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Abstract

This paper examines the relationship between the real exchange rate, level of capital flows, volatility of the flows, fiscal and monetary policy indicators and the current account surplus for the Indian economy for the period 1993Q2 to 2004Q1. The estimations indicate that the variables are cointegrated and each granger causes the real exchange rate. The generalized variance decompositions show that determinants of the real exchange rate, in descending order of importance include net capital inflows and their volatility (jointly), government expenditure, current account surplus and the money supply. A preliminary analysis suggests that a similar analysis can be performed for the foreign exchange reserves held by the RBI.

Keywords: real exchange rate, capital flows, foreign exchange reserves, cointegration,
JEL Classification: C32; F31; F41

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1. *Introduction*

The 1990s witnessed an upsurge in international capital flows the world over. This was a consequence of several factors such as financial liberalization and innovations, spread of information technology and proliferation of institutional investors. A noteworthy feature of the increased flows to developing countries was that private (equity and debt) flows rather than official flows became a dominant source of financing large current account imbalances. Furthermore, equity flows gained importance compared to debt flows.

At the same time, capital flows to developing countries have been very volatile in the recent past. This is evident from recent episodes of financial crises such as the East Asian crisis of 1997-98, followed by the turmoil in global fixed income markets. More recently, the collapse of Argentina's currency board peg in 2001 and the revelation of accounting irregularities and corporate failures in the U.S. in 2002 have affected capital flows.

Against this backdrop of an increase in magnitude and variability of capital flows, this study examines the impact of changes in the levels and volatility of capital flows on the Indian exchange rates, while accounting for other factors that have a potential influence on the real effective exchange rate (REER).

Until 1973, the Indian rupee followed a fixed exchange rate regime wherein the rupee was pegged to the pound sterling. With the breakdown of the Bretton Woods system in the early 1970s, India switched over to a system of managed exchange rates. During this period, the nominal exchange rate was the operating variable to achieve the intermediate target of a medium–term equilibrium path of the real effective exchange rate. REER fell[2] consistently between 1980-81 and 1992-93 from 104.48 to 57.08. In early 1990s, India was faced with a severe balance of payment crisis due to the significant rise in oil prices, the suspension of remittances from the Gulf region and several other exogenous developments. Amongst the several measures taken to tide over the crisis, was a devaluation of the rupee in July 1991 to maintain the competitiveness of Indian exports.

[2] The definition of REER used in this paper is based on trade weights. It is the weighted average of bilateral nominal exchange rates of the home currency in terms of the foreign currencies adjusted by domestic to foreign local-currency prices. Thus, a fall in REER implies depreciation and an increase in the same implies appreciation. The number of countries included is 36.

This initiated the move towards greater exchange rate flexibility. A liberalized exchange rate management system was put in place in March 1992 along with other measures to liberalize trade, industry and foreign investment. The unification of the exchange rate of the Indian rupee made it market determined. From then on, the foreign exchange market exhibited orderliness except for a few episodes of volatility during which the Reserve Bank of India (RBI) took steps to restore stability. Moreover, with the gradual opening of the current and capital account transactions and the growing investor confidence, there was an increase in the volume of capital inflows. There were surges in capital inflows in 1993-94, 1994-95 and the first half of 1995-96. This, along with robust export growth, began pushing the exchange rate upwards. Beginning with 1992-93, REER rose continuously and stood at 74.14 in the financial year 2003-04.

During the decade of 1980s net capital inflows to India were almost negligible and became a quantity to be reckoned with only 1993-94 onwards. From a low of Rs. 1699 crores in 1992-93, net capital inflows jumped to Rs. 13282 crores in 1993-94. From then on, except for a few aberrations (during 1998-99 net capital inflows fell to Rs. 10169 crores due to the East Asian crisis and in 2002-03, they again dipped to Rs. 27254 crores which can be attributed to the global economic slowdown), capital inflows have been mushrooming. The net capital inflows increased from an average of about Rs. 200 crores during the 1980s to an average of over Rs. 12,000 crores during the 1990s. While in 1993-94, net capital inflows amounted to Rs. 13282 crores, the figure increased over five times to reach Rs. 73461 crores in 2003-04.

The composition of capital inflows also changed markedly. Inflows in the form of foreign direct investment (FDI), portfolio investment, external commercial borrowings, non-resident deposits and social deposit schemes dominated the capital account and the dependence on aid was nearly eliminated. This is again a reflection of the growing confidence among international investors in India as it increasingly liberalized its policies. FDI to India which stood at a low level of Rs. 1837 crores during 1993-94, picked up significantly thereafter and during 2003-04, it stood at Rs. 21,463 crores; an average annual increase of over 100%. FII inflows to India started only in 1993-94 (Rs. 11,445 crores) and since then have been on the rise. They totaled Rs. 51,998 crores during 2003-04. Thus, over a span of ten years, FII inflows increased by over four times.

Total foreign investment (FII+FDI) in India over the period 1993-94 to 2003-04 accounted for over 55% of the total net capital inflows.

Figure 1[3] gives the relationship between nominal net capital inflows against REER for the period 1980-81 to 2003-04 and clearly shows the trends discussed above. It is evident from the figure that capital flows to India were near zero until the beginning of 1990s and began to increase significantly only thereafter as the country, with its newly initiated liberalization, increasingly provided attractive avenues to invest. At the same time, REER, which fell between 1980-81 and 1992-93, also began to appreciate as a result of increasing capital inflows and export growth. The correlation between net capital inflows and REER is as high as 0.787 for the period 1993-94 to 2003-04.

In this paper, robust econometric techniques are applied to Indian data to examine the relationship between capital flows, REER and foreign exchange reserves of the RBI for the period 1993Q2 to 2004Q1. An earlier study by Chakraborty (2003) discusses the relationship between capital flows and REER for India between 1993Q2 and 2001Q1. The study uses an unrestricted VAR framework and the variables included are, net capital inflows (aggregate of FDI, portfolio investment and external commercial borrowing), and rate of growth of domestic credit and rate of inflation as proxies for monetary and fiscal policies, respectively. The paper concludes that REER depreciated in response to one standard deviation innovation to foreign capital inflows. This conclusion, that is contrary to economic intuition, might be a result of the weak econometric methodology used in the paper.[4]

This paper is divided into the following sections. Section 2 describes the theoretical model. Section 3 reports the econometric methodology. The empirical estimates are reported in Section 4. Section 5 concludes the paper. Data definitions and sources are reported in the appendix.

[3] Figure 1 measures Net Capital Inflows by 'net foreign investment' defined as the sum of net foreign investment in India (Direct + Portfolio) and net foreign investment abroad.

[4] Marcelo and Hugo (2000) examine the long-run response of the real exchange rate to capital flows for Mexico. They conclude that a once and for all unit increase in the ratio of quarterly capital inflow to quarterly annualized GDP would, ceteris paribus, lead to a long-run real appreciation of the peso of about 12 percent. This conforms to economic theory.

2. *Theoretical Model*

To focus on the issue of capital flows, we need a model of imperfect asset substitutability between domestic and foreign assets. We abstract from the role of capital markets and investment – too many things have changed in the industrial structure of the Indian economy to permit incorporation in a small macro model.
So define (as in Branson et.al. (1977))

$$W \equiv \frac{M + B + (F / E)}{P} \tag{1}$$

where W is real wealth, M the nominal money supply, B the supply of (all short) government bonds, F is the net foreign assets of the private sector, E is the nominal exchange rate (here, the foreign currency price of domestic currency—an appreciation of the rupee is a rise in E[5]) and P is the price level. We could have deflated by a price index, which includes the foreign good price also – but this is probably not crucial to the empirical story.

There are three assets and by the balance sheet constraint, if two of these are in equilibrium, then so is the third one.

$$\frac{M}{P} = L\left(i, i^* - \overset{o}{E}/E, Y, W\right) \tag{2}$$

where L is the real demand for money, i (i*) is the domestic (foreign) nominal interest rate, Y is the output level. A dot over a variable is its time derivative. Similarly, there is a market-clearing condition for the domestic bond market.

$$\frac{B}{P} = J(\quad) \tag{3}$$

Here, L_1, $L_2 < 0$, $L_3 > 0$; 0 L_4 1

$J_1 > 0$, $J_2 < 0$, $J_3 < 0$, 0 J_4 1

Finally, there is an IS curve

$$Y = A(Y, i - \Pi, G) + TB(Y, Y^*, \frac{P^*}{EP}) \qquad (4)$$

where A is domestic absorption, Y (Y*) is the domestic (foreign) output, Π is the expected (and actual) rate of inflation, G government expenditure, TB the trade balance and P*/P is the relative price of foreign goods.

There are two dynamic equations – a Phillips Curve and a foreign asset accumulation equation.

$$\Pi = H(Y - \overline{Y}) - \frac{\overset{0}{E}^{y}}{E} \qquad (5)$$

$$\frac{\overset{o}{F}}{EP} = TB(\quad) + \frac{i^* F}{EP} \qquad (6)$$

The system (1) to (6) can be solved for 3 dynamic variables $\frac{EP}{P^*}$, F and $\frac{M+B}{P}$.

A semi-reduced form for $\frac{P^*}{EP}$ would look like the following:

$$\frac{EP}{P^*} = y\left(F, \frac{M}{P}, \frac{B}{P}, G_t, G_{t+1}, \ldots, i_t^*, i_{t+1}^*, \ldots, m_t, m_{t+1}\right) \qquad (7)$$

where the forcing variables are i*, G and μ (the growth rate of money).

The above is true for a freely floating exchange rate model. Where intervention takes place EP/P* becomes jointly determined with the intervention variable. In the Indian context with the Reserve bank of India intervening continuously to maintain a constant effective exchange rate, we can invert equation (7) to get the level of foreign exchange as the endogenous variable

$$F^C = \Phi(\frac{EP}{P^*}; F, \frac{M}{P}, \frac{B}{P}, G_t, G_{t+1}, \ldots, i_t^*, i_{t+1}^*, \ldots, m_t, m_{t+1}, \ldots) \qquad (8)$$

Equation (8) can be thought of as a semi-reduced form for EP/P* with the Central Bank's reaction function inserted in it. Or equivalently, it is the Exchange market Pressure Model

[5] That is how the data is reported in India.

with the variable of interest (for us) being the central Bank's stock of foreign exchange reserves.

Higher real balances are associated with a real depreciation, and therefore is negatively associated with the holding of foreign exchange (insofar as the Central Bank sells foreign exchange to prevent this). Similarly, for the country's stock of foreign assets, we should expect a positive relationship. In the estimated equation we should expect capital inflows and government expenditure to be positively associated with the foreign exchange reserves. Finally in keeping with the exchange market pressure literature an acquisition of foreign exchange takes place when the real value of the currency is high.

3. *Econometric Methodology*

Based on the model in the previous section, we evaluate in a VAR framework, the relationship between real effective exchange rate, net capital inflows and their volatility, fiscal policy indicator, monetary policy indicator, and real current account surplus. The section below describes the econometric methodology employed.

Tests for nonstationarity are first discussed, followed by a description of cointegration and granger causality, generalized impulse response and decomposition analysis. Finally, we analyze generalized impulse response analysis in a cointegrated VAR model.

Nonstationarity

The classical regression model requires that the dependent and independent variables in a regression be stationary in order to avoid the problem of what Granger and Newbold (1974) called 'spurious regression'. Nonstationarity or the presence of a unit root can be tested using the augmented Dickey-Fuller (ADF) test (1979, 1981), the Phillips Perron (PP) test (1988) and the KPSS test proposed by Kwiatkowski et al. (1992).

To test if a sequence y_t contains a unit root, three different regression equations are considered in ADF test:

$$\Delta y_t = a + g y_{t-1} + q t + \sum_{i=2}^{p} b_i \Delta y_{t-i} + e_t \tag{8}$$

$$\Delta y_t = a + g y_{t-1} + \sum_{i=2}^{p} b_i \Delta y_{t-i} + e_t \quad (9)$$

$$\Delta y_t = g y_{t-1} + \sum_{i=2}^{p} b_i \Delta y_{t-i} + e_t \quad (10)$$

The first equation includes both a drift term and a deterministic trend; the second excludes the deterministic trend; and the third does not contain an intercept or a trend term. In all three equations, the parameter of interest is γ. If $\gamma=0$, the y_t sequence has a unit root. The estimated t-statistic is compared with the appropriate critical value in the Dickey-Fuller tables to determine if the null hypothesis is valid. The critical values are denoted by τ_τ, τ_μ, and τ for equations (8), (9), and (10) respectively.

We follow Doldado, Jenkinson and Sosvilla-Rivero's (1990) sequential procedure for the ADF test when the form of the data-generating process is unknown. Such a procedure is necessary since including the intercept and trend term reduces the degrees of freedom and the power of the test implying that we may conclude that a unit root is present when, in fact, this is not true. Further, additional regressors increase the absolute value of the critical value making it harder to reject the null hypothesis. On the other hand, inappropriately omitting the deterministic terms can cause the power of the test to go to zero (Campbell and Perron, 1991).

The sequential procedure involves testing the most general model first (equation 8). Since the power of the test is low, if we reject the null hypothesis, we stop at this stage and conclude that there is no unit root. If we do not reject the null hypothesis, we proceed to determine if the trend term is significant under the null of a unit root. If the trend is significant, we retest for the presence of a unit root using the standardized normal distribution. If the null of a unit root is not rejected, we conclude that the series contains a unit root. Otherwise, it does not. If the trend is not significant, we estimate equation (9) and test for the presence of a unit root. If the null of a unit root is rejected, we conclude that there is no unit root and stop at this point. If the null is not rejected, we test for the significance of the drift term in the presence of a unit root. If the drift term is significant, we test for a unit root using the standardized normal distribution. If the drift is not significant, we estimate equation (10) and test for a unit root.

We also conduct the Phillips-Perron (1988) test for a unit root mainly because the Dickey-Fuller tests require that the error term be serially uncorrelated and homogeneous while the Phillips-Perron test is valid even if the disturbances are serially correlated and heterogeneous. The test statistics for the Phillips-Perron test are modifications of the t-statistics employed for the Dickey-Fuller tests but the critical values are precisely those used for the Dickey-Fuller tests.

In both the ADF and the PP test, the unit root is the null hypothesis. A problem with classical hypothesis testing is that it ensures that the null hypothesis is not rejected unless there is strong evidence against it. Therefore these tests tend to have low power, that is, these tests will often indicate that a series contains a unit root. Kwiatkowski et al. (1992) therefore suggest that based on classical methods it may be useful to perform tests of the null hypothesis of stationarity in addition to tests of the null hypothesis of a unit root. Tests based on stationarity as the null can then be used for confirmatory analysis, that is, to confirm conclusions about unit roots. Of course, if tests with stationarity as the null as well as tests with unit root as the null both fail to reject the respective nulls or both reject the respective nulls, there is no confirmation of stationarity or nonstationarity.

KPSS Test with the Null Hypothesis of Difference Stationarity

To test for difference stationarity (DS), KPSS assume that the series y_t with T observations (t=1,2,…,T) can be decomposed into the sum of a deterministic trend, random walk and stationary error

$$y_t = \delta t + r_t + \varepsilon_t$$

where r_t is a random walk

$$r_t = r_{t-1} + \mu_t$$

and μ_t is independently and identically distributed with mean zero and variance σ^2_μ. The initial value r_0 is fixed and serves the role of an intercept. The stationarity hypothesis is $\sigma^2_\mu=0$. If we set $\delta = 0$, then under the null hypothesis y_t is stationary around a level (r_0).

Let the residuals from the regression of y_t on an intercept be e_t, t=1,2,…,T. The partial sum process of the residuals is defined as:

$$S_t = \sum_{i=1}^{t} e_i$$

The long run variance of the partial error process is defined by KPSS as

$$s^2 = \lim_{T \to \infty} T^{-1} E(S_T^2)$$

A consistent estimator of σ^2, $s^2(l)$, can be constructed from the residuals e_t as

$$S^2(l) = T^{-1} \sum_{t=1}^{T} e_t^2 + 2T^{-1} \sum_{s=1}^{l} w(s,l) \sum_{t=s+1}^{T} e_t e_{t-s}$$

where $w(s,l)$ is an optional lag window that corresponds to the selection of a spectral window. KPSS employ the Bartlett window, $w(s,l) = 1 - s/(l+1)$ as in Newey and West (1987), which ensures the non-negativity of $s^2(l)$. The lag operator l corrects for residual serial correlation. If the residual series are independently and identically distributed, a choice of $l = 0$ is appropriate.

The test statistic for the DS null hypothesis is

$$\hat{h}_m = T^{-2} \sum_{t=1}^{T} S_t^2 / s^2(l)$$

KPSS report the critical values of $\hat{\eta}_\mu$ (p. 166) for the upper tail test.

Thus, three tests, ADF, PP and KPSS tests are used to test for the presence of a unit root. The KPSS test, with the null of stationarity, helps to resolve conflicts between the ADF and PP tests. If two of these three tests indicate nonstationarity for any series, we conclude that the series has a unit root.

If the variables are nonstationary, we test for the possibility of a cointegrating relationship using the Johansen and Juselius (1990) methodology. If the variables are indeed cointegrated, we can construct a vector error-correction model that captures both the short-run and long-run dynamics.

Cointegration and Granger Causality

The possibility of a cointegrating relationship between the variables is tested using the Johansen and Juselius (1990, 92) methodology. If the variables are indeed cointegrated, we can construct a vector error-correction model that captures both the short-run and long-run dynamics.

Consider the p-dimensional vector autoregressive model with Gaussian errors:

$$y_t = A_1 y_{t-1} + ... + A_p y_{t-p} + A_0 + e_t$$

where y_t is an $m \times 1$ vector of I(1) jointly determined variables. The Johansen test assumes that the variables in y_t are I(1). For testing the hypothesis of cointegration the model is reformulated in the vector error-correction form

$$\Delta y_t = -\Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + A_0 + e_t$$

where, $\Pi = I_m - \sum_{i=1}^{p} A_i, \quad \Gamma_i = -\sum_{j=i+1}^{p} A_j, \quad i = 1, \ldots.., p-1.$

Here the rank of Ð is equal to the number of independent cointegrating vectors. If the vector y is I(0), Ð will be a full rank $m \times m$ matrix. If the elements of vector y_t are I(1) and cointegrated with rank (Ð) = r, then $\Pi = \boldsymbol{ab'}$, where *á* and *â* are $m \times r$ full column rank matrices and there are $r < m$ linear combinations of y_t. The model can easily be extended to include a vector of exogenous I(1) variables.

Under cointegration, the VECM can be represented as

$$\Delta y_t = -ab' y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + A_0 + e_t$$

where á is the matrix of adjustment coefficients. If there are non-zero cointegrating vectors, then some of the elements of á must also be non zero to keep the elements of y_t from diverging from equilibrium.

Johansen and Juselius (1990, 92) suggest the LR test based on the maximum eigenvalue (λ_{max}) and trace (λ_{trace}) statistics to determine the number of the cointegrating vectors. Since λ_{max} test has a sharper alternative hypothesis as compared to λ_{trace} test, it is used to select the number of cointegrating vectors.

If the presence of cointegration is established, the concept of Granger causality can also be tested in the VECM framework. For example, if two variables are cointegrated, i.e. they have a common stochastic trend, then causality in the Granger (temporal) sense must exist in at least one direction (Granger, 1986; 1988). Thus in a two variable vector error correction model, we say that the first variable does not Granger cause the second if the lags of the first variable and the error correction term are jointly not significantly different from zero. This is tested by a joint F or Wald χ^2 test.

Generalized Impulse Response Analysis

Dynamic relationships among variables in VAR models can be analyzed using innovation accounting methods that include impulse response functions and variance decompositions. An impulse response function measures the time profile of the effect of shocks at a given point in time on the future values of variables of a dynamical system.

A major limitation of the conventional method advocated by Sims (1980, 81) is that the impulse response analysis is sensitive to the ordering of variables in the VAR (see Lutkepohl, 1991). In this approach, the underlying shocks to the VAR model are orthogonalized using the Cholesky decomposition of the variance-covariance matrix of the errors, $\Sigma = E(\varepsilon_t \varepsilon_t') = PP'$, where P is a lower triangular matrix. Thus a new sequence of errors is created with the errors being orthogonal to each other, and contemporaneously uncorrelated with unit standard errors. Therefore the effect of a shock to any one of these orthogonalized errors is unambiguous because it is not correlated with the other orthogonalized errors.

Generalized impulse responses overcome the problem of dependence of the orthogonalized impulse responses on the ordering of the variables in the VAR. Koop et. al (1996) originally proposed the generalized impulse response functions (GIRF) for non-linear dynamical systems but this was further developed by Pesaran and Shin (1998) for linear multivariate models. An added advantage of the GIRF is that since no orthogonality assumption is imposed, it is possible to examine the initial impact of responses of each variable to shocks to any of the other variables.

The generalized impulse response analysis can be described in the following way[6]. Consider a VAR (p) model:

$$x_t = \sum_{i=1}^{p} \Phi_i x_{t-i} + \boldsymbol{e}_t, \qquad t = 1,2,\dots, T. \qquad (11)$$

where $x_t = (x_{1t}, x_{2t}, \dots, x_{mt})'$ is an $m \times 1$ vector of jointly determined dependent variables and $\{\Phi_i, i=1,2,\dots,p\}$ are $m \times m$ coefficient matrices.

If x_t is covariance-stationary, the above model can be written as an infinite MA representation:

[6] For a detailed discussion and proofs, see Pesaran and Pesaran (1997) and Pesaran and Shin (1998).

$$x_t = \sum_{i=0}^{\infty} A_i \varepsilon_{t-i}, \qquad t = 1,2,,\ldots,T. \tag{12}$$

where m × m coefficient matrices A_i can be obtained using the following recursive relations:

$$A_i = \Phi_1 A_{i-1} + \Phi_2 A_{i-2} + \ldots + \Phi_p A_{i-p}, \qquad i = 1,2,\ldots.. \tag{13}$$

with $\mathbf{A}_0 = \mathbf{I}_m$ and $\mathbf{A}_i = \mathbf{O}$ for $i < 0$.

Consider the effect of a hypothetical m × 1 vector of shocks of size $\mathbf{d} = (\delta_1, \ldots, \delta_m)'$ hitting the economy at time t compared with a base-line profile at time t+n, given the economy's history.

The generalized impulse response function of x_t at horizon n, is given by:

$$GI_x(n, \boldsymbol{d}, \Omega_{t-1}) = E(x_{t+n} | \boldsymbol{\varepsilon}_t = \boldsymbol{d}, \Omega_{t-1}) - E(x_{t+n} | \Omega_{t-1}) \tag{14}$$

where the history of the process up to period t-1 is known and denoted by the non-decreasing information set Ω_t.

Here the appropriate choice of hypothesized vector of shocks, $\mathbf{d}$, is central to the properties of the impulse response function. By using Sims' (1980) Cholesky decomposition of Σ $(=E(\varepsilon_t \varepsilon_t')) = PP'$, the m × 1 vector of the *orthogonalized* impulse response function of a unit shock to the jth equation on x_{t+n} is given by:

$$\boldsymbol{\psi}_j^o = A_n P e_j, \qquad n = 0,1,2,.., \tag{15}$$

where $\mathbf{e}_j$ is an m × 1 vector with unity as its jth element and zero elsewhere.

However, Pesaran and Shin (1998) suggest to shock only one element (say j^{th} element), instead of shocking all elements of ε_t, and integrate out the effects of other shocks using an assumed or historically observed distribution of errors. Thus, now the generalized impulse response equation can be written as

$$GI_x(n, \boldsymbol{d}_j, \Omega_{t-1}) = E(x_{t+n} | \boldsymbol{\varepsilon}_{jt} = \boldsymbol{d}_j, \Omega_{t-1}) - E(x_{t+n} | \Omega_{t-1}) \tag{16}$$

If the errors are correlated a shock to one error will be associated with changes in the other errors. Assuming that ε_t has a multivariate normal distribution, i.e., $\varepsilon_t \sim N(0, \Sigma)$, we have

$$E(\boldsymbol{\varepsilon}_t | \boldsymbol{\varepsilon}_{jt} = \boldsymbol{d}_j) = (\boldsymbol{\sigma}_{1j}, \boldsymbol{\sigma}_{2j}, \Lambda, \boldsymbol{\sigma}_{mj})' \boldsymbol{\sigma}_{jj}^{-1} \boldsymbol{d}_j = \Sigma e_j \boldsymbol{\sigma}_{jj}^{-1} \boldsymbol{d}_j \tag{17}$$

This gives the predicted shock in each error given a shock to ε_{jt}, based on the typical correlation observed historically between the errors. This is different from the case where the disturbances are orthogonal and the shock only changes the jth error as follows:

$$E(\varepsilon_t | \varepsilon_{jt} = \delta_j) = \delta_j e_j \tag{18}$$

By setting $\delta_j = \sqrt{\sigma_{jj}}$ in equation (17), i.e. measuring the shock by one standard deviation, the generalized impulse response function that measures the effect of a one standard error shock to the jth equation at time t on expected values of x at time t + n is given by

$$\psi_j^g(n) = \sigma_{jj}^{-\frac{1}{2}} A_n \Sigma e_j , \qquad \text{n = 0, 1, 2, …..} \tag{19}$$

These impulse responses can be uniquely estimated and take full account of the historical patterns of correlations observed amongst the different shocks. Unlike the orthogonalized impulse responses, these are invariant to the ordering of the variables in the VAR.

Generalized Variance Decomposition Analysis

The forecast error variance decompositions provide a breakdown of the variance of the n-step ahead forecast errors of variable i which is accounted for by the innovations in variable j in the VAR. As in the case of the orthogonalized impulse response functions, the orthogonalized forecast error variance decompositions are also not invariant to the ordering of the variables in the VAR. Thus, we use the generalized variance decomposition which considers the proportion of the N-step ahead forecast errors of x_t which is explained by conditioning on the non-orthogonalized shocks, ε_{it}, ε_{it+1}, … , ε_{it+N}, but explicitly allows for the contemporaneous correlation between these shocks and the shocks to the other equations in the system.

Thus, while the orthogonalized variance decomposition (Lutkepohl, 1991) is given by,

$$q_{ij}^0(n) = \frac{\sum_{l=0}^{n} (e_i' A_l P e_j)^2}{\sum_{l=0}^{n} (e_i' A_l \Sigma A_l' e_i)} \qquad i,j = 1, 2, \dots, \text{m.} \tag{20}$$

the generalized variance decomposition is given by,

$$q_{ij}^{g}(n) = \frac{s_{ii}^{-1}\sum_{l=0}^{n}(e_i' A_l \Sigma e_j)^2}{\sum_{l=0}^{n}(e_i' A_l \Sigma A_l' e_i)} \quad i,j = 1, 2, \dots, \text{m} \tag{21}$$

While by construction $\sum_{j=1}^{m} q_{ij}^{0}(n) = 1$, due to the non-zero covariance between the non-orthogonalized shocks, $\sum_{j=1}^{m} q_{ij}^{g}(n) \neq 1$.

Pearsan and Shin (1998) have shown that the orthogonalized and the generalized impulse responses as well as forecast error variance decompositions coincide if Σ is diagonal and for a non-diagonal error variance matrix they coincide only in the case of shocks to the first equation in the VAR. Thus to select between the orthogonalized and generalized analysis, we first test if Σ is diagonal or not. The null hypothesis is:

H_0: $\sigma_{ij} = 0$, for all $\forall\, i \neq j$.

where σ_{ij} stands for the contemporaneous covariance between the shocks in the endogenous variables.

The Likelihood-ratio test statistic is given by

$$LR(H_0|H_1) = 2\,(LL_U - LL_R) \tag{22}$$

where LL_U and LL_R are the maximized values of the log-likelihood function under H_1 (the unrestricted model) and under H_0 (the restricted model), respectively. LL_U is the system log-likelihood and LL_R is computed as the sum of the log-likelihood values from the individual equations. The LR test statistic follows a χ^2 distribution with degrees of freedom equal to the number of endogenous variables.

Generalized Impulse Response Analysis in a Cointegrated VAR Model

The generalized impulse response analysis can be extended to a cointegrated VAR model. Consider the following Vector Error Correction Model (VECM) described by Pesaran and Shin (1998):

$$\Delta x_t = -\Pi x_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta x_{t-i} + e_t, \qquad t = 1,2,\dots,\text{T}. \tag{23}$$

where $\Pi = I_m - \sum_{i=1}^{p} \Phi_i$, $\Gamma_i = -\sum_{j=i+1}^{p} \Phi_j$ for i = 1,2,…,p-1, and Λ is an m $\times$ g matrix of unknown coefficients.

If x_t is first-difference stationary, $\Delta \mathbf{x}_t$ can be written as the infinite moving average representation,

$$\Delta x_t = \sum_{i=0}^{\infty} C_i e_{t-i}, \qquad t = 1,2,\ldots,T. \tag{24}$$

The generalized impulse response function of $\mathbf{x}_{t+n}$ with respect to a shock in the *j*th equation is given by:

$$y_{x,j}^{g}(n) = s_{jj}^{-\frac{1}{2}} B_n \Sigma e_j, \qquad n = 0,1,2,\ldots \tag{25}$$

where $B_n = \sum_{j=0}^{n} C_j$ is the *cumulative effect* matrix with $\mathbf{B}_0 = \mathbf{C}_0 = \mathbf{I}_m$.

Similarly, the orthogonalized impulse response function of $\mathbf{x}_t$ with respect to a variable-specific shock in the *j*th equation are given by

$$y_{x,j}^{o}(n) = B_n P e_j, \qquad n = 0,1,2,\ldots \tag{26}$$

Once again the two impulse response functions as well as the forecast error variance decompositions coincide if either the error variance-covariance matrix is diagonal or for a nondiagonal error variance-covariance matrix, if we shock the first equation in the VAR.

3. *Empirical Results*

The variables used in the paper are the real effective exchange rate, net capital inflows and their volatility, fiscal policy indicator, monetary policy indicator, and real current account surplus. The REER index is the weighted average (36-country) of the bilateral nominal exchange rates of the home currency in terms of foreign currencies adjusted by domestic to foreign relative local-currency prices. The exchange rate of a currency is expressed as the number of units of Special Drawing Rights (SDRs) that equal one unit of the currency (SDRs per currency). A fall in the exchange rate of the rupee against SDRs therefore represents a depreciation of the rupee relative to the SDR. Similarly, a rise in the exchange rate represents an appreciation of the rupee. The sum of foreign institutional investment and foreign direct investment has been taken as the proxy for net capital inflows. To compute real net capital flows, nominal capital flows are deflated by consumer price index.

The volatility of real net capital inflows has been calculated by using the 3-period moving standard deviation: $V_t = [(1/m)\sum_{i=1}^{m}(Z_{t+i-1} - Z_{t+i-2})^2]^{1/2}$, where m = 3 and Z denotes net capital inflows. Government expenditure and high-powered money are the fiscal and monetary policy indicators respectively. All the variables are in real terms computed by deflating the nominal variables by consumer price index.

We examine the relationship between trade based REER, net capital inflows and their volatility in the presence of fiscal and monetary policy indicators and real current account surplus. As discussed in the introduction, net capital inflows were negligible until the beginning of 1990s and picked up only thereafter. Since then they have been on the rise, except for some aberrations. REER has also exhibited an upward trend since 1992-93. REER and net capital inflows (Figures 1A, 1B, 2 and 3) generally moved in the same direction and the correlation coefficient between REER and net capital inflows is 0.486 for the period 1993Q2 to 2004Q1 (Table 1). FDI rose significantly in the early 1990s while FII flows started only in 1993. Both have been on the rise ever since. Figure 4 plots REER and the volatility of capital inflows. It is clear that both variables generally moved in tandem which is reflected by the correlation coefficient of 0.426.

Now we turn to the empirical estimates that are based on quarterly data from 1993Q2 to 2004Q1. We first test for nonstationarity of all the variables. The results of the three unit root tests are summarized in Tables 2A & 2B that show that all the variables can be treated as nonstationary. Testing for stationarity of differences of each variable confirms that all the variables are integrated of order one.

We use Johansen's FIML technique to test for cointegration between REER, real net capital inflows (sum of FII and FDI) and their volatility, real money supply, real government expenditure, and real current account surplus[7]. After ascertaining that the

[7] Alternative measures of all the variables were also tried. For instance, to capture capital inflows foreign exchange reserves were employed. Volatility was measured by the three-period and four-period moving average coefficient of variation. Alternative monetary policy measures included M3, M1 and domestic credit. Fiscal policy measures included a measure of fiscal stance as described by Joshi and Little (1998) as well as fiscal deficit. Various measures of interest rate differential we have tried – – three-month and one-year differential between the Treasury Bill rate and LIBOR, difference between commercial paper rate and

variables are integrated of the same order, we select the order of the VAR using the likelihood ratio test that suggests an optimal lag length of 3.

The next step is the selection of the deterministic terms in VAR. Since most macroeconomic data exhibit a linear trend (and not quadratic trend) which can be captured by an intercept, we select an intercept in VAR but not trend.

The maximum eigenvalue test statistic selects one cointegrating vector (Table 3A). We find that all of the variables in the cointegrating vector have the expected signs, as suggested by the theoretical model. The cointegrating vector suggests that while REER is positively related to real net capital inflows and their volatility, real government expenditure, and real current account surplus, it is negatively related to money supply. The signs are therefore economically plausible. The cointegrating equation[8] is as follows:

$$\textbf{MODEL 1: REER} = \underset{(.05)}{0.116^{*}\mathbf{cap}_{\mathbf{fii\&fdi}}} + \underset{(.00)}{0.651^{*}\mathbf{vol}} - \underset{(.15)}{0.011^{*}\mathbf{m}} + \underset{(.00)}{0.044^{*}\mathbf{g}} + \underset{(0.06)}{0.122^{*}\mathbf{ca}}$$

where **REER** is the trade based REER (36-country), $\mathbf{cap}_{\mathbf{fii\&fdi}}$ is real net capital inflows defined as sum of real net FII and FDI, $\mathbf{cap}_{\mathbf{total}}$ is real net capital inflows defined as aggregate real net capital inflows, **vol** is the 3-period moving standard deviation of $\mathbf{cap}_{\mathbf{fii\&fdi}}$, **m** is real M0, **g** is real government expenditure, and **ca** is real current account surplus.

In the above cointegrating vector, real net capital inflows, their volatility and real government expenditure are significant at 5% level of significance, current account surplus at 10% and real money supply at 15% (Table 4A).

Instead of using the aggregate of FII and FDI as the measure of net capital inflows, if we use the total capital inflows as they appear in the Balance of Payment accounts, we get the following cointegrating equation:

$$\textbf{MODEL 2: REER} = \underset{(.00)}{0.117^{*}\mathbf{cap}_{\mathbf{total}}} + \underset{(.00)}{0.647^{*}\mathbf{vol}} - \underset{(.11)}{0.009^{*}\mathbf{m}} + \underset{(.08)}{0.019^{*}\mathbf{g}} + \underset{(0.07)}{0.095^{*}\mathbf{ca}}$$

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three-month LIBOR, three-month LIBOR and one-year LIBOR. The variables selected and reported in model 1 and model 2 gave the most satisfactory results.

[8] p-values of the zero-restriction test for each variable are given in parentheses.

In the above cointegrating vector, real net capital inflows, volatility of aggregate FII and FDI are significant at 5% level of significance, real government expenditure and real current account surplus at 10% level of significance, and real money supply at 15% (Table 4B).

Using the vector error correction model, we test whether the variables individually Granger cause REER in both the equations. For this, we test for the joint significance of the lagged variables of each variable along with the error correction term. The results reported in Table 5A and Table 5B indicate that the null hypothesis of no Granger causality is strongly rejected in all the cases in both models.

An investigation of the dynamic interaction of various shocks in the post sample period is examined using the variance decomposition and the impulse response functions. Instead of the orthogonalized impulse responses, we use the generalized impulse responses and variance decompositions. The advantage of using the generalized impulse responses is that the orthogonalized impulse responses and variance decompositions depend on the ordering of the variables. If the shocks to the respective equations in VAR are contemporaneously correlated, the orthogonalized and generalized impulse responses may be quite different. On the other hand, if shocks are not contemporaneously correlated, then the two types of impulse responses may not be that different and also orthogonalized impulse responses may not be sensitive to a re-ordering of the variables. Thus, before proceeding further, we test the hypothesis that the off-diagonal elements in the covariance matrix equal zero. The LR test statistic is 58.569 for model 1 and 25.0181 for model 2 whereas the 95% critical value of the χ^2 distribution with 5 degree of freedom is 12.592. Therefore, the null hypothesis that Σ is diagonal is rejected for both models. Hence, we use the generalized impulse framework.

Generalized Variance Decompositions and Impulse Response Analysis

Variance decompositions give the proportion of the h-periods-ahead forecast error variance of a variable that can be attributed to another variable. These, therefore, measure the proportion of the forecast error variance of REER that can be explained by shocks given to its determinants. Results in Table 6A and 6B provide variance decompositions for a 24-quarter time horizon.

For model 1, at the end of the 24-quarter forecast horizon, around 68% of the forecast error variance of REER is explained by its own innovations. Real net capital inflows and their volatility together explain about 27% of the total variation after 24 quarters[9]. As for model 2, we find that for the same forecast horizon, around 73% of the forecast error variance of REER is explained by its own innovations, capital inflows explain around 55% and their volatility explains nearly 11% of the total variation in REER. Thus, the relationship between capital flows and REER is more prominent in model 2. In both models, determinants of REER in descending order of importance include net capital inflows and their volatility (jointly), government expenditure, current account surplus, and money supply.

Note that the forecast error variance decompositions only give us the proportion of the forecast error variance of REER that is explained by its determinants. They do not indicate the direction (positive or negative) or the nature (temporary or permanent) of the variation. Thus, the impulse response analysis is used to analyze the dynamic relationship among variables.

Impulse responses for model 1 are shown in figures 5A.1-5A.5 and those for model 2 are shown in figures 5B.1-5B.5. In both the models, the directions of changes observed in the impulse responses conform to the signs obtained earlier in the cointegrating vector. The immediate and permanent effect on REER of a one standard deviation shock to net capital inflows is positive. The net impact of a one standard deviation shock to the volatility is positive in the short run as well as in the long run. A one standard deviation shock to real money supply has a long run negative impact on REER, though it is positive in some of the initial periods. The immediate and permanent effect of a one standard deviation shock to government expenditure is positive. A one standard deviation shock to the current account surplus has a negative effect initially but the permanent effect is positive.

It is noteworthy that all shocks have a permanent effect on the REER, which is what we expect, given that it is nonstationary. Thus, both models give similar results.

[9] Note that the generalized forecast error variance decompositions add to more than 100 percent. The magnitude of the sum depends on the strength of the covariances between the different errors.

Now we turn to the results to capture the intervention by the Reserve bank of India. For this we look into the relationship between real foreign exchange acquisitions, trade based REER (36-countries), net capital inflows, fiscal policy indicator, monetary policy indicator, and real current account surplus. All three unit root tests (ADF, PP and KPSS – Table 2A and 2B) conclude that real foreign exchange acquisition is nonstationary. Therefore we use Johansen's FIML technique to test for cointegration between foreign reserve acquisitions, REER, real net capital inflows (sum of FII and FDI), real money supply, real government expenditure, and real current account surplus. We select the order of the VAR using the likelihood ratio test that suggests an optimal lag length of 3.

The maximum eigenvalue test statistic selects one cointegrating relation between the variables (Table 7). We find that all of the variables have the expected signs, as suggested by the theoretical model. The cointegrating vector suggests that while real foreign exchange acquisitions is positively related to REER, real net capital inflows, real government expenditure, and real current account surplus, it is negatively related to money supply. The signs are therefore economically plausible. The cointegrating equation[10] is as follows:

MODEL 1: forexacq = 3.98*REER + 0.76*cap – 0.015*m + 0.32*g + 1.47*ca

$$\text{forexacq} = \underset{(.02)}{3.98}\cdot\text{REER} + \underset{(.00)}{0.76}\cdot\text{cap} - \underset{(.00)}{0.015}\cdot m + \underset{(.00)}{0.32}\cdot g + \underset{(.00)}{1.47}\cdot ca$$

All the variables in the above cointegrating vector are significant at the 5% level (Table 8) and have the correct signs—i.e., in accordance with our theoretical presumption.

5. Conclusions

This paper finds that the real effective exchange rate is cointegrated with the level of capital flows, volatility of the flows, high-powered money, current account surplus and government expenditure. This relationship is statistically significant and each of the above determinants Granger causes the real effective exchange rate. The generalized variance decompositions show that determinants of the real exchange rate, in descending

[10] Real foreign exchange acquisitions are denoted by **forexacq**. p-values of the zero-restriction test for each variable are given in parentheses.

order of importance include net capital inflows and their volatility (jointly), government expenditure, current account surplus and the money supply. The direction of the generalized impulse responses conform to the signs obtained in the cointegrating vector. Shocks to each of the determinants have a long run impact on the real effective exchange rate that is consistent with economic theory.

Turning to the foreign exchange reserves of the RBI, we have tried to suggest that we can use a semi-reduced form (that includes the RBI's unknown reaction function) to get a cointegregating vector. This line of enquiry is fruitful and needs to be examined in detail.

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Table 1: Correlation Coefficients (1993Q2 – 2004Q1)

Real Variables							
	REER	**$Cap_{fii\&fdi}$**	**cap_{total}**	**vol**	**m**	**g**	**ca**
REER	1.000	0.486	0.369	0.426	0.843	0.172	0.711
forexacq	0.742	0.605	0.500	0.418	0.698	0.174	0.802

Table 2A: Unit Root Tests (1993Q2-2004Q1)

VARIABLE/ TESTS	Null: g=0 in Eq. (3) t_t	Null: g=0, a =0 in Eq. (3) f_1	Null: g=0 in Eq.(2) t_m	Null: g=0, a =0 in Eq. (2) f_1	Null: g=0 Eq. (1) t	RESULTS (UNIT ROOT PRESENT)
ADF Test REER	-1.4009	1.8080	0.04114	0.6484	1.1582	Yes
PP – Test REER	-2.1304	2.2999	-1.5191	2.2062	1.3670	Yes
ADF Test $cap_{fii\&fdi}$	-2.3060	2.8943	-2.0100	2.4078	-0.23922	Yes
PP – Test $cap_{fii\&fdi}$	-2.3263	2.9413	-2.0119	2.4115	-0.02029	Yes
ADF Test cap_{total}	-2.6388	3.6802	-2.1298	2.4788	-0.04329	Yes
PP – Test cap_{total}	-6.9248					No
ADF Test vol	–2.1143	2.7410	–1.4563	1.0676	–0.3011	Yes
PP – Test vol	–2.7770	3.9291	–2.7024	3.8795	–0.5398	Yes
ADF Test m	-0.5978	1.5670	1.3695	2.2683	1.8135	Yes
PP – Test m	-1.9132	2.2985	0.3213	2.6435	2.3285	Yes
ADF Test g	-2.5618	3.6078	-1.9449	1.9427	0.07158	Yes
PP – Test g	-8.3444					No
ADF Test ca	-1.7547	4.1156	0.14148	0.36052	-0.1611	Yes
PP – Test ca	-3.1244	5.3773	-1.9277	2.0253	-2.0482	Yes
ADF Test Forexacq	-1.1.0570	2.0193	0.1686	0.5987	0.9687	Yes

PP – Test **Forexacq**	-2.7294	4.5127	-1.3890	1.1195	–0.3760	Yes
Critical Values						
10%	-3.13	5.34	-2.57	3.78	-1.62	
5%	-3.41	6.25	-2.86	4.59	-1.95	
1%	-3.96	8.27	-3.43	6.43	-2.58	

Table 2B: KPSS Level Stationarity Test

Variables/ Lags	l=0	L=1	l=2	l=3	l=4	l=5	l=6	l=7	l=8	Conclusion (Unit Root Present)
REER	2.58	1.40	1.00	0.80	0.68	0.60	0.55	0.51	0.48	Yes
$cap_{fii\&fdi}$	0.67	0.43	0.36	0.33	0.31	0.31	0.31	0.32	0.31	No
cap_{total}	0.48	0.49	0.45	0.40	0.37	0.35	0.35	0.36	0.36	Yes
vol	0.83	0.48	0.37	0.33	0.32	0.31	0.30	0.29	0.28	No
m	3.64	1.97	1.39	1.09	0.91	0.79	0.70	0.64	0.59	Yes
g	0.57	0.60	0.66	0.74	0.58	0.52	0.50	0.51	0.46	Yes
ca	1.83	1.12	0.85	0.71	0.61	0.53	0.48	0.44	0.41	Yes
forexacq	1.91	1.12	0.84	0.68	0.58	0.51	0.46	0.42	0.40	Yes

Note: l is the lag truncation parameter.

Asymptotic critical values for $\hat{\eta}_\mu$:

Critical level:	*0.10*	*0.05*	*0.025*	*0.01*
Critical value($\hat{\eta}_\mu$):	*0.347*	*0.463*	*0.574*	*0.739*

Table 3A: Tests for Cointegration: λ_{max} Tests

H_0 :	H_1 :	Statistics	Critical values		RESULTS	No. of C. V.
			95%	90%		
MODEL 1 : REER = f($cap_{fii\&fdi}$, vol, m, g, ca)						
r = 0	**r = 1**	50.22	39.83	36.84	Reject Null Hypothesis	1
$r \le 1$	**r = 2**	26.08	33.64	31.02	Do not reject Null Hypothesis	

Note: r is the order of cointegration. C. V. denotes the cointegrating vector.

Table 3B: Tests for Cointegration: λ_{max} Tests

H_0 :	H_1 :	Statistics	Critical values		RESULTS	No. of C. V.
			95%	90%		
MODEL 2 : REER = f(cap_{total}, vol, m, g, ca)						
r = 0	**r = 1**	59.99	39.83	36.84	Reject Null Hypothesis	1
$r \le 1$	**r = 2**	19.18	33.64	31.02	Do not reject Null Hypothesis	

Note: r is the order of cointegration. C. V. denotes the cointegrating vector.

Table 4A: Zero-Restriction Test

Null Hypothesis	χ^2 (calculated)	Conclusion
$cap_{fii\&fdi} = 0$	3.80 (.05)	Reject null hypothesis
vol = 0	24.78 (.00)	Reject null hypothesis
m = 0	2.00 (.15)	Reject null hypothesis
g = 0	8.55 (.00)	Reject null hypothesis
ca = 0	3.65 (.06)	Reject null hypothesis

Note : p value in parenthesis

Table 4B: Zero-Restriction Test

Null Hypothesis	χ^2 (calculated)	Conclusion
$cap_{total} = 0$	14.82(.00)	Reject null hypothesis
vol = 0	35.32(.00)	Reject null hypothesis
m = 0	2.58(.11)	Reject null hypothesis
g = 0	3.13(.08)	Reject null hypothesis
ca = 0	3.26(.07)	Reject null hypothesis

Note : p value in parenthesis

Table 5A: Granger Causality Tests

Null Hypothesis	Number of Lags	$c2$ (calculated)	Conclusion
MODEL 1 : REER = f($cap_{fii\&fdi}$, vol, g, ca)			
REER is not Granger caused by $cap_{fii\&fdi}$	2	8.45 (.04)	Reject null hypothesis*
REER is not Granger caused by vol	2	5.53 (.14)	Reject null hypothesis***
REER is not Granger caused by m	2	10.56 (.01)	Reject null hypothesis*
REER is not Granger caused by g	2	7.03 (.07)	Reject null hypothesis**
REER is not Granger caused by ca	2	7.54 (.06)	Reject null hypothesis**

Note: p value in parenthesis.

*,**,*** *at 5%, 10% and 15% level of significance respectively*

Table 5B: Granger Causality Tests

Null Hypothesis	Number of Lags	$c2$ (calculated)	Conclusion
MODEL 2 : REER = f(cap_{total}, vol, g, ca)			
REER is not Granger caused by cap_{total}	2	7.61(.06)	Reject null hypothesis**
REER is not Granger caused by vol	2	10.15(.02)	Reject null hypothesis*
REER is not Granger caused by m	2	11.33(.01)	Reject null hypothesis*
REER is not Granger caused by g	2	8.27(.04)	Reject null hypothesis*
REER is not Granger caused by ca	2	8.13(.04)	Reject null hypothesis*

Note: p value in parenthesis.

*,** *at 5% and 10% level of significance.*

Table 6A: Generalized Forecast Error Variance Decomposition for REER

Horizon	REER	$cap_{fii\&fdi}$	vol	m	g	ca
0	1.000	0.000	0.008	0.083	0.105	0.001
1	0.876	0.050	0.091	0.037	0.171	0.001
4	0.814	0.051	0.084	0.035	0.184	0.025
8	0.688	0.106	0.159	0.020	0.145	0.065
12	0.688	0.103	0.162	0.016	0.142	0.067
16	0.685	0.104	0.165	0.014	0.139	0.069
20	0.683	0.104	0.167	0.012	0.137	0.071
24	**0.682**	**0.104**	**0.168**	**0.012**	**0.135**	**0.072**

Table 6B: Generalized Forecast Error Variance Decomposition for REER

Horizon	REER	cap_{total}	Vol	m	g	ca
0	1.000	0.232	0.037	0.099	0.135	0.001
1	0.920	0.352	0.100	0.042	0.137	0.005
4	0.830	0.473	0.077	0.039	0.117	0.038
8	0.731	0.535	0.107	0.022	0.085	0.074
12	0.740	0.539	0.106	0.019	0.086	0.071
16	0.734	0.547	0.108	0.016	0.082	0.074
20	0.734	0.550	0.108	0.014	0.081	0.074
24	**0.733**	**0.553**	**0.109**	**0.013**	**0.079**	**0.075**

Note: Entries in each row are the percentages of the variances of the forecast error in REER that can be attributed to each of the variables indicated in the column headings. The decompositions are reported for one-, four-, six-, twelve-, and twenty four-quarter horizons. The extent to which the generalized error variance decompositions add up to more or less than 100 percent depends on the strength of the covariances between the different errors.

Table 7: Tests for Cointegration: λ_{max} Tests

H_0 :	H_1 :	Statistics	Critical values		RESULTS	No. of C. V.
			95%	90%		
MODEL : forexacq = f(REER, cap, m, g, ca)						
r = 0	**r = 1**	54.45	39.83	36.84	Reject Null Hypothesis	1
$r \leq 1$	**r = 2**	28.77	33.64	31.02	Reject Null Hypothesis	

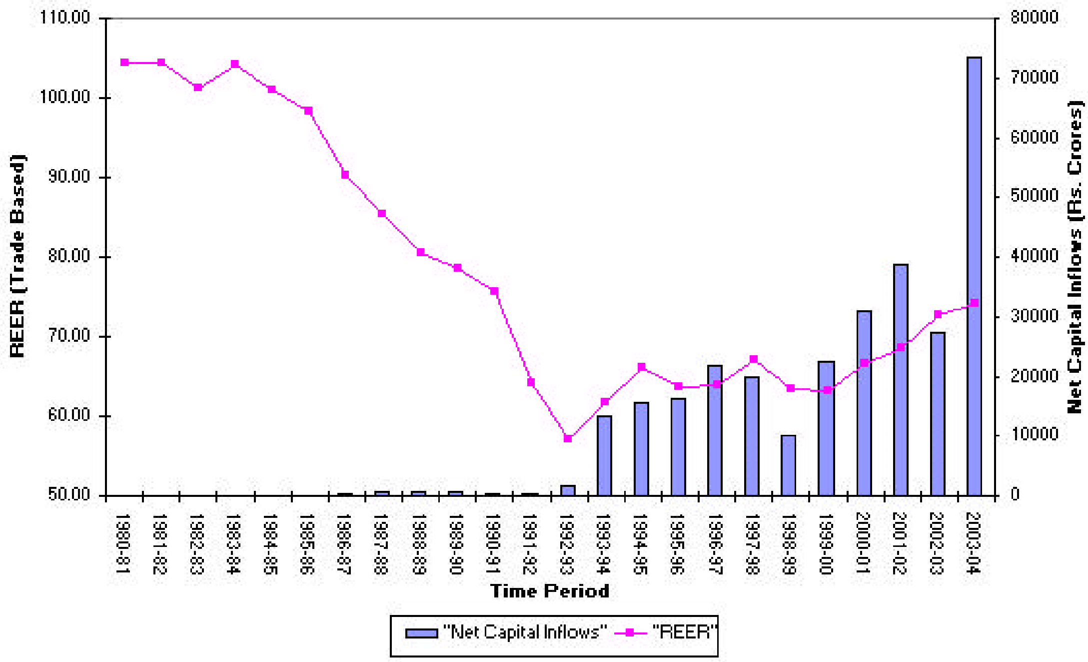
Note: r is the order of cointegration. C. V. denotes the cointegrating vector.

Table 8: Zero-Restriction Test

Null Hypothesis	χ^2 (calculated)	Conclusion
REER=0	05.42 (.02)	Reject null hypothesis
cap = 0	12.85 (.00)	Reject null hypothesis
m = 0	15.82 (.00)	Reject null hypothesis
g = 0	34.36 (.00)	Reject null hypothesis
ca = 0	08.91(.00)	Reject null hypothesis

Note : p value in parenthesis

Figure 1A: REER vs. Net Capital Inflows (Nominal)



Note: Prior to 1990, disaggregated data on FII and FDI are not available. Therefore we have measured Net Real Capital Inflows as foreign investment in India (FDI+FII) and abroad.

Figure 1B: REER vs. Net Capital Inflows (Real)

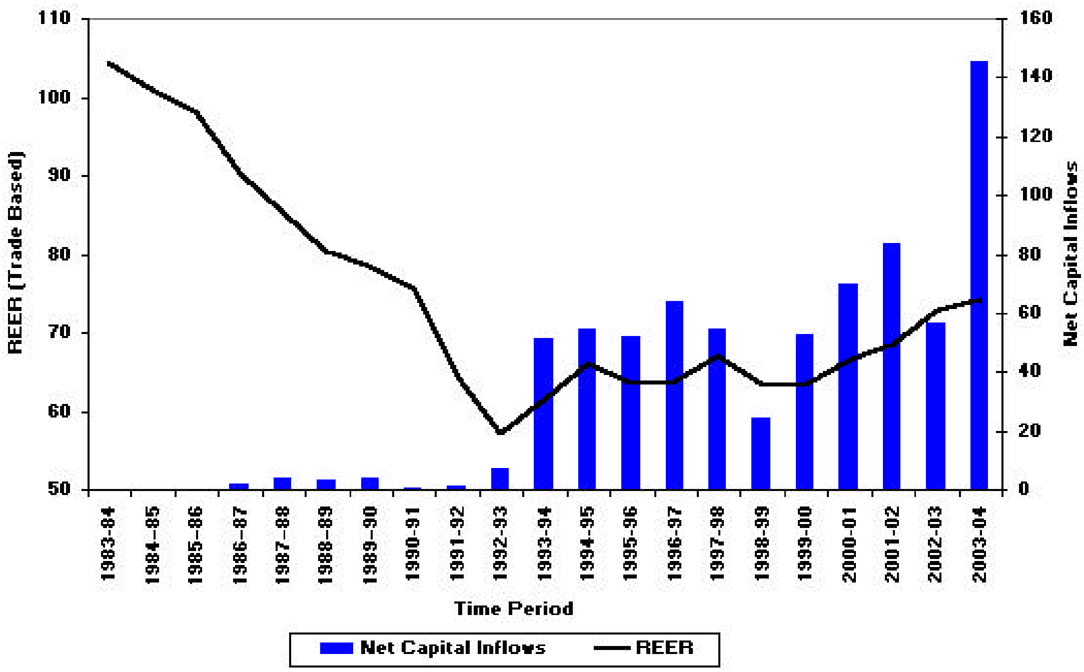


Figure 2: REER vs. Net Capital Inflows (FII+FDI) (Real)

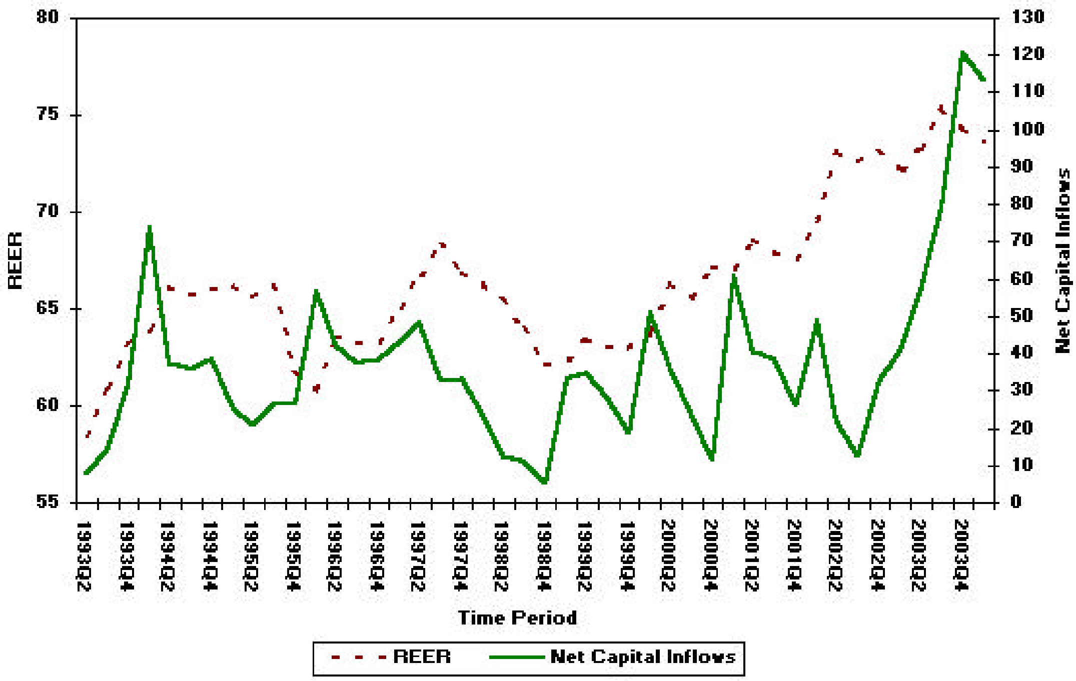
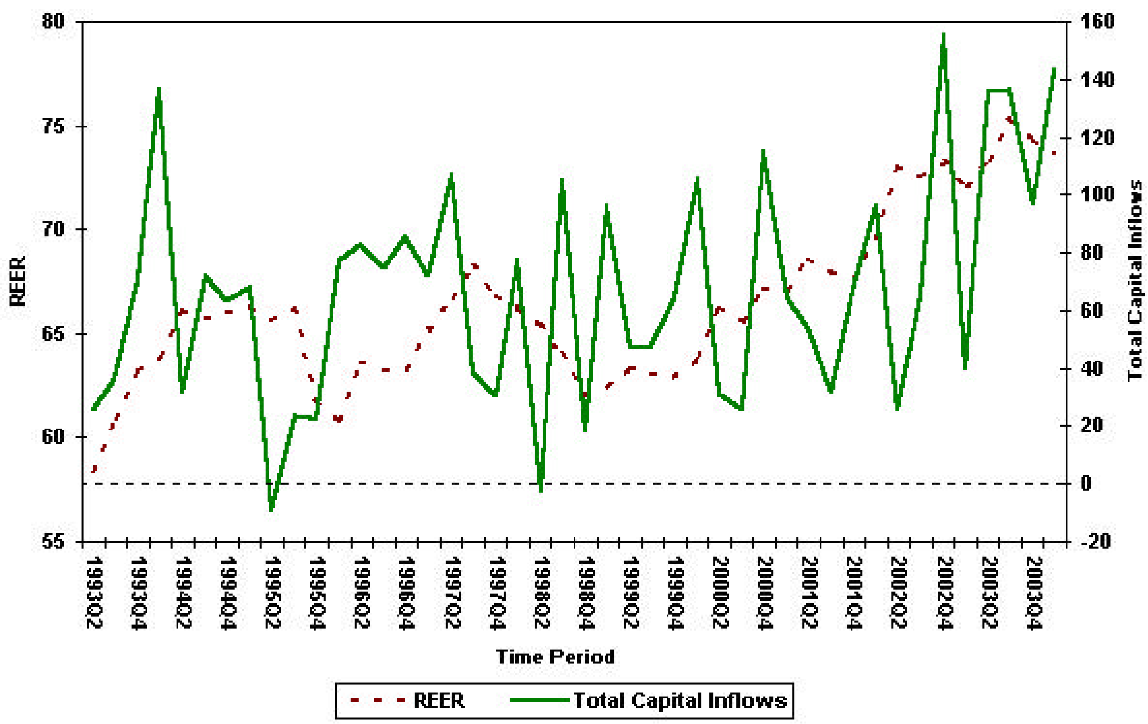
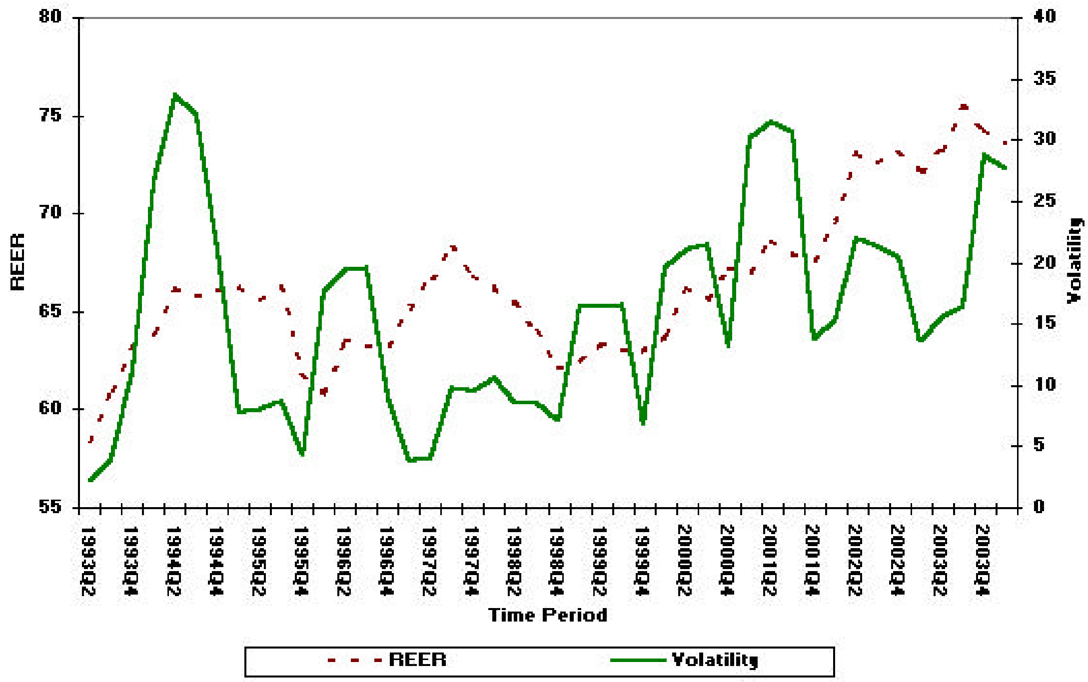


Figure 3: REER vs. Total Capital Inflow (Real)



Note: Total net capital inflows are taken as they appear in the Balance of Payment accounts.

Figure 4: REER vs. Volatility



Generalized Impulse Responses of REER to One Standard Error Shocks to other Variables:

Figure 5A.1: Shock to Real Net Capital Inflows ($cap_{fii\&fdi}$)

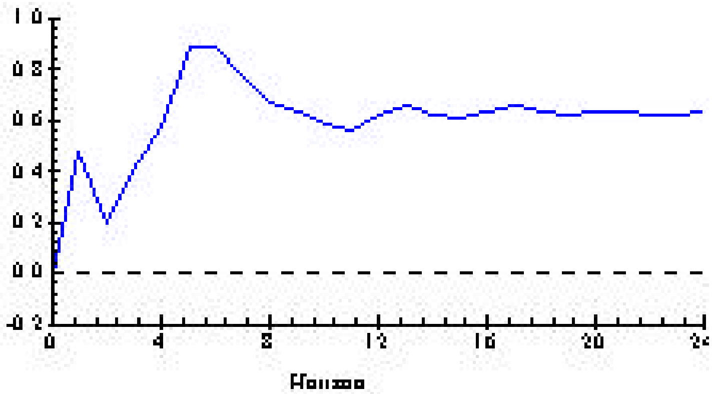


Figure 5A.2: Shock to Volatility of Real Net Capital Inflows (vol)

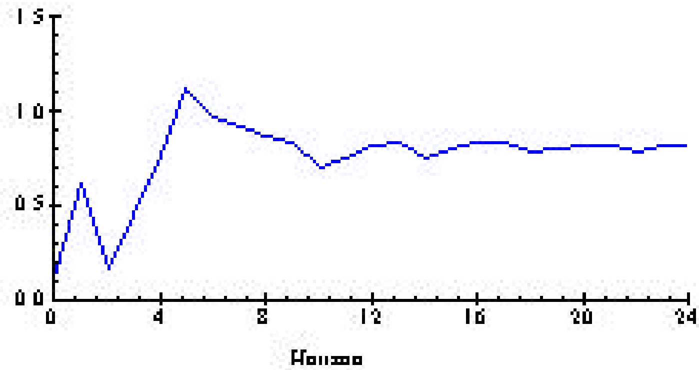


Figure 5A.3: Shock to Real Money Supply (m)

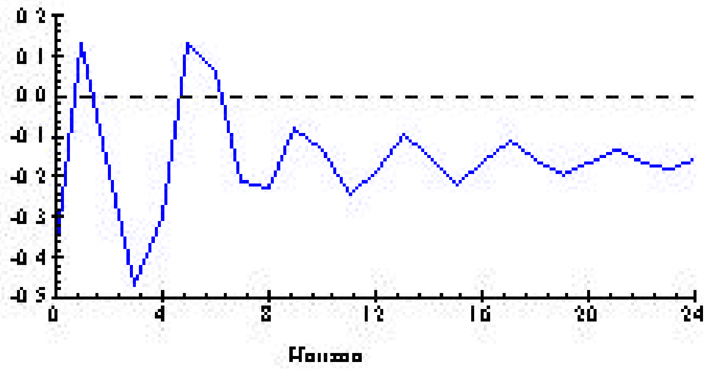


Figure 5A.4: Shock to Real Government Expenditure (g)

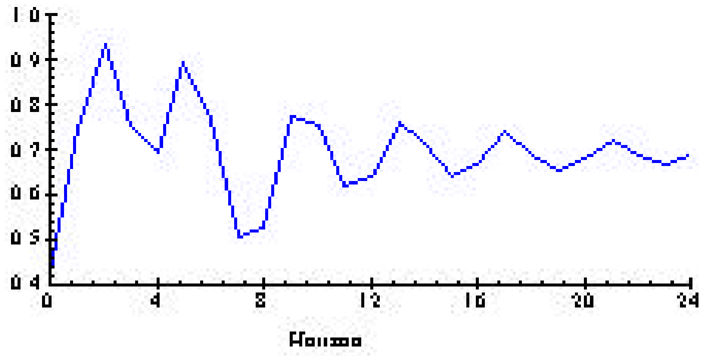


Figure 5A.5: Shock to Real Current Account Surplus (ca)

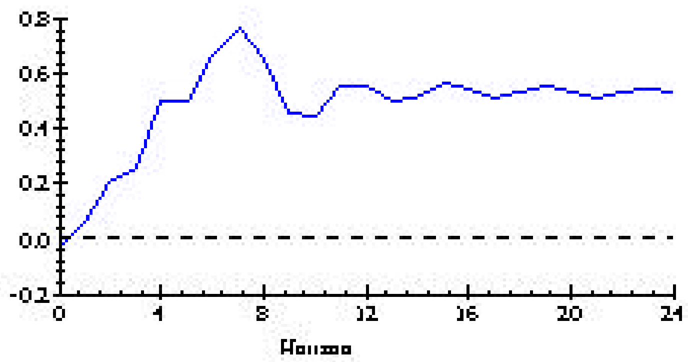


Figure 5B.1: Shock to Real Net Capital Inflows (cap_{total})

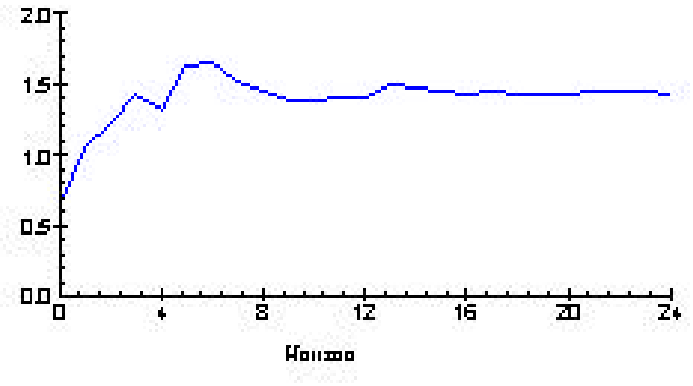


Figure 5B.2: Shock to Volatility of Real Net Capital Inflows (vol)

Figure 5B.3: Shock to Real Money Supply (m)

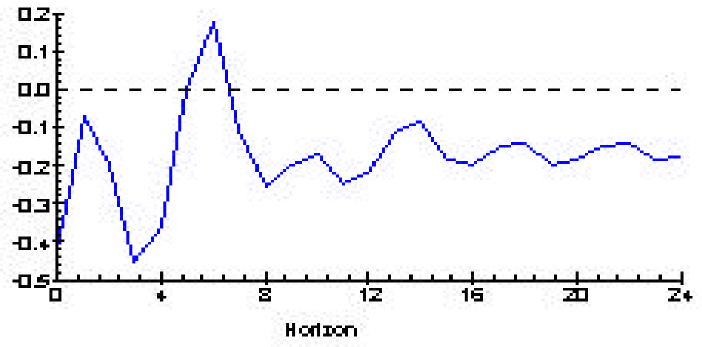


Figure 5B.4: Shock to Real Government Expenditure (g)

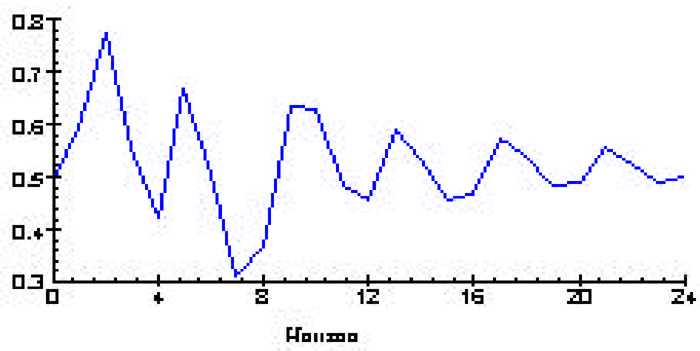
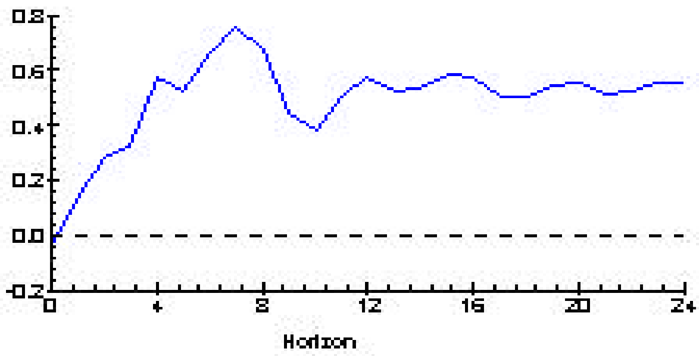


Figure 5B.5: Shock to Real Current Account Surplus (ca)



Data Definitions and Sources

Variables used in the models reported:

Variable	Definition	Source
Real Effective Exchange Rate (REER)	The REER index is the weighted average of the bilateral nominal exchange rates of the home currency in terms of foreign currencies adjusted by domestic to foreign relative local-currency prices. The exchange rate of a currency is expressed as the number of units of Special Drawing Rights (SDRs) that equal one unit of the currency (SDRs per currency). The number of countries used is 36.	Handbook of Statistics on Indian Economy and RBI Bulletin
Real Net Capital Inflows (cap)	Two measures: 1.Sum of real Foreign Institutional Investment and real Foreign Direct Investment ($cap_{fii\&fdi}$) 2. Sum of FII, FDI, Loans, Banking Capital, Rupee Debt Service and Other Capital (cap_{total})	Handbook of Statistics on Indian Economy and RBI Bulletin
Money Supply (m)	Real M0	Handbook of Statistics on Indian Economy and RBI Bulletin
Current Account Surplus (ca)	Aggregate Credits to Current Account minus Aggregate Debits to Current Account.	Handbook of Statistics on Indian Economy and RBI Bulletin
Government Expenditure (g)	Total Revenue Expenditure + Total Capital Expenditure	Monthly Abstract of Statistics and www.indiastat.com
Volatility in Real Net Capital Inflows (vol)	Three period moving average standard deviation of sum of real FDI and real FII: $V_t = [(1/m)\sum_{i=1}^{m}(Z_{t+i-1} - Z_{t+i-2})^2]^{1/2}$ where m=3 and Z is **cap**.	Calculated
Foreign Exchange Acquisitions (forexacq)	Change in the foreign exchange reserves over the last quarter.	Calculated

Variables in other models tried but not reported:

Variable	Definition	Source
Interest Differential	**Three measures:** 1. Commercial Paper Rate–3 months LIBOR 2. 3-month T-Bill rate – 3 months LIBOR 3. 1-year T-Bill interest rate – 1 year LIBOR **Two measures of foreign interest rate:** 1. 3 months LIBOR 2. 1 year LIBOR	Handbook of Statistics on Indian Economy, RBI Bulletin and www.forecasts.org
Real Domestic Credit	Outstanding Bank Credit to the commercial sector	Handbook of Statistics on Indian Economy and RBI Bulletin
Fiscal Deficit	Real Gross Fiscal Deficit	Handbook of Statistics on Indian Economy and Controller General of Accounts
Exchange Rate	Real Effective Exchange Rate (Export based)	Handbook of Statistics on Indian Economy and RBI Bulletin
Money Supply	**Two measures:** 1. Real M1 2. Real M3	Handbook of Statistics on Indian Economy and RBI Bulletin
Fiscal Stance	Difference between actual fiscal deficit (X) and cyclically neutral fiscal deficit (CNFD) where CNFD = g GDP* - t GDP*, g = expenditure to nominal GDP ratio (in a given base period) t = revenue to nominal GDP ratio (in a given base period) GDP* = trend value of GDP	Calculated on the basis of formula in Joshi, Vijay and I.M.D. Little (1998), "*India: Macroeconomics and Political Economy,1964-1991*" , Chapter 9, Oxford University Press.
Volatility of Capital Inflows	Time varying three-quarter or four-quarter coefficient of variation of real net capital inflows (both measures). This is calculated as follows: $CV_{t+m} = \dfrac{\left[\dfrac{1}{m}\sum_{i=1}^{m}(\varepsilon_{t+i-1} - \bar{\varepsilon})^2\right]^{1/2}}{\bar{\varepsilon}}$ where m = either 3 or 4 and Z is real net capital inflows.	Calculated