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Demand for Foreign Exchange Reserves for India: A Cointegration Approach

Prabheesh. K. P[a*], Malathy. D[b] and Madhumati. R[c]

[a, b] *Department of Humanities and Social Sciences, Indian Institute of Technology Madras; Chennai, India,*

[c] *Department of Management Studies, Indian Institute of Technology Madras, Chennai, India.*

Abstract

Using cointegraion and vector error correction approach, we estimate India's demand for foreign exchange reserves over the period 1983:1-2005:1. Our results establish that the ratio imports to GDP, the ratio of broad money to GDP, exchange rate flexibility and interest rate differential determine India's long-run reserves demand function. Our empirical results show that reserve accumulation in India is highly sensitive to capital account vulnerability and less sensitive to its opportunity cost. The speed of adjustment coefficient of vector error correction model suggests that Reserve Bank of India has to engage in more active reserve management practices.

Key words: foreign exchange reserves, capital account vulnerability, current account vulnerability, cointegration.

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I. Introduction

Over the past few years, there has been a tremendous increase in foreign exchange reserves with the central banks of developing economies around the world, especially in the aftermath of East Asian crisis 1997-98. Foreign exchange reserves held by developing countries have risen from 30 percent of global reserves to almost 60 percent by 2005 (Figure 1). The management of these huge reserves and the associated cost of holding are the major issues faced by the central banks of developing countries now.

Foreign exchange reserves are defined as external stock of assets, which is available to the country's monetary authorities to cover external payment imbalances or to influence the exchange rate of the domestic currency through intervention in exchange market, or for other purposes (IMF, 2000). A country's reserve consists of gold, foreign currencies, special drawing rights (SDR) and the reserve position with the International Monetary Fund (IMF). Historically under the Bretton-Woods system, the foreign exchange reserves were used by the central banks across the world to maintain the external value of their respective currencies at a fixed level. With the break down of Bretton-Woods system in the early 1970s, countries started adopting a relatively flexible exchange rate system, under which the reserves play only a less important role. Yet, the global exchange reserves have increased from1.75 to 7.8 percent of world GDP between 1960 and 2002 (Flood and Marion, 2002).

The present paper analyzes the demand for foreign exchange reserves in the Indian context. As an emerging economy, India has been accumulating a high level of foreign exchange reserves in the past few years and occupies the sixth position among the high reserve countries in the world (IMF Survey, 2005). However, a significant increase was observed only after 1990-91, the year of wide opening up of the Indian economy. The reserves, which touched an all time low of US $ 5 billion at the end-March 1991, increased to $141 billion in 2004-2005. The ratio of reserves to GDP has increased from

3.5 percent in 1991-02 to 20 percent in 2004-05 (figure 2). This will drive us to investigate the factors which induce the Reserve Bank of India (RBI) to hold high level of reserves.

Figure 1: Trends in reserve holdings in developing countries

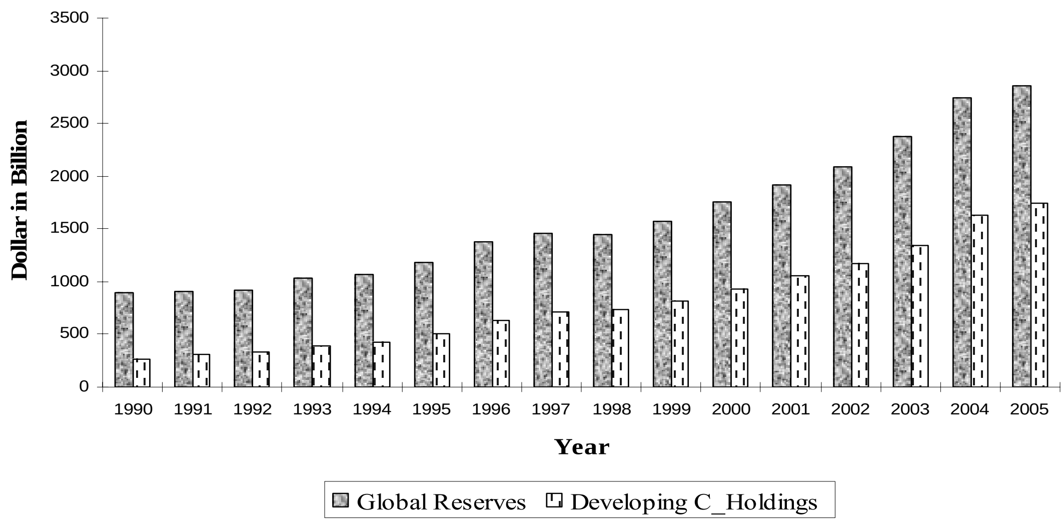
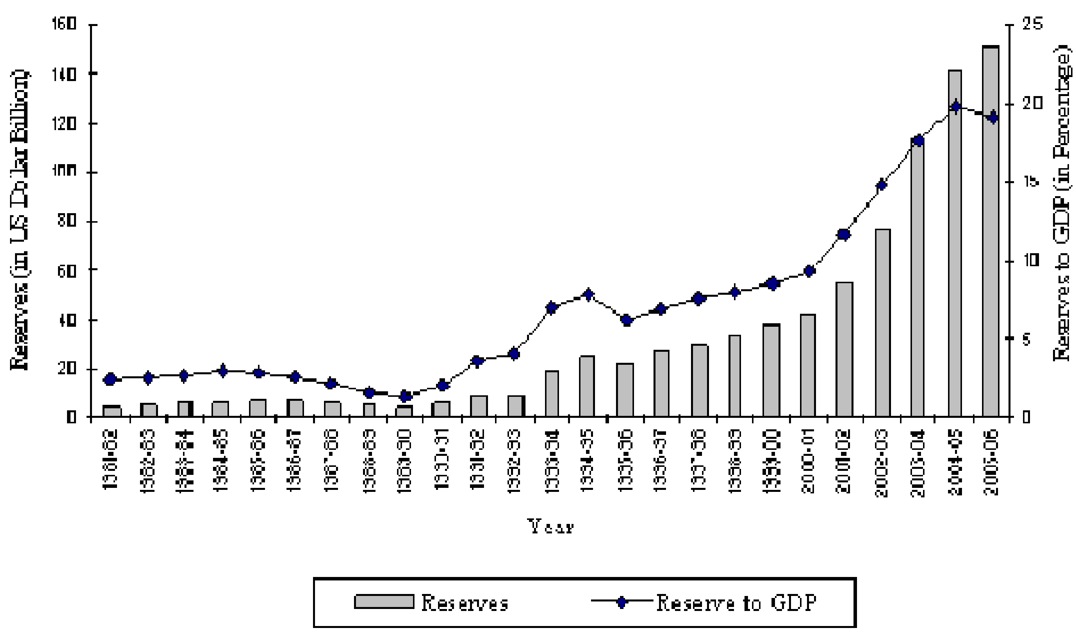


Figure 2: Trends in foreign exchange reserves in India



II. Demand for Reserves: Theory and Empirical Evidence

There has been a spurt in research in demand for reserves since 1960s (Grubel 1971). The demand for reserves is explained broadly using two approaches. The first approach postulates that the movements of reserves respond to discrepancies between the desired reserves and actual reserves held by a country (Clark 1970; Edwards 1983). The alternate approach explains the reserve holdings in terms of the monetary approach to balance of payments. According to this approach a change in reserve holdings is related to the disequilibrium in the domestic money market. Foreign exchange reserves will increase when there is an excess demand for money, given that domestic credit is constant; and conversely foreign exchange reserves will decrease if there is an excess supply of money. Thus, according to the monetary approach, foreign exchange reserves are a residual holding by a country (Edwards, 1984). The empirical studies following this approach hypothesized that the monetary market disequilibrium affects the demand for reserves only in the short run and found supported empirical evidence (Ford and Huang 1993; Badinger 2004). The two approaches can be reconciled if there is a stable demand for foreign exchange reserves, but in that case domestic credit cannot be treated as constant. This implies that change in domestic credit will partially depend on the relationship between actual and desired level of reserves (Edwards, 1984; Frankel, 1974).

Clark (1970) developed a theoretical relationship between demand for reserves and cost of adjustment in the economy. According him, the benefit of reserve holdings is simply the avoidance of the cost of adjustments. Reserves help to pursue domestic policy goals in the face of temporary deterioration in the balance of payment (BoP).The disturbance in BoP is either financed from reserves or eliminated by adjustments within the economy through appropriate government policies. According to him, the above two policies entail different cost for the country. That is, if a country holds higher level of reserves as buffer, the domestic investment will be low and there will be a reduction of income. If a country prefers a high speed of adjustment due to low reserves, this will lead to high variability in income. It is possible to maximize the welfare of a country by deriving an optimum combination of level of reserve and the rate of speed of adjustment.

Some of the recent studies in this context of demand for foreign exchange reserves are following. Aizenman and Marion (2003) in their cross country study of 122 developing countries over the period 1980-96, estimated foreign exchange reserve demand equation with a set of explanatory variables such as population of the country, real GDP per capita, volatility of real export receipts, share of import to GDP and volatility of the Nominal Effective Exchange Rate (REER). The result shows that more than 88 percentage of variation in reserves is explained by the above variables. An additional analysis indicates that the reserve demand in developing countries, especially in the aftermath of East Asian crisis, could be explained by the features of developing countries such as, limited access to global capital market, costly tax collection and relatively inelastic fiscal outlays.

The IMF (2003) analyzed the demand for foreign exchange reserves for 122 emerging economies over the period 1980 to 1996. The study hypothesized that reserves is expected to vary with respect to economic size, current account vulnerability, capital account vulnerability, exchange rate flexibility and opportunity cost. The results reveal that all explanatory variables significantly explain the reserve movements except capital account vulnerability measure and opportunity cost measure. The result shows that more than 90 percentage of variation in reserves is explained by the above variables.

In the Indian context, research on the demand for foreign exchange reserves has received little attention. Available studies have analyzed the impact of reserve variability and opportunity cost on demand for reserve using buffer stock model of Frankel and Jovanovic (Ramachandran, 2004). This paper contribute to the literature by providing estimates of reserve demand function for India by covering a larger period of time, using a broader set of explanatory variables and recent econometric techniques.

III. Empirical Framework

Following IMF (2003), the determinants of reserve holdings can be grouped into five categories, namely economic size, current account vulnerability, capital account vulnerability, exchange rate flexibility and opportunity cost.

Table 1: Empirical determinants of reserve holdings

Determinants	Explanatory variables
Economic size	Population and percapita GDP
Current account vulnerability	Ratio of import to GDP, ratio of trade to GDP and ratio of current account deficit to GDP
Capital account vulnerability	Ratio of capital account deficit to GDP, ratio of short-term external debt to GDP and ratio of broad money to GDP
Exchange rate flexibility	Standard deviation of exchange rate
Opportunity cost	Interest rate differential

Table 1 shows the potential explanatory variables for each of these categories of determinants. The empirical reserve demand function can be specified as

$$ln\ res_t = a + (b\ ln\ pop_t + c\ ln\ pci_t) + (d\ In\ im_t + e\ ln\ trade_t + f\ ln\ cad_t) + (g\ ln\ cac_t + h\ ln\ sted_t + i\ ln\ m_t) - j\ (ln\ er_t) - k\ (ird_t) + u_t \qquad (1)$$

Where *res, pop, pci, im*, *trade,* and *cad* are real reserves, population, real GDP percapita, ratio of real imports to GDP, ratio of real trade to GDP and real current account deficit to GDP respectively. Similarly, *cac*, *sted, m, er, and ird* represent ratio of real capital account to GDP, ratio of short-term debt to GDP, ratio of real money supply to GDP, standard deviation of exchange rate and interest rate differential respectively, and *b, c, d, e, f, g, h, i, j, k* are the parameters to be estimated, *a* is the intercept, *u* stands for error term and t denotes time. All the variables are expressed in natural logarithm except *ird*.

It is expected that reserve holdings will rise with respect to economic size. Similarly, a high ratio of import to GDP[1], high trade to GDP[2] and high current account deficit to GDP may lead to high current account vulnerability and this may in turn induce high reserve demand. Similarly a high ratio of capital account deficit to GDP, high short-term debt to GDP and high broad money to GDP[3] could be associated with higher capital account vulnerability[4] and this may lead to a rise in reserve holdings. Greater exchange rate flexibility would reduce the demand for reserves because central banks no longer need a large stock of reserves to manage a pegged exchange rate. Similarly, a higher opportunity cost is expected to lead to a reduction in reserve holdings because alternative investments become comparatively attractive.

IV. Data and Empirical Method

Data

Quarterly data from 1983:1 to 2005:1 compiled from various publications of the Reserve Bank of India (RBI) are used for the study. Quarterly estimates of GDP are available only from 1996 and hence, for the earlier period, we have used the estimates developed by Virmani and Kapoor (2003).[5] Some of the variables like GDP percapita, population and short-term debt to GDP, are available only on an annual basis and hence could not be incorporated in the analysis. The variables such as *res, im, trade, cad, cac*, and *m* are measured in constant prices (1993-94) deflated using Wholesale Price Index. The variable *res* is measured as reserves minus gold, since gold is not used as an intervention asset. The variable *ird* is constructed as *ird* = [(1+ Indian Call money rate) / (1+ US Fed rate)], definition given by Aizenman and Marion (2004) and *er* is calculated by taking rolling standard deviation of 12 quarters Rupee/ Dollar rate. The US Fed rate is drawn from the website of Federal Reserves System.

Equation (1) can be estimated using standard regression technique when the variables are stationary and the residual term is uncorrelated and homoscadastic. However, if the variables are nonstationary in their levels, then using standard regression method may lead to misleading conclusion or spurious relationship (Granger and Newbold, 1974).

Time series properties of the variables

In order to check for time series properties of the variables, the widely applied unit root tests such as the Augmented Dickey-Fuller (1981) and Phillips-Perron (1988) tests have been used. If the variables are found to be nonstationary, then the long-run relationship can be appropriately examined through cointegration test (Engle and Granger, 1987).

Cointegration test and vector error correction models

To establish the long-run relationship between reserves and its determinants, we used the systems method of cointegration proposed by Johansen and Juselius (1992). If the variables under consideration are cointegrated, the cointegrating vector is normalized with respect to reserves provides estimates of the long-run reserve demand function. It is also possible to verify short-run dynamics through VECM if variables are cointegrated. Johansen's cointegrating analysis involves estimating the following Vector Error Correction Model in reduced form

$$\Delta Y_t = \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \Pi Y_{t-1} + \lambda D + \varepsilon_t \qquad (2)$$

Where, Y_t is a vector of nonstationary variables, and Γ, Π, and λ are matrices of parameters to be estimated. The rank of the matrix Π determines the long-run relationship and can be decomposed as $\Pi = \alpha \beta'$, where α and β contain adjustments and the cointegrating vectors respectively. D is the vector of deterministic variables that may include constant term, the linear trend, dummy variables. Δ and ε_t refer change and error term respectively. Johansen has proposed two likelihood ratio statistics, the trace static and the maximum eigen value statistic, both of which determine the number of cointegrating vectors based on the significant eigen values of Π. The trace statistic tests the null of *r* cointegrating vector against the alternative of more than *r* cointegrating vector. While the maximum eigen statistic tests the null of *r* against the alternative of exactly *r* + 1 cointegrating vectors. Once we determine the number of cointegrating vectors, *r*, we can test hypothesis on both adjustment and cointegrating vectors.

V. Empirical Results

Unit root test

Based on Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests procedure the null hypothesis of unit root for all variables are accepted except for *trade*, *cad*, and *cac*, indicating the variables *res, im, m, er*, and *ird* are nonstationary (table 2).

Since most of the variables are nonstationary, the preferred cointegration technique is used.

Table 2: Unit root tests

Variables	ADF statistic		PP statistic	
	Level	First difference	Level	First difference
res	2.11	-9.41	2.07	-9.43*
im	-1.88	-4.74	-1.94	-18.51*
trade	-2.14*	-3.98*	-2.17*	-18.13*
cad	-3.91*	-8.45*	-3.67*	-34.98*
cac	-2.39*	-9.88*	-2.37*	-28.14*
m	2.63	-3.43*	1.08	-18.44*
er	-1.68	-4.46*	-1.23	-4.45*
ird	-1.19	-13.13*	-1.51	-13.11*

Notes: * denotes rejection of the hypothesis at 5 percent significance level.

Johansen cointegration test

Johansen's approach of cointegration begins with the formulation of the unrestricted Vector Auto Regressive Model (VAR). In the present context, we incorporated five dummy variables (for the quarters 1990-Q3, 1990-Q4, 1991-Q1, 1991-Q2, and 1991-Q3) in the VAR system, to capture the effect of foreign exchange reserve crisis in India during early nineties[6]. Using Akaike information criterion and Schwarz information criterion, the optimum number of lags for VAR is identified as two, where the residuals of the VAR are found to be uncorrelated and homoscadastic.

Table 3: Johansen cointegration test

Hypothesized no. of CE(s)	Trace statistic	5 % critical value	Max-Eigen statistic	5 % critical value
None*	86.21	68.52	44.52	33.46
At most 1	41.68	47.21	22.94	27.07
At most 2	18.73	29.68	12.36	20.97
At most 3	6.36	15.41	6.36	14.07
At most 4	0.004	3.76	0.004	3.76

Notes: * denotes rejection of the hypothesis at 5 percent significance level

Table 4: Normalized cointegrating coefficients and week exogeneity

Normalized cointegrating coefficients					
	res	*im*	*m*	*er*	*ird*
Normalized β	1	-2.32 (0.52)*	-2.96 (0.64)*	0.18 (0.10)	0.44 (0.16)*
Speed of adjustment coefficients and week exogeneity test					
Normalized α	-0.057	0.162	0.164	-0.039	-0.160
LR statistic	3.5*	18.05*	21.58*	1.25	2.89

Note: * indicates significance at the 5%
Figures in parenthesis indicate standard errors

Table 3 presents both trace and maximum eigen test statistics which provide evidence of one cointegrating vector, implying that there exists one set of cointegrating relationship among the five variables considered. The normalized cointegrating coefficients with respect to *res* are given in table 4. The long-run cointegrating equation for reserves demand can be written as

$$res = 2.32\, im + 2.96\, m - 0.18\, er - 0.44\, ird \qquad (3)$$

The normalized cointegrating equation exhibits theoretically expected signs and the standard errors in the parentheses indicate that the explanatory variables are statistically significant at 5 percent level, except the variable *er*.[7] The impact of ratio of broad money to GDP (*m*) exhibits a higher influence on reserve movements. This is consistent with an increasing role of self-insurance motive against potential residential based capital flight.[8] The effect of current account vulnerability variable (*im*) indicates that a one percent increase in import to GDP results in more than two percent increase in reserve holdings, suggesting the precautionary holding of reserves against the persistent current account deficit in India during the sample period. The interest rate differential (*ird*) enters the cointegrating vector significantly, but its impact is low compared to other variables. This implies that the reserve accumulation of the RBI is less sensitive to the opportunity cost of holding reserves. The measure of exchange rate flexibility (*er*) exhibits the right sign but is not statistically significant in the cointegrating vector.

The weak exogeneity test (table 4) enables us to find whether a variable enters in the adjustment process to correct the short-run disequilibrium or not. If the cointegrating vector does not have any influence on a particular variable, i.e. the speed of adjustment coefficient is not statistically different from zero, then that variable is said to be weakly exogenous with respect to long-run parameters. In the present context, exchange rate flexibility (*er*) and interest rate differential (*ird*) are weakly exogenous at 5 percent level of significance. The regular intervention of the RBI in the foreign exchange market can be a reason for the weak exogeneity of *er*. The evidence of weak exogeneity of interest rate can be ascribed to the fact that interest rates in India are mainly determined outside the system. The results indicate that the variables *res, im, and m* adjust in the short-run to attain long-run equilibrium.

Vector error correction model

The VECM of reserves (see Δres in Table 5) shows that all lagged independent variables in change exhibit the expected signs, except for Δm. This can be attributed to the reduction in money supply due to the sterilized intervention by the RBI in the short-run to avoid the inflationary impact of reserve accretion.[9] Therefore, in the short-run the variable *m* might have captured the effect of RBI's sterilized intervention instead of capital account vulnerability. All variables, except Δim_{t-1} and Δer_{t-1} are significant in the VECM model. All dummy variables that capture the effect of crisis are significant except for *dum90q3* in the VECM model. The speed of adjustment implied by the coefficient of error correction term (*ecm*) is -0.057, indicating that around five percent of the deviation from equilibrium is eliminated within each quarter. The negative coefficient of *ecm* indicates that Δres has to decline in order to achieve the long-run equilibrium, since it is above its long-run average position. The low speed of adjustment coupled with high reserve holdings in India seems to conform to Clark's proposition (Clark, 1970), that a country with a low speed of adjustment towards equilibrium would require a high level of reserves to finance its balance of payment.[10] We believe that the measure of speed of adjustment would be higher if RBI engaged in active reserve management. The diagnostic test statistics show no evidence of misspecification of functional form of VECM.

Table 5: Vector error correction model

	Δ res	*Δim*	*Δm*	*Δer*	*Δird*
ecm	-0.057 (1.98) *	0.163 (5.24)*	0.164 (6.39)*	-0.039 (-1.22)	-0.160 (-2.10)*
Δ res $_{t-1}$	0.49 (5.9*)	-0.073 (-0.86)	-0.057 (-0.79)	-0.088 (-0.97)	0.24 (1.11)
Δim $_{t-1}$	0.01 (0.10)	-0.419 (- 2.73)*	-0.137 (-1.06)	-0.171 (- 1.051)	-0.331 (-0.87)
Δm $_{t-1}$	-0.50 (-2.97)*	0.428 (2.47)*	0.174 (1.21)	0.140 (0.76)	-0.106 (-0.24)
Δer $_{t-1}$	-0.001 (-0.02)	0.160 (2.022)*	0.101 (1.48)	0.618 (7.12)*	-0.21 (-1.07)
Δird $_{t-1}$	- 0.11 (-2.32)*	0.012 (0.26)	0.002 (0.058)	0.098 (1.92)*	-0.241 (-2.05)*
Constant	0.025 (2.14)*	0.006 (0.51)	0.001 (0.06)	0.007 (0.59)	0.003 (0.11)
dum90q3	-0.007 (-0.06)	0.180 (1.69)	0.146 (1.64)	-0.081 (-0.71)	-0.194 (-0.73)
dum90q4	-0.75 (-7.31)*	0.208 (1.96)*	0.036 (0.41)	-0.105 (-0.94)	0.23 (0.90)
dum91q1	0.70 (5.72)*	0.152 (1.21)	0.242 (2.31)*	-0.119 (-0.90)	-0.009 (-0.02)
dum91q2	-0.92 (-8.07)*	-0.01 (-0.11)	0.207 (2.14)*	0.152 (1.23)	0.33 (1.18)
dum91q3	0.944 (7.54)*	0.167 (1.31)	0.138 (1.29)	0.158 (1.17)	-0.326 (-1.04)
R^2	0.74	0.50	0.53	0.51	0.25
F-stat	19.87	7.04	7.73	7.28	2.33
S.E.	0.09	0.10	0.08	0.10	0.24
Jarque-Bera 15.47 [0.11]					
White's Chi-sq 250 [0.52]					
Breusch-Godfrey LM 28 [0.3]					

Note: * indicates significance at the 5%. Figures in parenthesis and square brackets show t statistics and level of significance respectively.

VI. Conclusion

This paper has analyzed the demand for foreign exchange reserves for India from 1983 to 2005, by using quarterly data, a larger set of explanatory variables and recent development in econometric estimation. It is found that India's long-run reserves demand is a function of current account vulnerability, capital account vulnerability, exchange rate flexibility and opportunity cost of holding reserves. Evidence suggests that India holds reserves as a precautionary measure against current account vulnerability and capital account vulnerability. The reserve holding behavior is mainly influenced by the capital account vulnerability indicative of the self-insurance motive against residential based capital flight. The results also show that reserve accumulation in India is less sensitive to its opportunity cost. Moreover, the measure of exchange rate flexibility does not affect the reserve holdings significantly. Our measure of speed of adjustment suggests that RBI has to engage in more active reserve management practice.

NOTES

[1] The positive relationship between reserves and ratio of imports to GDP is dubious because, in the literature, it is used as a proxy for marginal propensity to import as well as the country's openness to external vulnerabilities. If it is a proxy for marginal propensity to import, then a negative relationship can be seen due to the application of Keynesian foreign trade multiplier model (Heller, 1966). On the other hand, a positive relation can be seen if it is an indicator of openness (Kelly, 1970; Cooper, 1968).

[2] It is also used as a proxy for trade openness.

[3] Measure of residential based capital flight or internal drain.

[4] It is also used to represent financial openness.

[5] The authors estimated the back series of GDP by adopting the methodology developed by Central Statistical Organization.

[6] Dummies are used to capture the effect of reserve depletion, current account deficit and consequent devaluation of Rupee in the beginning of the nineties.

[7] We also tested the statistical significance by imposing restrictions on parameters using likelihood ratio test and obtained similar results.

[8] Similar result is found in the Asian context by Gosselin and Parent (2005).

[9] Sterilized intervention is a kind of foreign exchange market intervention combined with open market operation by central banks in the short-run, to avoid the inflationary effect of capital inflows. The effective sterilization of RBI is confirmed by Kohli, (2001).

[10] Similar evidences are found in the context of developing countries with higher reserves (Bilson and Frenkel, 1979; Huang and Shen, 1999).

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