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Rucha R. Ranadive
L. G. Burange

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Author(s): **Rucha R. Ranadive** **L. G. Burange**	*External Participation:* **---**
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Abstract

The paper attempts to determine the factors affecting the real exchange rate in India. The fundamental determinants considered are productivity differences, government expenditure, foreign institutional investment, openness of the economy, interest rate differentials, inflation differentials, terms of trade, foreign exchange reserves and net foreign assets. The ARDL bounds testing approach confirms the long run relationship between the real exchange rate and these variables for the quarterly data 1993Q1-2011Q4. The error correction term also indicated 76 percent of the convergence towards the long run equilibrium level in the next quarter. The study confirmed the expected theoretical relationship between the variables and the real exchange rate in the long run.

***Key Words*:** Exchange Rate, Determinants, Cointegration, ARDL, VAR, VECM

***JEL Code(s)*:** F 31, C 32

THE DETERMINANTS OF INDIA'S REAL EXCHANGE RATE: AN ARDL APPROACH

Rucha R. Ranadive[1]
L.G. Burange[2]

1. INTRODUCTION:

The exchange rate has always remained a focal point of discussion and concern among policy makers. Any disturbance to the smooth functioning of the economy is immediately manifested in the external value of its currency. Especially, for the Emerging Market Economies (EMEs) like India, a steady exchange rate builds confidence among investors and speculators in the international financial market. Thus, it becomes essential for a country to maintain stability in its exchange rate in global markets. There are many factors underpinning the movement of the exchange rate either directly or indirectly in the external market. There are fundamental as well as monetary determinants of the exchange rate as put forward by Edwards (1988) and others. The analysis of the relationship between these determinants and the exchange rate has been undertaken in this study. We hope to contribute to a deeper understanding of the behaviour of the exchange rate of the rupee in the international financial market.

The paper aims at analysing the determinants of the real exchange rate in India. It investigates econometrically the relationship between the real exchange rate and ten determinants. We examine the long run and short run equilibrium relationships among variables. This analysis isolates the factors which affect the real exchange rate in India. We also compare the expected theoretical relationship between the real exchange rate and other determinants with the actual results derived from data and applied econometric technique in the Indian context.

The remainder of the paper is organised as follows. The theoretical relationship between the real exchange rate and determinants has been explored in

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[1]Research Scholar.
[2]Professor.
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Section *Two* and Section *Three* surveys data sources and methodology used in the analysis. Section *Four* analyses empirical results derived from the econometric analysis. The conclusions have been drawn in the *last* section.

A large literature has analysed various determinants by applying either the Johansen-Juselius or panel data cointegration techniques. Most of these studies confirmed that productivity differentials, terms of trade, net foreign assets, foreign exchange reserves, government expenditure, capital flows, interest rate differentials and degree of openness are some of the major determinants of the real exchange rate (Faruquee, 1995; Aron *et al.*, 1997; Mkenda, 2001; Joyce and Kamas, 2003; Clark and MacDonald, 1998, 2000; Maeso-Fernandez *et al.*, 2001; Nilson, 2002; MacDonald and Dias, 2007; Cottani *et al.*, 1990; MacDonald and Nagayasu, 1999; Drine and Rault, 2001; Villavicencio, 2006; Carrera and Restout, 2008; Ricci *et al.*, 2008).

There have also been many efforts to study factors underlying the behaviour of the exchange rate in India. Choudhury (2000) analysed the real and nominal determinants based on the Edward (1988) model and showed that the terms of trade, capital flows, government expenditure have a positive whereas openness exerts a negative effect on the real exchange rate in India. Using the standard Ordinary Least Squares (OLS) multiple regression analysis technique, Jayraj (2000), Mehta (2000), and Suthar (2008) confirmed that the real exchange rate is affected by foreign exchange reserves, inflation differentials, foreign investment flows, terms of trade and interest rate differences. These results were reasserted by Agarwal (2000), Hariharan (2000), Patnaik and Pauly (2001) and Dash (2012) using other methods. Apart from these studies, Chaudhri and Khan (2004) found that the Balassa-Samuelson effect is present and influences the real exchange rate in the long run in India.

Villavicencio and Bara (2006) explored the real exchange rate behaviour in Mexico from 1960 to 2005 using the Autoregressive Distributed Lag (ARDL) model. Their study demonstrated that the productivity differentials proxied by real GDP per capita differentials, higher interest rates and size of net foreign assets tend to appreciate the real exchange rate of Mexico. In the Indian context, an ARDL model was applied by Kumar (2010) for analyzing determinants of the real exchange rate in

India. He observed that there was a convergence to the long run equilibrium exchange rate. Following the Edwards (1988) model, the impact of productivity differentials, government consumption, foreign exchange assets, terms of trade and external openness has been assessed on the real exchange rate of the rupee against the U.S. $. Considering the quarterly data from 1997Q2 to 2009Q2, he found that productivity differentials were significant and exerted a negative effect on the real exchange rate. Similarly, foreign exchange assets and terms of trade were also significant and negatively correlated with the real exchange rate. External sector openness resulted in depreciation of the exchange rate. Though government consumption had a positive effect on the exchange rate it was found to be insignificant. Thus, productivity differentials, foreign exchange assets, terms of trade and external openness were the main determinants of the exchange rate for India. However, apart from these there are many fundamental variables affecting the real exchange rate such as inflation differentials, interest rate differentials, foreign investment inflow and foreign exchange reserves. He considered the differences in the variables with respect to only the U.S. rather than the other major trading partners of India.

In this paper, we aim to analyse the potential determinants which could affect the real exchange rate considering the major trading partners which has not been attempted by any other study in India. The differentials are computed considering the geometric weighted average of four major trading partners *viz.*, the U.S., the U.K., Euro zone and Japan. The period for the study is from the adoption of the managed floating exchange rate system in India, from 1993 to 2012 on the quarterly basis. Such an attempt would extend the existing research on the determinants of exchange rate in India.

2. EXPLANATORY VARIABLES:

From the literature it is evident that each variable has a distinct relationship with the real exchange rate. In fact some of the theories of the exchange rate determination have established such relationships. Therefore, such variables and their expected theoretical impact on the real exchange rate are outlined in this section.

2.1 Productivity Differentials:

The productivity differential effect on the real exchange rate is referred to as the Balassa-Samuelson hypothesis. According to this hypothesis, the relative price of non-tradables is determined by the productivity differentials between the traded and non-traded sectors. Let us assume

1. The economy comprises of two sectors, tradables and non-tradables.
2. Wages are equal in both sectors and are linked to the productivity in the sector.
3. The law of one price holds in the traded sector.
4. Interest rates are given exogenously.

The real exchange rate is defined as the relative price of non-tradables to tradables *i.e.*,

$$q = \frac{P_N}{P_T} \qquad \text{……..........................} \quad (1)$$

where,

q = Real exchange rate

P_N = Price of non-tradables

P_T = Price of tradables

If the productivity of the traded sector is higher than that of the non-traded sector, wages increase in the entire economy. In the non-traded sector, with lower productivity compared to its counterpart, the price of non-tradables (P_N) rises. This, in turn, increases the relative price of non-tradables (q) *i.e.*, appreciation of the real exchange rate. Formally, assuming a Cobb-Douglas production function and constant returns to scale in both sectors,

$$Y_T = A_T K_T^{1-\alpha} L_T^{\alpha} \qquad \text{.................................} \quad (2)$$

$$Y_N = A_N K_N^{1-\beta} L_N^{\beta} \qquad \text{.................................} \quad (3)$$

where,

Y_T = Total Production of tradables

Y_N = Total Production of non-tradables

A = Total Factor Productivity

K = Capital in the sector

L = Labour in the sector

α = Output elasticity of labour in tradable sector

β = Output elasticity of labour in non-tradable sector

Then, the Balassa-Samuelson effect is given by

$$\hat{q} = \hat{P}_N - \hat{P}_T = \frac{\beta}{\alpha}\hat{A}_T - \hat{A}_N \qquad \text{..............................} \quad (4)$$

where,

$\hat{q}$ = Growth rate of the real exchange rate

$\hat{P}_N$ = Growth rate of Price of non-tradables

$\hat{P}_T$ = Growth rate of Price of tradables

$\hat{A}_N$ = Growth rate of Total Factor Productivity in non-tradable sector

$\hat{A}_T$ = Growth rate of Total Factor Productivity in tradable sector

Thus, according to equation (4), the real exchange rate depends entirely on productivity differentials. The Balassa-Samuelson hypothesis asserts that with development the productivity in the tradables sector increases more than the non-tradable sector *i.e.*, faster growing countries tends to experience an appreciation of the real exchange rate (Carrera and Restout, 2008). The study of Balassa (1964) found a positive relationship between productivity differentials and the real exchange rate. He regressed the real exchange rate on the GDP per capita and found that productivity differentials are positively correlated with the real exchange rate appreciation. This hypothesis also tries to explain recurrent deviations of the real exchange rate from the long run value by relating currency appreciation with different states of productivity growth of countries (Drine and Rault, 2001).

2.2 Government Expenditure:

Traditionally, it is believed that the impact of increased government expenditure falls disproportionately on non-traded goods (Carrera and Restout, 2008). The impact of government expenditure on the real exchange rate depends upon the proportion and distribution of expenditure incurred on the traded or non-traded goods. If government expenditure is more in the non-tradable sector then demand for non-traded goods will increase and prices will go up. This would ultimately appreciate the real exchange rate. However, to finance this expenditure, government would levy higher taxes which would result in lowering of income of households. Since the disposable income of households has gone down the demand for non-tradables would fall and prices will decrease leading to depreciation of the real exchange rate (Edwards, 1988; Drine and Rault, 2001).

2.3 Capital Flows:

Since the collapse of Bretton Woods, advanced economies liberalized their economies. Many developing countries also introduced reforms in order to stabilize their economies. This deepened the foreign exchange market and integrated economies in the world. With flexible exchange rate systems, exchange rates were determined by supply and demand forces in the international capital market. Capital flows affected the exchange rate in the international market through changes in demand and supply. Capital inflows are associated with real exchange rate appreciation in the long run. A surge in capital flows increases the consumption demand for both tradables and non-tradables. In the non-traded sector, an increased demand is not matched by the increased supply to attain equilibrium. Thus, prices of non-tradables go up to reach equilibrium. On the other hand, an increased demand for tradables is matched by an increased supply through imports without altering the price of tradables. However, this results in widening of the trade deficit. Accordingly, a resultant increase in the relative price of non-tradables entails an appreciation of the real exchange rate (Kumar, 2010).

2.4 Openness of the Economy:

When a country liberalizes restrictions on imports, import prices decrease and so do prices of tradable goods, the real exchange rate appreciates. On the other hand, an increase in the demand for imported goods leads to a rise in the demand for foreign currency and depreciates the real exchange rate of the importing country. Conversely, trade liberalization tends to depreciate the long run real exchange rate. Increase in openness reduces tariffs and, thereby, prices of imported goods fall. This generates excess demand for imported goods and reduces the domestic demand for non-tradables. This leads to depreciation of the real exchange rate (Carrera and Restout, 2008).

2.5 Interest Rate Differentials:

The relationship between interest rates and exchange rates is established by the interest rate parity condition. The portfolio balance theories indicate a close link between the exchange rate and the interest rate. If assets are imperfect substitutes, then the lower interest rate compared to other countries creates excess demand for foreign currency as investors take advantage of the interest rate differential between countries. If the domestic authorities do not intervene in the foreign exchange market then this excess demand for foreign currency would depreciate the domestic currency. On the other hand, the central bank alters the exchange rate by changing key interest rates. If any country is offering higher rates of interest on its assets then investors buy more assets of that country. Thus, it attracts capital inflows and the real exchange rate appreciates. Thus, the interest rate and the exchange rates are linked through the financial asset market (Villavicencio and Bara, 2006).

2.6 Inflation Rate Differentials:

A higher rate of inflation in the home country compared to foreign countries will lead to a depreciation of the domestic currency. In general, a country with a relatively higher rate of inflation experiences a decline in the value of its domestic currency (Mkenda, 2001). However, the impact of inflation on the exchange rate will depend upon whether inflation is confined to one country or occurs simultaneously in all countries. If only one country experiences a high rate of inflation, goods of that particular country would be expensive. In order to maintain competitiveness, the exchange rate should depreciate by the extent of the rate of inflation in that country. Thus, the exchange rate of an inflated country depreciates by its rate of inflation and the quantity of currency traded increases by the rate of inflation.

2.7 Terms of Trade:

The terms of trade for each country is defined as the ratio of domestic export unit value to the import unit value relative to the equivalent foreign ratio. Changes in the terms of trade are considered one of the most important sources of real exchange rate fluctuations. The impacts of the terms of trade on the real exchange rate are ambiguous. There are two dominant effects which decide the ultimate impact on the real exchange rate.

A. *Income effect:* Deterioration in the terms of trade induces a negative income effect. A decline in domestic purchasing power reduces the private demand for non-traded goods and the real exchange rate appreciates.
B. *Substitution effect:* This effect makes imported goods more expensive and, thus, shifts demand in favour of non-traded goods. This would increase prices of non-tradables and would depreciate the real exchange rate.

The ultimate effect of the terms of trade depends upon the strength of the income and substitution effect (Carrera and Restout, 2008).

2.8 Foreign Exchange Reserves:

According to the theoretical relationship, foreign exchange reserves exert a positive impact on the real exchange rate. It is considered as a relatively liquid indicator of the stock of national wealth. An improvement in the stock of foreign exchange reserves is expected to appreciate the real exchange rate. Higher foreign exchange reserves increase the capacity and efficiency of the central bank to defend its currency in the foreign exchange market. Higher net foreign exchange reserves induce larger expenditure on domestic goods and raise prices of the non-tradables relative to the tradables and, thus, appreciate the real exchange rate (Aron *et al.*, 1997).

2.9 Net Foreign Assets:

The impact of net foreign assets on the real exchange rate has been studied by Obstfeld and Rogoff (1995) and Lane and Milesi-Feretti (2001). According to them the debtor countries have relatively depreciated real exchange rates. This is called the 'transfer problem'. It operates through the impact of wealth on labour supply. Deterioration in the net foreign asset position reduces national wealth. To prevent a large drop in consumption, households increase labour supply and, thus, increase the supply of non-tradables. Since the non-traded sector is in equilibrium each period the price of non-tradables falls and the real exchange rate depreciates. The rising current account deficit would be financed with excess capital inflows and would lead to the appreciation of the real exchange rate. Thus, the real exchange rate is expected to appreciate with an increase in net foreign assets. Another channel through which net foreign assets affect the real exchange rate is portfolio balance considerations. A deficit in the current account creates an increase in the net foreign debt of a country which needs to be financed by international investors. As a result, they demand higher yield on their investments to adjust their portfolios. If the interest rate remains unchanged this can be achieved through depreciation of the currency of the debtor country (Villavicencio and Bara, 2006).

3.METHODOLOGY:

The following sub-sections describe the method of construction of variables, data sources, sample period and the econometric methodology applied for the analysis.

3.1 Data Sources and Construction of Variables:

In order to analyse determinants of the real exchange rate in India, the study considers the period when the managed floating exchange rate regime was adopted by the Indian economy and thereafter. It uses the quarterly data from 1993 Q1 to 2011 Q4. The data is mainly drawn from the RBI's Handbook of Statistics on Indian Economy, RBI bulletin and National Accounts Statistics. For capturing differences against the foreign counterparts of the Indian economy, the study has selected four major trading partners of India *viz.,* the U.S., the U.K., Euro zone and Japan which have higher share in the total trade of India. Although China is the largest trading partner of India, due to the unavailability of data China has not been considered in the study. The weights of each trading partners have been assigned as per the 6-currency basket trade weights for the NEER and REER indices. Accordingly, the U.S., the U.K., Euro zone and Japan have 34.98 percent, 12.57 percent, 43.58 percent and 8.87 percent weights respectively. The data for these countries have been extracted from the International Financial Statistics of the IMF. For analysis purpose, the construction of variables is discussed below:

3.1.1 Real Exchange Rate (RER):

The real exchange rate has been calculated as its geometric weighted average *viz-à-viz* its four major trading partners following the formula given in Carrera and Restout (2008).

$$q_i = \prod_{j=1}^{n} \left(\frac{P_i}{E_{ij} P_j} \right)^{w_{ij}} \qquad \text{.......................................} \quad (5)$$

where,

q_i = Real Exchange Rate

P_i = Wholesale Price Index of India

P_j = Producer Price Index of the trading partners

E_{ij} = Nominal exchange rate of currency i against currency j

w_{ij} = Trade weight of partner j in total trade of country i

As per this formula, an increase in the real exchange rate implies an appreciation whereas a decrease indicates depreciation of the real exchange rate of the country.

3.1.2 Productivity Differentials (PD):

The Balassa-Samuelson effect is the relative price of traded and non-traded goods. This study employs an indirect proxy of the productivity differential which is a relative price differential between traded and non-traded goods domestically and internationally. It is proxied as the ratio of domestic CPI to domestic WPI or PPI relative to corresponding geometric weighted average of the foreign countries (Clark and MacDonald, 2000; Villavicencio, 2006).

$$PD = \frac{CPI_i / WPI_i}{\prod_{j=1}^{n} \left(CPI_j / PPI_j \right)^{w_{ij}}} \quad \text{.................................... (6)}$$

where,

CPI_i = Consumer Price Index in India

WPI_i = Wholesale Price Index in India

CPI_j = Consumer Price Index of country j

PPI_j = Producer Price Index of country j

w_{ij} = Trade weights of country j in the total trade of India

3.1.3 Inflation Differentials (INFD):

The inflation differential has been computed using the method suggested by Holden *et al*. (1979). As per their definition, it is the difference between the inflation rate of the home country and the sum of the trade-weighted inflation rates of the foreign countries. Symbolically,

$$INFD = \Pi_i - \sum_{j=1}^{n} w_{ij} \Pi_j \quad \text{................................ (7)}$$

where,

Π_i = Inflation rate in country i

Π_j = Inflation rate in country j

w_{ij} = Trade weights of country j in the total trade of country i

3.1.4 Real Interest Rate Differentials:

As suggested by MacDonald and Dias(2007), the real interest rate differential of India has been calculated as difference between the real interest rate of India and trade weighted real interest rate of the foreign countries under consideration. The real interest rate is obtained by deducting the inflation rate from the interest rate. Formally,

$$ID = (I_i - \Pi_i) - \sum_{j=1}^{n} w_{ij} (I_j - \Pi_j) \quad \text{.............................. (8)}$$

where,

I_i and I_j = Interest rates of country i and j

Π_i and Π_j = Inflation rate of country i and j

w_{ij} = Trade weights of country j in the total trade of country i.

The study has captured effects of the short run interest difference and the long run interest difference separately. For the short run interest difference (SRID), the interest rate on the Treasury Bills of 91-day has been considered whereas the long run interest difference (LRID) has been computed using the interest rate on 10-year government bonds. The data for both has been extracted from the Handbook of Statistics on the Indian Economy (RBI, 2012a).

3.1.5 Terms of Trade (TOT):

The terms of trade is nothing but ratio of the export unit value index and import unit value index expressed in the index form (Carrera and Restout, 2008).

$$\text{TOT} = \frac{\text{Export Unit Value Index}}{\text{Import Unit Value Index}} \times 100 \qquad \text{..............................} \quad (9)$$

Apart from above variables, government consumption is also included in the study. However, the data on government consumption is unavailable and therefore, a proxy, government final consumption expenditure (GFCE) at constant prices 2004-05 as a ratio to GDP at constant prices 2004-05 has been used for the analysis (Carrera and Restout, 2008; Drine and Rault, 2001). Similarly, openness of the economy (OPEN) as a ratio of the total trade *i.e.*, exports plus imports to GDP at constant prices 2004-05 has been chosen as a potential determinant of the real exchange rate in India (RBI, 2012a). To assess the effect of capital flows, the ratio of foreign institutional investment to GDP (FII) has also been included in the analysis. The ratio of foreign exchange reserves (FER) and net foreign assets (NFA) to GDP at constant prices 2004-05 constitute the remaining determinants included in the study. Also a dummy variable capturing effects of external shocks (EXTSH) on the exchange rate is included in the model. The period with crises or acute appreciation or depreciation in the exchange rate was assigned value one, otherwise zero.

3.2 Methodology:

The Johansen-Juselius test of cointegration has the restriction of variables being I(1) process. However, in the economic models, generally variables are mixture of I(0) *i.e.,* stationary or I(1) or of higher order of integration. Even in this study such a mixture of I(0) and I(1) variables was found and, thus, it would be appropriate to apply a technique which would overcome the problem of stationarity in the time series data. The data could be converted into stationary form by taking the first difference and the relationship could be estimated with OLS regression but such transformation would lead to greater loss of information and estimates may not be robust (Kumar, 2010). Therefore, to analyse the long run relationships and dynamic interactions among variables of interest in the model, it has been estimated by applying the bounds testing or ARDL approach for cointegration developed by Pesaran *et al.* (2001). The advantages of ARDL bounds test are:

1. The bound test is suitable for small samples and performs better compared to the other multivariate cointegration techniques such as Johansen-Juselius (1990).
2. This test does not impose restrictive assumption of the same order of integration for all variables. It is applicable irrespective of whether regressors in the model are purely I(0), purely I(1) or mutually cointegrated and, thus, it bypasses the issue of unit roots present in the variables (Villavicencio, 2006).
3. It also allows testing the cointegration relationship among variables by the OLS once the lag order of the model is identified.

This procedure consists of three steps to analyse the cointegration relationship among variables. Suppose, Vector Autoregressive (VAR) model is given as,

$$Y_t = \mu + \eta T_t + \sum_{i=1}^{p} \phi_i Y_{t-i} + \varphi D_t + \varepsilon_t \qquad \text{..........................} \quad (10)$$

where Y_t is (n x 1) vector containing the ‘n’ endogenous variables, μ is (n x 1) vector of intercepts or deterministic terms, η is (n x 1) vector of coefficients of the trend components T, ϕ_i is (n x n) matrix of parameters to be estimated, D_t is a vector of exogenous variables with corresponding parameters in φ matrix, ε_t is (n x 1) vector of Gaussian disturbance terms and p is the selected lag length of the VAR. The Vector Error Correction Model (VECM) is derived as,

$$\Delta Y_t = \mu + \eta\ T_t + \Pi\ Y_{t-1} + \sum_{i=1}^{P-1} \Gamma_i \Delta Y_{t-i} + \varphi\ D_t + \varepsilon_t \qquad \text{.........................} \quad (11)$$

where,

Y_t = Endogenous variable

Γ = (n x p-1) matrix of the short run coefficients

Π = (n x n) coefficient matrix

D_t = Exogenous variable

ε_t = vector of white noise processes with zero mean and variance

In order to assess the long run relationship among variables, the conditional VECM is given as,

$$\Delta Y_t = \mu + \eta T_t + \delta_y Y_{t-1} + \delta_x X_{t-1} + \sum_{i=1}^{P-1} \lambda_i \Delta Y_{t-i} + \sum_{i=1}^{P-1} \gamma_i \Delta X_{t-i} + \varphi D_t + \varepsilon_t \text{ .... } (12)$$

where,

X_t = other variables included in the model

For this study, the conditional VECM to be tested is given in equation (13).

$$\begin{aligned} \Delta RER = {} & \mu + \eta T_t + \delta_1 RER_{t-1} + \delta_2 PD_{t-1} + \delta_3 GFCE_{t-1} + \delta_4 FII_{t-1} + \delta_5 OPEN_{t-1} + \delta_6 SRID_{t-1} \\ & + \delta_7 LRID_{t-1} + \delta_8 INFD_{t-1} + \delta_9 TOT_{t-1} + \delta_{10} FER_{t-1} + \delta_{11} NFA_{t-1} + \sum_{i=1}^{p} \phi_i \Delta RER_{t-i} \\ & + \sum_{j=1}^{q} \varpi_j \Delta PD_{t-j} + \sum_{k=1}^{q} \gamma_k \Delta GFCE_{t-k} + \sum_{l=1}^{q} \theta_l \Delta FII_{t-l} + \sum_{m=1}^{q} \lambda_m \Delta OPEN_{t-m} + \sum_{n=1}^{q} \vartheta_n \Delta SRID_{t-n} \\ & + \sum_{r=1}^{q} \pi_r \Delta LRID_{t-r} + \sum_{g=1}^{q} \psi_g \Delta INFD_{t-g} + \sum_{h=1}^{q} \omega_h \Delta TOT_{t-h} + \sum_{s=1}^{q} \beta_s \Delta FER_{t-s} + \sum_{f=1}^{q} \xi_f \Delta NFA_{t-f} \\ & + \varphi EXTSH_t + \varepsilon_t \qquad \text{...........} \ (13) \end{aligned}$$

A. Bounds Testing Procedure:

It involves three steps to analyse the cointegration among variables.

Step 1:

The first step is to estimate conditional VECM equation (13) by OLS for testing the long run relationship among variables in the model by F-test for the joint significance of coefficients of variables.

$$H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = \delta_9 = \delta_{10} = \delta_{11} = 0$$
$$H_1 : \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq \delta_6 \neq \delta_7 \neq \delta_8 \neq \delta_9 \neq \delta_{10} \neq \delta_{11} \neq 0$$

Pesaran *et al.* (2001) prove that under the null hypothesis, the asymptotic distribution of F-statistic, is non-standard regardless of whether regressors are I(0) or I(1) and provide two adjusted critical values that form a lower bound for I(0) variables and an upper bound for I(1) variables of significance depending upon the dimension, cointegration rank and the presence of intercept and/or trend. As such five different cases and their critical values for various levels of significance have been provided by Pesaran *et al.* (2001) in their paper.

If the value of the computed F-statistic exceeds the appropriate upper critical value, we reject the null hypothesis of no cointegration and conclude that a long run relationship exist among the variables of interest. Conversely, if the F-statistic falls below the lower critical value, we fail to reject the null hypothesis of no cointegration. If the value of F-statistic lies between the lower and the upper critical value the test becomes inconclusive.

Step 2:

Once using the F-test of joint significance of coefficients the cointegration between variables is established the conditional ARDL ($p, q_1, q_2, q_3, q_4, q_5, q_6, q_7, q_8, q_9, q_{10}$) long run model of the real exchange rate (RER) has to be estimated. However, this requires selection of the lag orders of the ARDL model using the lag selection criterion of either the Akaike Information Criterion (AIC) or Schwarz Bayesian Criterion (SBC). The following conditional ARDL model to be estimated in this study:

$$\Delta RER = \mu + \eta T_t + \sum_{i=1}^{p} \delta_1 RER_{t-i} + \sum_{j=1}^{q_1} \delta_2 PD_{t-j} + \sum_{k=1}^{q_2} \delta_3 GFCE_{t-k} + \sum_{l=1}^{q_3} \delta_4 FII_{t-l} + \sum_{m=1}^{q_4} \delta_5 OPEN_{t-m} + \sum_{n=1}^{q_5} \delta_6 SRID_{t-n} + \sum_{r=1}^{q_6} \delta_7 LRID_{t-r} + \sum_{g=1}^{q_7} \delta_8 INFD_{t-g} + \sum_{h=1}^{q_8} \delta_9 TOT_{t-h} + \sum_{s=1}^{q_9} \delta_{10} FER_{t-s} + \sum_{f=1}^{q_{10}} \delta_{11} NFA_{t-f} + \varphi EXTSH_t + \varepsilon_t \quad \text{.................} (14)$$

Step 3:

Finally, the short run dynamic parameters can be estimated via an error correction model specified as follows:

$$\Delta RER = \mu + \eta T_t + \sum_{i=1}^{p} \phi_i \Delta RER_{t-i} + \sum_{j=1}^{q} \varpi_j \Delta PD_{t-j} + \sum_{k=1}^{q} \gamma_k \Delta GFCE_{t-k} + \sum_{l=1}^{q} \theta_l \Delta FII_{t-l} + \sum_{m=1}^{q} \lambda_m \Delta OPEN_{t-m} + \sum_{n=1}^{q} \vartheta_n \Delta SRID_{t-n} + \sum_{r=1}^{q} \pi_r \Delta LRID_{t-r} + \sum_{g=1}^{q} \psi_g \Delta INFD_{t-g} + \sum_{h=1}^{q} \omega_h \Delta TOT_{t-h} + \sum_{s=1}^{q} \beta_s \Delta FER_{t-s} + \sum_{f=1}^{q} \xi_f \Delta NFA_{t-f} + \varphi EXTSH_t + \sigma ecm_{t-1} + \varepsilon_t \quad \text{................} (15)$$

where, $\phi, \varpi, \gamma, \theta, \lambda, \vartheta, \pi, \psi, \omega, \eta$ and ξ are the short run dynamic coefficients of the model of convergence to the equilibrium and σ is the speed of adjustment.

4. EMPIRICAL RESULTS:

The estimation of determinants and application of the econometric technique to the data was executed using the R-Software version 2.15.1. In order to overcome the dilemma of selection of variables on the basis of their order of integration, the bounds testing approach and ARDL model is used. As this technique is indifferent to a variable being I(0) or I(1), all the variables are included in the model. The first step is to test the joint hypothesis of the existence of long run relationship among variables by regressing first differences of variables on each other using F-statistic. The null joint hypothesis indicates no long run relationship among variables whereas the rejection of null hypothesis implies cointegration in the variables. The model under consideration included an intercept and a trend term. Thus, the case V of unrestricted intercept and unrestricted trend described by Pesaran *et al*. (2001) is the relevant model and critical values of the lower and upper bound of that model at 5 percent level of significance are 2.33 and 3.46 respectively. The F-statistic is computed for the conditional ARDL. Results have been presented in Table1. The variable of interest is RER and the computed F-statistic of the regression normalised on RER is 3.67 which is greater than the upper critical value of the F-statistic. Thus, we reject the null hypothesis of no cointegration at 5 percent level of significance implying that there exists a long run relationship among the variables RER, PD, GFCE, FII, OPEN, SRID, LRID, INFD, TOT, FER and NFA. Likewise, it is also detected that there are eight cointegrating relationships among variables when the regression is normalised on all variables.

Table 1: Bounds Test for Cointegration

Dependent Variable	F Statistic	Outcome
Model with unrestricted intercept and unrestricted trend		
Critical Bounds at 5 percent: Lower bound = 2.33 and Upper Bound = 3.46		
F_{RER}(RER|PD,GFCE,FII,OPEN,SRID,LRID,INFD,TOT,FER,NFA)	3.67	Cointegration
F_{PD}(PD|RER,GFCE,FII,OPEN,SRID,LRID,INFD,TOT,FER,NFA)	4.98	Cointegration
F_{GFCE}(GFCE|RER,PD,FII,OPEN,SRID,LRID,INFD,TOT,FER,NFA)	10.23	Cointegration
F_{FII}(FII|RER,PD,GFCE,OPEN,SRID,LRID,INFD,TOT,FER,NFA)	4.93	Cointegration
F_{OPEN}(OPEN|RER,PD,GFCE,FII,SRID,LRID,INFD,TOT,FER,NFA)	5.21	Cointegration
F_{SRID}(SRID|RER,PD,GFCE,FII,OPEN,LRID,INFD,TOT,FER,NFA)	1.48	No Cointegration
F_{LRID}(LRID|RER,PD,GFCE,FII,OPEN,SRID,INFD,TOT,FER,NFA)	1.26	No Cointegration
F_{INFD}(INFD|RER,PD,GFCE,FII,OPEN,SRID,LRID,TOT,FER,NFA)	1.19	No Cointegration
F_{TOT}(TOT|RER,PD,GFCE,FII,OPEN,SRID,LRID,INFD,FER,NFA)	10.18	Cointegration
F_{FER}(FER|RER,PD,GFCE,FII,OPEN,SRID,LRID,INFD,TOT,NFA)	3.73	Cointegration
F_{NFA}(NFA|RER,PD,GFCE,FII,OPEN,SRID,LRID,INFD,TOT,FER)	4.58	Cointegration

Once the existence of a long run relationship between the endogenous variable RER and remaining variables has been established, the relationship between variables has been estimated using the equation (14) specified in step 2 of the bounds testing procedure. Based on the AIC lag selection criteria, the final model of ARDL(4,4,3,4,2,4,3,1,3,2,4) was selected. Results have been presented in Table 2. The intercept term in the model is highly significant. However, the trend term is insignificant. The estimated coefficients suggest that the real exchange rate is not affected by its own lagged values as none of the coefficients of its lagged term are significant. The productivity difference is significant only in its fourth lag but has a negative coefficient indicating depreciation of the real exchange rate in the long run, in contradiction with the Balassa-Samuelson hypothesis. The first and third lag of productivity difference, however, has a positive coefficient, though insignificant, implying an appreciation of the real exchange rate in the long run. Government final

Table 2: Estimated Long Run Coefficients Using ARDL Model

Regressor	Coefficient	Standard Error	t-value	Probability
ARDL (4,4,3,4,2,4,3,1,3,2,4) with intercept and trend				
Intercept	0.0773***	0.0133	5.811	0.000
Trend	0.0000	0.0001	0.240	0.812
RER L1	0.2329	0.1897	1.228	0.233
RER L2	0.1694	0.2220	0.763	0.453
RER L3	0.1674	0.2120	0.789	0.438
RER L4	-0.2820	0.2114	-1.334	0.196
PD L1	0.0137	0.0258	0.528	0.603
PD L2	-0.0133	0.0263	-0.505	0.618
PD L3	0.0194	0.0254	0.761	0.455
PD L4	-0.0496**	0.0225	-2.207	0.038
GFCE L1	-0.0487*	0.0271	-1.797	0.086
GFCE L2	-0.0363	0.0238	-1.526	0.141
GFCE L3	-0.0641**	0.0255	-2.517	0.020
FII L1	0.0734	0.0453	1.619	0.120
FII L2	-0.1335***	0.0413	-3.229	0.004
FII L3	0.0773*	0.0437	1.770	0.091
FII L4	-0.0190	0.0472	-0.403	0.691
OPEN L1	-0.0459***	0.0131	-3.511	0.002
OPEN L2	0.0548***	0.0127	4.320	0.000
SRID L1	-0.0041	0.0367	-0.110	0.913
SRID L2	-0.0625	0.0364	-1.716	0.100
SRID L3	-0.0837	0.0511	-1.639	0.115
SRID L4	0.0817**	0.0382	2.136	0.044
LRID L1	-0.0907*	0.0499	-1.817	0.083
LRID L2	0.0595	0.0552	1.079	0.292
LRID L3	0.1631***	0.0535	3.052	0.006
INFD L1	-0.1052*	0.0545	-1.930	0.067
TOT L1	0.0020*	0.0011	1.847	0.078
TOT L2	0.0015	0.0010	1.581	0.128
TOT L3	0.0039**	0.0013	2.999	0.007
FER L1	0.0023	0.0015	1.542	0.137
FER L2	-0.0027*	0.0014	-1.906	0.070
NFA L1	0.0086	0.0074	1.156	0.260
NFA L2	0.0013	0.0115	0.114	0.910
NFA L3	-0.0398***	0.0104	-3.835	0.001
NFA L4	0.0489***	0.0080	6.125	0.000
EXTSH	0.0014	0.0011	1.310	0.204
Residual Standard Error: 0.001601 on 22 degrees of freedom Multiple R-Squared: 0.9712, Adjusted R-squared: 0.9071 F-statistic: 15.15 on 49 and 22 DF, p-value: 2.073e-09				

Note: ***, ** and * denote statistical significance at 1, 5 and 10 percent level respectively.

consumption expenditure has a negative relationship and tends to depreciate the real exchange rate. As opposed to Kumar (2010) government expenditure is found to be highly significant in this study. The impact of the foreign institutional investment on the real exchange rate is rather diverse in the second and third lag. The second lag of FII exhibits a significant negative relationship whereas third lag depicts appreciation in the real exchange rate. Similar results have been showcased by openness. OPEN exerts a significant negative effect on RER in the first lag at 1 percent level of significance leading to depreciation in the real exchange rate while, on the contrary, in the second lag it has a positive relationship with RER connoting that increase in openness appreciates the real exchange rate in the long run. The short run interest difference correctly appreciates the real exchange rate in its fourth lag whereas the long run interest difference has a negative effect in the first lag and a positive effect in the third lag. It means that the immediate previous period's long run interest rate tends to depreciate the exchange rate and it settles in the third lag and appreciates it in the long run. Inflation difference has a correct negative sign and is significant at 5 percent level of significance. It is, thus, in line with the theoretical relationship that increase in inflation depreciates the real exchange rate. The terms of trade has a significant positive effect on the real exchange rate implying the ascendance of the income effect. The foreign exchange reserves have a positive effect but are insignificant in the first lag. Surprisingly, in the second lag it significantly depreciates the real exchange rate at 10 percent level. Net foreign assets appreciate the real exchange rate in the fourth period with a significant coefficient at 1 percent level.

Productivity differentials depicted mixed results of appreciation and depreciation in subsequent lags. Due to these mixed results, a long run effect of permanent one percent increase in PD on RER has been estimated using a difference equation formula. The long run effect of variable x on endogenous variable y is given by $\gamma/(1-\varphi)$ where φ is the coefficient of the first lag of y and γ is the coefficient of x. By employing the stated formula, it was found that a one percent increase in productivity differentials appreciates the real exchange rate by 0.0177.Similarly, a one percent permanent increase in the foreign exchange reserves led to 0.7671 percent appreciation in the real exchange rate which is in accordance with the theory.

The robustness of the model with estimated long run coefficients has been presented in the figures which show the actual RER and estimated RER with one lag, two lags, three lags and four lags respectively. The horizontal axis measures the number of observations and vertical axis measures RER. Panel A in these figures represents actual and estimated RER and Panel B displays residuals of the model. As we increase the number of lags the fitted line gets close to the actual line and the error term decreases. It has been observed that the estimated real exchange rate with four

Figure 1:
Estimate of RER with One Lag

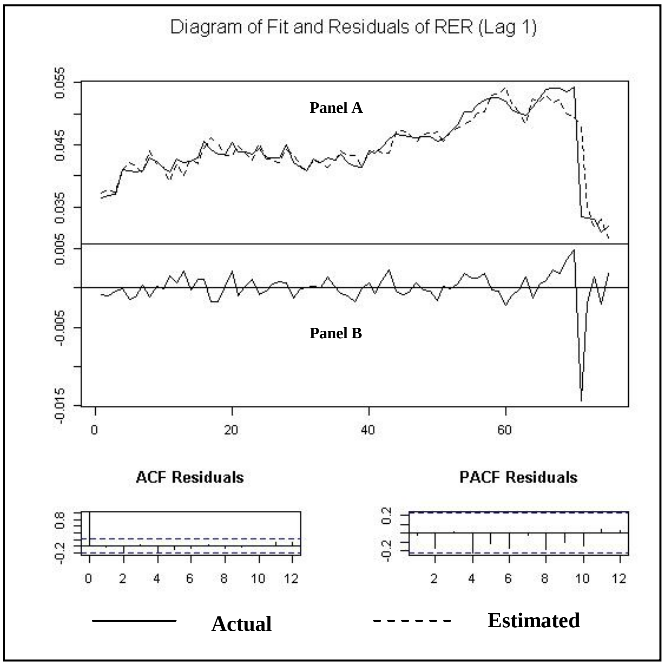


Figure 2:
Estimate of RER with Two Lags

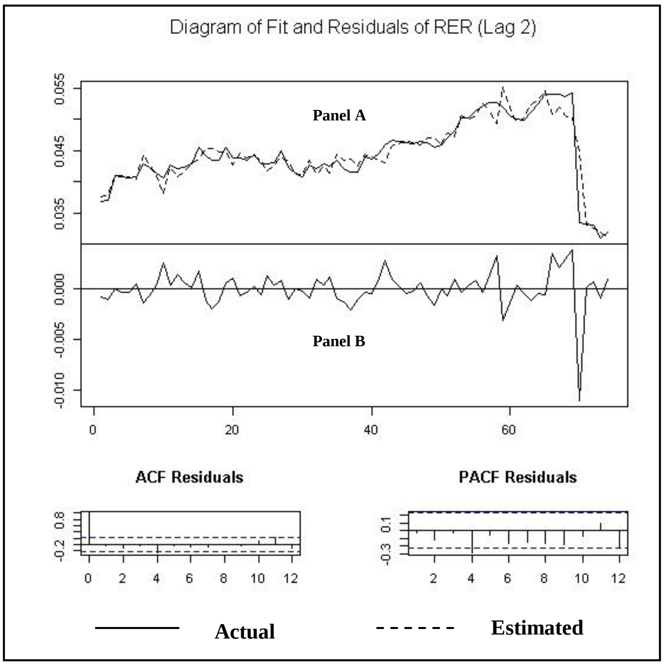


Figure 3:
Estimate of RER with Three Lags

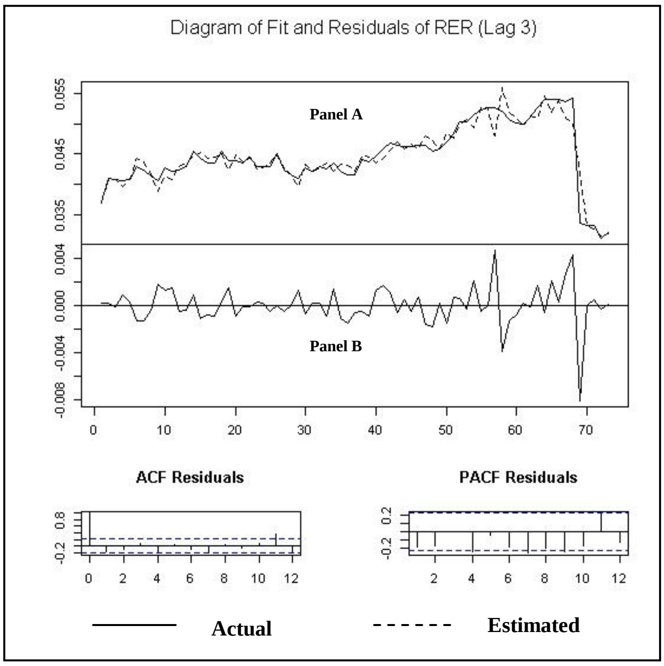
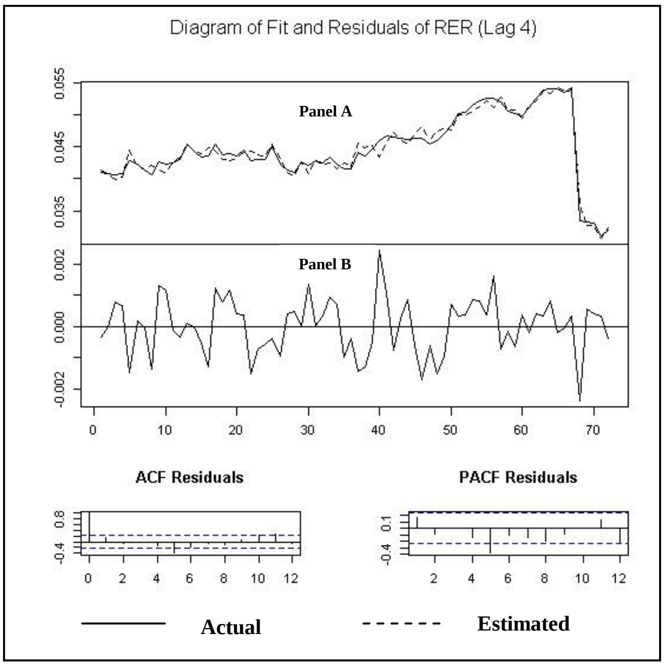


Figure 4:
Estimate of RER with Four Lags



lags is very close to the actual real exchange rate. Also the residuals are quite low in this model compared to the other three models. Thus, the ARDL model with four lags is the best fit model as indicated in Figure 4. The Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) of the residuals of the models have also been given in these figures. The higher R^2 (goodness of fit) confirms this result for the selected model.

Further, the short term dynamics are captured by the VECM as suggested in step 3 (Table 3). Error correction terms are significantly negative. The first error correction term of RER is (-) 0.76 implying that deviation of the real exchange rate from its long run mean is corrected by up to 76 percent in the next period. The short run dynamic impact on the real exchange rate is quite in tandem with the long run coefficients estimated previously. The real exchange rate is significantly affected by the first difference of its own lags. The change leads to depreciation in the real exchange rate. The productivity difference and foreign exchange reserves indicate the expected positive relationship though insignificant. GFCE exerts a negative impact on the real exchange rate at 1 percent level of significance. Foreign institutional investment significantly appreciates the real exchange rate at 10 percent level of significance. On the other hand, the first difference of openness lagged once demonstrates a negative impact with 1 percent level of significance leading to depreciation with increase in openness. The short run and long run interest difference exhibits mixed results. The first difference of short run interest difference significantly depreciates the real exchange rate in its second and third lag at 5 percent and 1 percent level whereas the long run interest difference indicates a negative relationship in its first lag and a positive relationship in the third lag. It implies that LRID depreciates the real exchange rate in the first lag. However, it appreciates the exchange rate in the third lag. Inflation difference tends to depreciate the real exchange rate at 5 percent level of significance. The income effect of terms of trade dominates and significantly appreciates the real exchange rate. The net foreign assets showcase a negative relationship, significant only at the third lag.

5. CONCLUSIONS:

With the opening up of the Indian economy, the exchange rate has increasingly been affected by various internal as well as external factors which have

Table 3: Error Correction and Short Run Dynamics in ARDL Model

Regressor	Coefficient	Standard Error	t-value	Probability
ECT 1	-0.7638**	0.3250	-2.350	0.026
ECT 2	-0.0144	0.0201	-0.715	0.481
ECT 3	-0.2714***	0.0704	-3.858	0.001
ECT 4	-0.0408	0.0391	-1.041	0.307
ECT 5	-0.0262	0.0156	-1.681	0.104
ECT 6	-0.1054**	0.0398	-2.647	0.013
ECT 7	0.0777	0.0518	1.501	0.145
Intercept	0.0714***	0.0102	7.006	0.000
Δ RER L1	-0.7717***	0.1738	-4.439	0.000
Δ RER L2	-0.6247**	0.2407	-2.596	0.015
Δ RER L3	-0.4650	0.2802	-1.660	0.109
Δ PD L1	0.0201	0.0231	0.868	0.393
Δ PD L2	0.0058	0.0211	0.274	0.786
Δ PD L3	0.0315	0.0244	1.294	0.207
Δ GFCE L1	-0.0622***	0.0217	-2.863	0.008
Δ GFCE L2	-0.1083***	0.0366	-2.960	0.006
Δ GFCE L3	-0.1848***	0.0500	-3.694	0.001
Δ FII L1	0.0697*	0.0389	1.790	0.085
Δ FII L2	-0.0720*	0.0358	-2.012	0.054
Δ FII L3	-0.0074	0.0401	-0.185	0.854
Δ OPEN L1	-0.0441***	0.0116	-3.798	0.001
Δ OPEN L2	0.0076	0.0132	0.579	0.568
Δ OPEN L3	-0.0018	0.0146	-0.121	0.905
Δ SRID L1	-0.0162	0.0316	-0.513	0.612
Δ SRID L2	-0.0784**	0.0332	-2.359	0.026
Δ SRID L3	-0.1778***	0.0392	-4.540	0.000
Δ LRID L1	-0.0941**	0.0454	-2.073	0.048
Δ LRID L2	-0.0192	0.0379	-0.508	0.615
Δ LRID L3	0.1478***	0.0444	3.328	0.003
Δ INFD L1	-0.1204**	0.0492	-2.445	0.021
Δ INFD L2	-0.0899*	0.0493	-1.825	0.079
Δ INFD L2	-0.0839	0.0531	-1.581	0.126
Δ TOT L1	0.0020**	0.0009	2.231	0.034
Δ TOT L2	0.0036***	0.0012	2.860	0.008
Δ TOT L3	0.0077***	0.0015	5.000	0.000
Δ FER L1	0.0020	0.0013	1.507	0.144
Δ FER L2	-0.0005	0.0016	-0.276	0.785
Δ FER L3	-0.0017	0.0022	-0.745	0.463
Δ NFA L1	0.0100	0.0066	1.502	0.145
Δ NFA L2	0.0109	0.0080	1.364	0.184
Δ NFA L3	-0.0294**	0.0083	-3.539	0.001
EXTSH	0.0006	0.0007	0.980	0.336
Residual standard error: 0.001493 on 27 degrees of freedom Multiple R-squared: 0.8858, Adjusted R-squared: 0.6955 F-statistic: 4.655 on 45 and 27 DF, p-value: 3.228e-05				

Note: ***, ** and * denote statistical significance at 1, 5 and 10 percent level respectively.

been examined in the empirical literature on the exchange rate over the period. Various determinants of the real exchange rate, incorporated in this study, have been analysed to test the relationship among them in the short and long run. The ARDL bounds testing approach confirmed a cointegration relationship between the real exchange rate and its determinants implying a long run relationship among these variables in India. The error correction terms introduced in these methods affirmed the convergence of the real exchange rate towards its long run equilibrium level in the next periods. Government expenditure, openness of the economy and inflation differentials correctly depreciates whereas long run interest difference and terms of trade appreciates the real exchange rate in the short and long run. Productivity difference and foreign exchange reserves, which are insignificant in the short run, are significant in the long run, however, posing opposite sign to the expected theoretical relationship. This could be due to the fact that productivity difference is a long run phenomenon and, thus, needs a sufficient large sample to prove the Balassa-Samuelson hypothesis. Also, Drine and Rault (2001) proved that it appears to be insignificant when analysed through time series techniques. Nevertheless, a permanent long run effect indicates that both variables tend to appreciate the real exchange rate. As expected, the foreign institutional investment appreciates the real exchange rate in the short and long run with mixed results at various lags. The short run interest difference and net foreign assets show negative relationship in the short run. On the contrary, in the long run these two variables appreciate the real exchange rate in line with the theory. Some of the unexpected relationships between the variables could be attributed to the formula used for the construction of variables. Also if China would have been included in the geometric weighted average for the differentials then the results could have been varied marginally.

Thus, it is important to notice in the case of India that the determinants demonstrated a logical relationship with the real exchange rate and exerted influence on it at various lags. Most of the variables indicated relationships in accordance with the theory. As expected the foreign institutional investment and long run interest rate difference explain the largest proportion of variation in the real exchange rate in India. Thus, it could be inferred that the real exchange rate is affected by an array of internal as well as external economic fundamentals and success of the economy depends on them. The potential crisis situation could be signalled by the persistent misalignment of the exchange rate from its long run equilibrium value and, thus, faster rate of convergence towards equilibrium would be preferable. While considering the exchange rate objective of curbing excessive rupee volatility more attention should be given on interest rates and capital flows as these variables tend to have greater impact on the exchange rate in India. Apart from these, productivity, inflation rates and government expenditure also influence the real exchange rate to a larger extent. The monetary authorities, therefore, should manoeuvre to attain the desired exchange rate objectives through their coordinated monetary and fiscal policy actions and be more concerned about the internal health and soundness of the economy rather than the factors out of their control to manage the stability of the exchange rate in India.

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