constant	0.002	0.000	Constant	0.004*	0.000
C(1,1)	0.041***	0.002	C(1,1)	0.037***	0.004
C(2,1)	0.001**	0.000	C(2,1)	0.021	0.000
C(2,2)	-0.006	0.001	C(2,2)	-0.003	0.001
A(1,1)	-0.316***	0.109	A(1,1)	-0.270***	0.083
A(1,2)	0.025***	0.008	A(1,2)	-0.027***	0.008
A(2,1)	0.945	1.076	A(2,1)	0.677	0.707
A(2,2)	0.464***	0.087	A(2,2)	0.933***	0.157
B(1,1)	-0.058	0.320	B(1,1)	-0.254	0.276
B(1,2)	-0.021	0.019	B(1,2)	0.029***	0.009
B(2,1)	0.597	1.016	B(2,1)	0.712	0.480
B(2,2)	0.874***	0.037	B(2,2)	-0.649***	0.073
Diagnostic Checks					
Log likelihood	1107.328			1119.324	
LB-Q (0-4)	31.130	0.013		49.627	0.000
LB-Q (0-8)	60.979	0.002		106.414	0.000
LB-Q (0-12)	108.007	0.000		200.408	0.000
LB-Q^2 (0-4)	23.191	0.109		21.283	0.168
LB-Q^2 (0-8)	40.987	0.133		42.641	0.099
LB-Q^2 (0-12)	51.543	0.337		70.125	0.020

The diagonal parameters A11 and A22 captures own arch effect, which is statistically significant implying the presence of ARCH in all variables. It means the volatility of foreign trade and the exchange rate is significantly determined by its past shocks. The estimated coefficients of B11 and B22 are all statistically significant except very few cases, indicating a strong GARCH (1, 1) effect in all GARCH models. The ARCH term (A_{11}, A_{22}) and GARCH terms (B_{11}, B_{22}) of its variables are not seen significant in the case of the dollar- import equation. This implies that in the univariate models of exchange rate variables, the past volatility plays a crucial role in determining the present volatility of the series. However, the focus of the study is not on checking the importance of variable's past shocks or volatility; but to explore the volatility transmission between the variables.

Table 6.11 Volatility Spillovers between Exchange Rate and Foreign Trade Estimated from Bivariate GARCH(1, 1)-BEKK Model

	Dollar- Import			REER- Trade Balance	
Parameters	Coef.	SE	Parameters	Coef.	SE
GDOLLAR{1}	-0.543***	0.059	GNEER{1}	-0.362***	0.060
R_M{1}	0.254	0.372	R_TB{1}	-0.641	0.457
Constant	0.010***	0.003	Constant	-0.002	0.003
GDOLLAR{1}	0.003	0.008	GNEER{1}	0.035***	0.010
R_M{1}	0.346***	0.069	R_TB{1}	0.341***	0.064
Constant	0.022	0.000	Constant	-0.035	0.000
C(1,1)	0.0323***	0.004	C(1,1)	0.027***	0.006
C(2,1)	-0.055	0.000	C(2,1)	-0.001	0.002
C(2,2)	0.002	0.001	C(2,2)	-0.000	0.004
A(1,1)	0.345***	0.112	A(1,1)	0.369***	0.117
A(1,2)	0.0327***	0.009	A(1,2)	0.025	0.016
A(2,1)	-0.828*	0.516	A(2,1)	0.170	0.616
A(2,2)	0.350	0.055	A(2,2)	-0.193*	0.105
B(1,1)	0.288	0.250	B(1,1)	0.476***	0.153
B(1,2)	1.513*	0.741	B(1,2)	0.071***	0.019
B(2,1)	0.010	0.020	B(2,1)	-3.375***	1.167
B(2,2)	-0.917***	0.034	B(2,2)	0.869***	0.089
Diagnostic Checks					
Log likelihood	1135.658			1100.383	
LB-Q (0-4)	5.521	0.9925		22.166	0.138
LB-Q (0-8)	23.418	0.865		42.580	0.100
LB-Q (0-12)	58.279	0.147		92.331	0.000
LB-Q^2 (0-4)	14.226	0.582		17.435	0.358
LB-Q^2 (0-8)	39.901	0.159		36.411	0.271
LB-Q^2 (0-12)	56.923	0.177		40.818	0.759

The off-diagonal elements of matrix *aij* and *bij* capture the cross-variable effects such as shock spillover and volatility spillover between the variables of exchange rate and trade variables in India. Analysis of volatility transmission from dollar- rupee exchange rate reveals that when A_{12} (ARCH) is significant, B_{12} (GARCH) is seen to be insignificant which means that the impact of past shocks from dollar is transmitted to trade balance whereas the past volatility of dollar is not transmitted to trade balance. As contrary to this, both the impact of past volatility and past shocks from trade balance are not transmitted to dollar since the coefficient A_{21} (ARCH) and B_{21} (GARCH) are not significant. As a whole, we can say that the interrelationship is limited to only shock transmission from the dollar to trade balance. But in the case of transmission between dollar exchange rate and Export, both ARCH term A_{12} and GARCH term B_{12} are significant, whereas both the ARCH terms A_{21} and GARCH terms B_{21} are not significant. It means that past shocks and volatility transmission are in a unidirectional way from the dollar to export whereas transmission from export to the dollar is not seen in the model. If we check the results of import- dollar model, A_{12} (ARCH) and B_{12} (GARCH) are found to be significant which means that the impact of past shocks and volatility from dollar is transmitted to import. As contrary to this, only the impact of past shocks (A_{21}- ARCH term) from import is transmitted to dollar whereas past volatility (B_{21}- GARCH term) is not at all transmitted. So the relationship can be explained even though the one GARCH term is not significant.

Secondly, we have made this analysis using Real Effective Exchange Rate to draw more general conclusions regarding exchange rate and trade variables in nonlinear setup. Unlike the previous chapters, Real Effective Exchange rate against Nominal effective exchange rate was used by considering the fact that the REER represents the competitiveness of the traders after compensating for the inflation differentials of various countries. Analysis of volatility transmission from REER to trade balance reveals that both A_{12} (ARCH) and A_{21} are found to be insignificant which means that the impact of past shocks from REER to trade balance and from trade balance to dollar are not transmitted. As contrary to this, the impact of past volatility of both NEER and trade balance are transmitted to each other since the coefficient B_{12} and B_{21} (GARCH) are very significant. Thus, we can say that the relationship is bi-directional only in GARCH terms not ARCH terms between the REER and trade balance. However, in the case of transmission between the REER and Export, both ARCH terms A_{12} and A_{21} are significant, whereas both the GARCH terms B_{12} and B_{21} are not significant. It means that there is past shocks transmission in the bidirectional way between the REER and Export whereas there is no volatility transmission to any direction. Finally, if we consider the relationship between exchange rate and import, Table 6.12 shows that there is shock transmission only from import to exchange rate whereas the volatility transmission happens in a bidirectional way.

Panel B of tables 6.10, 6.11 and 6.12 present the multivariate Q-statistic used to test the null hypothesis that the model is correctly specified or to check the presence of random noise. We report multivariate Q statistic for both standardised and standardised squared residuals up to lag 12 for each pair. Results show no serial dependence in the standardized residual and squared standardised residuals, validating the appropriateness of the MGARCH-BEKK model.

Table 6.12 Volatility Spillovers between Exchange Rate and Foreign Trade Estimated from Bivariate GARCH(1, 1)-BEKK Model

	REER- Export			REER- Import	
Parameters	Coef.	SE	Parameters	Coef.	SE
GNEER{1}	-0.538***	0.057	GNEER{1}	-0.548***	0.061
R_X{1}	-0.909**	0.411	R_M{1}	-0.087	0.434
Constant	0.008***	0.003	Constant	0.008***	0.003
GNEER{1}	0.020*	0.010	GNEER{1}	-0.006	0.009
R_X{1}	0.273***	0.067	R_M{1}	0.243***	0.067
Constant	-0.000*	0.000	Constant	-0.000	0.000
C(1,1)	0.031***	0.006	C(1,1)	0.024***	0.005
C(2,1)	0.002***	0.001	C(2,1)	-0.001	0.001
C(2,2)	-0.000	0.003	C(2,2)	-0.000	0.001
A(1,1)	-0.319***	0.136	A(1,1)	0.359***	0.117
A(1,2)	0.053***	0.017	A(1,2)	0.0135	0.012
A(2,1)	-1.202*	0.654	A(2,1)	-2.286***	0.505
A(2,2)	-0.309***	0.092	A(2,2)	-0.214***	0.075
B(1,1)	-0.490*	0.241	B(1,1)	-0.478***	0.170
B(1,2)	0.026	0.032	B(1,2)	0.070***	0.030
B(2,1)	-1.524	1.279	B(2,1)	2.224**	1.157
B(2,2)	0.762***	0.091	B(2,2)	0.825***	0.094
Diagnostic Checks					
Log likelihood	1111.069			1131.196	
LB-Q (0-4)	33.273	0.007		4.837	0.997
LB-Q (0-8)	71.591	0.000		21.991	0.908
LB-Q (0-12)	157.070	0.000		55.268	0.219
LB-Q^2 (0-4)	16.667	0.407		13.120	0.664
LB-Q^2 (0-8)	31.728	0.480		25.788	0.773
LB-Q^2 (0-12)	67.358	0.034		33.608	0.943

6.4. Summary and Concluding Remarks

The study used ARDL Bound Testing and Cointegration Approach to check the short and long-run relationship between exchange rate vis-a-vis domestic GDP, World GDP and Trade variables. Though the study could find expected signs in the long-run equations validating Marshal Lerner condition, any evidence to prove J- Curve hypothesis in the short-run equations was not found. Multivariate GARCH- BEKK models are used to check the nonlinear relationship between variables. According to the results, there is significant volatility and shock spillover between exchange rate and trade variables. Though in few cases, the relationship of GARCH and ARCH terms are unidirectional, bidirectional relationship between the variables was established in most of the cases. In sum, it can be said that there is enough evidence to continue a strong and significant linear and nonlinear relationship between the exchange rate and trade variables.

----xxx---

Chapter 7

Summary and Conclusions

7.1 Introduction

With the advent of the Bretton Woods system, spanning from 1970s to late 80s, several countries across the globe experienced noticeable shifts in their exchange rate policies. These countries witnessed a transition from fixed exchange rate to floating or managed exchange rate system. This shift also turned exchange rates from being passive to a more dynamic macro variable which in turn began to influence other macro and financial variables as well. In fact, it became a key monetary policy tool which helped stabilize the internal or external economy and maintain equilibrium. Effective exchange rate management contributes to promoting of internal macro variables in a certain favourable position. In which case, instability and extreme volatility of exchange rate invite inflation and hampers investment, trade flow and economic growth (Frankel and Rose, 2002). The waves of exchange rate shifts reached India in the 1990s. As a result of financial reforms, India witnessed a shift in pegged exchange rate regime to predominantly market determined managed floating regime in 1993. The study of inter- relationship of the exchange rate with inflation and foreign trade is very relevant during the post-reform period as the exchange rate was going through high volatility over the period.

Exchange rate pass-through is defined as the responsiveness of domestic consumer prices, producer prices or import price to the changes in exchange rate. It is measured as the degree of changes in the domestic prices as a result of changes in the exchange rate. Though the interest rate channel is more prominent in monetary transmission regardless of the monetary system prevailing in any economy, the exchange rate channel also holds due importance. In many emerging markets exchange rate channel stands as a key monetary transmission channel where interest rate channel is found to be comparatively weak (Norris and Floerkemeier, 2006; Mashat and Billmeier, 2007; Catao and Pagan, 2009). Bhattacharya, Patnaik and Shah (2011) found that the interest rate channel is weak in the Indian context, whereas the exchange rate channel is effective in monetary transmission.

One of the most important aims of the exchange rate policy is to pull the trade balance in a certain favourable direction that stimulates economic performance by promoting higher production, export and economic growth. The volatile nature of the exchange rate is also expected to have spillover on the trade balance.

The relationship among the economic variables may be linear or nonlinear. Generally, the exchange rate pass-through is analyzed in the literature on the assumption of a linear and symmetric relationship. Quite a few works published recently consider the presence of non-linearities and asymmetries in exchange rate pass- through in various ways. The presence of volatility in financial and currency markets had also drawn the attention of scholars in exploring different forms of nonlinearities and chaotic behavior in the exchange markets (Adrangi and Allender, 2011). Volatility spillover between exchange rate and inflation is analysed by using various multivariate GARCH models which can overcome the limitation of linear models and accommodate the clustering behavior of the return series more precisely. In the empirical literature across the countries, though there are several studies which used various linear models, the studies which examine volatility pass-through using nonlinear models are very limited, particularly, in the context of developing countries.

In this backdrop, the study tries to connect the three variables namely exchange rate, inflation and foreign trade, and examine the possible linear and nonlinear interactions of inflation and trade with the exchange rate in the Indian context.

Objectives of the Study

Accordingly the objectives of the study are formulated as follows:

1. To check the nature and pattern of linear exchange rate pass-through in the Indian context and measure the strength of the pass-through.
2. To check significant structural breaks in exchange rate volatility and analyze the changes of linear pass-through in different volatility regimes.

3. To analyze nonlinear exchange rate pass-through and study nonlinear dynamic interactions between exchange rate and inflation
4. To investigate linear and nonlinear dynamic interactions between exchange rate and foreign trade and empirically validate the Marshal Lerner condition and the J- Curve Hypothesis.
5. To evaluate the linear and nonlinear interactions of the exchange rate with inflation and foreign trade and recommend policy alternatives in Indian context to improve the exchange rate and monetary management.

7.2 Findings :

The aim of the first analysis chapter on linear exchange rate pass-through was twofold. First was to evaluate exchange rate pass-through by drawing the extent and speed of exchange in general level which is done by using SVAR Models following McCarthy (2000,2006). Second was to check the extent of exchange rate pass-through in the disaggregated level by classifying inflation, according to different product groups which are done by unrestricted VAR models. SVAR results show that during 1998 to 2014, the exchange rate pass-through coefficient is significant both in WPI and CPI inflation. The pass-through is found to be higher to the CPI inflation than to WPI inflation. Moreover, the pass-through impact is higher in the pre - crisis period compared to post-crisis period. It may be because of the high depreciating trend of exchange rate during the post-crisis period.

Estimation of Pass-through using Rupee- Dollar exchange rate with disaggregated WPI data reveals that Pass-through is significant in the primary articles, food items, Fuel and mineral oil products, Chemical and chemical products. Nonfood items, viz. manufactured products Beverages and tobacco products wood and wood products leather and leather products metal and metal products transport and transport equipment are not much affected by the changes in Exchange rate. Using NEER, the pass-through coefficient is significant at various lag levels in the case of the primary article, food articles, fuel, power and lubricants, whereas no evidence of pass-through is seen in the case of nonfood articles and mineral oils manufactured products beverages and tobacco products wood and wood products leather and leather products and transport and its equipment. In sum, the study conclude that primary articles, food articles are more affected by the drastic volatility in the exchange rate whereas nonfood items and manufactured products are not much affected.

The chapter on volatility pass-through and structural breaks examines the nonlinear relationship between exchange rate and inflation by checking volatility spillover using univariate and multivariate GARCH models. First, we have used a family of univariate GARCH models to estimate the volatility series. An ample number of models show significant ARCH and GARCH effects in the volatility. EGARCH models which capture the asymmetric impacts of shocks reveal that there is the leverage effect in the case of the dollar, where no such effects are seen in other variables. ICSS algorithm is used to check the structural shifts in volatility by taking volatility series of the best model from GARCH and EGARCH models. Though the study could find multiple break points in volatility, May 2008 is the period of major structural break in the volatility. If we consider this shift as a result of the global financial crisis, a clear distinction between pre and post financial crisis periods can be seen in the variance of various sub-sample time periods. Finally, the non-linear pass-through is tested by using Multivariate GARCH- BEKK models. The results reveal that there is evidence of a bi-directional volatility spillover between exchange rate and inflation in India. Spillover seems to be higher in the case of WPI inflation than CPI inflation. From both linear and nonlinear models, the impacts of exchange rate on domestic price level are very clear.

The analysis of the inflation and monetary scenario of Indian economy reveals that the monetary policies were not effective in containing inflation during the study period while the focus of the authority was to maintain desirable exchange rate. Sterilization measures adopted by RBI to bring inflation under control were not effective. The concentration of the monetary policy especially after the subprime crisis was to avoid the appreciation of the rupee and neutralizes the impact of foreign capital inflows. As a result, the exchange rate was continuously depreciating during this period. When the RBI took measures of sterilization and kept the rupee depreciating most of the period, the high level of the inflation was the outcome. In line with the results of Rashid and Husain (2010) in the context of Pakistan, our results also indicate that the inflationary impact of capital flows was significant in India.

The major objective of the final core chapter was to validate Marshal Lerner condition and the J - curve hypothesis by checking the long-run and short-run relationship between exchange rate and foreign trade. The study used ARDL Bound testing and Cointegration approach to check the short and the long-run relationship of the exchange rate with domestic GDP, World GDP, and foreign trade variables. The study could validate Marshal Lerner condition with expected signs. But there was no any evidence to prove the J - curve hypothesis in the short-run equations. Multivariate GARCH- BEKK models were used to check the nonlinear relationship between variables. The study revealed that there was significant volatility and shock spillover between exchange rate and trade variables. Though in a few cases the relationship of GARCH and ARCH terms are unidirectional, a bidirectional relationship of volatility spillover between the variables was evident in most of the cases.

7.3 Policy Implications:

The analysis of exchange rate pass-through and interactions of the exchange rate and foreign trade will be useful for different agents and institutions of the country. The government, monetary authorities, business companies, foreign trade partners, and investors are among the most benefited from the analysis. For the government and monetary authority, it is very crucial to know the exact amount of exchange rate pass-through to different products and product groups which will be helpful to determine the price level of that particular product by adjusting indirect taxes and support prices. Hence, the study of these interactions will be useful for proper management of exchange rate and forex market according to the requirements of the economy.

Secondly, the government and monetary authority need to know the extent of this relationship which can be used as a Magna Carta for the proper exchange rate management in a desirable manner for growth and development of the entire economy

Thirdly, business companies and trade partners are interested in the exchange rate pass-through and trade relationship to calculate their profit margins and to predict the demand for various products. It will be helpful to determine the supply of the products according to the demand and profit margin at various periods.

Lastly, exchange rate pass-through and inflation level of the various countries also helps to understand the economic position of the economy compared to other economies. More developed or advanced countries are seen to have low levels of exchange rate pass-through and low level of inflation. The less developed countries are forced to set their currency values according to the dominant currencies of the world which therefore leads to a higher level of exchange rate pass-through.

7.4 Alternative Policies and Recommendations

The study indicates that RBI responds to the capital flows by increasing the foreign reserves accordingly to keep the rupee depreciated and to avoid the chance of appreciation. Whenever there was a tendency of appreciation, the economy has been severely hit by mounting up the current account deficit. From the historical analysis, it is very clear that India intervened in the forex market at the cost of high inflation. As far as the managed floating is concerned, it is more flexible rather than fixed or controlled. So the attempt to maintain the floating exchange rate always required the sacrifice of the monetary autonomy in one way or another. Considering the fact that India is a developing country which has the problem of supply bottleneck and needs high capital flows and investment for the domestic development and growth, crawling peg with the broader band is more suitable for effective sterilization and to avoid the high volatility of capital flows and control the exchange rate in the desired direction. The adoption of this alternative will help to retain more autonomy on monetary policy and control inflation.

Secondly, sterilization policies which India adopts could not provide desired results. So the sterilization policies should be improved in such way that the excess domestic money supply pumped to the economy as a result of increasing foreign reserves should not lead to an increase in inflation.

Contrary to the negative impact of exchange rate on the domestic inflation, trade relationship with exchange rate is found to be positive in the long-run. Indian exporters could take advantage of the high depreciation during the post-crisis period. When the validity of J-Curve hypothesis is questioned in the Indian context, the possibility of any harmful aspect of exchange rate even in the short-run can be neglected. Thus, the exchange rate should be managed in such way that it minimizes the negative impact on inflation and promotes positive effects on the trade balance.

7.5 Limitations and Direction for Future Research

The present study suffers from some limitations. Firstly, the strength of the exchange rate pass-through depends on several factors such as the amount of export-import operations, the openness of the economy, whether the country belongs to developed or underdeveloped category, the credibility of monetary policy and inflation level of the country. The country which has more export-import operations, more openness, less developed economic characteristics, less credible monetary policy and high level of inflation is expected to have more exchange rate pass-through as compared to the countries with opposite characteristics. Since the study is carried out within the framework of a single country analysis, the determinants of exchange rate pass-through in various context is out of the scope of this study. It will be fascinating to take a few more countries together with India to check the attributes of exchange rate pass through.

Secondly, the relation between exchange rate pass-through and the behavior and pricing strategies of the firms is a broad area where works related to Indian context are very limited. The Attempt of to check the exchange rate pass-through in different firm level can be done by incorporating the exchange rate pass-through to various product groups.

Thirdly, according to the methodology of McCarthy (2000), the study of exchange rate pass-through will be more comprehensive if we include the complete distribution chain of pass-through. Hence, using variables such as import price, wholesale price and consumer prices on a chain basis could have produced more insights. However, we could not use import price since monthly data was not available for the entire study period.

Fourthly, since the focus of this study was to draw a conclusion on exchange rate pass-through to the price level in general and different products in particular, using secondary data, a detailed pricing behavior of the firms are not taken care of. The pricing behavior of the firm such as PCP or LCP plays avital role in determining the strength of the exchange rate pass-through.

Fifthly, the relative importance of different channels of the monetary mechanism is out of the scope of this work. Few works in this area published already identified the exchange rate channel as the most prominent, particularly in emerging economies.

Sixthly, there is a possibility of various non-linearities and asymmetries in the exchange rate pass-through channel. Despite the possibility of a non-linear relationship in various forms, the focus of this study is limited to the checking of volatility or uncertainty spill over from exchange rate to inflation and foreign trade using Multivariate GARCH models. Other non-linear relationships such as the threshold level effect of exchange rate movements (Frankel et al., 2012) and asymmetries in the direction of the changes (Bussiere, 2013) are still an unexplored area in the Indian context.

Seventhly, this study has limited the data period from 1998 onwards due to the unavailability of all the variables in monthly or quarterly basis before that. The extension of the data for the entire post liberalization period would have given more insights for the analysis of exchange rate- inflation or exchange rate- trade relationship.

Finally, despite several theories which connect exchange rate and foreign trade, this study tried to check the validity of Marshal Lerner condition and J-curve hypothesis.

So considering all the limitations mentioned above of this study, future research can be carried out on that lines.

----xxx----

References

Adolfson, M., Laseen, S., Linde, J and Villani, M. (2005). Bayesian estimation of an open economy DSGE model with incomplete pass-through.Working Paper 179, Sveriges Riks Bank.

Adrangi, B and Allender, M.E. (2011). Exchange rates and inflation rates: exploring nonlinear relationships. *Review of Economics and Finance*, 1(2), 1-16.

Albuquerque, C. R and Portugal, M. (2005). Exchange rate and inflation: a case of sulkiness of volatility. Working Paper Series- 106, Bankco Central Do Brasil.

Arize, C., Osang, T and Slottje, D.J. (2000). Exchange rate volatility and foreign trade: evidence from thirteen LDCs. *Journal of Business Economic Statistics*, 18 (1), 10–17.

Arora, S., Bahmani-Oskooee, M and Goswami, G. M., (2010). Bilateral J-Curve between Indian and her trading partners. *Applied Economics*, 35 (9), 1037-1041.

Bacchetta, P and Wincoop, E.V. (2001). A theory of the currency denomination of international trade. Working Papers- 01.07, Swiss National Bank, Study Center Gerzensee.

Bacchetta, P and Wincoop, E.V. (2005). A theory of the currency denomination of international trade. *Journal of International Economics,* 67 (2), 295–319.

Bach, I.W. (2002). Empirical modelling of Norwegian import prices. Working Papers. ANO. 2002/1. Norges Bank.

Bahmani-Oskooee, M and Kutan, A.M. (2007). The J-Curve in the Emerging Economies of Eastern Europe. *The International Trade Journal*, 19, 165–178.

Bahmani-Oskooee, M. and Malixi, M. (1992) More evidence on the J-curve from LDCs, *Journal of Policy Modeling*, 14 (5), 641–653.

Bahmani-Oskooee, M. (1985) Devaluation and the J-curve: some evidence from LDCs, *The Review of Economics and Statistic*s, 67 (3), 500–504.

Bahmani-Oskooee, M. (1985). Devaluation and the J-curve: some evidence from LDC's. *The Review of Economics and Statistics*, 67 (3), 500-504.

Bahmani-Oskooee, M. (1989). Devaluation and the J-curve: some evidence from LDCs: errata, *The Review of Economics and Statistics*, 71 (3), 553–554.

Bahmani-Oskooee, M and Alse, J. (1994). Short-run versus long run effects of devaluation: error correction modeling and cointegration, *Eastern Economic Journal*, 20(4), 453–64.

Bahmani-Oskooee, M and Brooks, T. J. (1999). Bilateral J-curve between US and her trading partners, *Weltwirtschaftliches Archiv*, 135, 156–65.

Bahmani-Oskooee, M. and Cheema, J. (2009). Short-run and long-run effects of currency depreciation on the bilateral trade between Pakistan and her major trading partners. *Journal of Economic Development*, 34 (1), 19-46.

Bahmani-Oskooee, M and Kutan, A. (2009). The J-curve in the emerging economies of Eastern Europe.*Applied Economics*, 41(20), 2523-32.

Bahmani-Oskooee, M and Malixi, M. (1992). More evidence on the J-curve from LDCs, *Journal of Policy Modeling,* 14 (5), 641–53.

Bahmani-Oskooee, M. and Ratha, A. (2004). The J-curve dynamics of US bilateral trade, J*ournal of Economics and Finance*, 28 (1), 32-38.

Bahmani-Oskooee, M. and Ratha, A. (2007). The bilateral J-curve: Sweden versus her 17 major trading partners. *International Journal of Applied Economics*, 4 (1), 1-13.

Bahmani-Oskooee, M and Alse, J. (1994). Short-run versus long-run effects of devaluation: error-correction modeling and cointegration. *Eastern Economic Journal*, 20 (4), 453–64.

Bahmani-Oskooee, M and Malixi, M. (1992). More evidence on the J-curve from LDCs. *Journal of Policy Modeling*, 14 (5), 641–653.

Bahmani-Oskooee, M and Mitra, R. (2009). The J- Curve at the industrial level: evidence from U.S.-India trade. *Economics Bulletin*, 29 (2), 1520-1529.

Bahmani-Oskooee, M and Wang, Y. (2006). TheJ-Curve: Chinaversus hertrading partners. *Bulletin of EconomicResearch*, 58(4), 323-343.

Bahmani-Oskooee, M., (1991). Is there a long-run relation between the trade balance and the real effective exchange rate of LDCs?. *Economics Letters*, 36(4), 403-407.

Bahmani-Oskooee, M., Goswami, G. and Talukdar, B. (2008). The bilateral J-curve: Canada versus her 20 major trading partners. *International Review of Applied Economics*, 22 (1), 93-104.

Barhoumi, K. (2009). Exchange rate pass−through into import prices in developing countries: an empirical investigation. *Economics Bulletin*, 3(26), 1−14.

Barkoulas, J. T., Baum, C. F and Caglayan, M. (2002). Exchange rate effects on the volume and variability of trade flows. *Journal of International Money and Finance*, *21*(4), 481–496. http://doi.org/10.1016/S0261-5606(02)00003-7

Baron, D.P. (1976). Fluctuating exchange rates and pricing of exports. *Economic Inquiry*, 14 (3), 425–438.

Basevi, G and Grauwe, D. (1977). Vicious and virtuous circles: a theoretical analysis and a policy proposal for managing exchange rates, *European Economic Review*, 10, 277-301

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.

Baum, C and Caglayan, M. (2009). The volatility of international trade flows and exchange rate uncertainty, Boston College working paper No. 695, 1–45.

Belaisch, A. (2003). Exchange rate pass-through in Brazil. IMF Working Paper, WP/03/141, International Monetary Fund.

Bergin, P. R. (2003). Putting the new open economy macroeconomics to a test. *Journal of International Economics*, 60 (1), 3–34.

Bergin, P. R. (2006). How well can the new open economy macroeconomics explain the exchange rate and current account? *Journal of International Money and Finance*, 25 (5), 675-701

Bergin, P. R and Feenstra, R. C. (2001). Pricing-to-market, staggered contracts, and real exchange rate persistence. *Journal of International Economics,* 54 (2), 333–359.

Berman, N., Martin, P and Mayer, T. (2012). How do different exporters react to exchange rate changes? *Quarterly Journal of Economics*, 127(1), 437–492.

Bernanke, B.S and Gertler, M. (1995). Inside the black box: the credit channel of monetary policy transmission, *Journal of Economic Perspectives*, 9 (4), 27-48.

Berument, H., Yalcin, Y and Yildirim, Y. (2009). The effect of inflation uncertainty on inflation: stochastic volatility in mean model within a dynamic framework. *Economic Modeling*, 26 (6), 1201-1207.

Betts, C. and Devereux, M. B. (1996). The exchange rate in a model of pricing-to-market. *European Economic Review*, 40 (3), 1007–1021.

Betts, C. and Devereux, M. B. (2000). Exchange rate dynamics in a model of pricing-to-market. *Journal of International Economics*, 50 (1), 215–244.

Betts, C. M and Kehoe, T. J. (2006). U.S. real exchange rate fluctuations and measures of the relative price of goods. *Journal of Monetary Economics*, 53 (7), 1297–326.

Betts, C and Devereux, M (1996). The exchange rate in a model of pricing-to-market. *European Economic Review*, 40 (3), 1007–1021.

Betts, C and Devereux, M (2000). Exchange rate dynamics in a model of pricing-to-market. *Journal of International Economics*, 50(1), 215–44.

Betts, C and Devereux, M.B. (1996). The exchange rate in a model of pricing-to-market. *European Economic Review*, 40 (3), 1007–1021.

Bhagwati, J and Srinivasan, T.N. (1975). *Foreign trade regimes and economic development: India,* New York: Columbia University Press.

Bhattacharya, R., Patnaik, H and Shah, A. (2011). Monetary policy transmission in an emerging market setting. IMF Working Paper No. 11/5. International Monetary Fund. Washington D.C.

Bhattacharya, R., Patnaik, I and Shah, A. (2008), Exchange Rate Pass-through in India. Working Paper, National Institute of Public Finance and Policy, New Delhi, http://macrofinance. nipfp.org.in/PDF/sl_0211_bhattacharya.pdf

Bhattacharyya, R. (2004). From fixed to flexible exchange rates: the case of India. MPRA Paper No. 30831, http://mpra.ub.uni-muenchen.de/30831/

Bhattarai, K. (2011). Impact of exchange rate and money supply on growth, inflation and interest rates in the UK, *International Journal of Monetary Economics and Finance*, 4 (4), 355-37.

Bhundia, A. (2002). An empirical investigation of exchange rate pass-through in South Africa, IMF Working Paper, WP/02/165, International Monetary Fund.

Bilson, J.F.O. (1979). The vicious circle hypothesis, IMF Staff Papers-26, 1-37.

Boivin, J., Kiley, M and Mishkin, F. (2011). How has the monetary transmission mechanism evolved over time? In Benjamin Friedman and Michael Woodford (ed.), *Handbook of Monetary Economics*, (pp. 369-422). Elsevier B.V.

Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics*, 31 (3), 307-327.

Bollerslev, T and Mikkelsen, H. O. (1996). Modeling and pricing long-memory in stock market volatility. *Journal of Econometrics*, 73 (1), 151–184.

Bond, M.E. (1980), Exchange rates, inflation, and vicious circles, IMF Staff Papers -27, 679-711.

Boyd,G.M and R.Smith. (2001). Real exchange rate effects on the balance of trade: Cointegration and the Marshal-Lerner condition. *International Journal of Finance and Economics*, 6 (3), 187-200.

Brada, J. C., Kutan, A. M and Zhou, S. (1993). China's exchange rate and the balance of trade, *Economic Change and Restructuring*, 26 (3), 229-42.

Buluswar, M. D., Thompson, H and Upadhyaya, K. P. (1996). Devaluation and the trade balance in India: stationarity and cointegration. *Applied Economics*, *28*(4), 429–432.

Burstein, A., Eichenbaum, M and Rebelo, S. (2003). Why is inflation so low after large devaluations? IEHAS Discussion Papers No. 0308, Institute of Economics, Hungarian Academy of Sciences.

Burstein, A., Eichenbaum, M and Rebelo, S. (2005). Large devaluations and the real exchange rate. *Journal of Political Economy*, 113 (4), 742–784.

Bussiere, M. (2013). Exchange rate pass-through to trade prices: the role of nonlinearities and asymmetries. *Oxford Bulletin of Economics and Statistics*, 75(5), 731-758.

Cagnong, J, E and Ihrig, J. (2001). Monetary policy and exchange rate pass-through. International Finance Discussion Papers- 704, Board of Governors of the Federal Reserve System (U.S.).

Campa, J. M and Goldberg, L.S. (2002). Exchange rate pass-through in to import prices: a macro or micro phenomenon? Staff Reports 149, Federal Reserve Bank of New York

Campa, J.M and Linda S. G. (2002). Exchange rate pass-through into import prices: a macro or micro phenomenon?. Staff Reports 149, Federal Reserve Bank of New York.

Campa, J.M., Goldberg, L.S and Minguez, G.J.M. (2005). Exchange-rate pass-through to import prices in the Euro area. National Bureau of Economic Research, Working Papers 11632. NBER.

Catao, L., and Pagan, A. (2009). The credit channel and monetary transmission in Brazil and Chile: a structured VAR approach. Working Papers Central Bank of Chile 579, Central Bank of Chile.

Chang, B.K and Lapan, H. E. (2003). Price commitment versus flexibility: the role of exchange rate uncertainty and its implications for exchange rate pass-through. *Review of International Economics,* 11 (4), 697–711.

Choudhri, E.U and Hakura, D.S. (2001). Exchange rate pass-through to domestic prices: does the inflationaryenvironment matter? Working Paper, WP/01/194, IMF.

Christie, A.A. (1982). The stochastic behavior of common stock variances: Value, leverage and interest rate effects. *Journal of Financial Economics*, 10 (4), 407-432.

Clark, P.B. (1973). Uncertainty, exchange risk, and the level of international trade. *Western Economic Journal*, 11 (3), 302–313.

Corsetti, G. and Dedola, L. (2005). A macroeconomic model of international price discrimination. *Journal of International Economics*, 67 (1), 129–155.

Corsetti, G. (2007). New open economy macroeconomics. EUI Working Papers RSCAS 2007/27, European University Institute.

Corsetti, G and Pesenti, P. (2004). Endogenous pass-through and optimal monetary policy: a model of self-validating exchange rate regimes. CEPR Working Papers No. 8737, Centre for Economic Policy Research, London.

Darvas, Z. (2001). Exchange rate pass-through and real exchange rate in EU candidate countries. Discussion paper 10/01, Economic Research Centre of the Deutsche Bundesbank, 1–68

Dash, A. K. (2013). Bilateral J-Curve between Indian and her trading partners: A Quantitative Perspective. *Economic Analysis and Policy*, 43 (3), 318-338.

De Cecco, M. (1983). The vicious/ virtuous circle debate in the twenties and in the seventies. *Banca Nozionale del Lavoro Quarterly Review*, 146 (36), 285-303.

Devereux, M. B, and Lane, P.R. (2001). Exchange rates and monetary policy in emerging market economies, Discussion Papers 2874, CEPR.

Devereux, M. B. and Engel, C. (2001). Endogenous currency of price setting in a dynamic open economy model. NBER Working Papers No. 8559, National Bureau of Economic Research.

Devereux, M. B., Engel, C and Storgaard, P. E. (2004). Endogenous exchange rate pass-through when nominal prices are set in advance. *Journal of International Economics*, 63 (2), 263–291.

Dholakia, R.H and Saradhi, R.V. (2000). Exchange rate pass-through and volatility: impact on Indian foreign trade, *Economic and Political Weekly*, 35 (47), 4109-4116.

Dixit, A. (1989). Hysteresis, import penetration, and exchange rate pass-through. *The Quarterly Journal of Economics*, 104 (2), 205-22.

Doojav, G. (2009). Exchange rate pass-through to inflation in Mongolia, Monetary Policy and Research Department of the Bank of Mongolia. 1-10.

Dornbusch, R. (1985). Purchasing power parity. NBER Working Paper Series, No. 1591, 27–34. http://doi.org/10.3386/w1591

Dornbusch, R. (1987). Exchange rates and prices. *American Economic Review*, 77(1), 93–106.

Dorrucci, E., Meyer-Cirkel, A and Santabarbara, D. (2009). Domestic financial development in emerging economies: evidence and implications. Database of Financial Sector Development of Lots of Countries, 102, European Central Bank.

Doyle, P., Jiang, G and Kuijs, L. (2001). Real convergence to EU income levels: central Europe from 1990 to the long term. IMF Working Papers 01/146, International Monetary Fund.

Dua, P and Ranjan, R. (2010). Exchange rate policy and modelling in India, Study No. 33, Department of Economic Analysis and Policy, Reserve Bank of India.

Enders, W. (2004). *Applied econometric time series*, United States of America: Wiley.

Engel, C. (2004). On the relationship between pass-through and sticky nominal prices. Working Papers No. 112004, Hong Kong Institute for Monetary Research.

Engel,R and Granger, C. (1987). Cointegration and error correction: representation, estimation, and testing,*Econometrica*, 55 (2), 251-276.

Engle, R. (1982). Autoregressive conditional heteroskedasticity with estimates of United Kingdom Inflation. *Econometrica*, 50 (4), 987-1008.

Feenstra, R. C., Gagnon, J. E and Knetter, M. M. (1996). Market share and exchange rate pass-through in world automobile trade," *Journal of International Economics,* 40 (1), 187–207.

Feinberg, R.M. (1989). The effects of foreign exchange movements on U.S. domestic prices,*Review of Economics and Statistics*, 71 (3), 505-11.

Fernandez, V. (2004). Detection of breakpoints in volatility. *Estudios de Administracion*, 11 (1), 1-38.

Fernandez, V. (2007). Stock market turmoil: worldwide effects of Middle East conflicts. *Emerging Markets Finance and Trade*, 43 (3), 58-102.

Franke, G. (1991). Exchange rate volatility and international trading strategy. *Journal of International Money and Finance*, 10 (2), 292–307.

Frankel, J and Rose, A. (2002). An estimate of the effect of common currencies on trade and income. *Quarterly Journal of Economics*, 117(2), 437-466.

Frankel, J., Parsley, D and Wei, S. J. (2012). Slow pass-through around the world: a new import for developing countries? *Open Economies Review*, 23(2), 213–251.

French, K. R., Schwert, G. W and Stambaugh, R. F. (1987). Expected stock returns and volatility. *Journal of Financial Economics*, 19(1), 3-29

Ftiti, Z., Tiwari, A and Fatnassi, F. (2014). Oil price and macro economy in India: an evolutionary cospectral coherence approach. Working Paper- 2014-068, IPAG Business School, Paris.

Gagnon, J.E. (1993). Exchange rate variability and the level of international trade. *Journal of International Economics*, 34 (3-4), 269–287.

Gandolfo, G. (1987), *International Economics II*, Berlin: Springer-Verlag.

Gandolfo, G and Padoan, P.C. (1984). *A disequilibrium model of real and financial accumulation in an open economy: theory, evidence and policy simulations*. Berlin, Heidelberg, New York, Tokyo: Springer-Verlag.

Ghosh, A and Rajan, R.S. (2007). How high is exchange rate passthrough in India? Has it changed over time?. *The Journal of International Trade and Economic Development: An International and Comparative Review,* 16 (3), 373-382.

Goldberg, P.K and Knetter, M.M. (1996). Goods prices and exchange rates: what have we learned? Working Paper Series No. 5862, NBER.

Goldberg, P.K and Knetter, M.M. (1997). Goods prices and exchange rates: what have we learned?. *Journal of Economic Literature*, 35(3), 1243-1272.

Granger, C.W.J. (1981). Some properties of time series data and their use in econometric model specification, *Journal of Econometrics*, 16 (1), 121-130.

Gust, C. and Sheets, N. (2006). The adjustment of global external imbalances: does partial exchange rate pass-through to trade prices matter? International Finance Discussion Papers-850, Board of Governors of the Federal Reserve System.

Hakura, D and Choudhri, E. U. (2001). Exchange rate pass-through to domestic prices: does the inflationary environment matter?. IMF Working Papers 01/194, International Monetary Fund.

Himarios, D. (1985). The effects of devaluation on the trade balance: a critical view and reexamination of Miles's new results, *Journal of International Money and Finance*, 4 (4), 553-63.

Humphrey, T. H. and Keleher, R (eds.), (1982). *The Monetary Approach to the Balance of Payments, Exchange Rates, and World Inflation*. New York: Praeger Publishers.

Inclan, C and Tiao, G. (1994). Use of cumulative sums of squares for retrospective detection of changes in variance. *Journal of the American Statistical Association*, 89 (427), 913- 923.

Jiang, J. (2012). Exchange rate pass-through to inflation in China, Sixth Annual APEA Conference, Singapore, June 2012, http://www.apeaweb.org/confer/sing12/papers/ SC104% 20Jiang.pdf

Johansen, S. (1991). Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. *Econometrica*, 59 (6), 1551-1580.

Johansen, S and Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration-with applications to the demand for money. *Oxford Bulletin of Economics and Statistics*, 52 (2), 169-210.

Joshi, V and Little, I. M. D. (1994). *India: macroeconomics and political economy, 1964-1991*. Delhi: Oxford University Press.

Kahn, G.A. (1987). Dollar depreciation and inflation. *Federal Reserve Bank of Kansas City Economic Review*, 72 (9), 342-349.

Kamin, S.B. (1988). Devaluation, external balance and macroeconomic performance: a look at NOS, Essay in International Finance, No 62, Princeton Studies.

Kang S.H., Cheong C. and Yoon S-M. (2011). Structural changes and volatility transmission in crude oil markets. Physica A, 390, 4317-4324.

Kapur, M and Bahera, H. (2012). Monetary transmission mechanism in India: a quarterly model. RBI Working Paper- W P S - 09/ 2012, Reserve Bank of India

Kawai, M. (1980). Exchange rate-price causality in the recent floating period. In. D. Bigman and T. Taya (eds.), 1980, 197-219

Khan, Z.K and Hossain, I. (2010). A model of bilateral trade balance: extensions and empirical tests. *Economic Analysis and Policy*, 40(3), 377-391

Khundrakpam, J.K. (2007). Economic reforms and exchange rate pass-through to domestic prices in India. BIS Working Papers No-225, Monetary and Economic Department, Basel, Switzerland

Kim, W.J. (2007). Exchange rate volatility, trade, export price and exchange rate pass-through in Korea, *The Journal of The Korean Economy*, 8 (1), 39-68.

Knetter, M. M. (1989). Price discrimination by U.S. and German exporters.*The American Economic Review*, 79 (1), 198–210.

Knetter, M. M. (1993). International comparisons of pricing-to-market behavior. *The American Economic Review*, 83 (3), 473–486.

Koray F and McMillin, W.D. (1999). Monetary shocks, the exchange rate, and the trade balance. *Journal of International Money and Finance*, 18 (6), 925-940.

Korhonen, I and Wachtel, P. (2005). A note on exchange rate pass-through in CIS countries, BOFIT/CEFIR workshop on Russian Macroeconomic and Financial Issues, March 2005, Moscow, Russia.

Krugman, P. (1986). Pricing to market when the exchange rate changes. NBER Working Paper Series. No. 1926

Krugman, P and Baldwin, R. (1987). The persistence of the U.S. trade deficit. *Brookings Papers on Economic Activity*, 1, 1-55.

Krugman, P.R. (1987). Pricing to market when the exchange rate changes. In S.W. Arndt and D. Richardson (Eds.), *Real-Financial Linkages among Open Economies*, MIT Press, Cambridge, 49–70.

Kulkarni, K. G. (1996). Balance of payment changes and the exchange rate devaluation: a case of India. *The Indian Journal of Economics*, 76 (303), 415-425

Kumar, A. (2014). Exchange rate pass through in India. *International Journal of Business and Management Invention*, 3 (2), 29-43.

Lafeche, T. (1996). The impact of exchange rate movements on consumer prices. Bank of Canada Review, Winter 1996-1997, 21-32.

Laffer, A.B. (1973). Exchange rates, the terms of trade and trade balance, (Mimeo), University of Chicago.

Lafleche, T. (1996). The impact of exchange rate movements on consumer prices, Bank of Canada Review, 1996, Winter 1996-1997, 21-32.

Leigh, D and Rossi, M. (2002). Exchange rate pass-through in Turkey, IMF Working Paper, WP/02/204, International Monetary Fund.

Magee, S. (1973). Currency contracts, pass-through, and devaluation. *Brookings Papers on Economic Activity*, 4 (1): 303–325

Mallick, S and Marques, H. (2010). Data frequency and exchange rate pass-through: evidence from India's exports. *International Review of Economics and Finance*, 19 (1), 13-22.

Mallick, S and Marques, H. (2006). Sectoral exchange rate pass-through: testing the impact of policy reforms in India, *Scottish Journal of Political Economy*, 53 (2), 280-303.

Mallick, S and Marques, H. (2008). Exchange rate transmission into industry-level export prices: a tale of two policy regimes in India. IMF Staff Papers, 55 (1), 83-108.

Mallick, S and Marques, H. (2012). Pricing-to-market with trade liberalization: the role of market heterogeneity and product differentiation in India's export. *Journal of International Money and Finance*, 31 (2), 310-338.

Mallick, S and Marques, H. (2013). Comparative advantage as a source of exporters' pricing power: evidence from China and India, GPEN- CGR Annual Conference, June 2013, Queen Mary University of London.

Mann, C.L. (1986). Prices, profits margins, and exchange rates, Federal Reserve Bulletin, 72 (6), 366-379.

Manning, L. M. and Adriacanos, D. (1993). Dollar movements and inflation: a cointegration analysis, *Applied Economics*, 25 (12), 1483-1488.

Marston, R.C. (1990). Pricing to market in Japanese manufacturing. *Journal of International Economics*, 29 (3-4), 217-236.

Mashat, R. A and Billmeier, A. (2007). The monetary transmission mechanism in Egypt. IMF Working Paper No. 07/285. International Monetary Fund. Washington D.C.

McCarthy, J. (2000). Pass-through of exchange rates and import prices to domestic inflation in some industrialized economies. Staff Reports 111, Federal Reserve Bank of New York.

Mccarthy, J. (2007). Pass-through of exchange rates and import prices to domestic inflation in some industrialized economies, *Eastern Economic Journal*, 33(4), 511-537

Menon, J. (1996). The degree and determinants of exchange rate pass-through: market structure, non-tariff barriers and multinational corporations.*The Economic Journal*, 106 (435), 434-444.

Miles, M.A. (1978). Currency substitution, flexible exchange rates and monetary independence. *American Economic Review*, 68 (3), 428-36.

Mirchandani, A. (2013). Analysis of macroeconomic determinants of exchange rate volatility in India.*International Journal of Economics and Finacial Issues*, *3*(1), 172–179.

Mishra, A and Ray, R. (2011). Prices, inequality, and poverty: methodology and Indian evidence. *Review of Income and Wealth, International Association for Research in Income and Wealth*, 57(3). 428-448.

Misra, D.P., Jena, A.B., and Shil, N.C. (2011). India's foreign trade during liberalization era: an assessment, *Journal of International Economic Review*, 4 (1), 39-50.

Modigliani, F and Padoa-Schioppa, T. (1978). The management of an open economy with "100% plus" wage indexation, essays in international finance, No.130, International Finance Section, Princeton University

Mohan, R. (2008) Monetary policy transmission in India, Working Paper No 35, Bank for International Settlements (BIS).

Mohanty, B and Bhanumurthy, N.R. (2014). Exchange rate regimes and inflation: evidence from India. Working Paper No. 2014-130, National Institute of Public Finance and Policy, New Delhi.

Mustafa, M., Rahman, M and Guru-Gharana. (2016). Brazil-US trade balance and exchange rate : dynamic empirics. *The Journal of Developing Areas*, 49 (3), 151–164.

Naqvi, B and Rizvi, S.K.A. (2011). Does Exchange Rate Pass-Through Even Exist in Asia or Inflation Targeting Framework is Irrelevant in its Determination?. Singapore Economic Review Conference, August- 2009, Singapore.

Narayan, P.K. (2005). The saving and investment nexus for China: evidence from cointegration tests. *Applied Economics*, 37 (17), 1979-1990.

Nelson, D.B. (1991). Conditional heteroskedasticity in asset returns: a new approach. *Econometrica*, 59 (2), 347-370.

Norris, E. D and Floerkemeier, H. (2006). Transmission mechanism of monetary policy in Armenia: evidence from VAR analysis, IMF Working Paper No. 06/248. International Monetary Fund, Washington D.C.

Nortey, E.N., Ngoh, D.D., Doku-Amponsah, K and Ofori-Boateng, K. (2015). Modeling Inflation rates and exchange rates in Ghana: application of multivariate GARCH models. *SpringerPlus*, 86 (4), 1-10.

Obstfeld, M. and Rogoff, K. (1995). Exchange rate dynamics redux. *Journal of Political Economy*, 103 (3), 624–660.

Obstfeld, M and Taylor, A.M. (1997). The great depression as a watershed:international capital mobility over the long run. National Bureau of EconomicResearch Working Paper No. 5960, Cambridge.

Ohno, K. (1989). Export pricing behaviour of manufacturing: A US-Japan comparison. Working Paper WP-88-78. International Monetary Fund. Washington D.C.

Onafowora, O. (2003). Exchange rate and the trade balance in East Asia: is there a J-curve?. *Economics Bulletin*, 5 (18), 1-13.

Panda, B and Reddy, R.K. (2015). Dynamics of India-China trade relations; testing for the validity of Marshall-Lerner condition and J-curve hypothesis, International Conference on Trade and exchange rate policies in the context of WTO and PTAs: challenges before emerging economies, IPE, Hyderabad.

Patnaik, I. (2007). The Indian currency regime and its consequences, *Economic and Political Weekly*, 42 (11), 911-913.

Peltzman, S. (2000). Prices rise faster than they fall. *Journal of Political Economy*, 108 (3), 466–502.

Pesaran, M., Shin, Y and Smith, R., (2001). Bounds testing approaches to the analysis of level relationships, *Journal of Applied Econometrics*, 16 (3), 289-326.

Pindyck. R.S. (1984). Risk, inflation, and the stock market. *American Economic Review*, 74 (3). 335-351.

Pollard, P.S and Coughlin, C.C (2004). Size matters: asymmetric exchange rate pass-through at the industry level. Research Paper -2004/13, University of Nottingham.

Ranadive, R.R and Burange, L. G. (2015). Transmission mechanism of exchange rate pass-through in India, *Foreign Trade Review*, 50 (4), 263-283.

Ranjan, R. (1995). Competitiveness of India's Exports: Some Aspects. Reserve Bank of India Occasional Papers, 16(4), 257-300.

Rashid, A and Husain, F. (2010). Capital inflows, inflation and exchange rate volatility: an investigation for linear and nonlinear causal linkages. PIDE-Working Papers 2010:63, Pakistan Institute of Development Economics.

Reinhart, C. M and Rogoff, K.S. (2002). The modern history of exchange rate arrangements: a reinterpretation. NBER Working PaperNo. 8963, National Bureau ofEconomic Research, Cambridge MA

Rose, A.K. (1991). The role of exchange rate in a popular model of international trade: does the Marshall-Lerner Condition hold? *Journal of International Economics*, 30(3/4), 301–316.

Rose, A.K and Yellen, J.L. (1989). Is there a J-curve? *Journal of Monetary Economics*, 24(1), 53–68.

Ross, K. (1998). Post stabilization inflation dynamics in Slovenia. IMF Working Papers 98/27, International Monetary Fund.

Roy, S.S and Pyne, P. K. (2011). Exchange rate pass-through and India's export prices, *Trade and Development Review*, 4 (1), 41-63.

Sachs, D.J. (1985). The dollar and the policy mix: 1985. NBER Working Paper Series, No. 1636.

Salent, M. (1974). Devaluations improve the balance of payments even if not the trade balance in effects of exchange rate adjustments, OASIA RES: 97-114, Treasury Department, Washington. DC.

Sanso, A., Arago, V and Carrion-I-Silvestre, J. L. (2004). Testing for changes in the unconditional variance of financial time series. *Revista de Economia Financiera*, 4, 32-53.

Sanusi, A.R. (2010). Exchange rate pass-through to consumer prices in Ghana: evidence from structural vector auto-regression. *The West African Journal of Monetary and Economic Integration*, 10 (1), 25-54.

Sauer, C and Bohara, A. (2001). Exchange rate volatility and exports: regional differences between developing and industrialized countries. *Review of International Economics*, 9 (1), 133–152.

Sercu, P and Vanhulle, C. (1992). Exchange rate volatility, international trade, and the value of exporting firms. *Journal of Banking and Finance*, 16 (1), 152–182.

Smets, F and Wouters, R. (2002). Openness, imperfect exchange rate pass-through and monetary policy. *Journal of Monetary Economics*, 49 (5), 947–981.

Soto, C and Selaive, J. (2003). Openness and imperfect pass-through: implications for the monetary policy. Central Bank of Chile Working Papers, No. 216.

Takatoshi, I and Kiyotaka, S. (2007). Exchange rate pass-through and domestic inflation: a comparison between East Asia and Latin American countries, Discussion Paper Series 07-E-040, RIETI, Tokyo.

Tandrayen-Ragoobur, V and Chicooree, A. (2013). Exchange rate pass through to domestic prices: evidence from Mauritius. *Journal of Economic Research,* 18 (1), 1 – 33

Taylor, J. (2000). Low inflation, pass-through, and the pricing power of firms, *European Economic Review*, 44 (7), 1389-1408.

Taylor, S.J. (1986). *Modeling Financial Time Series*. Chichester, UK: John Wiley and Sons.

Tse, Y.K. (2002). Residual-based diagnostics for conditional heteroskedasticity models. *Econometrics Journal*, 5, 358–373

Viktoria, D and Dmitriy, L. (2005). A study of exchange rate pass-through in Russia. In HSE Series Research in Economics and Finance. Moscow: Higher School of Economics.

Wilson, P. (2001). Exchange rates and the trade balance for dynamic Asian economies: does the J-curve exist for Singapore, Malaysia and Korea?. *Open Economies Review*, 12 (4), 389–413.

Yang, J. (1997). Exchange rate pass-through in U.S. manufacturing industries, *The Review of Economics and Statistics*, 79 (1), 95–104.

Zorzi M.C., Hahn E and Snchez, M. (2007). Exchange rate pass-through in emerging markets, Working Paper Series - No 739, European Central Bank.

"Exchange Rate Volatility, Pass-through and Foriegn Trade in India: 1998-2014"
(Library Similarity Checking Report of the Thesis)

ORIGINALITY REPORT

%15	%12	%8	%3
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Naz, Farah, Asma Mohsin, and Khalid Zaman. "Exchange rate pass-through in to inflation: New insights in to the cointegration relationship from Pakistan", Economic Modelling, 2012. Publication	%1
2	International Economics II, 1987. Publication	<%1
3	jer.hanyang.ac.kr Internet Source	<%1
4	www.degit.ifw-kiel.de Internet Source	<%1
5	rbidocs.rbi.org.in Internet Source	<%1
6	www.bis.org Internet Source	<%1
7	www.slideshare.net Internet Source	<%1
8	sites.uom.ac.mu Internet Source	<%1

9	Submitted to University of Cape Town Student Paper	<%1
10	reference.sabinet.co.za Internet Source	<%1
11	verde.esalq.usp.br Internet Source	<%1
12	Menla Ali, Faek(Caporale, GM and Hunter, J). "Essays in exchange rates and international finance", School of Social Sciences Theses, 2014. Publication	<%1
13	www.bof.fi Internet Source	<%1
14	Jimborean, Ramona. "The exchange rate pass-through in the new EU member states", Economic Systems, 2013. Publication	<%1
15	econstor.eu Internet Source	<%1
16	Submitted to CITY College, Affiliated Institute of the University of Sheffield Student Paper	<%1
17	www.scienpress.com Internet Source	<%1
18	"CHAPTER 1: INTRODUCTION AND OVERVIEW", Norges Bank: Doctoral Dissertations in Economics/15030741,	<%1

20060101
Publication

19	www.rbi.org.in Internet Source	<%1
20	www.akes.or.kr Internet Source	<%1
21	www.science.gov Internet Source	<%1
22	MISZTAL, Piotr. "The Phenomenon of Incomplete Exchange Rate Pass-Through to Prices in the Euro Area", EuroEconomica/15828859, 20100101 Publication	<%1
23	mpra.ub.uni-muenchen.de Internet Source	<%1
24	ideas.repec.org Internet Source	<%1
25	Submitted to University of Kent at Canterbury Student Paper	<%1
26	www.cesmaa.eu Internet Source	<%1
27	Journal of Economic Studies, Volume 37, Issue 6 (2010-11-08) Publication	<%1
28	Submitted to University of Essex Student Paper	<%1

29	www.goldbullioncompany.co.th Internet Source	<%1
30	services.bepress.com Internet Source	<%1
31	Beckmann, Elisabeth, and Jarko Fidrmuc. "Exchange Rate Pass-Through in CIS Countries", Comparative Economic Studies, 2013. Publication	<%1
32	businessperspectives.org Internet Source	<%1
33	pagesperso.dial.prd.fr Internet Source	<%1
34	eprints.usq.edu.au Internet Source	<%1
35	akw.apeaweb.org Internet Source	<%1
36	www.internationalconference.com.my Internet Source	<%1
37	Submitted to The University of Manchester Student Paper	<%1
38	wbiconpro.com Internet Source	<%1
39	Submitted to University of Sheffield Student Paper	<%1

40	www.rieti.go.jp Internet Source	<%1
41	pages.stern.nyu.edu Internet Source	<%1
42	www.cass.city.ac.uk Internet Source	<%1
43	www.dofin.ase.ro Internet Source	<%1
44	Ito, Takatoshi Sato, Kiyotaka. "Exchange rate changes and inflation in post-crisis Asian economies: vector autoregression analysis o", Journal of Money, Credit & Banking, Oct 2008 Issue Publication	<%1
45	gbata.org Internet Source	<%1
46	eprints.soas.ac.uk Internet Source	<%1
47	www.pef.czu.cz Internet Source	<%1
48	Submitted to University of Surrey Student Paper	<%1
49	Ganiyu, Lawal Omoniyi, Alabi Nurudeen Olawale, Ige Sikiru Ajibade, and Ibraheem Rahmat Abisola. "The Nexus between Nigerian Government Spending and	<%1

	Domestic Output in the Presence of Long-Term Crude Oil Price Shock: A Conditional Unrestricted Equilibrium Correction Model Approach", Open Journal of Statistics, 2016. Publication	
50	www2.um.edu.uy Internet Source	<%1
51	Submitted to University of Birmingham Student Paper	<%1
52	www.harfordchamber.org Internet Source	<%1
53	Ratha, Artatrana Kant, Eungmin. "ASIAN FINANCIAL CRISIS AND KOREAN TRADE DYNAMICS.(Report)", Contemporary Economic Policy, Oct 2014 Issue Publication	<%1
54	ccilindia.com Internet Source	<%1
55	Submitted to University of Venda Student Paper	<%1
56	eprints.ru.ac.za Internet Source	<%1
57	wdi.umich.edu Internet Source	<%1
58	fessud.eu Internet Source	<%1

59	fmwww.bc.edu Internet Source	<%1
60	openaccess.adb.org Internet Source	<%1
61	Akofio-Sowah, Naa Anyeley. "Is there a link between exchange rate pass-through and the monetary regime: evidence from Sub-Sahara", International Advances in Economic Resea, August 2009 Issue Publication	<%1
62	Submitted to University of Greenwich Student Paper	<%1
63	citeseerx.ist.psu.edu Internet Source	<%1
64	www.bundesbank.de Internet Source	<%1
65	Submitted to University of Wales, Bangor Student Paper	<%1
66	www.thirdpointre.bm Internet Source	<%1
67	routekaartchemie.nl Internet Source	<%1
68	International Journal of Energy Sector Management, Volume 8, Issue 1 (2014-03-28) Publication	<%1

69	www.fednewyork.org Internet Source	<%1
70	si2.bcentral.cl Internet Source	<%1
71	Submitted to University of Warwick Student Paper	<%1
72	Mallick, Sushanta Marques, Helena. "Exchange rate transmission into industry-level export prices: a tale of two policy regimes in India.", IMF Staff Papers, April 2008 Issue Publication	<%1
73	Submitted to University of Exeter Student Paper	<%1
74	www.rioss.com Internet Source	<%1
75	www.dailyexcelsior.com Internet Source	<%1
76	edoc.ub.uni-muenchen.de Internet Source	<%1
77	www.cluteinstitute.com Internet Source	<%1
78	www.investmentmanagement.pramerica.com Internet Source	<%1
79	irjaf.com Internet Source	<%1

80	www.escience.cn Internet Source	<1%
81	Studies in Economics and Finance, Volume 28, Issue 1 (2011-03-06) Publication	<1%
82	papers.ssrn.com Internet Source	<1%
83	www.vse.cz Internet Source	<1%
84	International Economics, 1986. Publication	<1%
85	www.ccwe.org.cn Internet Source	<1%
86	eprints.qut.edu.au Internet Source	<1%
87	ijbesar.teiemt.gr Internet Source	<1%
88	Caglayan, E.. "The Impact of Stock Index Futures on the Turkish Spot Market", Journal of Emerging Market Finance, 2011. Publication	<1%
89	www.business.uiuc.edu Internet Source	<1%
90	International Journal of Social Economics, Volume 40, Issue 2 (2013-01-12) Publication	<1%

91	source.icu-project.org Internet Source	<%1
92	www.ccsenet.org Internet Source	<%1
93	finmin.nic.in Internet Source	<%1
94	keydifferences.com Internet Source	<%1
95	is.muni.cz Internet Source	<%1
96	www.suerf.org Internet Source	<%1
97	Journal of Asia Business Studies, Volume 5, Issue 2 (2012-08-06) Publication	<%1
98	www.allbusiness.com Internet Source	<%1
99	www.researchgate.net Internet Source	<%1
100	ccsenet.org Internet Source	<%1
101	qje.oxfordjournals.org Internet Source	<%1
102	www.craig.csufresno.edu Internet Source	<%1

103	www.iep.ru Internet Source	<%1
104	www.wbiworldconpro.com Internet Source	<%1
105	accountingfutures.edu.au Internet Source	<%1
106	www.aueb.gr Internet Source	<%1
107	于 2012-10-08 提交至 University of Lincoln Student Paper	<%1
108	docslide.us Internet Source	<%1
109	www.centralbank.ie Internet Source	<%1
110	International Journal of Managerial Finance, Volume 11, Issue 4 (2015) Publication	<%1
111	faculty.chicagobooth.edu Internet Source	<%1
112	Review of Accounting and Finance, Volume 12, Issue 1 (2013-02-02) Publication	<%1
113	liontrust.co.uk Internet Source	<%1
114	users.erols.com Internet Source	<%1

115	www.mtome.com Internet Source	<%1
116	www.bus.qut.edu.au Internet Source	<%1
117	www.hnb.hr Internet Source	<%1
118	sciie.ucsc.edu Internet Source	<%1
119	www.adb.org Internet Source	<%1
120	internationaleconomics.net Internet Source	<%1
121	www.bullshouse.com Internet Source	<%1
122	wcfia.harvard.edu Internet Source	<%1
123	legene Internet Source	<%1
124	www.cesifo.de Internet Source	<%1
125	australianinvestmenteducation.com.au Internet Source	<%1
126	ijesar.org Internet Source	<%1

Egert, Balazs.. "Real Convergence, Price

127	Level Convergence and Inflation in Europe. Bruegel Working Papers, 2007/02, April 2007", Archive of European Integration, 2011. Publication	<1%
128	Submitted to University of Durham Student Paper	<1%
129	Cai, Yuzhi, Gabriel Montes-Rojas, and Jose Olmo. "Quantile Double AR Time Series Models for Financial Returns : Quantile Double AR Time Series Models", Journal of Forecasting, 2013. Publication	<1%
130	Mengesha, Lula G.. "Are there swift transitions in the smooth transition regressions of the exchange rate volatility of ", Comparative Economic Studies, March 2016 Issue Publication	<1%
131	Publication	<1%
132	www.cham.montefiore.org Internet Source	<1%
133	Submitted to Queen Mary and Westfield College Student Paper	<1%
134	Submitted to University of London External System Student Paper	<1%

135	Barkoulas, John T. Baum, Christopher F. . "Exchange rate effects on the volume and variability of trade flows.", Journal of International Money and Finan, August 2002 Issue Publication	<%1
136	Junttila, Juha, and Marko Korhonen. "The role of inflation regime in the exchange rate pass-through to import prices", International Review of Economics & Finance, 2012. Publication	<%1
137	ubm.opus.hbz-nrw.de Internet Source	<%1
138	clan360.net Internet Source	<%1
139	bitak.securities.bg Internet Source	<%1
140	Submitted to Cranfield University Student Paper	<%1
141	Sarno, Lucio Taylor, Mark P.. "Purchasing power parity and the real exchange rate.", IMF Staff Papers, March 2002 Issue Publication	<%1
142	50.116.1.122 Internet Source	<%1
143	openaccess.city.ac.uk Internet Source	<%1

144	www.lib.ncsu.edu Internet Source	<%1
145	www.investopedia.com Internet Source	<%1
146	www.centralbankmalta.com Internet Source	<%1
147	www.unity.edu Internet Source	<%1
148	Submitted to University of Plymouth Student Paper	<%1
149	arrow.dit.ie Internet Source	<%1
150	www.eaa.egss.ulg.ac.be Internet Source	<%1
151	www.citizenspact.org Internet Source	<%1
152	www.simpletaxindia.net Internet Source	<%1
153	Studies in Economics and Finance, Volume 25, Issue 2 (2008-06-01) Publication	<%1
154	Submitted to Cardiff University Student Paper	<%1
155	cepar.edu.au Internet Source	<%1

156	www.centreforsocialpolicy.eu Internet Source	<%1
157	www.erf.org.eg Internet Source	<%1
158	www.i-jibe.org Internet Source	<%1
159	ro.ecu.edu.au Internet Source	<%1
160	221.120.199.3 Internet Source	<%1
161	Submitted to University of Hull Student Paper	<%1
162	International Journal of Emerging Markets, Volume 9, Issue 4 (2014-09-16) Publication	<%1
163	eri.mn Internet Source	<%1
164	www.newyorkfed.org Internet Source	<%1
165	www.tritonia.fi Internet Source	<%1
166	www.deloitteaccesseconomics.com.au Internet Source	<%1
167	www.dollarsrus.com.au Internet Source	<%1

168	www.shareyouressays.com Internet Source	<%1
169	www.bde.es Internet Source	<%1
170	140.122.185.120 Internet Source	<%1
171	www.genrica.com Internet Source	<%1
172	iris.lib.neu.edu Internet Source	<%1
173	www.unc.edu Internet Source	<%1
174	robetta.bakerlab.org Internet Source	<%1
175	www.sgs.gov.cn Internet Source	<%1
176	worldwidescience.org Internet Source	<%1
177	Journal of Financial Economic Policy, Volume 6, Issue 3 (2014-09-16) Publication	<%1
178	www.rbf.gov.fj Internet Source	<%1
179	www.nbs.sk Internet Source	<%1

180	www.kosmix.com Internet Source	<%1
181	Submitted to University of Glasgow Student Paper	<%1
182	Managerial Finance, Volume 29, Issue 1 (2012-04-14) Publication	<%1
183	ec.europa.eu Internet Source	<%1
184	164.15.27.46 Internet Source	<%1
185	www.fe.unl.pt Internet Source	<%1
186	Journal of Chinese Economic and Foreign Trade Studies, Volume 7, Issue 1 (2014-01-11) Publication	<%1
187	homepage.stat.uiowa.edu Internet Source	<%1
188	URAL, Mert and KÜÇÜKÖZMEN, C. Coşkun. "Analyzing the dual long memory in stock market returns", TUBITAK, 2011. Publication	<%1
189	www.reportworld.co.kr Internet Source	<%1
190	polmeth.wustl.edu	

	Internet Source	<%1
191	www.icegec.org Internet Source	<%1
192	Journal of Advances in Management Research, Volume 10, Issue 3 (2013-10-19) Publication	<%1
193	ufh.netd.ac.za Internet Source	<%1
194	www-wds.worldbank.org Internet Source	<%1
195	france24.com Internet Source	<%1
196	www.youthcoalition.net Internet Source	<%1
197	www.rebs.ro Internet Source	<%1
198	data.daff.gov.au Internet Source	<%1
199	www.tcmb.gov.tr Internet Source	<%1
200	repec.rwi-essen.de Internet Source	<%1
201	www.suomenpankki.fi Internet Source	<%1

202	workshiftcalgary.ca Internet Source	<%1
203	m-e.mbri.ac.ir Internet Source	<%1
204	121.52.153.179 Internet Source	<%1
205	www.banrep.gov.co Internet Source	<%1
206	202.54.18.156 Internet Source	<%1
207	viessmanncentre.ca Internet Source	<%1
208	eng.kea.ne.kr Internet Source	<%1
209	Chan, Man-Ching Stella. "Real exchange rate adjustments to foreign exchange inflows in a fixed exchange rate system.(Abstract", Journal of Economics and Economic Educat, May 2015 Issue Publication	<%1
210	"Adjusting to lower commodity prices.(p. 123-166)", World Economic Outlook, Oct 2015 Issue Publication	<%1
211	Ali, FM, Caporale, GM and Spagnolo, N. "Exchange rate uncertainty and international	<%1

portfolio flows", Brunel University, 2013.
Publication

212 Kamal, Javed Bin Haque, A.K. Enamul. "Dependence between stock market and foreign exchange market in South Asia: a copula-GARCH approach.(", Journal of Developing Areas, Wntr 2016 Issue <%1
Publication

EXCLUDE QUOTES	ON	EXCLUDE MATCHES	< 5 WORDS
EXCLUDE BIBLIOGRAPHY	ON		