Exchange Rate and Fundamentals: An Empirical Analysis for Non-Linear Relationship

Thesis submitted to International Institute of Islamic Economics (IIIE), IIUI
is partial fulfillment of the requirements for the award of degree of

MS ECONOMICS

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May, 2016

بسم الله الرحمن الرحیم

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List of Acronyms and Abbreviations

ACE algorithm	Alternating Conditional Expectation algorithm
ADF unit root test	Augmented Dickey-Fuller unit root test
AIC	Akaike Information Criterion
ARDL Model	Autoregressive Distributed Lag Model
AVAS	Additivity and Variance Stabilization
BEER	Behavioral Equilibrium Exchange Rate
BIC	Bayesian Information Criterion
BOP	Balance of Payments
CIRP	Covered Interest Rate Parity
CPI	Consumer Price Index
CUSUM	Cumulative Sum
CUSUMSQ	Cumulative Sum of Squares
DCPS	Domestic Credit to Private Sector
DSGE	Dynamic Stochastic General Equilibrium
DW	Durbin Watson-Stat
ECM	Error Correction Model
EqcMs	Equilibrium Correction Models
ERER	Equilibrium Real Exchange Rate
ERM	European Exchange rate Mechanism
ESTAR Model	Exponential Smooth Transition Autoregressive Model
FDI	Foreign Direct Investment
FIBR	Floating Interbank Rate
GARCH Model	Generalized Autoregressive Conditional Heteroskedasticity Model
GATT	General Agreement on Tariffs and Trade
GDPDF	GDP Deflator
GDPPC	Real GDP Per Capita
GFCF	Gross Fixed Capital Formation
HQC	Hannan-Quinn Information Criterion
IMF	International Monetary Fund

INV	Investment
IS	Investment/Saving
IT	Information Technology
KSS unit root test	Kapetanios, Shin and Shell unit root test
LL	Log Likelihood
LM	Liquidity Preference/Money
MR-STAR Model	Multiple Regime Smooth Transition Autoregressive Model
MS-VECM Model	Markov-Switching Vector Error Correction Model
NFA	Net Foreign Assets
NN Type	Nearest Neighbor Type
OLS	Ordinary Least Squares
OPEC	Organization of the Petroleum Exporting Countries
PEG	Price/ Earnings to Growth ratio
PPP	Purchasing Power Parity
PRCD	Private Credit
PROD	Difference in Productivity
PSTR Model	Panel Smooth Transition Regression Model
R^2	R-Squared
R^2_{adj}	Adjusted R-Squared
REER	Real effective Exchange Rate
RSS	Residual Sum of Squared
SDR	Special Drawing Rights
SIC	Schwarz Information Criterion
STAR Model	Smooth Transition Autoregressive Model
TAR Model	Threshold Autoregressive Model
TDAP	Trade Development Authority of Pakistan
TECM	Threshold Error Correction Model
The SBP	The State Bank of Pakistan
TNCs	Transnational Corporations
TOT	Terms of Trade
TV	Television

TVECM	Threshold Vector Error Correction Model
UCIRP	Uncovered Interest Rate Parity
UECM	Unrestricted Error Correction Model
USSR	Union of Soviet Socialist Republics
BOP	Balance of Payments
WTO	World Trade Organization
VAR	Vector Autoregressive
VECM	Vector Error Correction Model
WDI	World Development Indicator
W_{LR}	Long run Wald Test
W_{SR}	Short run Wald Test

Abstract

Exchange rate is one of the macroeconomic variables that links one country with the rest of the world. History of exchange rate has passed through different stages, namely, flexible price monetary model, sticky price monetary model, liquidity and equilibrium models and portfolio balance model. These afore-named models claim that exchange rate and macroeconomic variables are linearly related. Later on, claim of linearity was rejected by empirical analyses. Therefore, linear model was extended to nonlinear one with incorporating different concepts.

Different models have been employed for the analysis of nonlinear relationship between exchange rate and macroeconomic variables. Indeed, Exchange rate is much important for Pakistan economy, hence, in this study, we investigate the linear and nonlinear relationship between real effective exchange rate and chosen macroeconomic variables for Pakistan using annual data over the period 1960- 2014. We employ autoregressive distributed lag ($ARDL$) model developed by Pesaran et al., 2001 for the estimation of linear analysis. The error correction term denotes that real effective exchange rate adjusts towards equilibrium point at a rate of 15.7 percent per year which further recommends that real effective exchange rate of Pak Rupee has not diverged from its equilibrium level.

The study also employs newly developed asymmetric cointegrating autoregressive distributed Lag ($ARDL$)or nonlinear($NADRL$) model of Shin et al. (2011) with partial sum decompositions of positive and negative of selected macroeconomic variables which allows more process of adjustment towards equilibrium level. Our asymmetric findings show significantly different response of real effective exchange rate either to positive or negative changes of macroeconomic variables both in the long and short runs. This evidence has essential implications for making policy and forecasting of exchange rate.

Declaration

I hereby declare that this thesis, neither as a whole nor as part thereof, has been copied out from any source. It is further declared that this submission is my own work and that, to the best of my knowledge and belief. I have carried out this research by myself and have completed it on the basis of my personal efforts under the guidance and help of my supervisor. If any part of this thesis is proven to be carried out or earlier submitted, I shall stand by the consequences. No portion of work presented in this thesis has been submitted in support of any application for any other degree or qualification in International Islamic University or any other university or Institute of higher learning.

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Date of viva voce Exam: May 10, 2016

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Dedication

To

My beloved Parents

Acknowledgement

By the name of Almighty Allah , most merciful, most compassionate, The kind that know all mysterious of world and His Holy Prophet, Hazrat Mohammad (S.AW) whose blessings allowed me to seek higher achievements of life and whose instructions have fulfilled as beacon for human beings during darkness and hopelessness.

I owe a debt of gratitude to my respected supervisor Dr. Arshad Ali Bhatti for his assistance and valuable time, without his instruction and support, I could not be able to finalize my thesis prosperously. I would also like to express acknowledgment to my friends and staff of IIIE for their motivation and cooperation.

Last but not the least, I would like to express my sincere thanks to my parents, sisters and brother, specially my mother who always keep fingers straight and pray for my success and prosperity and to whom I owe my life for her love, encouragement and blessings.

Finally, my sincere gratitude goes to my only one loving brother, Omar who always stand by me in all circumstances.

Mohammad Anwar

Chapter 1

Introduction

This chapter discusses the background of our study, research objectives, research questions, testable hypotheses, significance of the study and scheme of the study.

1.1 Background of the study

The economics of exchange rate has gone through different stages. The primary theoretical models were developed in 1970s, such as the flexible price monetary model developed in 1970, the sticky price monetary model (Dornbusch model) developed in 1976, liquidity and equilibrium models developed in 1980 and the portfolio balance model developed in 1982. Moreover, the mentioned models are associated with the first generation models that have guided to testable propositions which express changes in exchange rate are linearly related to news in fundamentals such as money stock, output, prices, current account and so on. Later on, the empirical testing of the afore-named models was rejected by the data; mostly by those countries who had experienced relatively low levels of inflation. Moreover, the previous exchange rate models have been examined that yield three major conclusions from the literature empirically.

First, even if economic agents are able to forecast the future direction of exchange rate accurately, however, this would not produce a better exchange rate forecast compared to a forecast that does not depend at all fundamentals such as random walk (Meese and Rogoff, 1988). In addition, Meese and Rogoff (1988) explore that generally random walk forecast performs better than any other forecast based on economic model even when a model has access to anticipate completely future fundamentals. Even though most of the researchers claim that their models could beat random walk hypothesis, today's scientific consensus is that the results explored by Meese and Rogoff (1988) still applicable and hold as far as short term (one period ahead) forecasting is concerned. Moreover, if forecasting is done for more than one year then fundamentals based models (nonlinear models) usually perform better than random walk because fundamentals forecast (based on perfect foresight of future fundamentals) use information which is much larger than the set of information required to make random walk forecast. Thus, it results that long term prediction on the basis of economic models use more information than short term prediction (Kilian and Taylor, 2003).

Second, volatility of both nominal and real exchange rates highly increased when the floating exchange rate regime was introduced; however, there was no empirical evidence to state that the volatility of fundamentals increases greatly during floating era comparatively to fixed exchange rate regime (Flood and Rose, 1995). This phenomenon is inconsistent with the first generation models which explain that the volatility of exchange rate is increased only by the volatility of underlying fundamentals. Hence, it is concluded that the volatility of exchange rate does not depend on the volatility of underlying fundamentals.

Third, this anomaly is linked to the first generation models with respect to news. The rational expectation assumption of first generation model is that news in fundamentals can only vary exchange rate at any given time which is called representative of exchange rate. In contrast, empirical analysis provides result against this statement. Moreover, De Boeck (2000) explores that unanticipated shocks in fundamental variables can only explain a small portion of unpredicted variations in exchange rate. It is further stated that news in variables such as output, interest rate and inflation explains only 5 percent of total unpredicted exchange rate variance for over forecast of up to one year and remaining 95 percent of news is approximately related to the exchange rate itself.

Various directions have been explored by researchers when first generation models had been rejected. The first direction one would say "second-generation models" is represented by Obstfeld et al. (1996). These models are based on the assumption of utility maximization subject to budget constraint of a representative agent. These models further explain that the coefficients of reduced form models are not supposed to be constant, rather they are changed by stochastic disturbance; more specifically, due to switching of preferences from domestic goods to foreign ones and also due to changing of policy regimes. The second-generation models are limited to few propositions to be tested that finally prove their validity to be false. These second-generation models are not developed; hence, it is difficult to investigate the strength of the mentioned models scientifically. Furthermore, second direction alternative to first one is introduced through presenting models with non-linearities (Frankel and Froot, 1990; De Grauwe and Dewachter, 1993; Kilian and Taylor, 2003). The main features of these models are presence of various agents utilizing various sets of information (e.g. fundamentalists and chartists) and presence of transaction costs. These models further state that persistent structural breaks are anticipated in linear exchange rate models. Thus, exchange rates are varied which are unassociated to the news in fundamentals variables. Moreover, the failure of linear exchange rate models are investigated by many researchers such as Meese and Rogoff (1983a), Flood and Rose (1995) , and Rose (1996). There might be successful empirical linear models claims (Mark, 1995), however, the sample period is extended each time and therefore structural break seems in such linear models (Faust et al., 2003). Furthermore, theoretical literature of linear exchange rate extension to nonlinear behavior has been growing. The nonlinear extension includes the concept of bubble with self-fulfilling expectations, target zone models, a stop-loss trading strategy or traders, nonlinear monetary strategies, fads or noise trading and aggregate market forecast model.

The nonlinearity of many macroeconomic variables and methods has been accepted for a long time. In a famous statement, Keynes (1936, p. 314) commented that "the substitution of a downward for an upward tendency often takes place suddenly and violently, whereas there is, as a rule, no such sharp turning point when an upward is substituted for a downward tendency". In recent times, the joint fields of economics and behavioural finance related most remarkably with Daniel Kahneman, Amos Tversky and Robert Shiller (e.g. Kahneman and Tversky, 1979; Shiller, 1994, 2005) have provided a significant movement to the modeling of asymmetry, emphasizing that nonlinearity is general within the social sciences and that asymmetry is fundamental to the human condition. In addition, a large literature has considered the joint issues of nonstationarity and nonlinearity since the mid-nineties. Indeed, this field has been dominated by three regime-switching models, namely, the threshold ECM developed by Balke and Fomby (1997), the Markov-switching ECM of Psaradakis et al. (2004), and the smooth transition regression ECM of Kapetanios et al. (2006). Moreover, The expansion of this literature reflects the idea that the information disclosed by linear models may be inadequately rich to allow strong conclusion or to result trustworthy predictions. Overall, it recommends a general concern that the assumption of linear adjustment may be extremely limiting in a wide range of efficiently interesting situations, especially where policy interventions are noticed in-sample and transaction costs are non-negligible. However, the majority of these studies sustain the assumption that the long-run relationship may be represented as a symmetric linear combination of nonstationary stochastic regressors. With the noteworthy exceptions of Saikkonen and Choi (2004), Escribano et al. (2006) and Bae and De Jong (2007), little research attempt has been dedicated to the analysis of nonlinear cointegration. Granger and Yoon (2002) further develop the idea that the cointegrating relationship may be defined between the positive and negative components of the underlying variables. In fact, they call that effect "hidden cointegration".

The increasing recognition of nonlinear modeling in the context of cointegrating long run relationships has caused to the rise of regime-switching models. Among existing studies, nonlinearity is generally restricted to the error correction mechanism and estimation results on the basis of either the threshold ECM related with Balke and Fomby (1997), the Markov-Switching ECM of Psaradakis et al. (2004) or the smooth transition regression ECM of Kapetanios et al. (2006). However, the common assumption that the underlying cointegrating relationship may be represented as a linear combination of the underlying nonstationary variables may be extremely limited. Typically, the long-run (cointegrating) relationship may also be conditioned to asymmetry or nonlinearity. We contribute to this literature by employing a nonlinear modeling framework based on the ARDL approach which provides a simple and flexible vehicle for the analysis of joint short- and long -run asymmetries.

Previous studies have used different models to evaluate the nonlinear relationship between exchange rate and its fundamentals. These nonlinearities can be modeled using Box-Cox method introduced by Box and Cox (1964), other studies have applied Alternating Conditional Expectation (ACE) algorithm developed by Breiman and Friedman (1985), additivity and variance stabilization (AVAS) algorithm suggested by Tibshirani (1988), Markov-switching vector equilibrium correction model (MS-VECM) introduced by Hamilton (1989) to detect nonlinear relationship among the underlying variables, threshold error-correction model (TECM) introduced by Balke and Fomby (1997), the Multiple Regime Smooth Transition Autoregressive model (MR-STAR) presented by Dijk and Franses (1999), Rank sum linearity test developed by Breitung (2001), Rashid and Husain (2010) suggest steps defined by Lin and Granger (2004) to test non-linear cointegration, and asymmetric ARDL cointegration method developed by Shin et al. (2011) that takes in to account partial sum decompositions of positive and negative to find out asymmetric (nonlinear) impacts both in the long and short terms. Therefore, there is increasing evidence of nonlinear features between exchange rate and its fundamentals.

Like other developing countries, exchange rate policy has significant role and implication on macro economy of Pakistan, mostly the existing literature emphasizes on the linear relationship between exchange rate and macroeconomic variables which creates a complicated situation for policy makers. Indeed, most of the previous studies that have been conducted for Pakistan (Zakaria and Ahmad, 2009; Zakaria and Ghauri, 2011; Abbas et al., 2011) focus on the long run relationship between exchange rate and macroeconomic variables and their studies do not use any nonlinear cointegration model. Moreover, by reviewing the existing literature of relevant area, it has been observed that until now there is no prominent empirical study presented to investigate between real effective exchange rate and macroeconomic variables for Pakistan. Therefore, apart from linear analysis, this study also attempts to examine the nonlinear relationship between real effective exchange rate and macroeconomic variables of Pakistan economy against its top ten trading partners from 1960-2014. This study applies both linear and nonlinear models to address the problem. Linear ARDL model developed by Pesaran et al., 2001 is used to investigate the linear cointegration and nonlinear ARDL cointegration method recommended by Shin et al, 2011) is used to test the nonlinear cointegration among the variables. The macroeconomic variables selected include productivity differentials, terms of trade, net foreign assets, investment to GDP and private credit to GDP.

Our findings of linear cointegration show that only short run coefficient of private credit has a negative and significant impact on real effective exchange rate. As far as long run coefficients are concerned, terms of trade, net foreign assets and investment have significant and positive impact on real effective exchange rate, while private credit and productivity differentials have negative and significant effects on real effective exchange rate. Moving to the findings of nonlinear cointegration, it is concluded that the existence of asymmetric long run effects run from private credit, net foreign assets, investment and terms of trade towards real effective exchange rate. However, the response of real effective exchange rate to positive and negative changes in productivity differentials is insignificant. Regarding short run effects, we find asymmetric effects which are statistically significant running from productivity differentials, private credit and terms of trade towards real effective exchange rate. However, the response of real effective exchange rate to positive and negative changes in net foreign assets and investment is statistically insignificant. There exist essential differences in response of real effective exchange rate to positive or negative changes of independent variables.

1.2 Objectives of the study

This study aims to achieve the following objectives;

1. To investigate the impact of selected macroeconomic variables on real effective exchange rate.
2. To investigate nonlinear relationship between real effective exchange rate and macroeconomic variables.
3. To investigate that the response of real effective exchange rate to positive shocks in macroeconomic variables may be different from response to negative shocks in macroeconomic variables.

1.3 Research questions of the study

This study addresses the following research questions;

1. Do macroeconomic variables affect real effective exchange rate?
2. Does nonlinear relationship exist between real effective exchange rate and its macroeconomic variables?
3. Is the sensitivity of real effective exchange rate to positive change in macroeconomic variables different from negative change in macroeconomic variables?

1.4 Hypotheses of the study

To meet the objectives of the study, we test the following three hypotheses;

1. Macroeconomic variables affect real effective exchange rate.
2. There is a nonlinear relationship between real effective exchange rate and its macroeconomic variables.
3. The response of real effective exchange rate to positive shocks in macroeconomic variables is different from response to negative shocks in macroeconomic variables.

1.5 Significance of the study

Globalization plays a key role as far as whole economy and exchange rate are concerned. Indeed, Pakistan being a small open economy in Asia has experience of real devaluation of exchange rate. Moreover, poor macroeconomic performance and steadily decline in the value of rupee shows that the State bank of Pakistan failed in performance and execution of monetary and exchange rate policies. Pakistan being a semi-industrialized economy has a well-integrated and cooperative agriculture sector that contributes almost 25.3 percent to its total GDP. In addition, Pakistan places its position in 26^{th} in terms of Purchasing power and 45^{th} in terms of nominal GDP in the World. Pakistan's export is mostly dependent on agriculture sector. Thus, proper policy is required considering today's environment.

The role of exchange rate was minimum in the era of fixed exchange rate system; however, its role is enhanced during the periods of trade liberalization and financial integration while evaluating the performance of macroeconomic and monetary policies. Although, variation in exchange rate might be profitable for a developing country, however, its impact is uncertain for a country like Pakistan because its agriculture sector fulfills most of the needs of domestic and foreign sectors. Furthermore, exchange rate is one of the macroeconomic variables that links one country with the rest of the world both in goods and assets markets; however, misrepresenting of trade opportunities and misallocation of resources are due to poor exchange rate policies. Therefore, to maintain economic stability, it is important to identify characteristics of exchange rate. In conclusion, the distinctive feature of Pakistan economy becomes a tool of encouragement if comprehensive study is done on the relationship between real effective exchange rate and its macroeconomic variables, as well as providing acceptable policies to sustain stability of macroeconomic system.

1.6 Scheme of the study

The rest of the study is structured as follows; the second chapter presents historical background of exchange rate in Pakistan, the third chapter presents relevant literature, the fourth chapter expresses theoretical framework, the fifth chapter describes empirical specifications, data, variables construction and methodology, the sixth chapter presents empirical results. Finally, the last chapter consists of conclusion and policy recommendation.

Chapter 2

Historical Background of Exchange rate in Pakistan

Pakistan has controversial cases while adjusting exchange rate of Pak rupee since the day of independence. Policy makers are mostly big businessmen in Pakistan who adopt biasness while determining the policy and merely concentrate on their own profitability and productivity. Furthermore, Choosing appropriate exchange rate system is an important issue in international economics and finance. Traditionally, it appears that an economy depends upon exchange rate while reacting to foreign shocks which actually describes an economy.

The Bretton Woods system commonly refers to the regime of international monetary that started from the end of World War II (1944) till early 1970s. the a fore-named system was attended from 44 allied countries plus one neutral government (Argentina), with over 700 representatives gathered at the Mount Washington Hotel in Bretton Woods, New Hampshire, United States, for the United Nations Monetary and Financial Conference, also known as the Bretton Woods Conference. Moreover, the mentioned conference created the international Monetary Fund (IMF) and World Bank, whereby the former is related to the handling exchange rates and lending reserves currencies to countries with trade deficit and the latter was designed to provide required capital to less developed countries and role of each afore-named institution has varied by the passage of time, more specifically, The World Bank became an organization to help developing nations. Furthermore, the World Bank and the IMF were called the sister of Bretton Woods organizations. Similarly, another organization, namely, International Trade Organization was also intended, however, not established at that time. Indeed, the General Agreement on Tariffs and Trade (GATT) played the role of promoting free trade for four decades. GATT became institutionalized as World Trade Organization (WTO) in 1995. Thus, we now have three sisters. Moreover, each of the 44 countries contributed a membership fee to fund these institutions and the amount of contribution mainly formulated economic ability of a nation. The goal of the Bretton Woods conference was to supply greater worldwide financial stability and enable capital to move toward struggling economies.

Moving toward the Bretton Woods system design, two opponents, namely, Harry Dexter White of the U.S. Treasury and John Maynard Keynes of Britain dominated discussion of the conference. In addition, John Maynard Keynes headed the British delegation, while American side was represented by Harry D. White of the US Treasury Department. These two nations negotiated importantly the contents of the new system. Furthermore, the US as a dominant economic power and military took the leadership form Britian who was losing global influence and war torn. In fact, proposal of John Maynard Keynes was rejected whose proposal was to establish a strong union for all nations whereby each of nation was to have an official account in this mechanism and surpluses and deficits of all balance of payments (BOP) would be documented via these accounts which means that imbalance has to be corrected by both deficit and surplus nations. On the other hand, idea of US became the base of newly created International Monetary Fund (IMF), whereby a certain amount (quota) would be contributed by each nation to this fund and member countries with difficulties of BOP would purchase or borrow hard currencies from this fund which means that responsibility would be tolerated by only deficit nations to accurate the imbalance. Later on, macroeconomic policies were implemented by borrowing countries to reduce the deficit in 1950. In addition, the Bretton Woods exchange rate system had a fixed exchange rates system with currencies fixed to the dollar. The dollar was pigged to gold price ($35 per ounce). Similarly, other nations agreed either to buy or sell US. dollars in order to keep their currencies within 1% of the pigged rate and therefore golden era of US. dollar started. The nations could only revalue their currencies in case of disequilibrium of fundamental. In fact, the primary plan of the Bretton Woods system was to provide stable exchange rates in order to persuade economic growth and investment and avoid competitive devaluation where short term advantage could be gained by reducing currency value.

Main characteristics of the Bretton Woods system were as: First, it was based on US dollar system where US dollar was playing an important role. The US provided stability to domestic price, while other nations could import, but didn't engage itself in intervention of currency. Whereas, other nations had the obligation to intervene in currency market to pig their exchange rates against US dollar. Second, it was an adjustable fix system. Third, control of capital was tight. Fourth, performance of macroeconomic was good, whereby high growth and stability of price were attained simultaneously under expanding of trade liberalization and historically achievement of macroeconomic was extraordinary.

With such a brilliant record of macroeconomic, why did the Bretton Woods collapse finally? The collapse of the Bretton Woods system was because of internal irregularity. Nominal commentator for the Bretton Woods was played by the American monetary discipline, however, when the US economy started to raise, the international monetary system based on the US dollar started to collapse. Moreover, shortage of dollar occurred in 1950, whereby Japan and Europe wanted to import during the recovery process form war damage, however, the only acceptable and internationally money was US dollar and their ability to import was limited by the availability of US dollar as a foreign reserves, but there was oversupply of dollar in international economy in late 1960. This circle was due to US balance of payments deficit, which had caused via expansionary fiscal policy. Indeed, there were three main reasons that US government raised its spending, 1. welfare expenditure, 2. the war in Vietnam and 3. the space race with the Union of Soviet Socialist Republics (USSR), where humans were sent to the moon by the end of 1960s. Furthermore, the IMF thought the need to provide a fresh international currency in order to supplement the dollar, but its negotiation took a long time and the artificial currency which is known as the Special Drawing Rights (SDR) was formed in 1969. In fact, there was a dollar surplus at that time. Moreover, domestic inflation of US started to go faster which stressed the Bretton Woods system. While the price stability was being provided by the US, other nations were willing to abandon independence of monetary policy and fix their currencies to the dollar, hence, their levels of price were also adjusted. However, other nations slowly refused to import inflation when the US started to have it and dollar was under downward pressure. The pigged rate between gold and dollar was abandoned in 1968 and eventually the pigged connection between dollar and other currencies was abandoned in 1971. US President Richard Nixon showed on television (TV) on August 15, 1971 and announced that the US would not sell gold to foreign central banks against the dollar anymore. This finished the Bretton Woods system working and main currencies started to float. Simultaneously, US President Richard Nixon also imposed measures such as controls of temporary price and overcharges of rigid import to fight against inflation and recover the balance of payments crisis which was being faced by the US.

Moving towards historical exchange rate of Pakistan, Pakistan economy faced five different exchange rate regimes such as fixed exchange rate system, controlled floating rate system, multiple exchange rate scheme, unified exchange rate system on the basis of market and free floating exchange rate system.

Fixed exchange rate system started from 1947 to 7th January 1982. At the beginning, Pak rupee was associated with GBP (British Pound). Furthermore, Britain had supplied many equipments to other countries during Second World War, after the end of mentioned war, countries who had imported equipments from Britain, had to pay back their debts, hence, these debtor countries predicted that GBP would devaluate. Meanwhile, after the Second World War, Britain would not be able to export goods to its major trading partners. Thus, its partners started importing consumer goods from USA in order to fulfill their needs and eventually GBP lost its attention to be kept as a reserve by foreign governments. On the other hand, US Dollar became more popular because of its obvious economic development; hence, Pak rupee was pegged with US Dollar at level of $1 against RS.4.76 in 1971. Moreover, in 1972, $1 was equal to RS.11, while in 1973, $1 was equal to RS.9.9 during Zulfikar Ali Bhutto government. This exchange rate system continued till 1982 (Janjua, 2007).

Managed floating exchange rate regime started from 8th January 1982 to 21st July 1998. Pakistan used to export most of its product to East Pakistan (Bangladesh), however, after separation of East Pakistan due to war of Indo-Pak in 1971, major of the products that were used to be exported to Bangladesh had to be remained in Pakistan. Consequently, cotton was accumulated with a surplus in 1971-1972 and foreign exchange revenue of West Pakistan was increased. However, the crude oil price was increased by the OPEC, in order to pay import; higher price had to be paid by the Pakistan. Furthermore, recession also occurred in that era and demand for goods and services were reduced in all over the world. Thus, export of Pakistan was also declined. These all mentioned reasons declined the Pak rupee value. The exchange rate of rupee was kept fixed against US Dollar for approximately nine years (1973-1981). In addition, US dollar was appreciated at the starting of 1980s. Since rupee was associated with US Dollar and it was overestimated because of market pressure. Therefore, imports became cheaper and exports became expensive for Pakistan in International Market, consequently, trade balance was deteriorated. To improve trade balance and sustain competitiveness in the worldwide market, the SBP preferred and switched towards a managed floating system on January 7th 1982 during government of General Zia Ul Haq; nominal exchange rate increased from RS. 9.9 to RS. 12.84 due to such movement. In addition, inward remittances also improved the Rupee value in 1981-1982 that further appreciated the real exchange rate, amended the current account, but many industries that were established during Zia`s regime suffered from import cost due to rupee devaluation by 38.5% between 1982-

1983 and reached to RS. 18.6 against one US Dollar although there had been bulk amount of foreign aid during rule of Zulfikar Ali Bhutto. As a consequence, many industries were damaged due to credit risk along with increasing crude oil price and impact of inflation (Subroto, 1993).

Multiple exchange rate system started from 22nd July 1998 to 18th May 1999. Pakistan became the 7th nuclear power in the world after conducting successful nuclear experiments on May 28, 1998. These successful experiments casted a negative impact on the economy of the Pakistan because Pakistan suffered crisis mainly from its primary donor and had to lessen financial crisis (Janjua, 2007). To lessen the crisis, Pakistan introduced multiple exchange rate system in 1998. For instance, official rate (fixed to US Dollar) exercised by government, Floating Interbank Rate (FIBR) exercised by banking sectors and composite rate (combination of Fixed and FIBR rates) exercised by private sectors. Moreover, according to the article VIII of IMF, a member country is not permitted to adopt dual exchange rate regime, but with the permission of IMF, such system may be adopted temporarily. In fact, Pakistan has been one of the members of IMF and in order to follow rules and regulations of IMF. Hence, Pakistan moved toward unified exchange rate system (Rafiq, 1999).

Unified exchange rate system, on the basis of market, started from 19th May 1999 to 20th July 2000. The three exchange rates were united and pegged to US Dollar after redemption of financial crisis in 1999. A market based exchange rate system became effective in 1999 when Pak rupee was permitted to move within a small band (Zulfiqar and Adil, 2006). Moreover, demand and supply of Pak rupee Interbank market identify the value of Rupee under unified exchange rate system. Interbank market's authorized dealer was responsible for all dealings such as imports of products, loan repayment, etcetera that were permitted on the basis of law. Similarly, market based exchange rate system granted the authority to SBP either to buy or sell foreign exchange. Later on, interference of the State Bank of Pakistan increased and even the SBP had the authority either to buy or sell the foreign exchange from sources inhabited abroad. Pak rupee value remained between RS. 50.70 to RS.52.16 and RS. 52.40 to RS. 54.40 against one US Dollar (Rafiq, 1999).

Free floating exchange rate system started from 20th July 2000 to present. In 2000, the afore-named band was removed and adopted a free floating exchange rate system which is still being exercised in Pakistan. Banks state their rates on the basis of short and long term positions. The SBP is responsible for all foreign investment and all banks are working as per policy of SBP. Indeed, The SBP controls all functions of foreign companies. Moreover, under free floating system, the exchange rate is determined through interaction of demand and supply. Monetary policy has a key role for the stability of exchange rate. In fact, tools of monetary policy, for instance, open market operations are employed to control the variations of foreign exchange rate effectively (Janjua, 2007). The difference between free floating and managed exchange rate systems is that SBP does not interfere, but it interferes whenever it is needed to sustain stability in the foreign exchange market (Husain, 2005). Furthermore, foreign remittance unofficial channels were limited after September 11th, 2001. As a consequence, inward remittance was documented that further increased reserves of foreign exchange and finally Pak rupee was appreciated. SBP bought 8.2 bln.US Dollar from 2001-2004 to enhance export. In addition, demand of importers increased for foreign exchange in the Interbank market that provides a signal for SBP to reduce the purchases and sustainability of liquidity was necessary for the SBP in the interbank market to pay high oil price (Janjua, 2007).

The year 2008 has been recorded a misfortune year in the historical exchange rate of Pakistan because large amount of foreign reserves were lost. The exchange rate approached to RS. 86.7 per US Dollar. The main reasons were political instability, unsuitable law and order and rise in oil price. Later on, these reserves were improved and brought to satisfactory level. Our main target is to understand whether macroeconomic variables affect the exchange rate while taking in to consideration the past analyses as well as to understand why Pak rupee fluctuates more as compared to other foreign currencies. Pakistan has maximum reduction in rupee value which has great impact on its economy. Likewise, expanding of imports also caste a negative impact on the economy. Therefore, it is required for the government to adopt various paces to manage this impact. In addition, these various paces might be enhancing exporting industries, role of the SBP should be limited to stability of price and financial flows, availability of ample credit facilities for potential exports, incentives should be provided by government to sustain competitiveness, exports should be diversified, more specifically, exports should be concentrated in commodities such as leather products, sports good, surgical instruments, carpets, rice, textile, etcetera, similarly, concentration of exports in services is also needed such as machinery, information technology (IT), plants, cottage, jewelry, dairy products, industrial products, etcetera.

We conclude that it is important for the SBP to know reasons that fluctuate real exchange rate, as few fluctuations might require to be corrected immediately, while others might not. It is also important to understand that what sorts of amendments should be taken in to consideration that show signal (either win or loss) in the competitive economy of Pakistan externally, more specifically, if real exchange rate appreciates due to improvement in macroeconomic variable, for instance, if productivity grows faster in tradable goods than non-tradable ones, then it is not necessary for central bank to intervene. On the other hand, the central bank may intervene if real exchange rate deviates from its equilibrium point and ultimately Pak economy is stabilized.

Table 2.1: Exchange Rate Regime.

Date/Period	Exchange Rate Regime	(Pak Rupee per US Dollar)
Prior to August, 1955		3.31
8/1/1955	(1) Fixed Exchange Rate from	4.76
5/11/1972	14th Aug. 1947 to 7th Jan. 1982	11
13/02/1973		9.9
8/01/1982		10.1
1981-82		10.5535
1982-83		12.7063
1983-84		13.4838
1984-85		15.1668
1985-86		16.1391
1986-87		17.1795
1987-88		17.5994
1988-89		19.2154
1989-90	(2) Managed Float from	21.4453
1990-91	8th Jan. 1982 to 21st July 1998	22.4228
1991-92		24.8441
1992-93		25.9598
1993-94		30.1638
1994-95		30.8507
1995-96		33.5684
1996-97		38.9936
1997-98		43.1958
1998-99	(3) Multiple Exchange Rate from 22nd July 1998 to 18th May 1999	50.0546
1999-00	(4) Unified Exchange Rate: SBP defending The exchange rate within a narrow band From 19th May 1999 to 20th July 2000	51.7709
2000-01	(5) Free Floating Exchange Rate Regime Since 20th July, 2000	58.4378
2001-02		61.4258
2002-03		58.4995
2003-04		57.5745
2004-05		59.3576
2005-06		59.8566
:		:
:		:
2015-16		104.9

Chapter 3

Literature Review

The main objective of the literature is to review the contributions which have been done either in a specific topic or an area theoretically, empirically and methodologically. The existing literature review helps researchers while revealing the existing literature gaps and further filling up a number of avenues raised by research. Indeed, this chapter reviews three strands of literatures which links exchange rate to macroeconomic variables.

The first strand some of the important theories of exchange rate determination (Purchasing Power parity, interest rate parity models, the Mundell- Fleming model, etcetera).

The second strand explains absence of connection[1] (Krugman, 1988; Flood and Rose, 1995; Duarte and Stockman, 2002) and unstable[2] relationship (Meese and Rogoff, 1983a; Altavilla, 2008; Bacchetta and Van Wincoop, 2013) between exchange rate and macroeconomic variables.

The third strand interprets comparison between linear[3] and nonlinear[4] exchange rate models (Schinasi and Swamy, 1989; Sarantis, 1999; Sarno, 2003; Cushman, 2008; Zhao, 2010; Ahmad et al., 2013).

The fourth strand of literature explores the nonlinear relationship between exchange rate and macroeconomic variables (Meese and Rose, 1990, 1991; Taylor and Peel, 2000; Ma and Kanas, 2000; Akram, 2004; Frommel et al., 2005; Altavilla and De Grauwe, 2010; Su, 2012; Tang and Zhou, 2013; Dauvin, 2014). The literature is reviewed according to the afore-named strands, but our main emphasis is on the third strand because it is more relevant to our study and is one of the main objectives of present study which investigates nonlinear relationship between real exchange rate and macroeconomic variables.

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[1] Macroeconomic variables are unable to estimate more than a minor portion of change in exchange rate.

[2] Expectations can change overtime which yield unstable relationship.

[3] The elasticity of exchange rate with respect to independent variables is constant and the functional form is known (Tang and Zhou 2013).

[4] The elasticity of exchange rate with respect to independent variables is inconstant and the functional form is unknown (Tang and Zhou 2013).

3.1 Theories of Exchange Rate Determination

This section outlines some of the well-known theories of exchange rate determination.

3.1.1 Purchasing power parity

Purchasing power parity (PPP) is possibly one of the most distinguished textbook theories of exchange rate determination. This theory provides that the price of a commodity expressed in a common currency should be the same in every country in the absence of tariffs and shipping costs. Moreover, PPP relies on the concept of commodity arbitrage and the law of one price; if the price of a given commodity is priced differently in different countries, then, arbitragers would purchase the commodity in the market where it is cheap and sell it in the market where it is more expensive. For example, if US goods are more expensive than those in the UK, consumers in both countries will tend to buy UK goods. The increased demand for UK goods will drive the £UK higher with respect to the $US until the prices are equalized.

In conclusion, the theory of PPP rests on a number of important assumptions. First, there are no restrictions on the movement of commodities, since any restriction will be difficult for smooth operation of commodity arbitrage. Second, there are no transportation costs. Third, there are no tariffs, because tariffs have the same effect on the relationship as transportation costs. Finally, it is assumed that agents are risk neutral as they do not require a risk premium to operate in foreign commodity markets. The main problem with the Purchasing Parity Approach in the determination of Exchange rates is that it does not hold true in the short or the medium term, but this is very much applicable in the long run.

3.1.2 Interest rate parity models

Like PPP, interest rate parity models of exchange rate determination rest on the concepts of arbitrage and market efficiency. By the time of the gold standard, monetary policymakers have concluded that changes in exchange rates are influenced by monetary policy. The rise in domestic interest rates are usually followed by the appreciation of domestic currency, and a reduction in domestic interest rates follow the devaluation of national currency. Furthermore, the theory has two forms, namely, the covered interest rate parity (CIRP) and uncovered parity rate of interest (UCIRP). In addition, CIRP refers to a condition where the relationship between interest rates and the forward and spot currency values of two countries are in equilibrium. As a result, there are no interest rate arbitrage opportunities between those two economies or currencies. The UCIRP is a parity condition stating that the difference in interest rates between two countries is equal to the expected change in exchange rates between the countries' currencies. If this parity does not exist, there is an opportunity to make a profit.

3.1.3 Sticky price monetary model

Dornbusch (1976) developed a competing model of the monetary approach to exchange rates. Similar to Keynes, he proposed that prices are rigid and would only adjust gradually. He indicated that as domestic money supply decreases relative to domestic money demand, there would not be a matching drop in prices. The domestic interest rate would rise with regard to foreign interest rates creating an inflow of foreign capital. Domestic currency would appreciate immediately. The result would be a negative relationship between the exchange rate and nominal interest rate. Dornbusch stated that a sticky price model would mean that PPP would only hold true in the long run. The result of this restatement of the monetary model suggests that there will be a short-run "overshooting" of the nominal exchange rate. However, in the long run, one would expect prices to adjust as well as output in response to an increase in aggregate demand. Exchange rates would be affected accordingly.

3.1.4 The Mundell-Fleming model

Money is important because it serves as a medium of exchange, the dominant value, and storage devices. The Mundell-Fleming model developed by the extension of the investment/saving and liquidity preference/money (IS-LM) for an open economy and thus to ensure an understanding of how the exchange rate is determined.

The Mundell–Fleming model represents the short-run relationship between an economy's nominal exchange rate, interest rate, and output (in contrast to the closed-economy IS-LM model, which focuses only on the relationship between the interest rate and output).

One of the most important issues in the model, the so-called trilemma, which states that a perfect capital mobility, independence of monetary policy and a fixed exchange rate regime can not be achieved simultaneously. Specifically, it is argued that the country's independence, monetary policy can not be tied to the perfect capital mobility. This argument, however, occurs in an environment small country, and is not necessarily true for the largest economy, for example, China. What we saw in China, is not so small, and maintain certain capital and control of monetary policy appeared to be independent so far. The model also predicts that the level of the exchange rate is perfectly correlated with the level of money supply in the long term and so monetary policy can only play a minor role. Another important implication is that price/earnings to growth ratio (PEG) may lead to further devaluation if fiscal discipline, inflation and balance of payments are not managed well. Finally, the effect of devaluation on improving the current account balance can also be weakened if an economy is highly dependent on the re-manufacturing.

3.1.5 Exchange rate and productivity: the Balassa-Samuelson model (1964)

Supply and demand for the products are associated with the producer and consumer behavior as a starting point for determining the real exchange rate which is associated with the micro- foundations of the theory of exchange rate. Balassa-Samuelson model (1964) assumes that the law applies to a price of tradable goods and world prices of tradable goods equal to one without loss generally. Moreover, it assumes perfect mobility between sectors within each industry, but labor mobility is considered equal to zero between farms. Given the level of productivity at home and abroad, the highest nominal GDP growth at home than abroad leads to knowledge of the real exchange rate. Moreover, since the rate of economic growth, higher productivity in the non-tradable in the country of origin and in the foreign country will lead to devaluation of the real exchange rate.

The model forecasts that the national economy is experiencing a real evaluation of the benefits of productivity growth in tradable exceeds the benefits of productivity growth in non-tradable. Indeed, The Balassa-Samuelson model is a pillar of traditional theory of the real exchange rate equilibrium. Assumption of Balassa-Samuelson model is that productivity growth in the tradable sector will enable the growth of real wages and proportional, believing that the link is assigned to the non-tradable sector, the wage and price increases in non-tradable sector. This leads to an increase in the general price level in the economy, leading to knowledge of the real exchange rate. However, the short coming of this model is clear. First, it assumes that the selling price is the same at home and abroad. This is obviously an unrealistic special form of PPP, but only in tradable goods. Second, regardless of consumer behavior and demand, it is difficult to interpret the fact that market prices develop gradually. Last and most importantly, this model does not address the role of money, this may be the best explanation is that, in part, the real exchange rate is determined.

3.2 Studies on the Absence of Connection and Unstable Relationship between Exchange rate and Macroeconomic Variables

There is a lot of literature that examines the relationship between exchange rate and macroeconomic variables which is proposed by conventional theories that determine floating exchange rates' modern era (1973-onwards), however, little support is found by these studies for the mentioned relationship. Precisely, on one hand, exploring proof of cointergration between exchange rate and macroeconomic variables such as income differentials and money differentials has sometimes failed. One of the relevenat stuides is conducted by Baillie and Selover (1987) who use sample of 5 countries[5] and find no coingration between exchange rate and macroeconomic variables. The findings of this study is consistent with the findings of Meese (1986), McNown and Wallace (1989), Baillie and Pecchenino (1991) and Neely and Sarno (2002). On the other hand, even though few studies find cointegration between exchange rate and macroeconomic variables, such proof is a minor support for the relationship of exchange rate and macroeconomic variables (Cushman, 2000). Similarly, Mark (1995) recommends that more than a minor change of variation in exchange rate can not be estimated by fundamentals due to smaller capability of conventional statistical tests that are unable to reject the null hypothesis of no cointegration, which is false. His finding is similar to the findings of Mark and Sul (2001) who uses panel of 19 countries[6] and quarterly data from 1973Q1- 1997Q1. They additionally state that macroeconomic variables have ability to forecast exchange rate. In addition, Flood and Rose (1995) explore that there is no clear cut connection between exchange rate and macroeconomic variables, namely, output and money. The study uses data of both floating and fixed exchange rates from 1960- 1991 for 8 industrialized countries[7]. There are few other studies who find the same results as Flood and Rose (1995) do such as Baxter and Stockman (1988), Krugman (1988), Rogoff and Feldstein (1999), Obstfeld and Rogoff (2001) and Duarte and Stockman (2002). Whereas, Barone-Adesi and Yeung (1990) express the opposite statement. The study uses descriptive statistics and regression analysis for sample of developed countries and further state there is negative correlation between volatility of output growth and volatility of exchange rate. Likewise, some other studies, for instance, Wei and Parsley (1995), Bleaney (1996),

[5] Japan, the United Kingdom, Canada, France and West Germany

[6] Austria, Australia, Belgium, Canada, Denmark, Finland, France, Germany, the United Kingdom, Greece, Italy, Japan, Korea, the Netherlands, Norway, Spain, Sweden, Switzerland and the United States.

[7] Canada, France, Germany, Holland, Italy, Japan, Sweden and the United Kingdom.

Andersen (1997), Smith (1999), Calvo and Reinhart (2000a, 2000b), Engel and Rogers (2001), Baum et al. (2001), Bleaney and Fielding (2002), Devereux and Engel (2003) and Chen (2004) express the same statements like Barone-Adesi and Yeung (1990) do. Moreover, many of the previous studies are unable to analyze a clear connection between exchange rate and macroeconomic variables empirically even in the short run. but a few latest studies using new structural models and powerful tests yield positive forecasting as far as short run is concerned (Gourinchas and Rey, 2007; Engel et al., 2007; Molodtsova and Papell, 2009), but Rogoff and Stavrakeva (2008) explore just a little amendment in comparisons of out-of-sample. They state that although structural models function effectively in recent time periods, however, it is not necessary that the forecasting performance plays well in other time periods. The study uses sample of 11 countries and additionally recommend that the main problem faced during forecasting of exchange rate is lack of robustness on different periods of time. Lack of robustness might be because of structural breaks or nonlinear functional forms.

One of the earliest studies by Meese and Rogoff (1983a) analyze the connection between exchange rate and macroeconomic variables. Their study concludes that the relationship between afore-named variables is structurally unstable and unstable evidence is continuously accumulated in linear econometric exchange rate models (Cheung et al., 2005). Similarly, De Grauwe and Vansteenkiste (2007) develop a nonlinear model based on the existence of transaction costs in goods market that are linked to exchange rate regime. The main message of the analysis is that the relationship between changes in nominal exchange rate and news in its basic macroeconomic variable is stable and significant for high –inflation countries. Whereas, due to persistent regime-switches such relationship is unstable for low-inflation countries. Likewise, Altavilla (2008) discusses that the relationship between the euro-dollar and its primary fundamentals is occasionally unstable. The study employs Markov-switching vector error correction (MS-VECM) model to check the nonlinearity of the residual by using sample period from 1979M1- 2004M4. The study concludes that when exchange rate is far away from equilibrium level, it is likely to be much sensitive to any distorting shocks in the fundamentals and vice versa. It is also detected that exchange rate can be a nonlinear model when deviations revert back to their mean in the long run; however, these deviations often follow a nonstationary process. Moving to other relevant study, Bacchetta and Van Wincoop (2013) in their survey evidence suggest the unstable relationship between exchange rate and macroeconomic variables due to expectation of structural parameters. Monthly data is calibrated from 1975M9- 2008M9 for five industrialized countries. The result of the study shows that expectation leads to unstable relationship because of scapegoat effect[8]that can vary overtime.

The performance of exchange rate models is empirically poor. Thus, it provides meaningful paths to explore a clear connection between exchange rate and macroeconomic variables.

3.3 Studies on the Comparison between Linear and Nonlinear Exchange rate Models

Generally most of the previous studies have explored exchange rate models in a linear way that indicates that there is a constant relationship between exchange rate and macroeconomic variables. Exchange rate models have been commonly analyzed either in linear or nonlinear models, but most of the economic procedures are nonlinear and linear shall lead us to severe misspecification. Furthermore, nonlinear models are able to state important characteristics which can not be explained by linear models. For example, leverage effects, leptokurtosis and volatility clustering (Brooks. 2014). Nonlinear models are represented when the theory suggests that the relationship between dependent and independent variables can not be a linear model, however. the underlying theory can not explain much whether the relationship between dependent and explanatory variable is linear or nonlinear. Thus, empirical issue is involved while making selection between linear and nonlinear models. Linear exchange rates can not reject the nonstability easily due to weak power of traditional linear unit root tests. Moreover, nonstationarity tests of linear exchange rate models might not be able to find out mean reversion of exchange rate if the actual series of exchange rate is a stationary nonlinear procedure. Besides. approaches of nonlinear coefficients usually improve the forecasting power of exchange rate models (Schinasi and Swamy, 1989; Diebold and Nason, 1990). Hence, explosion of interest have been witnessed among econometricians about nonlinear models for the last few years (Potter, 1999). Basically explanations of deviations of exchange rate from purchasing power parity have made an interest to nonlinear exchange rate models. For instance, Narayan and Narayan (2007) examine stationarity and linearity of real exchange rate for Italy with its six major trading partners. The study employs threshold autoregressive model (TAR) by using monthly data over the period 1973M1-

[8] Perfectly rational effect

2002M12. The estimation result of the study shows that there is a nonlinear process in Italy's real exchange rate which is basically not identified by a unit root process for its five trading partner countries that presents a strong evidence for purchasing power parity. In addition to, Leon and Najarian (2005) use monthly data and take the sample of 26 countries[9] including 13 industrial countries by employing various nonlinear model such as TAR, STAR and MS-VECM models. The study dedicates the adjustment of nonlinear exchange rate towards equilibrium to transaction costs. They further recommend other reasons[10] for nonlinearity, such as price of local currency and involving diversity in expectations of market participants. This finding is almost similar to the findings of Dixit (1989), Sercu et al. (1995), Obstfeld and Taylor (1997) and Taylor et al. (2001)[11]. Similarly, Sekioua (2003) models deviation of exchange rate from equilibrium level in the existence of transaction costs. The study employs nonlinear TAR unit root tests for three major currencies in relation to US dollar. The study concludes that the deviation series revert back toward its mean nonlinearly which is able to reject nonstationarity and linearity null hypothesis. This finding is almost similar to the finding of Hong and Oh (2009), who examine purchasing power parity hypothesis in won/dollar and won/yen real exchange rate using monthly data from 1980M1- 2007M12 and their findings confirm the effectiveness of nonlinear exponential smooth transition autoregressive (ESTAR) framework compared to other TAR models. Furthermore, the importance of nonlinearity is emphasized in the presence of transaction costs, that such costs explain puzzle in international macroeconomics (Dumas, 1992; Uppal et al., 1995; De Grauwe and Grimaldi, 2005). Moving to other relevant study, Sarantis (1999) takes the sample of 10 major industrial countries to model and test nonlinearities. The study finds that during 1980s and 1990s the linear real effective exchange rate hypothesis is rejected in 8 industrial countries. In addition, Bec et al. (2006) compare linear exchange rate model with nonlinear one. Indeed, they reexamine the properties of nonlinear real exchange rate in a band threshold autoregressive (B-TAR) model using monthly data from 1980M1- 1997M12 for the

[9] All G-7 countries, few advanced countries (Australia, Belgium, Israel, Korea, New Zealand and Spain), few developing countries from Asia (India, Indonesia, Malaysia, Philippines and Thailand) and Latin America (Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico, Paraguay and Uruguay).

[10] Most of the research has emphasized that nonlinear dynamics emerge from policy regime nature (Flood and Garber, 1983; Froot and Obstfeld, 1991; Kaminsky, 1993). Either to revaluate or devaluate the domestic currency under a fixed exchange rate system might cause nonlinearities (Flood and Marion, 1999). Sarantis (1999) states that diversity of participant is one of the main sources of nonlinearities in foreign exchange market.

[11] They recommend that ESTAR models are more appropriate in the literature of exchange rate for two reasons: first, because of interesting property; second, they are simple comparatively.

group of seven (the G-7) countries. The result of this study reveals that real exchange rate has an obvious nonlinear dynamics which definitely rejects the random walk-hypothesis.

Linear estimation method has been one of the most distinctive method which analyzes monetary models empirically (MacDonald and Taylor, 1994). Contrarily, results obtained by this study have been unable to provide a clear link between exchange rate and monetary fundamentals empirically even in the short run. Turning to other relevant studies, Meese and Rogoff (1983a, 1983b) propose that conventional monetary models are not able to perform well in aspect of random walk hypothesis while explaining nominal exchange rates behavior. This proposition appeared valid until 1990s. In contrast, some other studies show that deviations from a limited group of fundamentals are able to forecast US dollar exchange rates either in the long or medium run. Still, the relationship between exchange rates and monetary fundamentals is weak in the short horizon (Cheung et al., 2000; MacDonald, 1999; Neely and Sarno, 2002; Alquist and Chinn, 2008). The findings are consistent with the results obtained by Groen (2000). The study employs method of panel regression and finds out that monetary fundamentals are significantly important while predicting future exchange rates, however, still random walk hypothesis can not forecast much better. On the contrary, the afore-named studies are criticized by Berben and Dijk (1998), Kilian (1999) and Berkowitz and Giorgianni (2001) on the basis of stable cointegration assumption that does not enhance the ability of monetary fundamentals to forecast while using a linear data, hence, they recommend a nonlinear data.

A clear link is provided due to weak empirical performance[12] of exchange rate models. Indeed, the main weakness in most previous studies probably is that they have indirectly and linearly assumed adjustment of exchange rate towards its sets of monetary fundamentals. In this context, one of the earliest studies is by Sarno (2003) who reviews a number of papers that address nonlinear exchange rate models and these studies provide empirical support for the real exchange rates nonlinear mean reversion behavior since 1973.The study explores that previous literature presents the existence of nonlinearities by using Markov-switching model. The finding is consistent with the results obtained by Balke and Fomby (1997) and Taylor et al. (2001). These studies further express and claim that there are possibilities of smooth essential adjustment nonlinearities between exchange rate and monetary fundamentals to

[12]Linearity in real exchange rate models has been failed empirically by most of the studies (Michael et al., 1997a; Sarantis, 1999; Sarno, 2000; Taylor and Peel, 2000; Baum et al., 2001)

forecast exchange rate in the long run, but linear estimation method fails. The mentioned studied are supported by Aksoy and Akdogan (2005) who explore the predicting ability of linear models in the perspective of nonlinear adjustment while predicting errors for Sterling pound with respect to Dollar. Indeed, they expand the study of Kilian and Taylor (2003) in aspect of computing for reverting in real time datasets in macroeconomic variables and also do expand the study of Faust et al. (2003) in aspect of nonlinearity of mean-reverting. Aksoy and Akdogan (2005) further state that linear model determines real time exchange rate values towards its fundamentals, but adjustment of exchange rate towards macroeconomic variables might be nonlinear either in the form of smooth or discrete. The study concludes that in real time dataset nonlinear model can adjust exchange rate towards macroeconomic variables in a discrete style while forecasting in the short run. On contrary, prediction in the long run may be disclosed in a smooth pattern. In like manner, a number of other studies, especially Engel and Hamilton (1990) and Engel (1994) extend the nonlinearity, but with a little bit success and their forecasts are not superior to the hypothesis of random walk. The studies employ Markov-switching regression models and conclude that theoretically models are appropriate; however, their empirical analysis is insufficient during floating exchange rate mechanism. The main argument might have been the nonlinearity of exchange rate data series which can not be identified merely by methods of linear estimation. On the other hand, Pippenger and Goering (1993) provide a brief review of effectiveness of unit root tests and linear estimation methods that estimate the nonlinearities in real exchange rate. The study suggests that the cointegration and conventional unit root tests are able to find out the long term relationships in the presence of transactions costs.

Al-Abri and Goodwin (2009) use quarterly data from 1975Q1- 2002Q2 of five industries for 16 Organization for Economic Cooperation and Development (OECD) countries to examine "whether import prices respond quickly to any shock in nominal exchange rate with threshold vector error correction (TVEC) model or with standard vector error correction (VEC) model". The study finds that import prices react quicker to any shock in nominal exchange rate with TVEC model than VEC model. This study also supports empirically the existence of pass-through equilibrium rate hypothesis. Besides; methods of conventional cointegration mostly suppose linearity of variables. Thus, they are being pointed out improper (Juvenal and Taylor, 2008). Similarly, Dufrénot et al. (2008) analyze an empirical model to investigate whether the misalignments of real exchange rate are associated with persistent dynamics[13] or with temporary deviations[14] hypothesis from macroeconomic variables. The econometric models have been designed by using panel data of five European countries namely, The Netherlands, France, The UK, Portugal and Germany for the period from 1979-1999. The study uses linear, fractional and nonlinear cointegration estimation methods. Even though linear framework is able to capture the deviations, however, it does not represent properly adjustment procedure towards equilibrium level because it assumes a constant rate. Whereas, adjustment process probably does not have a constant value. The result of the study shows that all three mentioned tests yield same result for Portugal unlike for others .On the other hand, long memory model can represent perfectly adjustment dynamics for France real exchange rate as well as long memory model is better than nonlinear one for forecasting correctness in case of Germany, however, there is no any major difference between the fractional and nonlinear tests' results for the Netherlands and the United Kingdom real exchange rates while forecasting accurately.

One of the important studies by Cushman (2008) tests direction of linear stationarity against nonlinear one for the sample of 13 bilateral real exchange rates of US and German and with six OECD countries[15] by using quarterly data over the period of 1974-1998. The study finds that applications of nonlinear trends specify eight tests; however, linear refused. Thus, it has been supported statistically that nonlinear-direction stationarity is more likely than linear one to be used as an alternative. Moreover, Chen and Chen (2012) use monthly data for real exchange rate observations and prices of real stocks to test the two hypotheses. The first one is "the stock price-affected hypothesis of exchange rate", and second is "exchange rate affected hypothesis of the stock price". The study takes the sample of 12 OECD countries. consisting of developed countries, the G-7 countries and a number of emerging economies such as South Korea, Hungry, Poland, Czech Republic, Turkey and takes different sample period for different countries according to data availability. The finding of this study shows that there is not only linear, but also nonlinear causal relationship between exchange rates and stock prices. In the same way Zhao (2010) analyzes the relationship between stock price and real effective exchange rate for China with both vector autoregression and multivariate generalized autoregressive conditional heteroskedasticity (VAR and GARCH) models. The

[13] long memory(fractional) cointegration method

[14] Nonlinear cointegration method

[15] Germany-Canada, Germany-France. Germany-Italy, Germany-Japan. Germany-the Netherlands. Germany-UK, US-Canada, US-France , US-Italy, US-Japan, US-the Netherland and US/UK.

study uses monthly data from 1991-2009. The study concludes that there is both linear and nonlinear relationship between stock prices and exchange rate. The variation between studies is that Chen and Chen (2012) present result from nonlinear Granger causality while Zhao (2010) presents result from VAR and GARCH models. The estimation result of a long run equilibrium relationship between exchange rates and stock prices is consistent with Chen and Chen (2012). However, it is inconsistent with Zhao (2010).

One of the recent studies by Ahmad et al. (2013) evaluate the power of dynamic stochastic general equilibrium (DSGE)[16] models that can lead to the nonlinear dynamics of real exchange rate. The study estimates smooth transition autoregressive (STAR) approach by using quarterly data from 1970Q1- 2009Q4 for the sample of different G7 countries. The findings of the study recommend few important points; first, if a group of linear equations specify the true picture of linear models, then linear real exchange rate models that employ autoregressive (AR) models have nonlinear behavior when the relevant variables are not included. The nonlinear behavior reduces when the relevant explanatory variables[17] are included in the linear models and studies which are not successful to handle this problem may come across with incorrect nonlinearities; second, there are still nonlinearities even after incooperating the relevant variables to linear tests. These mentioned findings show that empirical dynamics of real exchange rate must be built on the basis of its fundamental theoretical model.

3.4 Studies on the Nonlinear Relationship between Exchange rate and Macroeconomic Variables

A huge literature can be found that studies the relationship between exchange rate and macroeconomic variables. Indeed, much research has been done and is being done on nonlinear cointegration empirically since the failure of Meese and Rogoff (1983a). They were the pioneers who analyzed the relationship of dollar/mark, dollar/yen and dollar/pound rates with their monetary variables. Basically they compare the correctness forecasting of out-of-sample of different structural exchange rate models[18]. The study employs ordinary least squares, instrumental variable techniques and generalized least squares by using monthly

[16] It is comprised of four extensions, incomplete markets, pricing of local currency, non tradable goods and consumption home bias that presents better dynamics of real effective exchange rate than random walk forecast. It is a well known tool among researchers and policy makers.

[17] Lagged output, inflation and capital stock.

[18] Sticky price, flexible price and sticky price incorporating the current account.

forecasting[19] period data for each model from 1973M3- 1981M6. Their study concludes that although exchange rate structural models are forecasted on the basis of their realized explanatory variables' values, they fail to improve the prediction of random walk hypothesis due to some reasons namely, omitted variables, sampling errors. biasness of simultaneous equations, unstable structure[20] and lack of attempt to check the nonlinearity. The finding of this study has confused most of the international economists as well as policy makers and convinced them to start researching on this issue.

Chinn (1991) transforms both dependent and explanatory variables through Alternating Conditional Expectation (ACE) algorithm. The study estimates Nearest Neighbor (NN) type procedure to linearize the relationship of transformed variables by using quarterly data over the period 1974Q1- 1988Q4 on exchange rates of $/mark and $/yen. The study finds that nonlinear predictions are superior in-sample and out-of sample and perform better than random walk hypothesis. Similarly, Tang and Zhou (2013) employ ACE algorithm by using quarterly data from 1980Q1- 2009Q4 to investigate the nonlinear relationship between real exchange rates of two currencies namely, Chinese Yuan and South Korean Won with respect to US dollar and macroeconomic variables. Their study finds that nonlinearity exists between real exchange rate and macroeconomic variables. This finding is almost similar to the finding of Ma and Kanas (2000) in case of Netherlands-Germany but inconsistent in case of France-Germany. The study uses monthly data from 1980M1- 1996M10. However, Meese and Rose (1990, 1991) use nonparametric techniques and fail to detect nonlinearities during the Bretton Woods fixed exchange rate regime as well as for European Exchange rate Mechanism (ERM); similarly, Flood et al. (1991) test target zone exchange rate model to detect nonlinearities in three ways, namely, parametric testing, studying graphically and forecasting analysis of out-of sample. The study employs daily data for the Exchange rate Mechanism (ERM) countries. The finding of their study shows that overall the three tests yield little support empirically for the presence of target zone exchange rate model. The finding is consistent with the result obtained by Lindberg and Soderlind (1994a) who use Swedish daily data from 1st Jan 1980- 15th Nov 1990 and employ different econometric tests. Later on, another study by the same authors (Lindberg and Soderlind, 1994b) for the same region consider the role of Swedish center bank intervention policy by using daily Swedish

[19] Forecasts are at horizons of 1, 3, 6 and 12 months.
[20] Change of government policy at macro level and shocks of oil price.

intervention data. The study finds that intervention by the central bank in the foreign exchange market is the main reason that indicates why researches find less evidence of nonlinear relationship between exchange rate and fundamentals.

Turning to other relevant studies, Jamal (2005) develops a model to represent the United States exchange rate with its major trading partners namely, the United Kingdom and Japan. The result of the study shows that there is a nonlinear relationship between exchange rates and independent variables and further states that economic activity is the key factor that affects the exchange rate among the United States and its mentioned trading partners. Similarly, Junttila and Korhonen (2011) explore the presence of nonlinearity between exchange rate and macroeconomic variables in five industrialized countries namely, the United Kingdom, Canada, Italy, France and Germany with reference to the United States over the quarterly period 1974Q1- 2001Q3. The study employs error correction estimation model. The result of the study shows that inflation differentials with regard to the rate of US inflation are the main sources that develop nonlinearity in exchange rate monetary models. Likewise, nonlinearity may be raised by the effective monetary policy behavior investigated by Kempa and Riedel (2013) for Canada. The study applies Markov-switching model for monthly observations from 1991M2- 2008M12. Following Taylor (2004, 2005), Menkhoff and Taylor (2007), Reitz and Taylor (2008) examine the benefit of monetary authorities interventions in foreign exchange market by using daily intervention data only on US dollar against mark for the period 2nd Jan 1980- 31st Dec 1992. The variation between three studies is that Taylor (2004, 2005) mentions the causation of nonlinearity by applying Markov regime-switching model and using intervention data in 1980s for the dollar/yen and dollar/mark from the Bank of Japan, the Federal Reserve and the Bundesbank. Secondly, the intervention policy in terms of purchasing power parity seems to be less efficient. In contrast, Reitz and Taylor (2008) present result by modeling and estimating a microstructure exchange rate model and secondly, monetary authority's intervention policy is effective that bring exchange rate back to its equilibrium level through coordination and Menkhoff and Taylor (2007) express that usage of technical analysis by the monetary authority in the foreign exchange intervention cause nonlinearity.

Su (2012) uses quarterly data over the period 1994Q1- 2010Q4 for China. The study employs Threshold error correction model (TECM) to detect the casual nonlinearity and Rank sum linearity test to find out the nonlinear relationship between exchange rate and macroeconomic variables[21]. The finding of the study suggests that there is a nonlinear relationship between exchange rate and macroeconomic variables which supports the asymmetrical error-correction process hypothesis in the long run in China. Furthermore, Camarero and Ordonez (2012) use ESTAR model over the period 1970Q1-2009Q2 to explore the nonlinear mean-reverting of dollar-euro exchange rate towards the macroeconomic variable proxied by productivity differential. The study finds nonlinearities and these nonlinearities are persistent with the adjustment of real euro-dollar exchange rate toward the productivity variable in the long run. In addition, a lot of literature relating to the connection between real exchange rates and purchasing power parity is reviewed by Sarno and Taylor (2002) and come to the conclusions that relationship between exchange rate and purchasing power parity holds among large industrialized countries in the long term and nonlinear mean reversion behavior in real exchange rate is shown significantly. Following Juvenal and Taylor (2008), Yoon (2010) examines nonlinearity between disaggregated real exchange rates and their explanatory variables. The study uses the same sample and framework as used by Juvenal and Taylor (2008). The variation between both studies is that Juvenal and Taylor (2008) find sufficient empirical nonlinearity evidence. Whereas, Yoon (2010) detects no nonlinearity evidence. Additionally, Zhang (2014) uses monthly data set according to the data availability of Japanese yen and Euro against US dollar to explore the nonlinear relationship between exchange rates and monetary variables. This study uses Johansen cointegration estimation method and find out the long run relationship between mentioned variables. Indeed, this study is different from other studies due to applying different nonlinear techniques between exchange rates and monetary variables, namely, error correction estimation methods, threshold estimation techniques and nonparametric estimation methods without any restriction. All the mentioned methods except threshold find nonlinearities due to either threshold variable selection or threshold method selection.

One of the important studies by Taylor and Peel (2000) examine the nonlinear relationship between the nominal exchange rates and monetary fundamentals in Germany, the United States and United Kingdom. The study employs ESTAR model by using quarterly data from the period 1973Q1-1996Q4 and nominal exchange rates are formed on the basis of CPI indices. Augmented Dickey-Fuller (ADF) unit root test is used to check the unit root behavior

[21] Ratio of government expenditure to real GDP, M2, openness of economy and relative productivity activity differential.

of each nominal exchange rate series and they are able to reject the null hypothesis of unit root in each case at 5% significance levels for both dollar/sterling and dollar/mark. Therefore, testing procedure is complicated by the presence of a unit root under the null hypothesis. Hence, Monte Carlo method is used to estimate the significance level of this test empirically. The result of the study shows that nominal exchange rate shows a unit root behavior during small deviations period from monetary fundamentals. Whereas, they find out fast adjustment of nominal exchange rate towards equilibrium level during large deviations. Their findings are consistent with the findings of Taylor et al. (2001) who use the same method and find out strong evidence for nonlinearity of exchange rate and purchasing power parity, however, variation between both studies is that Taylor et al. (2001) use real exchange rates for Japanese yen and French franc including UK sterling and German mark with respect to US dollar by using monthly data for the same period as is used by Taylor and Peel (2000). A number of other studies use Markov-switching models to detect the nonlinear relationship between exchange rate and its fundamentals (De Grauwe and Vansteenkiste, 2001; Frommel et al., 2005). Furthermore, Kilian and Taylor (2003) see the role of ESTAR model by using quarterly data from 1973Q1-1998Q4 on real exchange rates for Switzerland, Germany, UK, France, Italy, Canada and Japan against US dollar. The finding of the study indicates that ESTAR model provides significant results. Thus, they fit ESTAR model for the mentioned real exchange rates. Similarly, Hasan (2006) uses the same model (ESTAR) by using annual data over period of one century on Australia and Canada against UK to examine empirically the purchasing power parity hypothesis. This study uses both whole price and consumer price indices. First of all he uses different methods including cointegration estimation technique to test unit root of real exchange rates. Later on, he finds empirically poor type of purchasing power parity hypothesis in all cases excluding Canadian dollar real exchange rate based on whole price indices against British pound in the long run. The empirical finding of the study shows that nonlinear mean reversion behavior is found only in case of Canada. Likewise, Michael et al. (1997a) also use ESTAR model to explore the possibility of nonlinear adjustment in real exchange rates in a pair of six countries namely, UK-US (sterling/dollar), UK-FR (sterling/franc), UK-GE (sterling/mark), US-GE (dollar/mark), US-FR (dollar/franc) and FR-GE (franc/mark) by using monthly data including annual data of two centuries for sterling/dollar and sterling/franc. Real exchange rates are formed on the basis of whole price indices. The study employs Engle-Granger estimation method and yields that franc/mark, dollar/mark and sterling/mark reject the null hypothesis of no cointergration, however, others provide weak evidence to reject the null hypothesis especially monthly sterling/dollar. Applying linearity tests on all apart from franc/mark, dollar/mark and sterling/mark and reject the linearity. ESTAR model is suggested for all pairs after getting significance results excluding monthly sterling/dollar and LSTAR is suggested to be fit for sterling/dollar. The finding of the study shows that the movement of adjustment between regimes is faster for the monthly series than for the annual ones and ESTAR model can represent the adjustment process of nonlinear real exchange rates. There are a number of other studies that investigate the possibility of nonlinear adjustment process in real exchange rates (Bleaney and Mizen, 1996; Goldberg et al., 1997; Pippenger and Geppert, 1997; Michael et al., 1997b; Pippenger and Goering, 1998; O'Connell, 1998; Liew et al., 2003).

Altavilla and De Grauwe (2010) develop a simple theoretical model of the exchange rate that is linked to exchange rate regime. The study employs MS-VECM model by using quarterly data from 1979Q1- 2004Q4 for the United States and euro area. The key message of the analysis is that relationship between the nominal exchange rate and macroeconomic variables is time varying. The finding is consistent with the results obtained by Yuan (2011) in case of Canada, the United Kingdom and Australia nominal exchange rates against US dollar. He uses quarterly data over the period 1973Q1- 2007Q2 by developing a model that nonlinearity is considered in the relationship of nominal exchange rates and macroeconomic variables in Markov-switching process via transition probabilities[22]. Furthermore, Chang and Su (2014) consider the role of structural breaks in the long run relationship between exchange rates and explanatory variables by employing MS-VECM model on the sample of selected eleven Pacific Rim countries[23] for different monthly observations period according to the data availability. The study finds that there is a long run relationship between exchange rate and macroeconomic variables after including structural breaks behavior in Thailand, Canada, South Korea and Japan with respect to US dollar as well as there is a causal relationship between the explorative macroeconomic variables in the a fore-named countries. Similarly, Sarno et al. (2004) uses MS-VECM model to the connection between nominal exchange rates and monetary macroeconomic variables for the sample of six industrialized countries namely,

[22] Changes in situation of macroeconomic variables are called transitions and probabilities related with these different variables changes are named transition parameters.

[23] Malaysia, Thailand, Korea, Taiwan, Japan, Singapore, Indonesia, the Philippines, the United States, Canada, South Korea and Chile.

France, Switzerland, Belgium, Italy, Finland and Portugal over the period of beginning of 20th century- end of 20th century. The finding of the study shows that a long term connection between exchange rates and fundamentals is time-varying.

Joyce and Kamas (2003) provide a brief review of long run relationship between real exchange rates and real variables for Mexico, Argentina and Colombia. VEC models are applied by using availability of quarterly data for each country differently. The cointegration estimation method shows that real exchange rate has a long run equilibrium connection with real explanatory variables that eliminates the role of central bank intervention and nominal variables. In contrast, Akram (2004) investigates the existence of nonlinearity in the relationship between nominal exchange rate of Norway and oil prices. The study uses equilibrium correction models (EqCMs) and detects that there is a nonlinear relationship between nominal exchange rate and oil prices from 1986M1-1998M8. The key finding of this study indicates that there is a negative connection between Norwegian Krone nominal exchange rate and prices of oil and this relationship gets stronger when oil prices are less than $14. Later on, further research has been done to find out a particular channel through which nonlinear relationship is created between nominal exchange rate and oil prices. For example, Dauvin (2014) analyzes the nonlinear relationship between exchange rates and energy prices. The study estimates panel smooth transition regression (PTSR) models by using annual data from 1980-2011 for the sample of commodity-exporting as well as energy-exporting countries. The findings of the study suggest that there is a specific level beyond which oil prices affect real exchange rates of both mentioned exporting countries through the channel of terms of trade (TOT) and further it states that real exchange rates are not affected by TOT ,however, affected by other usual explanatory variables when fluctuations are low in the oil prices. Furthermore, a lot of literature related to the evidence of nonlinearity between exchange rate and its fundamentals can be found as far as industrialized economies are concerned, however, such afore-named literature is completely insufficient for African economies. For instance, Coleman et al. (2010) investigate the role of oil prices as a major determinant of real exchange rates on 13 African countries[24]. The study uses both vector error correction model (VECM) model and Smooth Transition (STR) model for the period of 1970Q1-2004Q4. The finding of the study explains the nonlinear deviations of exchange rates

[24] Burkina Faso, Togo, Madagascar, Seychelles, Nigeria, Ivory Coast, Senegal, Cameroon, Morocco, Kenya, Rwanda, South Africa and Mauritius.

in the short run which is based upon linear long run cointegration relationship between oil prices and exchange rates in Morocco, Burkina Faso, Kenya and Cameroon; however, the impacts of oil prices on real exchange rates of each afore-named four countries are different. Moreover, Bahmani-Oskooee and Gelan (2006) use KSS (2003)[25] new unit root test and standard ADF unit root test to estimate nonlinearity by using quarterly data over the period 1971Q2-2004Q3 for selected 21 African countries[26]. The study concludes that there is asymmetric nonlinear mean reversion behavior in 9 out of 21 real effective exchange rates of African countries. However, the study does not consider other sources that might cause nonlinearity such as structural changes. Thus, Cuestas and Mourelle (2011) fill this gap through applying a nonlinear ESTAR method for the probability of nonlinear trend model under alternative hypothesis and using the same sample of African countries and period as used by Bahmani-Oskooee and Gelan (2006).The finding of this study shows that ESTAR models can find out the nonlinear real exchange rates behavior for most of the African countries.

[25] Kapetanios et al. (2003) provide a new unit root test that estimates the nonlinear mean reversion behavior in time series data.

[26] Togo, Burkina Faso, Morocco, Cameroon, Tanzania, Gabon, Ivory Coast, Senegal, Ghana, Burundi, Madagascar, Egypt, Nigeria, Ethiopia, South Africa, Niger, Sierra Leone, Kenya, Seychelles, Rwanda and Mauritius.

3.5 Concluding Remarks

The relevant economic theories and relevant empirical studies show that there is nonlinear relationship between exchange rate and macroeconomic variables. The literature review discussed in this chapter indicates different approaches regarding the nonlinearity of exchange rates and its explanatory variables. It shows that either linear or linear connection between exchange rate and macroeconomic variables varies from region to region, country to country depending upon the country specific conditions and type of model framework to be used.

By reviewing the existing literature of relevant area, it has been observed that until now there is no prominent empirical study presented to explore the nonlinear relationship between real exchange rate and macroeconomic variables for Pakistan.

The study by Hyder and Mahboob (2006) indicates a long run linear cointergrating relationship and short term dynamics between real effective exchange rate and macroeconomic variables for Pakistan by using Ordinary Least Square (OLS) and error correction models (ECMs) over the period of 1978-2005. Their study does not use any nonlinear cointegration model. The theoretical debate indicates that the macroeconomic variables may show nonlinearities and conventional linear cointegration methods have low power to find out the nonlinearities between exchange rate and macroeconomic variables.

An empirical analysis in the nonlinearity between real exchange rate and macroeconomic variables in Pakistan rather than a theoretical discussion is required to fill the literature gap. Hence, it is useful to investigate empirically the nonlinear relationship between real effective exchange rate and macroeconomic variables by using nonlinear cointegration estimation technique. This study tries to analyze the hypotheses that macroeconomic variables have nonlinear relationship with real effective exchange rate and changes in macroeconomic variables affect real effective exchange rate of Pakistan. The present study uses panel data from Pakistan including top ten major trading countries for the period 1960-2014. The detail of data and econometric methodology is given in the chapter 5 of this thesis.

Chapter 4

Theoretical Framework

The theoretical models which determine a nonlinear relationship between exchange rate and its economic fundamental either directly or indirectly can be classified as target zone models, microfoundation of trading behavior models, bubbles models, government monetary policies models, fads and noise trading models and aggregate market forecast model.

Krugman (1991) presents a **target zone model** that finds out nonlinear relationship between exchange rate and its fundamentals. The main reason is rational expectation. Furthermore, target zone model shows a range whereby authorities keep nominal exchange rate in such appointed limit.

It is assumed that demand for money depends on price level, real income and nominal interest rate level where all variables except interest rates expressed in logarithms, monetary equilibria in the domestic and foreign country respectively are given by:

$$m_t = p_t + ky_t - \theta i_t \qquad (4.1)$$

$$m_t^* = p_t^* + k^* y_t^* - \theta^* i_t^* \qquad (4.2)$$

m denotes demand for money, p is for price level and θ denotes nominal interest rate level. Variables with asterisk show foreign variables.

Relative purchasing power parity implies that changes in the exchange rate are equal to changes in relative national prices.

$$s_t = \alpha + \beta p_t + \beta^* p_t^* + u_t \qquad (4.3)$$

An important assumption in the flexible price monetary model is continuous purchasing power parity. Thus, we set $\beta - \beta^o = 1$ (a test of restriction) which would be interpreted as a test of relative purchasing power parity and normalize the price indices in equation 4.3, where s_t denotes the logarithm of exchange rate.

We get the condition of purchasing power parity from equation 4.3:

$$s_t = p_t - p_t^* \tag{4.4}$$

Solving equation 4.1, 4.2 and 4.3 for the exchange rate gives the equation 4.5:

$$s_t = m_t - m_t^* - ky_t + k^* y_t^* + \theta i_t - \theta^* i_t^* \tag{4.5}$$

The model is started with the flexible price monetary model along with assumption of continuous purchasing power parity. s_t denotes exchange rate, m_t and m_t^* denote domestic money and foreign money, ky_t and $k^* y_t^*$ denote domestic real income and foreign real income, θi_t and $\theta^* i_t^*$ denote domestic level of nominal interest rate and foreign level of foreign interest rate. Moreover, if domestic money supply is increased relatively to foreign money supply, s_t increases and therefore domestic currency is depreciated in terms of foreign currency. If domestic real income rises, other things keep constant, demand for domestic money supply increases and people reduce their expenses in order to increase real money balances, hence, domestic residents reduce expenditure and domestic prices gradually decline till equilibrium of market is achieved. Through purchasing power parity, falling domestic prices with keeping the foreign prices constant resulting an appreciation of the domestic currency in terms of foreign currency. Similarly, if domestic interest rate is increased, it reduces excess demand for money and consequently domestic currency depreciates.

In Practice, researchers sometimes simplify the model by imposing $k = k^o$ and $\theta = \theta^o$ in equation 4.5. We can substitute Δs_{t+1}^e for $(i_t - i_t^*)$ by using uncovered interest parity condition[27] and get the following equation:

$$s_t = m_t - m_t^* - k(y_t - y_t^*) + \theta \Delta s_{t+1}^e \tag{4.6}$$

Considering a flexible price monetary exchange rate model stated in continuous-time of equation 4.6 under the assumption of rational expectations:

$$s = m + v + \frac{\theta E[ds|\Omega(t)]}{dt} \tag{4.7}$$

[27] It is a parity condition explaining that the difference in interest rates between two countries is equal to the expected change in exchange rates between the currencies of the countries.

Where v represents variables namely, real income and nominal interest rate level of model 1, $\Omega(t)$ represents the information set which is available at time t, $\theta E[ds|\Omega(t)]/dt$ shows the expected change in exchange rate.

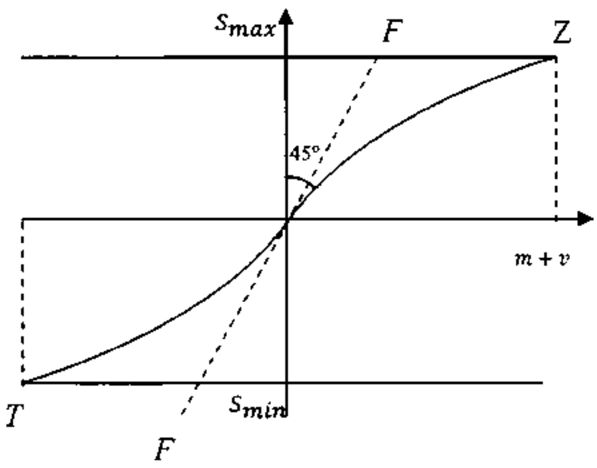


Figure 4.1: The Basic Target Zone Model

Monetary authority controls money supply(m) as a policy explanatory variable and v is supposed to follow a Brownian movement. In a flexible exchange rate regime, monetary authorities do not change m in order to offset the motion in v because s follows a Brownian movement and expected variation in exchange rate is zero. Therefore, graphically exchange rate (s) against its fundamentals ($m + v$) remains on 45° ray (See Figure 4.1). On the other hand, in a fixed exchange rate regime, the monetary authorities change m to balance motions in v and again expected change in exchange rate is zero, however, graph of exchange rate against its fundamentals is drawn at single point. In addition, monetary authority interferes at the upper and lower edges of the zone by changing the level of explanatory variables to keep the exchange rate within the zone space. Thus, target zone model explores that the relationship between exchange rate and its fundamentals is nonlinear due to forward looking assumption of exchange rate. As the exchange rate starts moving closely to the band, forward-looking anticipate an intervention and incorporate this in to their expectation. Repeated versions of exchange rate expectations will lead to an S-shaped which is a nonlinear relationship between exchange rate and its fundamentals. The slope of *TZ* graphically shows the responsiveness of exchange rate to variation in its fundamentals.

Similarly, Krugman and Miller (1993) derive a nonlinear relationship between exchange rates and fundamentals within a free-floating exchange rate regime on the basis of **micro-**

foundation of trading behavior. Speculative foreign investors adopt stop-loss trading strategies and these strategies cause a change in the risk premium that arise nonlinearity. Moreover, assets specified in domestic currency are assumed to be kept by these investors and would start selling these domestic assets when the value of domestic currency declines (exchange rate falls) in order to protect themselves and leaving markets by these investors leads to change risk premium on domestic assets. Similarly the other (non-stop) traders purchase domestic assets and sell foreign assets. This is in turn causes a change in the risk premium on the foreign assets. This result can be obtained when investors are risk averse along with imperfect substitutability of foreign and domestic bearing assets.

Exchange rate model incooperating risk aversion is introduced as follows:

$$s = k + \gamma(\frac{E[ds]}{dt} - \beta s') \tag{4.8}$$

k represents general fundamental, β denotes risk premium and s' indicates elasticity of exchange rate with respect to fundamentals. In addition, when the stop-loss traders leave the market, the nonstop-loss traders sell foreign assets and purchase domestic assets which lead to vary (fall) the risk premium on foreign assets. This variation in risk premium generates a break path in flexible exchange rates. Hence, represents a nonlinear relationship between exchange rate and fundamentals.

Likewise, Ikeda and Shibata (1995) introduce **the intrinsic bubble** into exchange rate which leads to a monotonic (nonlinear) relationship between the exchange rate and its fundamentals and the relation might be even non-monotonic. Exchange rates developed with bubbles are probably less changeable as compared to fundamentals with limited samples. Moreover, the exchange rate deviates from its fundamentals in the existence of random process shifting of market fundamentals under flexible exchange rate regime. However, its deviation is restricted in case of random regime switching under flexible exchange rate regime. Besides, it might also deviate from fundamentals under uncertainty of fundamentals caused by uncertain economic environment nature. Ikeda and Shibata (1995) determine specifically exchange rate as a dependent variable on market fundamentals and time.

Considering the flexible exchange rate monetary model determination:

$$e(t) = m(t) + \left(\frac{1}{\alpha}\right) E[de(t)|\Omega_t]/\text{dt}, \quad \alpha > 0 \tag{4.9}$$

$m(t)$expresses market fundamentals or random explanatory variables that have impact on money market or it might be the difference of domestic and foreign money supplies, $\left(\frac{1}{\alpha}\right)$ denotes money demand's semi elasticity with respect to expected percentage change in exchange rate, $E[.|\Omega_t]$ shows expectation parameter which is dependent on information available at time t. All the values are expressed in log form.

Moving to other theoretical study, a nonlinear relationship between exchange rate and fundamental is presented in **government monetary policies** due to speculative attacks on government controlled exchange rates (Flood and Marion, 1999). Indeed, two cases are studied for policy nonlinearity.

The first case of policy nonlinearity depends upon switching or shift of domestic credit growth rate (element of domestic money supply) conditional on whether there is an attack or not. Each growth rate reflects a way that the exchange rate follows. When speculators attack and the credit growth rate changes, the exchange rate jumps from the non-attack path to the attack path, thereby establishing a nonlinear relationship between exchange rate and fundamentals.

Graphically, Domestic credit growth increases at μ_1 rate when fixed exchange rate is attacked and in case of non attack, domestic credit growth increases at μ_0 rate.

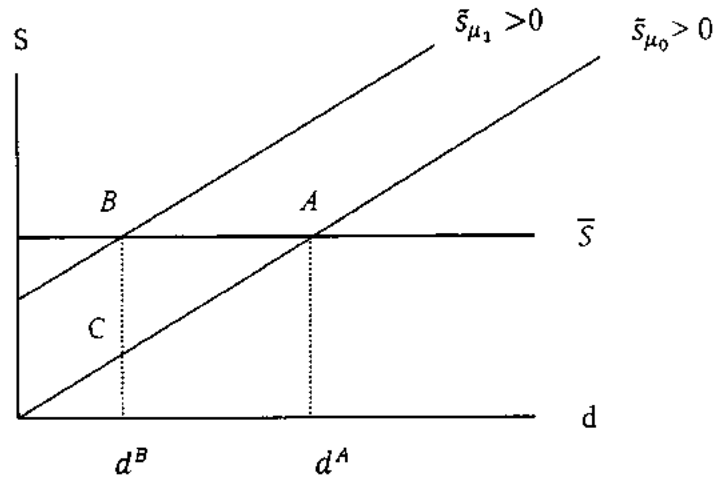


Figure 4.2: Times of Attack with Attack subject to Policy Switching

Figure 4.2 denotes that there are two lines of exchange rate, one related to the credit expansion rate of μ_0 and another one related to the higher credit expansion rate of μ_1. $\mu = \mu_0$ intersects the line rate which is $\overline{S}$ at point *A*, similarly, $\mu = \mu_1$ intersects the line rate at point *B*. Furthermore, the credit rate would be at $\tilde{s}_{\mu_0}$ line if there is no attack and in case of attack, the rate jumps to $\tilde{s}_{\mu_1}$ line below the fixed exchange rate. If domestic credit is below d^B, there is no incentive for fixed exchange rate to be attacked because speculators face capital loss. When there is no increase in domestic credit ($\mu_0 = 0$), policies of fixed exchange rate and domestic credit are suitable to each other. Suppose the rate is at point *C* where $\mu = \mu_0$ at d^B level, the mentioned rate jumps from point *C* to *B* when the speculator attacks. The speculators can not achieve quick capital gain although the attack is successful. Thus, equilibrium point can be either at point *C* or *B*.

The second case of policy nonlinearity follows linear rule with an escape clause and nonlinearity is established in the face of self-fulfilling speculative attacks.

Model for conducting exchange rate policy:

$$min\ L = \frac{\Theta}{2}\delta^2 + \frac{(\delta - E\delta - u - k)^2}{2} \tag{4.10}$$

L expresses social loss function, δ denotes currency depreciation rate, Eδ denotes expected currency depreciation rate, *u* denotes zero mean distribution with σ^2 variance, *k* expresses distortion measure and θ shows weight assigned according to changes of price.

Rule[28] and discretion[29] are generally two methods that make policy. Expected value of loss function is calculated for the rule where δ = 0 and Eδ = 0:

$$EL^R = \frac{\sigma^2 + k^2}{2} \tag{4.11}$$

Expected value of loss function is calculated for discretion where $E\delta^D = \frac{k}{\theta}$ and θ=1:

$$EL^D = \frac{\sigma^2}{4} + k^2 \tag{4.12}$$

[28] Government sets policy irrespective of the state of the economy.
[29] Government sets policy while observing the current state of the economy including expectations.

Society is better off with rule as compared to discretion. however, when a matter can not be specified by rule then discretion is better to be applied. Moreover, mixed strategy should be chosen including escape clause[30] when the disturbance gets uncontrollable although implication of escape clause is costly (C) to government. Thus, the rule is followed when $L^R < L^D + C$. Policy makers must identify the disturbance value that raises escape clause:

$$L^R(\overline{u}) = L^D(\overline{u}) + C \qquad (4.13)$$

Equation 4.13 is statistically nonlinear as individual expects about depreciation of currency by counting the expected weighted average rate to be appointed under rule $(E\delta^R = 0)$ and discretion$(E\delta^D > 0)$.

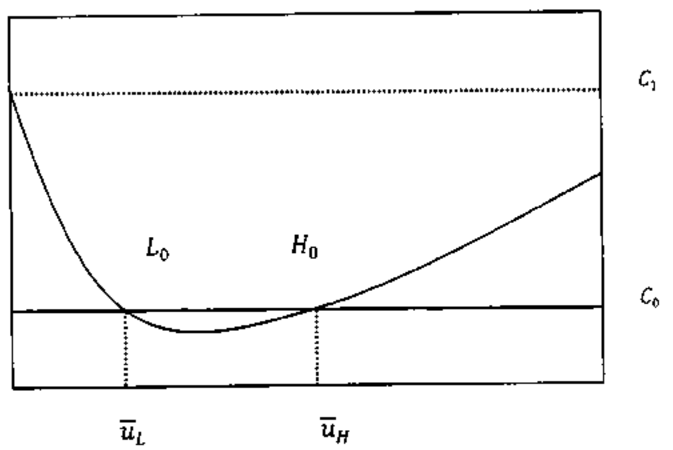


Figure 4.3: Size of Shock, u

Figure 4.3 expresses the nonlinear problem stated by Equation 4.13. The curved line $(L^R - L^D)$ intersects the horizontal line (C) at two points, at low and high values for disturbances ($\overline{u}_L$ and $\overline{u}_H$). If private sector chooses $\overline{u}_H$ and believes that government will quit rule at such level of disturbance, then it is better for the government to choose this point to solve its problem, similarly, if private sectors chooses $\overline{u}_L$ and believes that rule will be quit by government at this point, then this point is optimal for the government to be chosen.

Moreover, **Fads and noise trading** might generate nonlinearity between exchange rate and its fundamental. **In a fads model** presented by Shiller et al. (1984), it is thought that investor's behavior is not an important factor of financial market as far as predictability of stock return is concerned, however, if investor's fads influences stock prices, then it can be stated that movement of stock returns are predictable to some extent .Furthermore, variations

[30] It is to devalue the currency and policy makers ought to pay fixed cost privately while choosing discretion.

in dividends are fairly predictable and variations in dividends are occasionally proclaimed. Thus, stock prices can be forecasted considering the paid dividends. Unpredictability of stock returns can be denoted by $E_t R_t = \delta$, where E_t expresses expectation on information available at time *t*, R_t denotes real rate of return that includes both capital gain and dividends on stock between *t* and *t+1* and δ expresses and constant value.

Rational expectation model is as follows:

$$R_t = \frac{P_{t+1} - P_t + D_t}{P_t} \qquad (4.14)$$

D_t shows the dividend payment at time *t* and P_t shows real price share at time *t*.

The powerful efficient markets model is:

$$P_t = \sum_{k=0}^{\alpha} \frac{E_t D_{t+k}}{(1+\delta)^{k+1}} \qquad (4.15)$$

Equation 4.15 expresses that real price equals to payments of expected future dividends, discounted to net present value and therefore price predicts the flow of dividends that will be played by the stock in the future.

In a noise trading model presented by De Long et al. (1990), many investors can be found that do not incorporate advice advised by economists while buying and holding market portfolio. Investors often use their own judgment to diversify their portfolio in bundle of stocks rather than in a single stock. Moreover, such investors that use incorrect information and beliefs are known as noise traders. On the other hand, rational arbitrageurs are risk averse and their positions are limited in the market because of incorrect beliefs and lack of inside information exercised by noise traders that generates risk. More specifically, this risk is called fundamental risk and even if arbitrageurs bear all the mentioned risk, they could not beat noise traders; however, returns of noise traders would be higher if they tolerate extra fundamental risk. Prices can be pushed towards fundamental values when experienced traders purchase stocks when prices are reduced and sell when prices are increased by noise traders. Psychological hurdle is recognized by investors to growing movements in exchange rate in a fads model. Noise traders either enter or exit the market when exchange rate is induced to move and a new exchange rate point is achieved. Therefore, rational investors' speculative behavior generates nonlinearity between exchange rate and fundamentals.

Turning to other relevant theoretical study, **Persistent regime change** is another factor that identifies a nonlinear relationship between exchange rate and its macroeconomic variables introduced by Altavilla and De Grauwe (2010). In fact, agents forecast future exchange rate by using two sorts of predicting rules namely, fundamentalists and chartists or technical analysts. Moreover, in fundamental analysis[31], the exchange rate moves so close to fundamental exchange rate. Whereas, exchange rate is not determined well in technical analysis[32].When agents become approximately rational and further use useful predicting rule, hence, exchange rate diverges actively from fundamental or market exchange rate becomes insensitive to its underlying value when agents are extremely analytical.

Market forecast at aggregate level is obtained as follows:

$$E_t \Delta e_{t+1} = -w_{f,t}\psi(e_t - e_t^*) + w_{c,t}\beta\Delta e_t \qquad (4.16)$$

Equation 4.13 expresses exchange rate market forecast as a weighted expectations average of fundamentals and chartists, where E_t denotes forecast in period t, change in exchange rate in period t, $-w_{f,t}$ and $w_{c,t}$ denote population proportion who use predicting rules of fundamentalists and chartists, ψ shows the speed through which fundamentalists hope exchange rate gets back to fundamental, β measures the degree through which chartists anticipate previous variations in exchange rate. The presence of different regimes is predicted by the model and therefore generates nonlinear relationship between exchange rate and macroeconomic variables.

Overall, the above models suggest a non-linear relationship between real exchange rate and macroeconomic variables.

[31] Stock value is investigated via employing economic factors.

[32] Forecasting movements of price is identified through using current security price movements.

Chapter 5

Empirical Specification, Data Set, Definitions of Variables and Construction and Methodology

In this chapter, we discuss the empirical specification of variables, data source, constructing variables and econometric methodology.

5.1 Empirical Specification

The first model of equilibrium real exchange rate (ERER) for developing countries was represented by Edward (1989) who extends the study of equilibrium real exchange rate determination and improves real exchange rate model related to its fundamentals such as government consumption, technological progress, terms of trade, level of imports tariffs, capital inflows and other explanatory variables. Clark and MacDonald (1998) present real exchange rate models to its fundamentals such as interest rates, net foreign assets, terms of trade, productivity and government debt with a new frame work of Behavioral Equilibrium Exchange Rate (BEER) for empirical analysis. Indeed, these mentioned variables are chosen with respect to their meaningful theoretical backgrounds and they may change if different theories are adopted. Consequently, application of different variables with different model specifications change the BEER approach that further leads to a broad application in empirical studies while determining equilibrium real exchange rates.

This study uses approach of BEER of Pakistan and is supposed to be identified by the following macroeconomic variables:

$$REER = f(PROD, TOT, NFA, INV, PRCD) \tag{5.1}$$

The left hand side variable $REER$ is the abbreviation of real effective exchange rate and the right hand side variables are $PROD$ for difference in productivity, TOT for terms of trade, NFA for net foreign assets, INV for investment and $PRCD$ for private credit. Most of the variables are chosen with instructions of Montiel (1999) and with availability of data.

More specifically, relationship between real effective exchange rate and macroeconomic variables is modeled in the following way:

$$\log(REER_t) = \alpha_0 + \alpha_1 \, log(PROD_t) + \alpha_2 \, log(TOT_t) + \alpha_3 \, log(NFA_t) + \alpha_4 \, log(INV_t) + \alpha_5 \, log(PRCD_t) + \varepsilon_t \quad (5.2)$$

Where, all the variables are taken in log form.

5.2 Data Set

To illustrate the implementation of testing procedure for the relationship between the real exchange rate and macroeconomic variables, annual data is used for Pakistan economy along with its ten trading partners. The data period is from 1960-2014. The data set of the sample countries is taken from World Development Indicators (WDI), The World Bank.

The exchange rate determines the value of one currency relative to another currency. Explanatory variables are also constructed as domestic variables with respect to foreign ones. Thus, exchange rate movement is sensitive to the differentiation between domestic and foreign explanatory variables. Furthermore, multilateral effective exchange rate is discussed rather than a single bilateral exchange rate; hence, all variables are stated in effective terms, more specifically, proportion of domestic variable relatively to foreign variable and the foreign variable is a trade-weighted average of domestic country's major trading partners. Top ten main trading partners of Pakistan are China, the United States of America, Saudi Arabia, Singapore, Kuwait, the United Kingdom, India, Germany, Japan and Malaysia (See Table 5.1, Appendix). The afore-named trading partners are selected according to their bilateral trade volumes (exports and imports) with Pakistan. Exports and imports data for the trading partners are taken from State bank of Pakistan (SBP).

Weight is calculated for each trading partner in the following way:

$$W_{iPt} = FT_{iPt}/TFT_{Pt}$$

i=1,2,3,...,10. P= Denotes Pakistan

FT_{iPt} =It is partner i's trade volume with home country (Pakistan)

TFT_{Pt}= It is Pakistan's total foreign trade with its top ten trading partners.

5.2.1 Descriptive Statistics

In this section we discuss summary statistics and correlation matrix.

5.2.1.1 Summary Statistics

Table 5.2 (See Appendix) reports summary statistics of variables used in our analysis. Net foreign assets (NFA) have the lowest mean (0.0227) and median (0.0196) values respectively. Productivity differential (PROD) has the highest mean (5504.75) and median (610.679) values respectively. The lowest standard deviation belongs to real effective exchange rate (REER) is 0.0258. It indicates that there are little variations in real effective exchange rate (REER). On the other hand, the highest standard deviation belongs to the productivity differential (PROD) is 25578.8 which shows that volatility is more in productivity differential (PROD) than any other variable. If we look at the number of observations, all the variables have equal number of observations that further yields that there is balance in our data set.

5.2.1.2 Correlation Matrix

Table 5.3 (See Appendix) shows correlation among all variables which are analyzed in this study. Highest positive correlation of 83.3% is detected between private credit (PRCD) and investment (INV). Lowest positive correlation of 4.2% is found between private credit (PRCD) and real effective exchange rate (REER). Lowest negative correlation of 23.5% is found between net foreign assets (NFA) and real effective exchange rate (REER). Investment (INV) and real effective exchange rate (REER) have highest 14.85% negative correlation.

5.3 Definitions of Variables and Construction

This section provides an overview of the definitions and construction of variables that are used in our analysis.

5.3.1 Dependent Variable

Keeping in view the nature of the research, this study is carried out to test two separate models, namely linear and nonlinear. The two equations are independent and required to be estimated separately. The main dependent variable of the study is real effective exchange rate which is discussed as follows.

5.3.1.1 Real Effective Exchange rate (REER)

Exchange rate is expressed with regard to foreign currency either to buy or sell one unit of domestic currency. Real effective exchange rate is the weighted average of bilateral real exchange rate measured by the relative significance of each individual country in trade with the host country. Indeed, REER is adjusted for price differential relatively between domestic currency and foreign currency which gives some idea about how the domestic currency is performing comparatively to the rest of the world, hence, if there is any increase or decrease in the value of domestic currency it shows that domestic currency is appreciated and vice versa (Tang and Zhou, 2013). The real effective exchange rate is calculated by using the following formula:

$$REER_{Pt} = GDPDF_{Pt}R_{Pt} / \prod_{i=1}^{10} (GDPDF_{it}R_{it})^{W_{iPt}}$$

$GDPDF$ is GDP deflator[33], R is the nominal exchange rate of home currency in terms of US dollars, subscripts P and i indicate domestic country and its partner i, correspondingly and $\prod$ or Pi is used to multiply succeeding terms.

5.3.2 Independent Variables

This study has five explanatory variables such as productivity differential, terms of trade, net foreign assets, investment and private credit. Each of the aforementioned is discussed as follows:

5.3.2.1 Difference in Productivity (PROD)

Difference in productivity follows Balassa-Samuelson theory (1964). If relative productivity grows faster in tradable goods than non-tradable ones sector of an economy will lead to real appreciation of its currency. As a result, pressures on wages emerge in the non-tradable sector due to higher wages in tradable sector and higher relative price of non-tradable appears. Balassa-Samuelson effect is commonly used which is the relative price of non-tradable to tradable goods and is proxied by real GDP per capita or we can state that real GDP per capita (GDPPC) is used as a proxy for productivity differential[34] (Tang and Zhou, 2013). It is calculated using the following formula:

[33] GDP deflator (base year = 2005) is the ratio of nominal GDP to real GDP.

[34] Relative productivity differential can be viewed as a proxy for technological progress.

$$PROD_{Pt} = GDPPC_{Pt} / \prod_{i=1}^{10} (GDPPC_{it})^{w_{iPt}}$$

$PROD$ is for difference in productivity, Pt is for Pakistan at time t and w_{iPt} is calculated weight of partner i of host country P at time t.

5.3.2.2 Terms of Trade (TOT)

Terms of trade is defined as the ratio of prices of exports to prices of imports. The impact of TOT is ambiguous due to income effect and substitution effect. Moreover, income from export rises when trade improves and demand for non-tradable goods rises. Hence, their prices go up that lead to the appreciation of domestic currency in income effect. On the other hand, through substitution effect, when TOT[35] improves which means that import becomes cheaper and portion of domestic demand for non-tradable goods are substituted for imports. Therefore, prices of non-tradable goods go down which lead to the depreciation of domestic currency (Terra and Valladares, 2010; Tang and Zhou, 2013). It is calculated in the following way:

$$TOT_{Pt} = (TOT_{Pt}) / \prod_{i=1}^{10} (TOT_{it})^{W_{iPt}}$$

5.3.2.3 Net foreign assets (NFA)

Net foreign assets are defined as total foreign assets minus total foreign liabilities. Net foreign debt of a country is mainly caused by current account deficit and it has to be removed. Thus, channel of international capital inflow is adapted to finance, however, higher rate of return is demanded by the foreign investors and is only achieved if the debtor country depreciates its currency intentionally to repay its interest payment gained from trade surplus. Hence, net foreign assets lead to the appreciation of the real exchange rate (Tang and Zhou, 2013). Strong position of net foreign assets leads to real appreciation. On the other hand, weak position leads real depreciation. Net foreign assets to GDP is used to pay attention to economy size and is calculated in the following formula:

$$NFA_{Pt} = (NFA_{Pt})/GDP_{Pt} - \sum_{i=1}^{10} w_{ipt} (NFA_{it})/GDP_{it}$$

[35] The ratio of total trade to GDP is used as a measure of International trade liberalization.

5.3.2.4 Investment (INV)

The addition to the total stock of capital of a country is called investment. The impact of investment is ambiguous. On one hand, improvement in the productivity of an economy is achieved through increasing investment which further leading to the appreciation of real exchange rate. On the other hand, higher spending on tradable (imported raw materials and machinery) due to increase in investment will lead to the current account deficit and finally real exchange rate is depreciated (Ajevskis et al., 2012). Gross fixed capital formation (GFCF) to GDP is used as a proxy for investment and is calculated in the following method:

$$INV_{Pt} = (GFCF_{Pt}/GDP_{Pt})/\prod_{i=1}^{10}(GFCF_{it}/GDP_{it})^{W_{iPt}}$$

5.3.2.5 Private credit (PRCD)

Expansion in domestic credit in the context of expansionary macroeconomic policy raises domestic demand. If the increased demand is directly mostly toward tradable goods (non-tradable goods) then it will cause the real exchange rate to depreciate (appreciate). Private credit also appreciates real exchange rate because of growing inflationary difference between home country and its trading partners (Kwakye, 2012). Domestic credit to private sector (DCPS) to GDP is used as a proxy for private credit and is calculated in the following formula:

$$PRCD_{Pt} = (DCPS_{Pt}/GDP_{Pt})/\prod_{i=1}^{10}(DCPS_{it}/GDP_{it})^{W_{iPt}}$$

5.4 Description of Methodology and Testing Procedure

In this section we describe the econometric methodology and testing procedure to analyze the linear and nonlinear relationship between real effective exchange rate and its macroeconomic variables for Pakistan. The study is started by testing and estimating two different models which are Autoregressive Distributed Lag (ARDL) model and asymmetric Autoregressive Distributed Lag or non-linear ARDL (NARDL) model.

5.4.1 Unit Root Test

Most of the macroeconomic time series move either upward or downward. They are likely to be non-stationary. Standard Ordinary Least Squares (OLS) method yields incorrect results if the variables are non-stationary. This study starts by testing and estimating non-stationarity of the variables to prevent such spurious regression analysis.

5.4.1.1 Augmented Dickey-Fuller (ADF) Test

It is used to detect stationarity in a time series data set. Indeed, it is an improved version of Dickey-Fuller test which carries out complex time series models. In addition, ADF test contains additional dependent variable's lagged terms to terminate autocorrelation. If ADF test statistics gets more negative number, probability of rejection of null hypothesis which is unit root becomes stronger at some confidence level. Bayesian information criterion (BIC) which is also known as Schwarz information criterion (SIC) is used to determine additional lag period. We apply ADF test to identify variables' integration order. The ADF test is specified as follows:

$$\Delta Y_t = \beta_1 + \beta_2 t + \gamma Y_{t-1} + \alpha \sum_{i=1}^{p} \Delta Y_{t-i} + e_t \qquad (5.3)$$

Δ is the difference operator of the chosen variable, t denotes time index, β_1 is an intercept which is also called a drift, $\beta_2 t$ shows time trend with coefficient β_2 that presents unit root process, p is the lag order and e_t is an independent distributed residual term. Furthermore, the null hypothesis of the mentioned model is that variable is not stationary or $(\gamma = 0, \beta_2 \neq 0)$ and alternative is that variable is stationary or $(\gamma < 0, \beta_2 \neq 0)$. In the following section we apply co-integration estimation technique after testing stationarity of the time series data.

5.4.2 Autoregressive Distributed Lag (ARDL) Bounds Testing Approach

ARDL bounds testing approach has been well known and recommended by many studies such as, Pesaran and Pesaran (1997), Pesaran and Smith (1998), Pesaran and Shin (1999) and Pesaran et al. (2001). This study applies ARDL model because of several advantages. First, Pesaran and Pesaran (1997) state that this model can be used regardless of whether variables are integrated of order zero or one (I(0), I(1)) or mixture of both unlike other co-integration methods such as Engle and Granger (1987) and Johansen (1995). Second, enough lags have been taken by this model in order to represent specific model from general to specific one during process of data generation (Laurenceson and Chai, 2003). Third, we can derive easily and simply error correction model (ECM) via linear transformation from ARDL model (Banerjee et al., 1993). Fourth, Pesaran and Shin (1999) suggest ARDL bounds testing approach because it is stronger than other mentioned co-integration techniques as far as small samples are concerned. Fifth, estimation can be carried out even if there is endogeneity among explanatory variables (Pesaran and Pesaran, 1997; Pesaran et al., 2001).

ARDL framework of Equation 5.2 is written in the following way:

$$\Delta reer_t = \beta_0 + \sum_{i=1}^{p} \delta_i \Delta reer_{t-i} + \sum_{i=0}^{p} \phi_i \Delta prod_{t-i} + \sum_{i=0}^{p} \varpi_i \Delta tot_{t-i} + \sum_{i=0}^{p} \gamma_i \Delta nfa_{t-i}$$
$$+ \sum_{i=0}^{p} \theta_i \Delta inv_{t-i} + \sum_{i=0}^{p} \eta_i \Delta prcd_{t-i} + \lambda_1 reer_{t-1} + \lambda_2 prod_{t-1} + \lambda_3 tot_{t-1}$$
$$+ \lambda_4 nfa_{t-1} + \lambda_5 inv_{t-1} + \lambda_6 prcd_{t-1} + \epsilon_t \quad (5.4)$$

Where p denotes optimal lag length, the $\sum$ terms show short run dynamics and the λ terms denote long run relationship. All the variables are taken in natural logarithmic form (*ln)* due to elasticity term that is used to interpret the response degree of dependent variable with regard to its independent variable(s).

5.4.2.1 Estimation Technique

ARDL framework is based on the following three steps:

First step, Equation 5.4 is estimated by Auto-regressive Distributed Lag (ARDL) Models method selecting Schwarz Information Criterion (SIC) because SIC presents more accurate and parsimonious model. Second step, we calculate F-statistics to find out whether long run relationship exists among the variables or not and null hypothesis is tested against alternative one.

$$H_0 = \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = \lambda_6 = 0$$

$$H_1 \neq \lambda_1 \neq \lambda_2 \neq \lambda_3 \neq \lambda_4 \neq \lambda_5 \neq \lambda_6 \neq 0$$

The null hypothesis shows that there is no long run relationship among the variables. Whereas, the alternative hypothesis shows the existence of long run relationship among the variables. Third step, we compare the calculated F-statistics with the lower and upper critical values given by Pesaran et al (2001) or Narayan (2004)[36] for the given significance level. If the F-statistics is greater than the upper bound, we reject the null hypothesis of no co-

[36] Critical values in Narayan (2004) are based on small samples covering 30 to 80 observations.

integration which shows the existence of long run relationship among the variables, if the F-statistics is less than lower bound, we accept the null hypothesis which means that there is no co-integration among the variables and F-statistics becomes undetermined or ambiguous when it lies between the lower and upper bounds.

ECM_{t-i} (See Appendix, Table 6.11) stands for error correction term which is the residuals' lagged value of the long run relationship of equation 5.11, the coefficient of ECM is the rate at which series is corrected from disequilibrium. ECM can be defined as the adjustment speed. It is expected to lie between 0 and 1 and it should be negative and significant.

5.4.2.2 Diagnostic and Stability Tests

To ensure whether model is fitted well or not, the diagnostic and stability tests are performed. More specifically, the diagnostic checks analyze LM test for serial correlation, heteroscedasticity, functional form and normality, respectively related to the assigned models. For stability of the model, cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) recursive residuals tests are carried out at some level of significance.

5.4.3 Asymmetric Autoregressive Distributed Lag (ARDL) Cointegration or Non-Linear ARDL (NARDL) model

This study employs the methodology of asymmetric ARDL model to explore the nonlinear relationship between real effective exchange rate and its macroeconomic variables.

Economic theory is almost related to the determinants, however, not to the relationship between dependent and independent variables in terms of functional form. If the cointegrating relationship among the variables is nonlinear, then applying linear might be incorrect. Furthermore, hidden cointegration which is a case of nonlinear cointegration was introduced by Granger and Yoon (2002) who express that if hidden cointegration exists between two time series, then their positive and negative elements are also cointegrated with each other.

Asymmetric (nonlinear) ARDL cointegration was developed by Shin et al. (2011). Indeed, the mentioned model is the extension of ARDL model of Pesaran et al (2001) where they actually use series of variables that have been decomposed in to positive and negative partial sum in order to find out nonlinear impacts in the long run as well as in the short run among the macroeconomic variables. Moreover, if real effective exchange rate and analyzed explanatory variables are cointegrated it means that even though they might separate from each other for a limited period of time, they have a tendency to return back to equilibrium point in the long run.

We generally consider the following asymmetric coinegration model:

$$reer_t = \beta^+\chi_t^+ + \beta^-\chi_t^- + u_t \tag{5.5}$$

Where, β^+ and β^- denote long run parameters and χ_t is k×1 regressors vector that is decomposed as below:

$$\chi_t = \chi_0 + \chi_t^+ + \chi_t^- \tag{5.6}$$

Where χ_0 is the initial or fundamental value and χ_t^+ and χ_t^- express positive and negative partial sums, respectively.

$$\chi_t^+ = \sum_{z=1}^{t} \Delta\chi_z^+ = \sum_{z=1}^{t} \max(\Delta\chi_z, 0) \text{ and } \chi_t^- = \sum_{z=1}^{t} \Delta\chi_z^- = \sum_{z=1}^{t} \min(\Delta\chi_z, 0) \tag{5.7}$$

If we associate Equation 5.7 to the standard linear ARDL model, we get the following nonlinear error correction model:

$$\Delta reer_t = \lambda reer_{t-1} + \varpi^+\chi_{t-1}^+ + \varpi^-\chi_{t-1}^- + \sum_{z=1}^{p-1} \delta_i \Delta reer_{t-z} + \sum_{z=0}^{q} (\eta_i^+ \Delta\chi_{t-z}^z + \eta_i^- \Delta\chi_{t-z}^z) + e_t \qquad \text{for } z = 1, \dots, q \tag{5.8}$$

Where $\varpi^+ = -\lambda\beta^+$ and $\varpi^- = -\lambda\beta^-$.

We further proceed to the estimation of asymmetric error correction model of Equation 5.8 in the following form:

$$\Delta reer_t = \beta_0 + \lambda_1 reer_{t-1} + \lambda_2^+ prod_{t-1}^+ + \lambda_2^- prod_{t-1}^- + \lambda_3^+ tot_{t-1}^+ + \lambda_3^- tot_{t-1}^- + \lambda_4^+ nfa_{t-1}^+$$

$$+ \lambda_4^- nfa_{t-1}^- + \lambda_5^+ inv_{t-1}^+ + \lambda_5^- inv_{t-1}^- + \lambda_6^+ prcd_{t-1}^+ + \lambda_6^- prcd_{t-1}^- + \sum_{i=1}^{p-1} \delta_i \Delta reer_{t-i}$$

$$+ \sum_{i=0}^{q} \phi_1^+ \Delta prod_{t-i}^+ + \sum_{i=0}^{q} \phi_1^- \Delta prod_{t-i}^- + \sum_{i=0}^{q} \phi_2^+ \Delta tot_{t-i}^+ + \sum_{i=0}^{q} \phi_2^- \Delta tot_{t-i}^-$$

$$+ \sum_{i=0}^{q} \phi_3^+ \Delta nfa_{t-i}^+ + \sum_{i=0}^{q} \phi_3^- \Delta nfa_{t-i}^- + \sum_{i=0}^{q} \phi_4^+ \Delta inv_{t-i}^+ + \sum_{i=0}^{q} \phi_4^- \Delta inv_{t-i}^-$$

$$+ \sum_{i=0}^{q} \phi_5^+ \Delta prcd_{t-i}^+ + \sum_{i=0}^{q} \phi_5^- \Delta prcd_{t-i}^- + \epsilon_t \qquad (5.9)$$

We follow general to specific method to choose the final ARDL model by starting p=max and q=12 and drop all those stationary series which are insignificant.

5.4.3.1 Estimation Technique

We follow four steps procedure for the estimation of unrestricted nonlinear error correction model (with respect to Equation 5.8):

Step 1, we use standard OLS for the estimation of mentioned model via general to specific method. Step 2, F-test is applied to the lagged level variables' coefficients $(reer_t, \chi_t^+, \chi_t^-)$ of unrestricted error correction model to detect whether they are jointly

equal to zero $(\lambda = \varpi^+ = \varpi^- = 0)$ or not and compare F-test value with lower and upper critical values given by Pesaran et al (2001). Indeed, we use joint null hypothesis to investigate long run association among the variables. Step 3, we use Wald test to examine long run symmetry through $\varpi = \varpi^+ = \varpi^-$ and symmetry of short run through $\sum_{i=0}^{q} \eta_i^+ = \sum_{i=0}^{q} \eta_i^-$. Step 4, the long run coefficients are computed as $\beta^+ = -\varpi^+/\lambda$ and $\beta^- = -\varpi^-/\lambda$, respectively. We implement our estimation method in Eviews 9.0.

5.4.3.2 Diagnostic and Stability Tests

To make sure the fitness of the model, diagnostic and stability tests are applied. The diagnostic tests analyze LM test for serial correlation, heteroscedasticity, functional form and normality, respectively related to the assigned model. For stability of the model, cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) recursive residuals are carried out at some level of significance.

Chapter 6

Empirical Results and Discussion

In this chapter, we discuss results of autoregressive distributed lag (ARDL) bounds testing approach. We divide this chapter in to three main sections that is the results of augmented Dickey-Fuller (ADF) test, co-integration test including estimations of long run and short run relationship, finally diagnostic and stability tests.

6.1 Results of Augmented Dickey-Fuller (ADF) Test

This study applies augmented Dickey-Fuller (ADF) test to investigate the stationarity of underlying variables. The test results of Table 6.1 indicate that all the original series except productivity differentials and investment are non-stationary at 5% level of significance. More precisely we say that our underlying variables become stationary at first difference or integrated of order one $I(1)$, while productivity differentials and investment are stationary at level or integrated of order zero $I(0)$ and none of the variables are integrated of order two $I(2)$ or beyond that. Therefore, we proceed towards ARDL estimation technique.

Table 6.1: ADF unit root test Results.

Variables	SIC lags	ADF test statistic		Critical value at 5%	Decision
		Level	1st Difference		
REER	1	-3.3172 (0.0750)	-5.7413*** (0.0001)	-3.4987	$I(1)$
PROD	1	-10.6824*** (0.0000)		-3.4969	$I(0)$
TOT	1	-2.5011 (0.3261)	-5.8557*** (0.0001)	-3.5064	$I(1)$
NFA	1	-2.2631 (0.4461)	-6.6994*** (0.0000)	-3.4987	$I(1)$
INV	1	-3.8994** (0.0189)		-3.4969	$I(0)$
PRCD	0	-2.6925 (0.2438)	-11.2399*** (0.0000)	-3.4969	$I(1)$

Note: 1. ADF statistics is with trend and intercept. 2. MacKinnon (1996) one-sided p-values are in parentheses. 3. Null hypothesis: series are non-stationary. Lag length is selected automatically on the basis of SIC. 4. ** & *** is significant statistically at 5% & 1% significance level, respectively. REER is real effective exchange rate, PROD is difference in productivity, TOT is terms of trade, NFA is net foreign assets, INV is investment and PRCD is private credit.

6.2 Autoregressive Distributed Lag (ARDL) Bounds Testing Approach

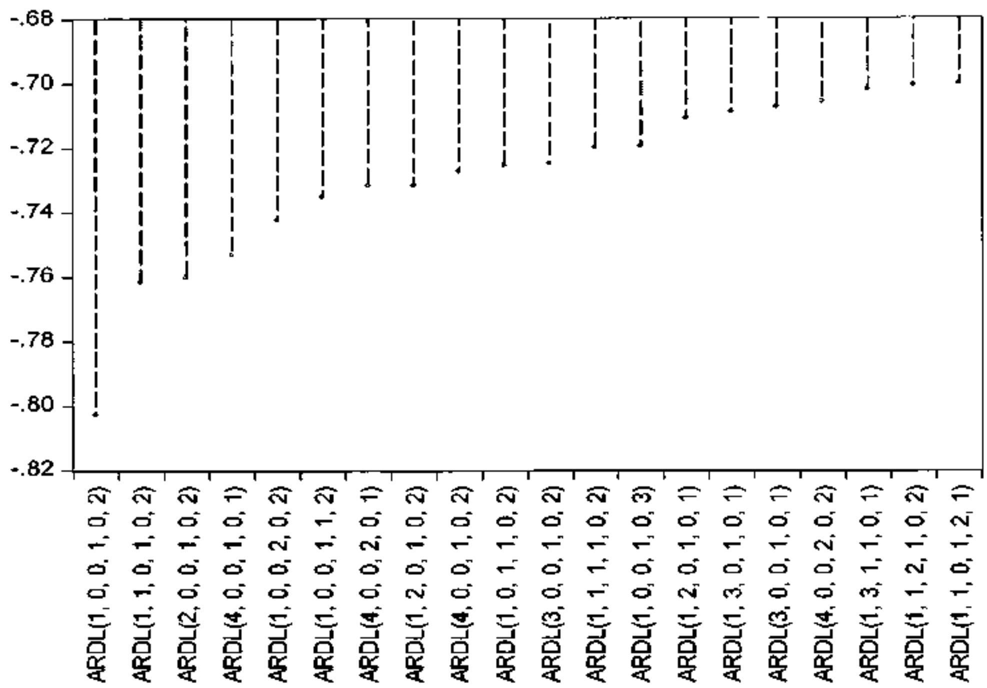
While testing the order of integration for our variables to be used in this study, we note that some variables are integrated of order one, I(1); whereas, others are integrated of order zero, I(0). Hence, we use ARDL bounds testing approach which may be the best method in this context.

6.2.1 Model Selection Criteria

We use Schwarz information criterion (SIC) for model selection because it gives us a more parsimonious model as compared to other criterion like Akaike information criterion (AIC), Hannan-Quinn information criterion (HQC), etcetera.

We start by choosing maximum 04 number of lags for each variable. The automatic procedure implemented in Eviews 9.0 considers 12500 various specifications and generates a summary of top 20 models as shown in Figure 6.1. It is clear from Figure 6.1 that a model where first variable (REER) is lagged once, the next two variables (PROD and TOT) are not lagged, fourth variable (NFA) is lagged once, fifth variable (INV) is not lagged and the sixth variable (PRCD) is lagged twice is the best specification (See Appendix, Table 6.9).

Figure 6.1: Schwarz Criteria (top 20 models)



6.2.2 Co-integration test of ARDL model

We estimate unrestricted equilibrium error correction model (UECM) of Equation 5.4 and report its result in Table 6.2. Specification for the fitness of model is R-squared (0.672) and adjusted R-squared (0.602).

Table 6.2: Estimation Based on Equation 5.4.

Dependent Variable: $\Delta REER_t$			
Variable	**Coefficient**	**t-value**	**p-value**
Constant	-1.3570***	-3.1417	0.0031
ΔNFA_t	-1.5069	-1.5898	0.1194
$\Delta PRCD_t$	-0.5134***	-2.8427	0.0069
$\Delta PRCD_{t-1}$	-0.4869***	-3.3675	0.0016
$PROD_{t-1}$	-0.1212*	-1.7097	0.0947
TOT_{t-1}	0.3216***	3.3681	0.0016
NFA_{t-1}	1.6819***	2.6797	0.0105
INV_{t-1}	0.9049***	3.8548	0.0004
$PRCD_{t-1}$	-0.3642**	-2.1640	0.0362
$REER_{t-1}$	-0.1716***	-2.6961	0.0101
$Lprod_{t-1}$	-0.707*	$Ltot_{t-1}$	1.87***
$Lnfa_{t-1}$	9.8***	$Linv_{t-1}$	5.27***
$Lprcd_{t-1}$	-2.12**		
R^2	0.672	R^2_{adj}	0.602
F-statistic	9.59 (0.000)	SIC	-0.452
DW	1.719	S.E. of Regression	0.146
R.S.S	0.906	LL	31.51

Note: Estimated unrestricted error correction model is chosen on the basis of Schwarz information criterion (SIC). Δ shows difference or change in a variable. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively. NFA is net foreign assets, PRCD is private credit, PROD is difference in productivity, TOT is terms of trade, INV is investment and REER is real effective exchange rate. R^2, R^2_{adj}, SIC, DW, R.S.S and LL denote R-squared, adjusted R-squared, Schwarz information criterion, Durbin-Watson stat, residual sum of squared and log likelihood, respectively. L s' are the estimated coefficients of long run defined by $\beta^{\wedge} = -\lambda_i^{\wedge}/\lambda_1$ (See equation 5.4, where, λ_1 is the coefficient of REER and $\lambda^{\wedge}$ is the coefficient of other explanatory variables such as NFA, PRCD, PROD, TOT and INV).

We follow method of Kamas and Joyce (1993) to select optimum lag lengths using Schwarz information criterion to construct unrestricted error correction model (UECM) and report its result in Table 6.2. Moreover, the coefficient of net foreign assets is not statistically significant in the short run, however, contribution from private credit to real effective exchange rate is about -0.51 percent in the short run and short run lag-one period of private credit elasticity is -0.49 percent and are significant at 1 percent level of significance, means that, keeping other variables constant, if private credit changes by 1 percent, real effective exchange rate changes by -0.51 percent and changes of 1 percent in one year lagged of private credit changes real effective exchange rate by -0.49 percent keeping other variables constant. Furthermore, long run multiplier between productivity differentials and real effective exchange rate is – (-0.1212 / (-0.1716)) = - 0.71, means that an increase of 1% percent in productivity differentials leads to a decrease of 0.71 percent in real effective exchange rate keeping other variables constant and is significant at 10 percent level of significance. It shows that relative productivity grows faster in non-tradable goods than tradable ones. Moreover, Terms of trade is significant at 1 percent significance level and exerts a positive impact on real effective exchange rate. This result denotes that in the long run, other variables are kept constant, a 10 percent increase in terms of trade increases real effective exchange rate by 18.7 percent per year. The net foreign assets have a positive impact on real effective exchange rate and the impact of this variable is relatively high and significant at 1 percent level, means that a 1 percent increase in net foreign assets increases real effective exchange rate by 9.8 percent in the long run, all other things remain constant. Table 6.2 also depicts that investment has a significant and positive influence on real effective exchange rate at 1 percent level of significance keeping other variables constant. This result shows that in the long run a 1 percent increase in investment increases real effective exchange rate by 5.27 percent. As far as private credit is concerned, it has also significant impact on real effective exchange rate but it is negative, means that a 1 percent increase in private credit leads to decrease of real effective exchange rate by 2.12 percent at 5 percent significance level, all other things remain constant. The results of terms of trade, net foreign assets, private credit and investment are consistent with the previous literature (Lamouchi and Zouari, 2013).

In Table 6.3, the calculated F-statistic is 11.82 which is greater than upper bound critical value at 1% recommended by Pesaran et al (2001) and Narayan (2004). As a result, the null hypothesis of no co-integration is rejected at 1% level of significance and it indicates that there exists a long run relationship among REER, PROD, TOT, NFA, INV and PRCD.

Table 6.3: Bounds Check for Co-integration Test.

Critical value	Lower Bound Value	Upper Bound Value
1%	3.41	4.68
5%	2.62	3.79
10%	2.26	3.35

Note: Calculated F-statistic: 11.821, (Significant at 5% level).Critical Values are quoted from Pesaran et al. (2001), Table CI (iii), Case III: Unrestricted intercept and no trend.

Once we obtain co-integration, then we move towards second stage of the process, that is estimation of the lagged error correction term (Ecm_{t-1}) See Appendix, Table 6.11. The mentioned term is negative as well as highly significant as expected which helps us that there is co-integration among the variables. Feedback parameter has coefficient of -0.157 which suggests that when real effective exchange rate exceeds its long run relationship with productivity differentials, terms of trade, net foreign assets, investment and private credit, it adjusts downwards at a rate of 15.7 percent per year. Therefore, this finding shows that it approximately takes three years and three months for deviations of 50 percent from long run equilibrium to be adjusted.

Over all the tests indicate that the model is homoscedastic, the model has accurate functional form and residuals are uncorrelated serially. Thus, the outcomes are reliable to be interpreted.

6.2.3 Stability Tests

Figure 6.2 and 6.3 depict result of cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ). Plots of CUSUM and CUSUMSQ stay within the critical bounds showing that all coefficients of unrestricted error correction model (UECM) are stable. Thus, there is neither any structural change nor instability at 5 percent level of significance which is represented by the straight lines.

Figure 6.2: Plot of Cumulative Sum of Recursive Residuals for Equation 5.4.

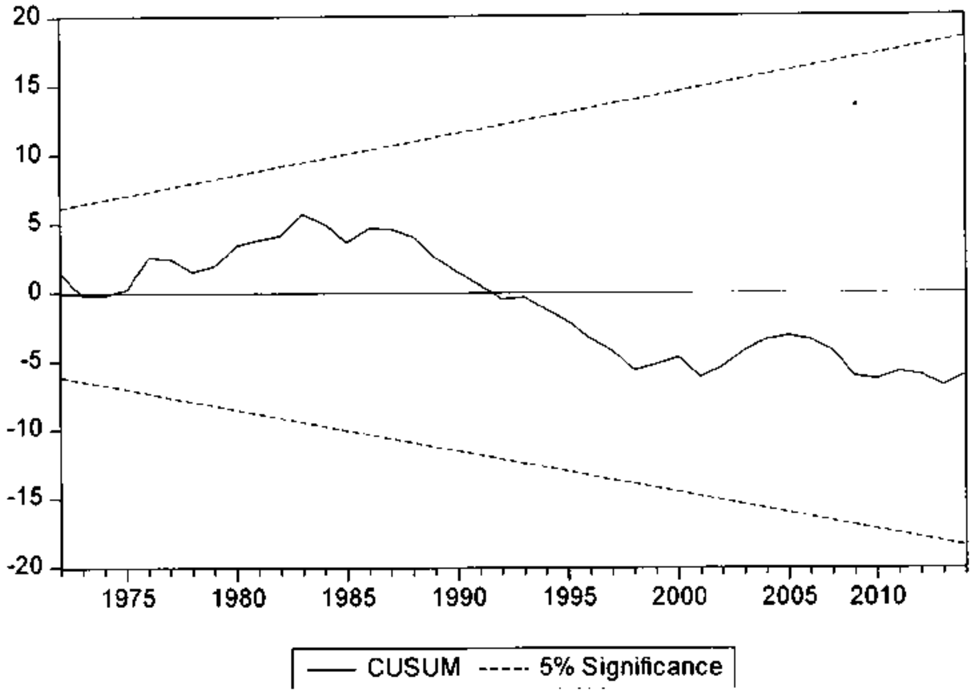


Figure 6.3: Plot of Cumulative Sum of Squares of Recursive Residuals for Equation 5.4.

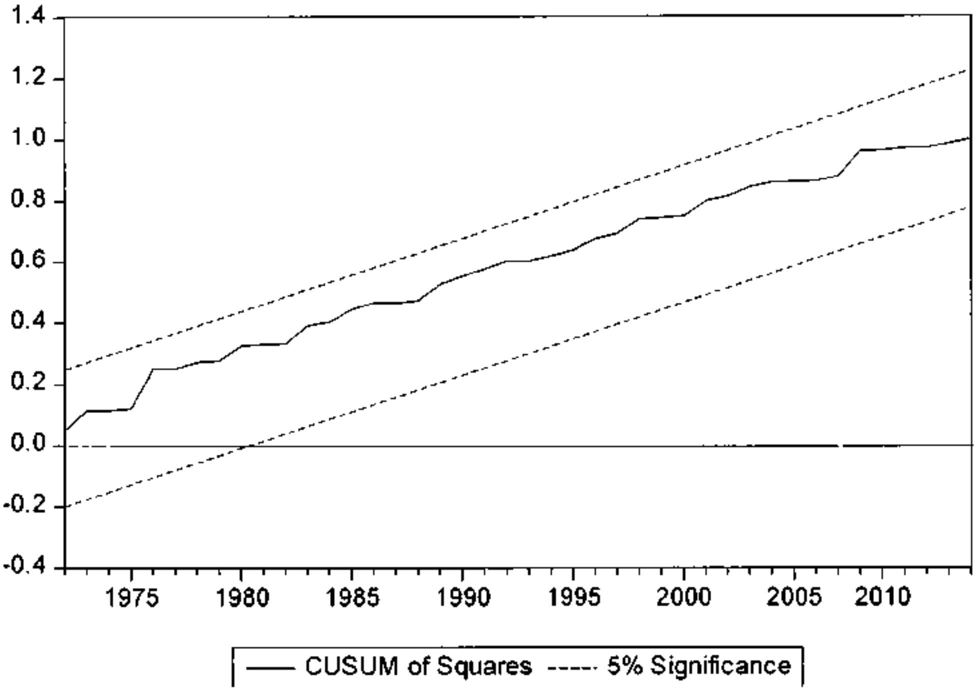


Table 6.4: Diagnostic and Stability tests of Equation 5.4.

x^2_{SC}	1.428 (0.232)	x^2_{FF}	0.653 (0.424)
x^2_{NORM}	8.56 (0.013)	x^2_{HET}	12.88 (0.168)
CUSUM test	Stable	CUSUMSQ test	Stable

Note: x^2_{SC}, x^2_{FF}, x^2_{NORM}, x^2_{HET}[37], CUSUM test and CUSUMSQ test indicate serial correlation LM tests, functional form, normality, heteroscedasticity, cumulative sum and cumulative sum of squares, respectively.

6.3 Asymmetric Autoregressive Distributed Lag (ARDL) Cointegration or Non-Linear ARDL (NARDL) model

6.3.1 Co-integration test of NARDL model

In this section we conduct cointegration test (joint null hypothesis) to determine whether long run cointegrating relationship exists among the variables or not. We use NARDL method and present estimation of NARDL model in Table 6.5. We choose general to specific approach to select maximum lags and drop all insignificant lags sequentially. Specification for the fitness of model is R-squared (0.975) and adjusted R-squared (0.94).

[37] Breusch- Godfrey serial correlation for LM test. Ramsey Reset test for functional form, Jerque-Bera test for normality and Breusch- Pagan Godfrey for heteroscedasticity.

Table 6.5: Asymmetric Estimation based on Equation 5.9.

Dependent Variable: $\Delta REER_t$			
Variable	**Coefficient**	**t-value**	**p-value**
Constant	-46.4393	-0.7259	0.4772
ΔNFA^{+}_{t-1}	-0.5338	-0.5769	0.5711
ΔNFA^{-}_{t-4}	-2.4278**	-2.7585	0.0129
$\Delta PRCD^{+}_{t-9}$	-0.5061**	-2.6943	0.0148
$\Delta PRCD^{-}_{t-1}$	0.4678**	2.5929	0.0184
$\Delta PROD^{+}_{t-1}$	3.6752***	3.5814	0.0021
$\Delta PROD^{+}_{t-2}$	1.5853***	5.1149	0.0001
$\Delta PROD^{-}_{t-3}$	0.2661*	1.9124	0.0719
ΔINV^{+}_{t-1}	-0.4925*	-1.8709	0.0777
ΔINV^{-}_{t-1}	0.4772	1.0944	0.2882
ΔTOT^{+}_{t}	1.6431***	3.5953	0.0021
ΔTOT^{+}_{t-1}	1.0514***	2.8781	0.0100
ΔTOT^{-}_{t}	-0.8715***	-4.5450	0.0003
ΔTOT^{-}_{t-2}	0.6638***	3.4606	0.0028
$\Delta REER_{t-8}$	0.1138*	1.9052	0.0729
$PROD^{+}_{t-1}$	-1.3561***	-3.5388	0.0023
$PROD^{-}_{t-1}$	-6.1775	-0.6935	0.4969
TOT^{+}_{t-1}	-1.2309**	-2.6263	0.0171
TOT^{-}_{t-1}	-0.2345***	-1.7341	0.1000
NFA^{+}_{t-1}	-0.8248*	-1.7869	0.0908
NFA^{-}_{t-1}	3.4795***	3.0964	0.0062
INV^{+}_{t-1}	1.0191***	5.5292	0.0000
INV^{-}_{t-1}	-0.6325*	-2.0512	0.0551
$PRCD^{+}_{t-1}$	0.3293	1.4593	0.1617
$PRCD^{-}_{t-1}$	-0.4894**	-2.6429	0.0165
$REER_{t-1}$	-0.5699***	-11.5789	0.0000

$LPROD^{+}_{t-1}$	-2.38***	$LPROD^{-}_{t-1}$	-10.84	$LPRCD^{+}_{t-1}$	0.578
$LPRCD^{-}_{t-1}$	-0.859 **	$LNFA^{+}_{t-1}$	-1.45*	$LNFA^{-}_{t-1}$	6.105***
$LINV^{+}_{t-1}$	1.79***	$LINV^{-}_{t-1}$	-1.11*	$LTOT^{+}_{t-1}$	-2.16**
$LTOT^{-}_{t-1}$	-0.41***				

R^2 0.975 R^2_{adj} 0.94 F-statistic 28.15 (0.000) SIC -2.145

DW 2.4 S.E. of Regression 0.042 R.S.S 0.032 LL 96.39

Note: Estimated dynamic unrestricted asymmetric or NARDL model is chosen on the basis of general to specific approach and drop all insignificant stationary variables sequentially. Δ shows difference or change in a variable. ***, ** and * indicate 1%, 5% and 10% levels, respectively.

NFA is net foreign assets, PRCD is private credit, PROD is difference in productivity, TOT is terms of trade, INV is investment and REER is real effective exchange rate. The superscripts "+" and "-" shows partial sums of positive and negative, respectively. R^2, R^2_{adj}, SIC, DW, R.S.S and LL stand for R-squared, adjusted R-squared, Schwarz criterion, Durbin-Watson stat, residual sum of squared and log likelihood, respectively. L s' are the estimated coefficients of long run defined by $\beta^{\wedge} = -\lambda_i^{\wedge}/\lambda_1$ (See Equation 5.9, where, λ_1 is the coefficient of REER and $\lambda^{\wedge}$ is the coefficient of other explanatory variables such as NFA. PRCD, PROD, TOT and INV).

Turning now to the asymmetric short run coefficients, the relative Wald tests (Table 6.6) are highly significant for productivity differentials, private credit and terms of trade, however, short run asymmetry Wald tests are statistically insignificant for investment and net foreign assets. Moreover, short run coefficient of $\Delta prod_{t-1}^{+}$, $\Delta prod_{t-2}^{+}$ and $\Delta prod_{t-3}^{-}$ are 3.67, 1.58 and 0.266, respectively. The results show that a 1 percent positive change in one period lagged of productivity differentials suggesting an impact of appreciation in real effective exchange rate by 3.67 percent. Similarly, if a two-period lagged of productivity differentials changes positively by 1 percent, it recommends that real effective exchange rate increases by 1.58 percent. On the other hand, a 1 percent negative change in a three-period lagged of productivity differentials has an effect of depreciation on real effective exchange rate by 0.266 percentage point. Simply put, in the short run, positive changes of productivity differentials have a considerably greater impact on real effective exchange rate compared to the negative ones. Short run coefficients of $\Delta prcd_{t-9}^{+}$ and $\Delta prcd_{t-1}^{-}$ are -0.51 and 0.467, respectively. The results demonstrate that a 1 percent positive change in a nine-period lagged of private credit leads to depreciation of real effective exchange rate by 0.51 percentage point, however, a 1 percent negative change in a one- period lagged of private credit tends to depreciate real effective exchange rate by 0.467 percentage point. Furthermore, Short run coefficients of Δtot_{t}^{+}, Δtot_{t-1}^{+}, Δtot_{t}^{-} and Δtot_{t-2}^{-} are 1.64, 1.05, -0.87 and 0.66, respectively. It means that a 1 percent positive change in terms of trade leads to appreciate real effective exchange rate by 1.64 percent. Similarly, a 1 percent positive change in a one-period lagged of terms of trade suggests an impact of appreciation in real effective exchange rate by 1.05 percent. In contrast, if negative component of terms of trade is changed by 1 percent, it yields an impact of appreciation in real effective exchange rate by 0.87 percentage point, however, real effective exchange rate is deprecated by 0.66 percent if 1 percent negative change occurs in a two-period lagged of terms of trade. Simply we can say that negative changes of terms of trade dominate the response of real effective exchange rate, compared to negative components of terms of trade at lag two. Moving to the coefficients of Δnfa_{t-1}^{+}, Δnfa_{t-4}^{-}, Δinv_{t-1}^{+} and Δinv_{t-1}^{-}, short run coefficient of net foreign assets and investment are insignificant because they accept the null of short run asymmetrical Wald tests.

Moving to the interpretation of long run coefficients presented in Table 6.5, both positive($Linv_{t-1}^{+}$) and negative ($Linv_{t-1}^{-}$) long run coefficients of investment are significant. The long run coefficients of $Linv_{t-1}^{+}$ and $Linv_{t-1}^{-}$are 1.79 and -1.11, respectively. We may conclude that a 1 percent increase in investment results a 1.79 percent (increase) appreciation in real effective exchange rate. Likewise, a 1 percent decrease in investment results a 1.11 percent appreciation (increase) in real effective exchange rate. Indeed, the great effect is from positive changes. Both positive ($Ltot_{t-1}^{+}$) and negative ($Ltot_{t-1}^{-}$) long run coefficients of terms of trade are also significant. The long run coefficients of $Ltot_{t-1}^{+}$ and $Ltot_{t-1}^{-}$ are -2.16 and -0.41, respectively. It is concluded that a 1 percent increase in terms of trade would depreciate (decrease) real effective exchange rate by 2.16 percent. On the other hand, a 1 percent decrease in terms of trade would appreciate (increase) real effective exchange rate by 0.41 percent. Regarding $Lnfa_{t-1}^{+}$ and $Lnfa_{t-1}^{-}$, a 1 percent increase of net foreign assets lowers real effective exchange rate by about 1.45 percent. Similarly, a 1 percent decrease of net foreign assets decreases real effective exchange rate by 6.105 percent. Thus, decrease has noticeable effect on real effective exchange rate because impact from negative component of net foreign assets on real effective exchange rate is comparatively bigger. Relative Wald test shows that long run asymmetry is insignificant in case of $Lprod_{t-1}^{+}$ and $Lprod_{t-1}^{-}$. Moving to the long run coefficients of $Lprcd_{t-1}^{+}$ and $Lprcd_{t-1}^{-}$, private credit does not have increasing effects on real effective exchange rate in the long run, however, a 1 percent decline in private credit would appreciate (increase) real effective exchange rate by 0.859 percent in the long run.

Table 6.6: Long run Short run Symmetry Wald tests based on Equation 5.9.

$W_{LR, PROD}$	0.29 (0.596)	$W_{LR, PRCD}$	5.02**(0.0378)
$W_{LR, NFA}$	23.48***(0.0001)	$W_{LR, INV}$	15.74***(0.0009)
$W_{LR, TOT}$	3.81*(0.0668)	$W_{SR, PROD}$	19.93***(0.0003)
$W_{SR, PRCD}$	16.24***(0.0008)	$W_{SR, NFA}$	2.1 (0.164)
$W_{SR, INV}$	2.597 (0.1244)	$W_{SR, TOT}$	27.98***(0.0000)

Note: ***, ** and * indicate 1%, 5% and 10% levels, respectively. NFA is net foreign assets, PRCD is private credit, PROD is difference in productivity, TOT is terms of trade, INV is investment and REER is real effective exchange rate. W_{LR} refers to the long run symmetry null hypothesis and is defined by $-\lambda_i^+/\lambda_1 = -\lambda_i^-/\lambda_1$. W_{SR} refers to the short run symmetry null hypothesis and is defined by $\sum_{i=0}^{q}\phi_i^+ = \sum_{i=0}^{q}\phi_i^-$.

Wald test is applied for both long run (W_{LR}) and short run (W_{SR}) to confirm the correctness of an asymmetric model. The result depicted in Table 6.6 denotes the acceptance of alternative hypothesis of long run symmetry between positive and negative decompositions of each of the variables. Moreover, the Wald test for private credit is 5.02 (p-value = 0.0378), for the components of net foreign assets is found to be 23.48 (p-value = 0.0001), the Wald test for investment components is 15.75 (p-value = 15.74), long run Wald test for terms of trade components is 3.81 (p-value = 0.0668), however, long run symmetry null hypothesis between positive and negative productivity components is accepted. In addition, short run symmetry null hypothesis using Wald test against alternative one is also tested. In the lower panel of Table 6.6, short run Wald test for productivity differentials is 19.93 (p-value = 0.0003). Likewise, short run Wald tests for private credit and terms of trade are 16.24 (p-value = 0.0008) and 27.98(p-value = 0.0000), respectively. Whereas, short run symmetry Wald tests are accepted in case of investment and net foreign assets which are 2.597 (p-value = 0.1244) and 2.1 (p-value = 0.164), respectively.

Next, we apply cointegration test, more specifically, we examine whether the lagged level variables' coefficients are jointly equal to zero ($\lambda_1 = \lambda_2^+ = \lambda_2^- = \lambda_3^+ = \lambda_3^- = \lambda_4^+ = \lambda_4^- = \lambda_5^+ = \lambda_5^- = \lambda_6^+ = \lambda_6^- = 0$) against alternative ($\lambda_1 \neq \lambda_2^+ \neq \lambda_2^- \neq \lambda_3^+ \neq \lambda_3^- \neq \lambda_4^+ \neq \lambda_4^- \neq \lambda_5^+ \neq \lambda_5^- \neq \lambda_6^+ \neq \lambda_6^- \neq 0$) or not. Our results show existence of statistically significant long run cointegration relationship among REER, $PROD^+$, $PROD^-$, TOT^+, TOT^-, NFA^+, NFA^-, INV^+.

INV^{-}, $PRCD^{+}$and $PRCD^{-}$. The F-statistic is calculated in Table 6.7 for testing the joint restrictions and found to be 22.99 which is significant at 1 percent level. It suggests that there exists a long run relationship among REER, PROD, TOT, NFA, INV and PRCD because its value exceeds the upper bound critical value.

Table 6.7: Bounds Check for Co-integration Test.

Critical value	Lower Bound Value	Upper Bound Value
1%	2.54	3.86
5%	2.06	3.24
10%	1.83	2.94
Note: Calculated F-statistic: 22.99, (Significant at 5% level).Critical Values are quoted from Pesaran et al. (2001), Table CI (iii), Case III: Unrestricted intercept and no trend.		

Our diagnostic tests show that the model is homoscedastic, the model has accurate functional form, residuals are normally distributed and residuals are uncorrelated serially. Thus, the outcomes are reliable to be interpreted.

6.3.2 Stability Tests

Figure 6.4 and 6.5 depict result of cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ). Plots of CUSUM and CUSUMSQ stay within the critical bounds showing that all coefficients of nonlinear unrestricted error correction model (UECM) are stable. Thus, there is neither any structural change nor instability at 5 percent level of significance which is represented by the straight lines.

Table 6.8: Diagnostic and Stability tests of Equation 5.9.

x^2_{SC}	3.175 (0.074)	x^2_{FF}	0.524 (0.478)
x^2_{NORM}	4,245 (0.119)	x^2_{HET}	21.09 (0.687)
CUSUM test	Stable	CUSUMSQ test	Stable
Note: x^2_{SC}, x^2_{FF}, x^2_{NORM}, x^2_{HET}[38], CUSUM test and CUSUMSQ test indicate serial correlation LM tests, functional form, normality, heteroscedasticity, cumulative sum and cumulative sum of squares, respectively.			

[38] Breusch- Godfrey serial correlation for LM test, Ramsey Reset test for functional form, Jerque-Bera test for normality and Breusch- Pagan Godfrey for heteroscedasticity.

Figure 6.4: Cumulative Sum test on NARDL equation 5.9 with LR and SR Asymmetry.

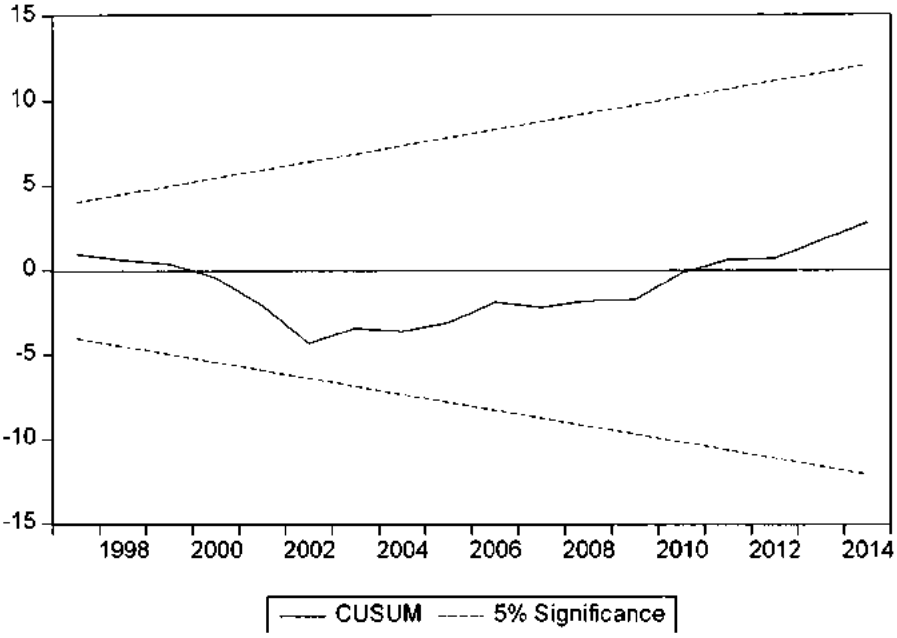
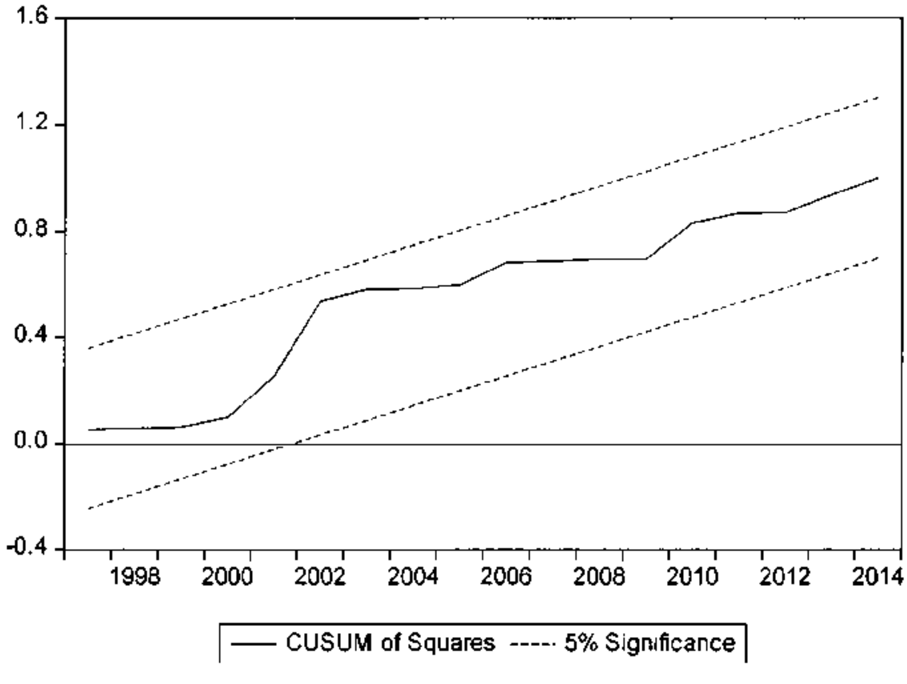


Figure 6.5: Cumulative Sum of Squares of Recursive Residuals test on NARDL Equation 5.9 with LR and SR Asymmetry.



Chapter 7

Conclusion

This chapter contains three sections. In section one; we describe the conclusion of whole thesis. Section two includes policy recommendations for policy makers and future research in this area.

7.1 Conclusion

Exchange rate is one of the macroeconomic variables that links one country with the rest of the world both in goods and assets markets; however, misrepresentation of trade opportunities and misallocation resources are due to poor policy of exchange rate in an economy. Therefore, to maintain economic stability, it is important to identify the characteristics of exchange rate.

The relationship between real effective exchange rate and macroeconomic variables has been debated since 1970s. The first generation models include the flexible price monetary model developed in 1970, the sticky price monetary model developed in 1976, liquidity and equilibrium models developed in 1980 and the portfolio balance model developed in 1982. These first generation models have a claim that changes in exchange rates are associated linearly to news in macroeconomic variables; however, this claim was rejected by empirical analysis. Later on, researchers started searching for another direction. The first direction one would say "second generation models" was introduced with the assumption that the coefficients of reduced form equations should not be constant, rather they are changed by stochastic disturbances. In contrast, analyses of second generation models were limited, so they proved themselves to be false. Thus, second direction has been taken alternative to first generation models via introducing nonlinearities in the models (Frankel and Froot, 1990; De Grauwe and Dewachter, 1993; Kilian and Taylor, 2003).

Although a number of studies have been conducted for Pakistan (Zakaria and Ahmad, 2009; Zakaria and Ghauri, 2011; Abbas et al., 2011) which mostly focused on the long run relationship between exchange rate and macroeconomic variables; however, none of them have discussed the asymmetric effects between real effective exchange rate and selected macroeconomic variables. Thus, apart from linear analysis, this study also attempts to explore the nonlinear relationship between real effective exchange rate and macroeconomic variables for Pakistan.

In this study, we test the real effective exchange rate-macroeconomic variables nexus by applying linear Autoregressive distributed Lag (ARDL) model developed by Pesaran et al., 2001 to investigate the linear cointegration and asymmetric Autoregressive distributed Lag model or non-linear ARDL (NARDL) model recommended by Shin et al, 2011) to test the nonlinear cointegration among the variables. In addition, we test cointegration for both of the mentioned models and find out cointegration among REER, PROD, TOT, NFA, INV and PRCD which means that there exists a long run relationship among afore-named variables in both ARDL and NARDL models. Indeed, information provided by linear analysis may not be sufficient to present reliable forecast. Therefore, our exploration contributes to the literature by applying the mentioned nonlinear model on the basis of ARDL approach which presents a simple tool for joint exploration of short and long run asymmetries. The data period ranges from 1960-2014 and includes exchange rate, productivity differentials, terms of trade, net foreign assets, investment to GDP and private credit to GDP. Interesting result of this literature is that asymmetry direction might change between long run and short run. For instance, a positive change might have a greater absolute impact in the short run. On the other hand, a negative change might have a greater absolute impact in the long run or vice versa. More specifically, our findings of linear ARDL cointegration show that only short run coefficient of private credit has a significant impact on real effective exchange rate negatively. Regarding long run coefficients, terms of trade, net foreign assets and investment have positive and significant impacts on real effective exchange rate, while private credit and productivity differentials have negative and significant impacts on real effective exchange rate. Turning to the findings of asymmetric ARDL methodology, our results show the existence of long run asymmetric impacts from terms of trade, net foreign assets, investment and private credit towards real effective exchange rate. Regarding short term, we detect significant adjustment impacts running from productivity differentials, private credit and terms of trade towards real effective exchange rate. However, the sensitivity of real effective exchange rate is different to positive or negative changes of macroeconomic variables.

7.2 Policy Recommendation

The policy recommendation derived from our results shows that the relationship between real effective exchange rate and macroeconomic variables might be nonlinear, policy makers do not keep in mind the constant elasticity depicted by linear analysis rather they ought to provide suitable and acceptable policies in accordance to environment. Furthermore, results of this study show the following important points as policy implication for policy of exchange rate in Pakistan.

First, macroeconomic variables affect real effective exchange rate either positively or negatively, hence, REER can not be kept fixed. Second, flexible exchange rate policy may be maintained in order to compete in the market globally. Third, policy measures have to be introduced, identified and may be corrected immediately in case of deviation of exchange rate from its equilibrium point. Fourth, greater coordination is needed among stakeholders: Board of Investment and Planning Commission, the SBP and government, Export Promotion Bureau, the Latter Comprising Finance, Commerce. Fifth, facilities may be provided at local, provincial and federal level. Sixth, policy of exchange rate failed in Pakistan for a number of reasons. One of the important reasons is devaluation because of poor monetary policy. Besides, increase in money supply yielded a high rate of inflation that further caste a neutralized impact on real exchange rate of Pakistan and Pakistan was not able to obtain any target from devaluation. Therefore, it is necessary for the SBP to have tight monetary policy in order to handle real exchange rate except in case of emergency, it may devalue its currency. Seventh, it is also necessary for Pakistan to diversify its export to have a competitive place in the world. Indeed, this objective can be fulfilled if attention is paid to foreign direct investment (FDI) that is received by exports industries which use comparative advantages of country. As a result, it will create links between Transnational Corporations (TNCs) and domestic firms that further let local firms use technological expertise and finally move towards production systems of integrated worldwide. Eighth. the structure of Pakistan's export recommend that it is required for the policy to be shifted, means that exports may be diversified in value-added products and it can be done only if strategies are well-defined and consistent. Similarly, it is also needed that exports may be diversified in such products in which Pakistan has less cost and has comparative advantages that will help in boosting the exports of Pakistan. Furthermore, Pakistan does not have a well-developed processing industry although fish, fruit and vegetables are produced abundantly. One of the main reasons is lack of canning and storage facility. Products of agro based such as dairy products, vegetables, fruits and fish can enhance domestic production and exports by adopting modern technology for packing, processing and storage, etcetera. In conclusion, we would say that the Trade Development Authority of Pakistan (TDAP) which was previously known as Export Promotion Bureau may build storage in areas where fruits and other products are grown to handle productions of farms for exports purposes. Ninth, there are structural reasons such as energy crisis which have adversely affected the export growth, the recent decline can be attributed to a loss in the price competitiveness of domestic products in International market.

7.3 Limitations and Directions for Future Research

Though NARDL model has some advantages, it has some limitations as well, namely, the mentioned model denotes existence of asymmetry and identifies its degree, however, it does not let us know that what are causes lie behind this. Secondly, by explanation of positive and negative partial sums decomposition, this model assumes a zero threshold. Moreover, it is argued by Granger and Yoon (2002) that interpretation of estimation becomes so easy and natural when a zero threshold is used, this assumption might be limited, however.

Future research in the area of newly developed asymmetric ARDL method can be carried out by allowing error correction term or speed of adjustment and panel data can be used for future research.

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Appendix

Table A contains major trading partners of Pakistan along with their weights.

Table 5.1: List of Main Trading Partners.

S.No	Country	Weight
1	China	0.246373
2	United States of America	0.140997
3	Saudi Arabia	0.13373
4	Singapore	0.126971
5	Kuwait	0.079434
6	United Kingdom	0.066991
7	India	0.061963
8	Germany	0.061915
9	Japan	0.047629
10	Malaysia	0.033998
		1

Table 5.2: Summary Statistics

Variables	Observations	Mean	Median	Std. Dev.	Maximum	Minimum
REER	55	0.0384	0.0311	0.0258	0.1068	0.0084
PROD	55	5504.75	610.679	25578.8	182922	306.3807
TOT	55	1.6008	1.3663	0.5561	2.7987	0.8054
NFA	55	0.0227	0.0196	0.0475	0.1156	-0.0658
INV	55	18.3709	17.0252	8.1314	61.4105	11.4351
PRCD	55	27.8305	24.8132	9.8156	64.1812	15.4392

Note: All the variables are taken in their original forms. REER represents real effective exchange rate. PROD stands for productivity differentials. TOT is the abbreviation of terms of trade. NFA stands for net foreign assets. INV shows investment to GDP and PRCD is the abbreviation form of private credit to GDP. The table uses time series data set calculated from 1960-2014 for Pakistan against its top ten major trading partners.

Table 5.3: Correlation Matrix

	REER	PROD	TOT	NFA	INV	PRCD
REER	1					
PROD	-0.2153	1				
TOT	0.5681	0.2642	1			
NFA	-0.2353	0.2411	0.1122	1		
INV	-0.1485	0.7693	0.3283	0.2724	1	
PRCD	0.0419	0.5714	0.5113	0.3494	0.8334	1

Note: All the variables are taken in their original forms. REER denotes real effective exchange rate. PROD represents productivity differentials. TOT and NFA are the abbreviation forms of terms of trade and net foreign assets, respectively. INV represents investment to GDP and PRCD shows private credit to GDP. The table uses time series data set ranging from 1960-2014 for Pakistan against its top ten major trading partners.

Table 6.9: Model Selection Criteria (Top 20 Models).

Dependent Variable: REER, Method: ARDL			
The estimation sample is 1962-2014			
Maximum dependent lags: 4 (Automatic selection)			
Model selection method: Schwarz information criterion (SIC)			
Dynamic regressors (4 lags, automatic): PROD, TOT, NFA, INV and PRCD			
Fixed regressors: C			
Number of models evaluated: 12500			
Selected Model: ARDL(1, 0, 0, 1, 0, 2)			
Variable	**Coefficient**	**t-value**	**p-value**
$\mathbf{REER_{t-1}}$	0.8092	14.4910	0.0000
$\mathbf{PROD_t}$	-0.2359	-3.3063	0.0019
$\mathbf{TOT_t}$	0.2677	3.2580	0.0022
$\mathbf{NFA_t}$	-0.7854	-0.9109	0.3675
$\mathbf{NFA_{t-1}}$	3.0592	3.5810	0.0009
$\mathbf{INV_t}$	1.1556	6.1385	0.0000
$\mathbf{PRCD_t}$	-0.8004	-4.4149	0.0001
$\mathbf{PRCD_{t-1}}$	-0.0051	-0.0307	0.9757
$\mathbf{PRCD_{t-2}}$	0.5339	3.9769	0.0003
Constant	-1.6669	-4.8595	0.0000
R^2	0.96	R^2_{adj}	0.96
F-statistic	126.3 (0.000)	SIC	-0.65
DW	1.66	S.E. of Regression	0.133
R.S.S	0.74	LL	36.76

Note: ARDL is autoregressive distributed lag model, REER is real effective exchange rate, PRCD is private credit, PROD is difference in productivity, TOT is terms of trade, INV is investment and C is constant. R^2, R^2_{adj}, SIC, DW, R.S.S and LL denote R-squared, adjusted R-squared, Schwarz information criterion, Durbin-Watson stat, residual sum of squared and log likelihood, respectively.

Table 6.10: OLS Estimation Results.

Dependent Variable: REER, Method: Least Squares			
Variable	**Coefficient**	**t-value**	**p-value**
Constant	-1.2287	-3.1523	0.003
$\mathbf{PROD_t}$	-0.3937	-3.8775	0.0004
$\mathbf{PROD_{t-1}}$	0.1545	2.1082	0.0412
$\mathbf{TOT_t}$	0.1868	2.1268	0.0395
$\mathbf{NFA_t}$	-0.7969	-0.9614	0.342
$\mathbf{NFA_{t-1}}$	2.8884	3.4998	0.0011
$\mathbf{INV_t}$	1.0579	5.6636	0.0000
$\mathbf{PRCD_t}$	-0.5968	-2.9952	0.0046
$\mathbf{PRCD_{t-1}}$	-0.1917	-1.0434	0.3029
$\mathbf{PRCD_{t-2}}$	0.5121	3.9549	0.0003
$\mathbf{REER_{t-1}}$	0.8378	15.1305	0.0000

$$reer_t = \beta_1 + \sum_{i=1}^{p} \delta_{1i} reer_{t-i} + \sum_{i=0}^{p} \phi_{1i} prod_{t-i} + \sum_{i=0}^{p} \varpi_{1i} tot_{t-i} + \sum_{i=0}^{p} \gamma_{1i} nfa_{t-i} + \sum_{i=0}^{p} \theta_{1i} inv_{t-i} + \sum_{i=0}^{p} \eta_{1i} prcd_{t-i} + \mu_t \quad (5.10)$$

R^2	0.97	R^2_{adj}	0.96
F-statistic	123.5 (0.000)	SIC	-0.68
DW	1.67	S.E. of Regression	0.13
R.S.S	0.67	LL	39.44

Note: OLS is ordinary least squares, REER is real effective exchange rate, PRCD is private credit, PROD is difference in productivity, TOT is terms of trade and INV is investment. Equation 5.10 shows long –run model. R^2, R^2_{adj}, SIC, DW, R.S.S and LL denote R-squared, adjusted R-squared, Schwarz information criterion, Durbin-Watson stat, residual sum of squared and log likelihood, respectively.