Chapter 4: Research Objectives & Methodology

4.1 Research Objectives

The main objectives of the proposed research are as follows:

(1) To analyze the relationship between capital flows and its components to India and the real exchange rate.

(2) To investigate the linkage between the real exchange rate volatility in India and the volatility of capital flows and that of its components and the direction of causality.

(3) Based on results of the analysis to draw inferences for policies for effective management of the capital account in India.

4.2 Scope

The scope of this research is to estimate the relationship between Net Capital flows and its components viz Net Foreign Direct Investment flows, Net Portfolio flows, Net Debt Creating flows (comprising of Banking Capital loans, external commercial borrowings by corporates) and other capital on real exchange rate in India for the period 1996-97 to 2012-13. The initial transitory period of liberalization of capital flows when important policies relating to exchange rate, opening of restrictions on various categories of capital flows, sterilization etc were being implemented and the system was getting stabilized has been omitted from the analysis. The dynamic interaction between foreign capital shocks and real exchange rate is further examined using the generalized impulse response analysis and generalized variance decomposition analysis. Further an investigation is made on the linkage between the exchange rate volatility and the volatility of the net capital flows and that of its components in India for the period 1996-97 to 2012-13. The empirical evidence that has emerged from the analysis has been used to draw inferences for policies for effective management of the capital account in India in the context of the policies that have been put in place in India since the onset of liberalization to manage capital flows so as to mitigate the stress imposed by them on the real economy through appreciation of real exchange rate and increase in volatility of the real exchange rate. Base on this, suggestions have been made for the guidance of the policy makers in India.

4.3 The Conceptual Model & Evolution of Model Variables

In order to analyze the relationship between the real exchange rate and capital flows and its components for the Indian economy the functional relationship between real exchange rate and the capital flows and other explanatory variables needs to be defined. As indicated in the chapter on Literature Review, capital flows are not the only determinants of real exchange rate and that despite substantial contributions over the years to both theory and empirical literature on real exchange rate determination there is no consensus on what variables actually determine the real exchange rate. Most studies emphasize the role of a number of real and monetary variables and domestic policies in determination of real exchange rate. A menu of the important variables that have been used in the literature for real exchange rate determination includes Net Capital Flows, Current Account Balance, Financial Openness/Capital Controls, Government Consumption Expenditure, Trade Openness/Trade restrictions, Technology, Productivity, Terms of Trade, Money Supply, Exchange rate policy, etc. Other variables have been included in some countries where such factors play an important role in determining real exchange rate. Some of the variables are correlated with each other and capture similar and overlapping effects. In this study although the prime objective is to study the relationship between the net capital flows and the real exchange rate in the Indian economy the following variables are used in the analytical model based on the consideration indicated against them.

REER: In order to measure the real exchange rate the Real Effective Exchange Rate (REER) index is included in the baseline model. REER index is the weighted geometric average of the bilateral nominal exchange rates of the home currency (Indian Rupee in this case) in terms of foreign currencies adjusted by the ratio of domestic prices to the foreign prices.

$$\text{REER} = \prod_{i=1}^{n}[(e/e_i)(P/P_i)]^{w_i}$$

Where e = Exchange Rate of Indian Rupee against a numeraire. i.e., the IMF's Special Drawing Rights (SDRs) in indexed form

e_i = Exchange rate of foreign currency 'i' against the numeraire (SDRs) (i.e., SDRs per currency i) in indexed form

w_i = Weights attached to foreign currency/country 'i' in the index.

$$\prod_{i=1}^{n} w_i = 1$$

P = India's Wholesale Price Index (WPI)

P_i = Consumer Price Index of country i (CPI_i), and

n = Number of countries/currencies in the index other than India.

NCF: Net Capital flows is the main explanatory variable in the study and hence included in the model. In order to measure the volume of net capital flows relative to the size of the economy the ratio of the Net Capital Flows into the Indian economy in the quarter and the Quarterly GDP at Market prices current prices (NCF) is used. It has four main components (i) FDI which is the ratio of the Net Foreign Direct Investment in the quarter and the Quarterly GDP at Market prices current prices (ii) PORT which is the ratio of the Net Portfolio Flows in the quarter and Quarterly GDP at Market prices current prices (iii) DEBTCF which is the ratio of the aggregate of Net loans, banking capital, Rupee debt service in the quarter and the Quarterly GDP at Market prices current prices and (iv) OTHCAP which is the ratio of the other capital and the Quarterly GDP at Market prices current prices.

TOT: As indicated in the previous chapter Terms of Trade is an important determinant as it captures the effect of change in relative price of exports on the real exchange rate through a combination of income and substitution effects. For the Indian economy Net Terms of Trade (TOT) is calculated as the ratio of Exports General Unit Value Index and Imports General Unit Value Index. The indices indicate the temporal fluctuation in trade i.e. export or import of the country in terms of unit value. They are a measure of average change in unit value of a group of homogeneous commodities over time. A rise in TOT can be associated with a rise or fall of the real exchange rate depending upon whether the income effect or the substitution effect dominates.

GFCE: Government spending is an important fundamental determinant of real exchange rate as it adds to the aggregate demand and impacts the price levels in the economy and is therefore included in the model. In order to measure the size of public spending relative to the size of the economy, Government final consumption expenditure in the quarter as proportion of the Quarterly GDP at Market prices current prices (GFCE) is used in the analysis. As a sizeable portion of the Government Expenditure in India is devoted to imports of essential commodities the association of GFCE with REER is expected to be ambiguous.

TRADE: Trade Openness is an important determinant included in the model as it impacts the price levels in the economy. The ratio of sum of exports and imports in the quarter to the Quarterly GDP at Market prices current prices (TRADE) is used as a proxy indicator of the trade openness of the Indian economy. As indicated in the previous chapter trade openness is expected to be associated with depreciation of the real exchange rate.

GR: Technological progress and productivity differential is included as an important determinant of real exchange rate in the model as it impacts the prices of nontradables due to increase in wages. Percentage growth rate of the Quarterly GDP at Factor Cost at Constant Prices over the corresponding quarter in the previous year (GR) is used as a proxy for the Balassa-Samuelson effect associated with technological progress and productivity differential. Higher Growth rate is expected to be associated with increase in productivity and an appreciation of the real exchange rate.

CAB: Net Current Account Balance has been included in the analysis as a sizeable portion of capital flows in India is used to finance the current account deficit. Capital flows to the extent of utilization for meeting the financing needs of the country are not expected to cause adverse macroeconomic consequences. It is the surplus capital flows over and above the financing requirements that have an adverse impact on the economy. Current Account Balance in the quarter as a proportion of the quarterly GDP at Market prices current prices (CAB) is used in the analysis. A more negative CAB is expected to be associated with depreciation of the real exchange rate.

CFER: Reserve Bank of India maintains foreign exchange reserves in the form of Special Drawing Rights (SDRs), Gold, Foreign Currency Assets and Reserve Tranche Position. Change in Foreign Exchange Reserves in the quarter as a proportion of the Quarterly GDP at Market prices current prices (CFER) is used as a proxy for capturing the effect of change in foreign exchange reserves on the real exchange rate. The change in foreign exchange reserves is on account of change in rupee value of the components of foreign exchange reserves viz SDRs, Gold, Foreign Currency Assets and Reserve Tranche Position held by the RBI which is different from the increase/decrease in foreign reserves due to overall balance of payments. An increase in foreign exchange reserves to the extent it is accompanied with prevention of increase in money supply (due to sterilization etc) is expected to lead to depreciation of the real exchange rate for the Indian economy. On the other hand increase in foreign exchange reserves accompanied with increase in money supply is expected to lead to appreciation of the real exchange rate in the economy.

With this choice of variables the functional relation between Real Exchange Rate and the underlying determinants is represented as follows:

$$REER_t = f\{NCF_t, GFCE_t, TRADE_t, GR_t, TOT_t, CAB_t, CFER_t\}; \quad \text{t refers to time}$$

To estimate the relation between the dependant variable i.e. real effective exchange rate and the net capital flows and its components along with other explanatory variables, two econometric models with following log-linear specifications are used.

Model 1: This Model is used to analyze the relationship between real effective exchange rate index and the net capital flows. The log linear equation for this model is as specified below:

$$LNREER_t = C + \beta_1 NCF_t + \beta_2 GFCE_t + \beta_3 LNTRADE_t + \beta_4 LNGR_t + \beta_5 LNTOT_t + \beta_6 CAB_t + \beta_7 CFER_t + \epsilon_t$$

Here, ϵt is a stochastic white noise at time t.

LNREER = *natural log* (REER), LNTRADE= *natural log* (TRADE),

LNGR = *natural log* (GR), LNTOT = *natural log* (TOT)

Model 2: This Model is used for examining the relationship between the real exchange rate index and the components of the net capital flows viz Foreign Direct Investment, Portfolio flows, Debt Creating flows and Other Capital flows. The log linear specification for this model is as indicated below:

$$LNREER_t = C + \beta_1 FDI_t + \beta_2 PORT_t + \beta_3 DEBTCF_t + \beta_4 OTHCAP_t + \beta_5 GFCE_t + \beta_6 CAB_t + \beta_7 CFER_t + \epsilon_t$$

4.4 Empirical Methodology for estimating the relationship between the real effective exchange rate and net capital flows and other explanatory variables

4.4.1 Time Series Analysis of variables

Before estimating the model, the dependent and independent variables are separately subjected to unit roots tests using the Augmented Dickey Fuller Test (ADF) (Dickey and Fuller, 1979) and

Philips Perron (Philips and Perron, 1988) (PP) Test for testing the stationarity and order of integration. Usually, all variables are tested with an intercept with and without a linear trend.

The ADF test is based on the following regression:

$$\Delta Y_t = C + \alpha t + \rho Y_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Y_{t-i} + \varepsilon_t$$

Where C represents the intercept, αt represents the deterministic time trend; m is the lag length and ε_t is a white noise process.

Null Hypothesis $H_0 : \rho = 0$ or Y_t is non stationary

$H_1 : \rho < 0$ or Y_t is stationary

As long as the t-statistic on ρ is larger than the relevant critical value the null hypothesis of unit root cannot be rejected.

The ADF framework does not provide a fully adequate test for the existence of unit roots in cases of uncertainty regarding the dynamic structure of the time series of the variable under study and where the error term may be non-white noise. In particular, the power of the ADF test is likely to be low where moving average terms are present or where the disturbances are heterogeneously distributed. In such circumstances Philips and Perron have proposed further set of statistics using non parametric adjustments that are modifications of the t-statistics employed for the Dickey-Fuller Test. The Philips and Perron tests can provide superior results and the non-parametric adjustments of the PP test are likely to raise the power of the test.

4.4.2 Cointegration Analysis:

In the econometric literature different methodological approaches have been used to empirically analyze the long run relationships and dynamic interactions between two or more time-series variables. The most widely used methods for estimating the cointegrating vector between a set of time series variables include the EG two step procedure (Engle and Granger, 1987) and the maximum-likelihood approach (Johansen and Juselius 1990). Both these methods require that all the variables under study are integrated of order one, *I*(1). This in turn requires that the variables are subjected to pre-testing for ascertaining their orders of integration before including them in particular cointegrating regressions. This introduces a certain degree of uncertainty into the analysis. Apart from this, some of these test procedures have very low power and do not have good small sample properties.

One of the relatively recent developments on univariate cointegration analysis is the Autoregressive Distributed Lag (ARDL) approach to cointegration introduced by Pesran and Shin (1999) and further extended by Pesaran et al (2001). The main advantage of the ARDL method over the Johansen and Juselius (1990) approach is that it allows for a mix of $I(1)$ and $I(0)$ variables in the same cointegration equation. Also, as shown by Pesaran et al (2001), the ARDL models yield consistent estimates of the long-run coefficients that are asymptotically normal irrespective of whether the underlying regressors are purely $I(0)$, purely $I(1)$ or mutually cointegrated. Another advantage of this procedure is that it has superior statistical properties in small samples. The ARDL test is more efficient and the estimates derived from it are relatively more robust in small sample sizes as compared to traditional Johansen-Juselius cointegration approach, which typically requires a large sample size for the results to be valid. In particular, Pesaran and Shin (1999) show that the ARDL approach has better properties in sample sizes up to 150 observations.

In addition to the advantages of ARDL estimation technique as indicated above, the choice of ARDL bounds testing procedure as a tool for investigating the existence of a long-run relationship is based on the important consideration that both dependent and the independent variables can be introduced in the model with lags. “Autoregressive” refers to lags in the dependent variable. Therefore, the past values of a variable are allowed to determine its present value. “Distributed lag” refers to the lags of the explanatory variables. This is a highly plausible feature because, conceptually, a change in the economic variables may not necessarily lead to an immediate change in another variable. The reaction to a change in each variable may be different depending on various factors. Hence, in some cases, they may respond to the economic developments with a lag and there is usually no reason to assume that all regressors should have the same lags. Hence, ARDL bounds testing approach is appropriate as it allows flexibility in terms of the structure of lags of the regressors in the ARDL model as opposed to the cointegration VAR models where different lags for different variables is not permitted (Pesaran *et al*, 2001).

The ARDL approach has the advantage that it takes a sufficient number of lags to capture the data generating process in a general-to-specific modelling framework. Furthermore, the lag orders can be selected based on four different selection criteria taking into consideration the results of the diagnostic tests for residual serial correlation, functional form misspecification, non-normality, and heteroscedasticity. Since the ARDL approach draws on the unrestricted error correction model, it is likely to have better statistical properties than the traditional cointegration techniques.

The ARDL approach is particularly applicable in the presence of the disequilibrium nature of the time series data stemming from the presence of possible structural breaks as happens with most economic variables. With the ARDL approach, it can be conveniently tested whether the underlying structural breaks have affected the long-run stability of the estimated coefficients.

The ARDL analysis also provides estimates of the corresponding Error Correction Model (ECM) which shows how the endogenous variable adjusts to the deviation from the long-run equilibrium.

In view of these considerations in order to analyze the long run relationship between the variables Real effective exchange rate (REER) on the one hand and the ratio of Net Capital Flow to GDP (NCF) and its components namely the ratio of Foreign Direct Investment to GDP (FDI), ratio of net Portfolio flows to GDP (PORT) and ratio of Debt Creating Flows to GDP (DEBT), the ARDL approach to Cointegration, as suggested by Pesran et al (2001), is employed in this research.

An ARDL (p, q_1 , q_2, ….. q_k) model has the form (Pesaran, and Pesaran, 2009)

$$\emptyset(L,p)y_t = \sum_{i=1}^{k} \beta_i(L, q_i)x_{it} + \gamma' z_t + \varepsilon_t \qquad (1)$$

Where $\emptyset(L,p) = 1 - \emptyset_1 L - \emptyset_2 L^2 - \ldots - \emptyset_p L^p$

$$\beta_i(L, q_i) = \beta_{i0} + \beta_{i1}L + \ldots\ldots + \beta_{iqi}L^{qi}, \quad i=1,2,\ldots k$$

y_t is the dependant variable, x_{it} , i = 1,.., k are explanatory variables, L is a lag operator such that $Ly_t = y_{t-1}$ and z_t is a s x 1 vector of deterministic variables such as the intercept term , time trends or seasonal dummies, or exogenous variables with fixed lags.

Brief description of the ARDL estimation procedure

The ARDL procedure involves two stages.

First Stage: In the first stage of the ARDL procedure the existence of the long run relation between the variables under investigation is tested by computing the F statistics for testing significance of the lagged levels of the variables in the error correction form of the ARDL model. This basically involves testing whether the resultant residual term of the cointegration equation is stationary even if some of the variables are non-stationary. The error correction form of ARDL model with maximum order of lag m is given as follows:

$$\Delta y_t = a + \sum_{j=1}^{m-1} b_{0j}\Delta y_{t-j} + \sum_{j=1}^{m-1} b_{1j}\Delta x_{1_{t-j}} + \sum_{j=1}^{m-1} b_{2j}\Delta x_{2_{t-j}} + \ldots + \sum_{j=1}^{m-1} b_{kj}\Delta x_{k_{t-j}}$$

$$+ \delta_0 y_{t-1} + \delta_1 x_{1t-1} + \delta_2 x_{2t-1} + \ldots\ldots\ldots + \delta_k x_{kt-1} + u_t$$

The selection of the lag is an important step in the ARDL procedure. The maximum lag is chosen by the researcher depending on the sample size.

The null hypothesis of non-existence of the long run relationship between the variables is defined by:

$$H_0: \delta_0 = \delta_1 = \delta_2 = \ldots\ldots\ldots = \delta_k = 0$$

This is tested against the alternate hypothesis of existence of long run relationship between the variables given by

$$H_1: \delta_0 \neq 0, \delta_1 \neq 0, \delta_2 \neq 0, \ldots\ldots\ldots \delta_k \neq 0$$

Pesaran, Shin and Smith (1996) have tabulated two sets of critical values for F statistic for different number of regressors (k) depending on whether the ARDL model contains an intercept and/or trend. One set of critical values (lower bound) assumes all the variables in the ARDL model are I(0) and another set (upper bound) assumes that all the variables are I(1). If the computed F statistic exceeds the upper bound of the critical value band then the null hypothesis of no long run relationship between the dependent and explanatory variables can be rejected irrespective of the order of their integration. On the other hand if the F statistic lies below the lower bound critical value then the null hypothesis of no long run relationship between the variables in the model cannot be rejected. However, if the computed F statistic falls within the critical value band the result of the investigation are inconclusive and depends on whether the underlying variables are I(0) or I(1).

Second Stage: Once the existence of long run relationship is established then in the second stage the long run coefficients and the error correction model are estimated. First equation (1) is estimated by the OLS method for all possible values of p = 0,1,2,…,m, q_i = 0,1,2,….m, i=1,2,…k; namely a total of $(m+1)^{k+1}$ different ARDL models. All the models are estimated for the same sample period, namely t= m+1, m+2,…, n. Thereafter one of the $(m+1)^{k+1}$ estimated models is selected using one of the following four model selection criteria: the R^2 criterion, Akaike Information criterion (AIC), Schwarz Bayesian criterion (SBC), and the Hannan and Quinn (H&Q) criterion. Thereafter, the long-run coefficients and their asymptotic standard errors for the selected ARDL model are computed. The estimates of the Error Correction Model (ECM) that corresponds to the selected ARDL model are also computed. The long-run coefficients for the response of y_t to a unit change in x_{it} are estimated by

$$\hat{\theta}_i = \frac{\hat{\beta}_i(1,\hat{q}_i)}{\hat{\phi}(1,\hat{p})} = \frac{\hat{\beta}_{i0}+\hat{\beta}_{i1}+..+\hat{\beta}_{iq_i}}{1-\hat{\phi}_1-\hat{\phi}_2-\cdots.-\hat{\phi}_p}, \qquad i=1, 2,\ldots..,k$$

where $\hat{p}$ and $\hat{q}_i$, i=1,2,…k are the selected (estimated) values of p and q_i, i=1,2,…,k. Similarly, the long-run coefficients associated with the deterministic/exogenous variables with fixed lags are estimated by

$$\hat{\psi} = \frac{\hat{\gamma}(\hat{p},\hat{q}_1,\hat{q}_2,\ldots..\hat{q}_k)}{1-\hat{\phi}_1-\hat{\phi}_2-\cdots..-\hat{\phi}_{\hat{p}}}$$

Where $\hat{\gamma}(\hat{p},\hat{q}_1,\hat{q}_2,\ldots..\hat{q}_k)$ denotes the OLS estimate of γ for the selected ARDL model.

The Error Correction Model associated with the ARDL ($\hat{p},\hat{q}_1,\hat{q}_2,\ldots..\hat{q}_k$) model can be obtained by writing (1) in terms of the lagged levels and the first differences of y_t, x_{1t}, x_{2t}, ….., x_{kt}, and $\mathbf{z_t}$.

$$y_t = \Delta y_t + y_{t-1}$$

$$y_{t-s} = y_{t-1} - \sum_{J=1}^{S-1} \Delta y_{t-j} \qquad s = 1,2,\ldots,p$$

And similarly

$$z_t = \Delta z_t + z_{t-1}$$

$$x_{it} = \Delta x_{it} + x_{i,t-1}$$

$$x_{i,t-s} = x_{i,t-1} - \sum_{J=1}^{S-1} \Delta x_{i,t-j,} \qquad s = 1,2,\dots,q_i$$

Substituting these relations into equation (1) and after some rearrangements, the following relation is obtained.

$$\Delta y_t = \emptyset(1,p)EC_{t-1} + \sum_{i=1}^{k} \beta_{i0}\,\Delta x_{it} + \delta' \Delta z_t - \sum_{i=1}^{\hat{p}-1} \emptyset_j^* \,\Delta y_{t-j} - \sum_{i=1}^{k}\sum_{j=1}^{\hat{q}_i-1} \beta_{ij}^* \,\Delta x_{i,t-j} + u_t$$

Where EC_t is the correction term defined by

$$EC_t = y_t - \sum_{i=1}^{k} \hat{\theta}_i \, x_{it} - \widehat{\psi}' z_t$$

$\emptyset(1,\hat{p})$=1-$\widehat{\emptyset}_1$-$\widehat{\emptyset}_2$-…….- $\widehat{\emptyset}_{\hat{p}}$, measures the quantitative importance of the error correction term. The remaining coefficients $\emptyset_j^*$ and β_{ij}^*, relate to the short-run dynamics of the model's convergence to equilibrium. These are given by

$\emptyset_1^*$ = $\emptyset_{\hat{p}}$+$\emptyset_{\hat{p}-1}$+….+$\emptyset_3$+$\emptyset_2$

$\emptyset_2^*$ = $\emptyset_{\hat{p}}$+$\emptyset_{\hat{p}-1}$+….+$\emptyset_3$

⋮ ⋮ ⋮

$\emptyset_{\hat{p}-1}^*$= $\emptyset_{\hat{p}}$

And similarly

$$\beta_{i1}^* = \beta_{i,qi} + \beta_{i,\hat{q}i-1} + \cdots + \beta_{i,3} + \beta_{i,2}$$

$$\beta_{i2}^* = \beta_{i,qi-1} + \beta_{i,\hat{q}i-1} + \ldots + \beta_{i,3}$$

$$\vdots \qquad \vdots \qquad \vdots$$

$$\beta_{i,\hat{q}i-1}^* = \beta_{i,\hat{q}i}$$

For the **Model 1** that specifies the relations between Real Effective Exchange Rate (REER) and the net capital inflows and other explanatory variables the ARDL (p, q_1,q_2, q_3,q_4,q_5,q_6,q_7) model is represented as follows:

$$LNREERt = C + \delta t + \phi_1 LNREER_{t-1} + \phi_2 LNREER_{t-2} + \ldots + \phi_p LNREER_{t-p}$$

$$+ \ \beta_{10}NCF_t + \beta_{11}NCF_{t-1} + \ldots\ldots\ldots + \beta_{1q1}NCF_{t-q1}$$

$$+ \beta_{20}GFCE_t + \beta_{21}GFCE_{t-1} + \text{-------} + \beta_{2q2}GFCE_{t-q2}$$

$$+ \beta_{30}LNTRADE_t + \beta_{31}LNTRADE_{t-1} + \text{-------} + \beta_{3q3}LNTRADE_{t-q3}$$

$$+ \beta_{40}LNGR_t + \beta_{41}LNGR_{t-1} + \text{-------} + \beta_{4q4}LNGR_{t-q4}$$

$$+ \beta_{50}LNTOT_t + \beta_{51}LNTOT_{t-1} + \ldots\ldots\ldots + \beta_{5q5}LNTOT_{t-q5}$$

$$+ \beta_{60}CAB_t + \beta_{61}CAB_{t-1} + \ldots\ldots\ldots + \beta_{6q6}CAB_{t-q6}$$

$$+ \beta_{70}CFER_t + \beta_{71}CFER_{t-1} + \ldots\ldots\ldots + \beta_{7q7}CFER_{t-q7} + U_t$$

The long run relationship of the Model 1 is given as:

$$LNREER_t = C + \beta_1\ NCF_t + \beta_2\ GFCE_t + \beta_3\ LNTRADE_t + \beta_4\ LNGR_t \ \ + \beta_5LNTOT_t + \beta_6\ CAB_t$$

$$+ \beta_7\ CFER_t + \epsilon_t$$

For the **Model 2** that specifies the relations between Real Effective Exchange Rate (REER) and the components of the net capital inflows and other explanatory variables the ARDL (p, q_1,q_2, q_3,q_4,q_5,q_6,q_7) model is represented as follows:

$$LNREERt = \mathrm{C} + \delta\mathrm{t} + \phi_1LNREER_{t-1} + \phi_2LNREER_{t-2} + \ldots\ldots + \phi_pLNREER_{t-p}$$

$$+ \ \beta_{10}FDI_t + \beta_{11}FDI_{t-1} + \ldots\ldots\ldots + \beta_{1q1}FDI_{t-q1}$$

$$+ \beta_{20}PORT_t + \beta_{21}PORT_{t-1} + \text{-------} + \beta_{2q2}PORT_{t-q2}$$

$$+ \beta_{30}DEBTCF_t + \beta_{31}DEBTCF_{t-1} + \text{-------} + \beta_{3q3}DEBTCF_{t-q3}$$

$$+ \beta_{40}OTHCAP_t + \beta_{41}OTHCAP_{t-1} + \text{-------} + \beta_{4q4}OTHCAP_{t-q4}$$

$$+ \beta_{50}GFCE_t + \beta_{51}GFCE_{t-1} + \ldots\ldots\ldots + \beta_{5q5}GFCE_{t-q5}$$

$$+ \beta_{60}CAB_t + \beta_{61}CAB_{t-1} + \ldots\ldots\ldots + \beta_{6q6}CAB_{t-q6}$$

$$+ \beta_{70}CFER_t + \beta_{71}CFER_{t-1} + \ldots\ldots\ldots + \beta_{7q7}CFER_{t-q7} + U_t$$

The long run relationship of the Model 1 is given as:

$LNREER_t = C + \beta_1\, FDI_t + \beta_2\, PORT_t + \beta_3\, DEBTCF_t + \beta_4\, OTHCAP_t + \beta_5 GFCE_t + \beta_6\, CAB_t$

$+ \beta_7\, CFER_t + \epsilon_t$

4.5 Methodology for analyzing the dynamic relationship between the real effective exchange rate, the capital flows and other explanatory variables

4.5.1 The Generalized Impulse Response Functions (GIRF): In order to gain further insights into the dynamic interactions between capital flows and the real exchange rates it is proposed to examine the impulse response functions of the real exchange rate (REER) to innovations in capital flows using unrestricted Vector Auto Regression (VAR) model. A shock to a time series variable not only directly affects itself but is also transmitted to all the other endogenous variables through the dynamic (lag) structure of the VAR. An impulse response function traces the effect of shocks at a given point of time on the current and future values of the endogenous variables of a VAR system.

The GIRF were originally proposed for non-linear dynamic systems by Koop et, al (1996) but this was further developed by Pesaran and Shin (1998) for linear multivariate models. Using GIRF it is possible to examine the impact of responses of each variable to shocks to any of the other variables. The main advantage of the GIRF is that it circumvents the problem of the dependence of the orthogonalized impulse responses to the ordering of variables in the VAR in the conventional method advanced by Sims (1980) and Sims (1981).

In the GIRF analysis initially a VAR model of the jointly determined dependent variables is set up. The mathematical representation of a VAR model with order p is:

$$y_t = \sum_{i=1}^{p} \emptyset_i y_{t-i} + \varphi x_t + \epsilon_t \qquad t = 1, 2, \ldots T$$

Where $y_t = (y_{it}, y_{2t}, \ldots. y_{kt})'$ is a k x 1 vector of jointly determined endogenous variables, x_t is a d x 1 vector of exogenous variables, $\emptyset_i$, i = 1, 2,…, p are 1 x k coefficient matrices and ϵ_t is a k x 1 vector of innovations that may be contemporaneously correlated but are uncorrelated with their own and lagged values and uncorrelated with all of right hand side variables.

If the VAR model is stable (y_t is covariance stationary), the above model can be written in the infinite moving average representations as follows:

$$y_t = \sum_{j=0}^{\infty} A_j \epsilon_{t-j} + \sum_{j=0}^{\infty} B_j x_{t-j}$$

Where the k x k coefficient matrices A_j are computed using the recursive relations:

$$A_j = \emptyset_1 A_{j-1} + \emptyset_2 A_{j-2} + \ldots + \emptyset_p A_{j-p} \qquad j = 1, 2, \ldots\ldots$$

With $A_0 = I_k$ and $A_j = 0$ for $j < 0$ and $B_j = A_j\,\varphi$, for j = 1, 2,…

If a system wide k X 1 vector of shocks of size δ = (δ1, ….δk) hits the dynamical system at time t, the Generalized Impulse Response function of yt at time t + N for the shock δ is defined by:

$$GI_y(N, \delta, \Omega_{t-1}) = E(y_{t+N} | \epsilon_t = \delta, \Omega_{t-1}) - E(y_{t+N} | \Omega_{t-1})$$

Where Ω_{t-1}, is a non-decreasing information set that denotes the particular historical realization of the process at time t-1.

In the case of VAR model with infinite moving average representation the GIRF is given by

$$GI_y(N, \delta, \Omega_{t-1}) = A_N \delta$$

which is independent of the history of the system. The history invariance property of the impulse response function is specific feature of the linear systems.

In the event that the VAR model is perturbed by a shock of size δ_m to only one element (say m^{th} element) at time t, the GIRF by definition can be represented as:

$$GI_y(N, \delta_m, \Omega_{t-1}) = E(y_{t+N} | \epsilon_{mt} = \delta_m, \Omega_{t-1}) - E(y_{t+N} | \Omega_{t-1})$$

If the innovations are correlated then a shock to one innovation will be associated with changes in other innovations. The computation of the conditional expectations depends on the nature of distribution for the innovations ϵ_t. In the case ϵ_t has a multivariate normal distribution, i.e. $\epsilon_t \sim N(0, \Sigma)$ where $\Sigma = (\sigma_{mn})$ then

$$E(\epsilon_t | \epsilon_{mt} = \delta_m) = (\sigma_{1m}/\sigma_{mm}, \sigma_{2m}/\sigma_{mm}, \quad ,\sigma_{km}/\sigma_{mm})'\delta_m = \Sigma e_m \sigma_{mm}^{-1}\delta_m \quad m,n = 1,2,..,k$$

Where e_m is a k X 1 selection vector

$e_m = (0, 0, \ldots.0, 1, 0, \ldots0)'$ having 1 as the m^{th} element and all other elements as 0.

If the shock is defined by $\delta_m = \sqrt{\sigma_{mm}}$ ie of one standard deviation size then using the infinite moving average representation, the GIRF is obtained as :

$$GI_y(N, \delta_m = \sqrt{\sigma_{mm}}, \Omega_{t-1}) = \frac{A_N \Sigma e_m}{\sqrt{\sigma_{mm}}} \qquad m, n = 1,2,\ldots,k$$

The Generalized Impulse Response Function (GIRF) for a unit standard deviation shock to the mth equation at time t in the VAR model on the nth variable at time t + N is given by the nth element of the above equation. This can also be expressed as

$$GI_{mn,N} = \frac{e_n' A_N \Sigma e_m}{\sqrt{\sigma_{mm}}} \quad m, n = 1,2,\ldots,k$$

Unlike the orthogonalised impulse responses in the conventional model the generalized impulse response are invariant to the ordering of the variables in the VAR.

4.5.2 Generalized Variance Decomposition Analysis: The forecast error variance decompositions provide a decomposition of the variance of the forecast errors of the variables in the VAR at a future time horizon. The generalized variance decomposition considers the proportion of the N step ahead forecast errors of y_t that are explained by conditioning on the non orthogonalised shocks, $\epsilon_{mt}, \epsilon_{m,t+1}, \ldots, \epsilon_{m,t+N}$, but explicitly allowing for the contemporaneous correlations between these shocks and the shocks to the other equations in the system.

The N step ahead generalized variance decomposition for mth variable in y_t due to innovations in the nth variable in the VAR model explained above is given by the equation (Pesaran and Pesaran, 2009);

$$\Psi_{mn,N} = \frac{\sigma_{mm}^{-1} \sum_{l=0}^{N} (e_n' A_l \Sigma e_m)^2}{\sum_{l=0}^{N} e_n' A_l \Sigma A_l' e_n} \qquad m, n = 1.2\ldots,k$$

It measures the proportion of the N step ahead forecast error variance of mth variable in y_t that is explained by the non-orthogonalised innovations in the nth variable.

4.5.3 Econometric Model for analyzing the dynamic relationships

To analyze the dynamic relationship between the real exchange rate and capital flows and its components and the capital flows and its components two Unrestricted VAR Models are set up as follows:

Model 1 uses REER, GFCE, NCF, LNTRADE (natural logarithm of TRADE), LNTOT (natural logarithm of TOT), LNGR (natural logarithm GR), CAB and CFER as endogenous variables and C as a vector of intercepts.

Model 2 uses REER, GFCE, FDI, PORT, DEBTCF, OTHCAP, CAB and CFER as endogenous variables and C as a vector of intercepts

4.6 Methodology to investigate the linkage between Volatility of Capital flows and REER

4.6.1 Measuring the real exchange rate volatility

In order to investigate the linkage between the volatility of the Real Effective Exchange rate and the volatility of the Net Capital Flows and of its components for the Indian economy, at the first instance the proxies for the real exchange rate volatility are estimated. Three measures for volatility of real effective exchange rate are estimated as indicted below

(i) Conditional Variance of a first order ARCH model, VREERA. In order to estimate this volatility first order ARCH is set up as follows

$LNREER_t = C + \theta\ LNREER_{t-1} + u_t$

$u_t \sim N(0, VREERA_t)$

$VREERA_t = \omega + \alpha u_{t-1}^2$

(ii) Conditional Variance of a GARCH (1, 1) Model, VREERG. In order to estimate this volatility the following GARCH specification is set up

$LNREER_t = C + \theta\ LNREER_{t-1} + u_t$

$u_t \sim N(0, VREERG_t)$

$VREERG_t = \omega + \alpha u_{t-1}^2 + \beta\ VREERG_{t-1}$

(iii) Moving Standard deviation of the growth rates of the quarterly real exchange rate over a four quarter window computed as follows

$VREERT_t = [\frac{1}{4} \sum_{j=t-3}^{t}(LNREER_j - LNREER_{j-1})^2]$

4.6.2 Measuring the volatility of Net Capital Flow and that of its components.

Similarly three corresponding measures of volatility of Net Capital flows and its components are estimated using the following specifications:

(i) Conditional Variance of a first order ARCH model, VNCFA. In order to estimate this volatility first order ARCH is set up as follows

$NCF_t = C + \theta\ NCF_{t-1} + u_t$

$u_t \sim N(0, VNCFA_t)$

$VNCFA_t = \omega + \alpha u_{t-1}^2$

(ii) Conditional Variance of a GARCH (1, 1) Model, VNCFG. In order to estimate this volatility the following GARCH specification is set up

$NCF_t = C + \theta\ NCF_{t-1} + u_t$

$u_t \sim N(0, VNCFG)$

$VNCFG_t = \omega + \alpha u_{t-1}^2 + \beta\ VNCFG_{t-1}$

(iii) Moving Standard deviation of the changes of the quarterly net capital flows over a four quarter window computed as follows

$VNCFT_t = [\frac{1}{4} \sum_{j=t-3}^{t} (NCF_j - NCF_{j-1})^2]$

The volatility of the net capital flow components i.e. VFDI (volatility of FDI - quarterly net Foreign Direct investment as a ratio of quarterly GDP), VPORT (volatility of PORT- net portfolio flows in the quarter as a ratio of quarterly GDP), VDEBTCF (volatility of DEBTCF – net debt creating flows comprising of banking capital, loans, rupee debt service in the quarter as a ratio of quarterly GDP), and VOTHCAP (volatility of net other capital flows in the quarter as a ratio of quarterly GDP) are computed in a similar manner.

4.6.3 Cointegration Tests:

To explore the possibility of a long run relation between the volatility of real exchange rates and the volatility of the capital flow variables test of cointegration is applied between the three types of proxy measures of volatility. For this purpose VAR based cointegration tests using the methodology developed by Johansen (1991, 1995) are employed (EViews 5 Users Guide).

The mathematical representation of a VAR model with order p is:

$$y_t = \sum_{i=1}^{p} \emptyset_i y_{t-i} + \varphi x_t + \epsilon_t \qquad t = 1, 2, \ldots T$$

Where $y_t = (y_{it}, y_{2t}, \ldots y_{kt})'$ is a k x 1 vector of jointly determined endogenous variables, x_t is a d x 1 vector of exogenous variables, $\emptyset_i$, i = 1, 2,…, p are 1 x k coefficient matrices and ϵ_t is a k x 1 vector of innovations.

This VAR can be rewritten as

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varphi x_t + \epsilon_t$$

Where, $\Pi = \sum_{i=1}^{p} \emptyset_i - I$, $\Gamma_i = -\sum_{j=i+1}^{p} \emptyset_j$

As per Granger's representation theorem if the coefficient matrix Π has reduced rank r < k then there exists k x r matrices α and β each with rank r such that $\Pi = \alpha\beta'$ and βy_t is I(0). r is the number of cointegrating relations.

Johansen's cointegration test is conducted using EViews 5.0. As this is a test for cointegration it is valid only if the series are nonstationary.

The trace statistic tests the null hypothesis of r cointegrating relations, against the alternative of k alternative relations, for r = 0,1,…, k-1.

The trace statistic for the null hypothesis of r cointegrating relations is computed as:

$$LR_{tr}(r|k) = -T\sum_{i=r+1}^{k} \log(1-\lambda_i)$$

Where λ_i is the i-th largest eigen value of the Π matrix.

4.6.4 Exploring the causality between the Volatility of the Real Exchange Rate and the Volatility of the Net Capital Flows and the Volatility of its components:

In order to examine the unidirectional or bidirectional causality between a pair of variables causality test is applied. If a variable X causes Y and also Y causes X then there is bidirectional causality and if only one variable causes the other then there is unidirectional causality. Granger Test is one of the oldest tests in the literature for detecting causality. The intuition behind the Granger (1969) approach to the question whether X causes Y is to see as to how much of the current Y can be explained by the lagged values of Y and then to see whether adding lagged values of X can improve the explanation of Y (EViews 5 Users Guide) . Y is said to be Granger caused by X if X helps in the prediction of Y which means that the coefficients on lagged values of X are statistically significant. Often there is a possibility of two way causality i.e. the X Granger causes Y and Y Granger causes X. The following model is applied to test the statistical significance of the lagged variables:

$$Y_t = \sum_{i=1}^{p} \alpha_i X_{t-i} + \sum_{i=1}^{p} \beta_i Y_{t-i} + \varepsilon_{1t}$$

$$X_t = \sum_{i=1}^{p} \gamma_i X_{t-i} + \sum_{i=1}^{p} \delta_i Y_{t-i} + \varepsilon_{2t}$$

Where p is the order of the lag that corresponds to the beliefs about the longest time over which one of the variables can help predict the other variable.

The null hypothesis is that X does not Granger cause Y in the first equation and that Y does not Granger cause X in the second equation.

H_{01}: $\alpha_1 = \alpha_2 = \ldots = \alpha_p = 0$

H_{02}: $\delta_1 = \delta_2 = \ldots = \delta_p = 0$

The joint significance is tested using the Wald F statistics. The stationarity of variables is a precondition for Granger causality test.

4.7 Data Sources:

The dataset comprises the quarterly data for the Indian economy for the period 1996-97(Q1) to 2012-13(Q4).

The data for the variable Real Effective Exchange Rate (REER) is obtained from the Handbook of Statistics published by the Reserve Bank of India (RBI) which provides monthly average of the Real Effective Exchange Rate Indices for the Indian Economy. The RBI publishes the six-currency and thirty six currency indices of REER. The six currency indices represent the US, the Eurozone, UK, Japan, China and Hong Kong SAR (RBI, Bulletin Dec. 2005). In the 36 – currency REER indices countries have been chosen based on three broad criteria. (i) the share in India's exports and trade (ii) regional representation and (iii) the regular availability of data on exchange rates and prices on a monthly basis. The countries/regions represented by thirty six currencies together account for on an average 77 per cent and 89 per cent of India's total foreign trade and exports during 2002-03 to 2004-05. The REER indices (both six-currency and 36 – currency) use the Wholesale Price Index (WPI) as a proxy for Indian prices and the Consumer Price Index (CPI) as a proxy for foreign partner countries. The exchange rate of a currency is expressed as the number of units of numeraire (SDR) per i^{th} currency. A rise in e or e/e_i thus represents an appreciation of rupee relative to the currency i and vice versa. The Special Drawing Right (SDR) is used as the numeraire currency in construction of REER indices. Since the exchange value of the SDR is determined by a weighted average of basket of currencies this would offset the fluctuations in individual currencies. The 6 – currency REER indices have two base years, 1993-94 as fixed base and 2003-04 as a moving base which changes every year. For the 36 currency REER indices, 1993-94 is the base year. The choice of 1993-94 base year is on account of the significant changes in the macroeconomic environment due to structural reforms introduced subsequent to the balance of payment crises in 1990-91. Even though the choice of the base year affects the level of REER indices at a point of time, the indices being geometric series, the percentage difference between any two periods remain the same irrespective of the base year. The six currency REER indices use a three year moving average trade weights (exports plus imports) to reflect the dynamically changing pattern of India's foreign trade with the major trading partners. The 36 currency REER indices also use the three year moving average normalized weights (both exports and trade weights) for the 36 currencies. The REER index used as dependent variable in the study is the average of the monthly trade weighted 36 Currency Real Effective Exchange Rate Indices for the quarter.

The Net Capital flows (NCF) comprises of Net Foreign Direct Investment (FDI), Net Portfolio Investment(PORT), Net Debt Creating Flows (DEBTCF) (which in turn comprises of Loans, Net Banking Capital, and Net Rupee Debt Service) and Net Other Capital flows (OTHCAP) in the quarter. These variables are measured as a ratio of the corresponding quarterly estimates of Gross Domestic Product (GDP) at Market Prices at Current Prices (Base Year 2004-05). The data for the Net Capital Flow and its components is obtained from the Handbook of Statistics published by the Reserve Bank of India and for GDP from the National Account Statics of the Central Statistical Office, Ministry of Statistics and Programme Implementation.

The Government Final Consumption Expenditure (GFCE) is measured as a ratio of quarterly estimates of Government Final Consumption Expenditure at Market Prices at current prices

(Base year 2004-05) to the quarterly estimates of GDP at Market Prices at Current Prices (Base Year 2004-05). The data is obtained from the National Account Statics of the Central Statistical Office, Ministry of Statistics and Programme Implementation.

The values of variable TRADE which is a proxy for trade openness are measured as a ratio of the sum of total Rupee Exports and Imports in the quarter to the quarterly estimates of GDP at Market Prices at Current Prices (Base Year 2004-05). The data for exports and imports is obtained from the Handbook of Statistics published by the Reserve Bank of India.

The Net Current Account Balance (CAB) is measured as a ratio of the net current account balance in the quarter to the quarterly estimates of GDP at Market Prices at Current Prices (Base Year 2004-05). The data for net current account balance is obtained from the Handbook of Statistics published by the Reserve Bank of India.

The Change in Foreign Exchange Reserves (CFER) is measured as a ratio of the change in total foreign exchange reserves from the end of the previous quarter to the end of the present quarter in rupees to the quarterly estimates of GDP at Market Prices at Current Prices (Base Year 2004-05). The data for foreign exchange reserves is obtained from the Handbook of Statistics published by the Reserve Bank of India.

The Net Terms of Trade (TOT) is measured as the ratio of General Unit Value Index of Exports to the General Unit Value Index of Imports. The data for the Unit Value Indices is published by Directorate General of Commercial Intelligence and Statistics (DGCI&S). The DGCI & S provides the data with the old series 1978-79 base year and 1999-2000 as base period and the linking factor for calculating old indices based on new indices.

The Growth Rate (GR) which is a proxy for productivity differential is measured as the percentage changes in the quarterly GDP at factor cost at fixed prices as compared to the corresponding quarter in the previous year. The data is obtained from the National Account Statics of the Central Statistical Office, Ministry of Statistics and Programme Implementation.