The Demand for International Reserves and Monetary Equilibrium: New Evidence from India

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and

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Abstract

The main aim of this study is to investigate India's demand for international reserve and the role of national monetary disequilibrium on reserve movements during the independent floating period from 1991:01 to 2009:02. We assessed India's position in terms of reserve adequacy and found that India has sufficient stock of international reserves to meet the minimum adequacy requirements. The estimates of reserve demand function suggests that scale of foreign trade, uncertainty (short-term external debt) and profitability considerations play significant role in determining India's long-term reserve demand policies. More importantly, giving support to the monetary approach to balance of payment our results show that national monetary disequilibrium does play a significant role in the short-run reserve movements. An excess of money demand (supply) induces an inflow (outflow) of international reserves with an elasticity of 0.56. The elasticity of reserve movements with respect to monetary disequilibrium clearly indicates that Reserve Bank of India respond to correct the domestic money market disequilibrium and did not leave it completely on the mercy of reserve inflows.

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1. Introduction

The purpose of this study is three-fold: first to assess India's position in terms of reserve adequacy using some standard reserve adequacy benchmarking measures; second to study what determines the level of international reserves that Indian central bank wish to hold in the long-run; and third to study the link between national monetary disequilibrium and reserve movements in the short-run mainly focusing on the monetary approach to the balance of payments.

In the last decade, the Indian economy has seen a dramatic transformation from highly regulated environment to one which is more market-oriented. The results of this transition have been so outstanding that a crisis hit economy that was not able to finance its three months of imports in 1991, has accumulated such a huge stock of international reserves that was sufficient to fund eleven months of import in 2007. Major economic reforms and initiatives were launched in 1991 to open the external sector of the economy. Since then India's international reserves holding has witnessed continuous improvement. Over the last decade, the pace of accretion in the India's stock of international reserve has been so striking that it has registered more than 1000% growth, despite the fact that India has entered into flexible exchange rate system since March 1993 (Ramachandran, 2006). And now it seems convincing to believe that India has surpassed many standard measures of reserve adequacy to rest in a somewhat protected zone. Theoretically, it was believed that under flexible exchange rate system countries will need to keep less stock of international reserves, since central banks were not obligated to defend their parities through frequent interventions. Therefore, under flexible regime the demand for international reserves holding should decline because now monetary authorities need to hold relatively less reserves to defend currency values.

Nevertheless, irrespective of all the theoretical justifications, the stock of international reserves of many emerging and developing countries, including India, has increased substantially even after their official announcements about commitment to the flexible exchange rate system (Flood and Marion, 2002). For example, starting from a low level of US $ 5.8 billion at end-March 1991, the stock of international reserves increased steadily to US $ 38 billion by end-March 2000 and reached their peak at US $ 314.6 billion in end-May 2008 (see figure 1). Thereafter, owing the international financial chaos caused by sub-prime crisis of 2008 and strengthening of the US dollar vis-à-vis other international currencies[1], the stock of reserve declined to US $ 252 billion at the end of March 2009 and again touched the height of US $ 283.6 billion in December 2009 (Economic Survey, 2010)[2]. This clearly indicates that irrespective of all the theoretical justifications, India's stock of international reserves like many emerging countries has been continuously increasing during the independent floating period (1993-2009). While providing an empirical justification to this paradox, Calvo and Reinhart (2000) argued that exchange rate policies of many countries are highly dominated by the fear of float and the announced shift to flexible regime is actually an illusion. Therefore, Reserves requirement may still persists because countries need lager stock of reserves to manage their exchange rates even in the floating regime (Flood and Marion, 2002). Therefore, while a regime shift from fixed exchange rate to floating system theoretically reduces the need for holding international reserves, however, on practical grounds care should be taken to conclude that countries that float require lesser international reserves (De Beaufort Wijnholds and Kapteyn, 2001).

[1] It is noteworthy that India's international reserves are measured in dollar term.
[2] Economic Survey is presented and published by Ministry of Finance, Government of India every year in the month of February, a day before the presentation of annual national budget in the parliament. The economic survey is also available at http://indiabudget.nic.in/.

In short, nations hold international reserves for several reasons: to smooth out temporary fluctuations in external payment imbalances, to neutralize speculative attacks on currencies, for boosting international confidence on domestic economy, for prestige and as collateral for international borrowing (see Bahmani-Oskooee and Brown, 2002).[3] Alternatively, reserve accumulation can also be used to keep the exchange rate favourable for export growth and more FDI inflows, which may finally lead to higher economic growth and more employment in the domestic economy.[4] In the last few years, developing economies have witnessed several changes in their external sectors. Especially frequent movements of capital across the boundaries are proved to be perilous. It is argued that at any point of time massive outward movement of capital may expose the country to a greater risk of liquidity squeeze, which occasionally leads to a full-fledge financial crises (see, Aizenman and Marion, 2003*)*. Therefore, holding high level reserves may be a quick fix solution for this possible threat. Sachs, Tornell and Velasco (1996) highlighted a new empirical fact that weak fundamentals coupled with low stock of international reserves have a significant explanatory power for the occurrence of crises.[5] However, there are some high degree of risks and costs involved in hoarding huge stocks of international reserves. For instance, if the domestic currency appreciates against the dollar (or against the other reserves foreign currency) the country will lose the value of the asset in the national currency.

Therefore, for an emerging economy like India, faced with growing demand of financial resources to put the economy on a high growth trajectory, it is very relevant as well as interesting

[3] Keeping the space constraints in mind, we do not include a comprehensive review of literature on demand for international reserves in this study. However, for reviews of the literature, see Clower and Lipsey (1968), Grubel (1971), Bahmani-Oskooee (1985) and Bahmani-Oskooee and Brown (2002).

[4] If an economy has this motive t hold reserves then it is called mercantile motive (see, for example, Calvo and Reinhart, 2002; Rajan, 2002; Dooley et al, 2003; Aizenman and Lee, 2007).

[5] However, it is still a debatable issue that how long reserves holding can prevent financial crisis if the fundamentals are weak. See, for example, Sachs et al. (1996); Tornell (1998); Bussiere and Mulder (1999); Nitithanprapas and Willett (2000) and Li and Ouyang (2009) for more details.

to have a clear understanding of what factors play crucial role in determining India's demand for international reserves. India has been pursuing economic reform and liberalization policies since 1991 and has witnessed spectacular growth in its Gross Domestic Product (GDP) in the previous decade. Further, there is a huge shortage of required financial resources to support the ongoing developmental projects and the need is growing up at much faster rate. In this context, it is generally argued that maintaining a high stock of international reserves to support uninterrupted economic growth and foreign confidence on domestic economy is crucial and, therefore, imposes constraint on the policy makers (see Huang, 1995). However, given the lack of empirical studies on India's demand for international reserves, it is still an unsettled issue that what determines India's demand for international reserves in the long-run and what factors affect it in the short run.

Against this background, this study is set to study India's demand for international reserve during the flexible exchange rate regime. This study offers many significant contributions to the existing wealth of related literature. First, at the onset of balance of payment crisis in 1991, India's stock of international reserves was not sufficient to finance even three months of import. Therefore, the issue of reserve adequacy became a major challenge for policy makers and the central bank during this period (1991-2009). Moreover, in the era of flexible exchange rate regime and high capital mobility, the accumulation of sufficient international reserves has also become a very crucial issue for developing countries like India. Therefore, recognizing the importance of this issue, we attempt to assess the reserve adequacy in India using some standard minimum benchmarking rule-of-thumbs. Second, despite the fact that the literature on international reserve is very rich, to date, only a few studies, for example Prabheesh et al., (2009) and Ramachandran (2006), have attempted to model India's demand for International reserve under flexible exchange rate regime. Three, most studies on demand for international reserves consider rolling standard deviation of exchange rate as a proxy for volatility in the reserve demand function. We use an alternative volatility measure of exchange rate generated from generalized autoregressive conditional heteroscedasticity (GARCH) models advocated by Engle (1982) and Bollerslev (1986). A key advantage of using GARCH models to generate volatility series of exchange rate is that it helps to model the phenomena of volatility clustering present in data and incorporates heteroscedasticity into the estimation procedure (Bollerslev, 1986). Four, a study of demand for international reserves in isolation from the national money market ignores a very crucial result of the monetary approach to the balance of payments, which hypothesizes that disequilibrium on the national money market results in reserve changes into the short run (see Badinger, 2004). However, so far none of the studies on India have attempted to pay any attention on the role of the national monetary disequilibrium in demand for international reserve.[6] In this study, following Badinger (2004), we estimate and incorporate the national monetary disequilibrium into the vector error correction model (VECM) to address the aforementioned issue. Five, with increased capital flows, the size of short-term external debt has been widely recognized as an important single indicator of reserves for countries that borrow in international markets. Therefore, unlike to many previous studies, we include short-term external debt and foreign portfolio investment as explanatory variables in the reserve demand function. Six, given the huge disparity in the institutional characteristics of monetary authorities, monetary policies, exchange rate systems, it is argued that country specific studies should be given preference over cross countries studies in addressing the issue of demand for international reserve. Finally, we utilize comparatively larger data set to cover most part of the post-reform

[6] However, in the case of other countries Elbadawi (1990), Ford and Huang (1994) Huang (1995), Huang and Shen (1999) and Badinger (2004) have explicitly included the national monetary disequilibrium component into the error correction system to model its short-run impact on the demand for international reserves.

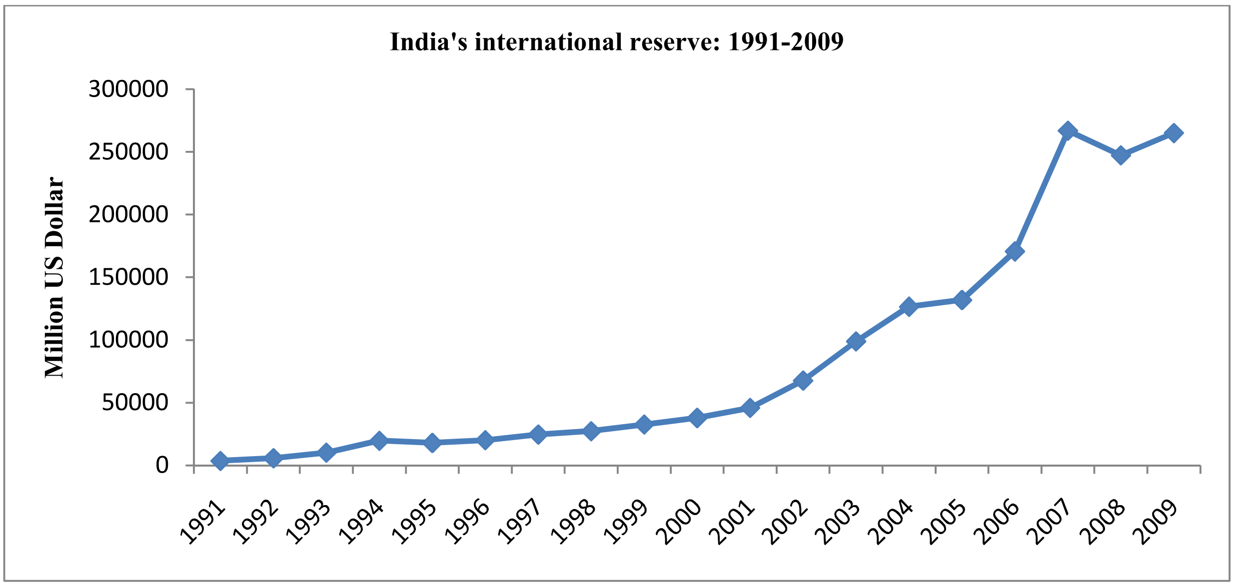
and flexible exchange rate system during which India witnessed massive growth in its stock of international reserves.

The rest of the paper is organized as follows. Section 2 discusses the adequacy of international reserves in India whereas section 3 presents data and data sources. Section 4 presents theoretical aspects of the reserve demand function and section 5 presents the empirical results reserve demand function. Section 6 discusses the role of national monetary disequilibrium in reserve movements. Finally section 7 provides main findings and conclusions of the study.

2. Reserve Adequacy under Flexible Regime: where does India stand?

The level of India's international reserves has witnessed massive revival and continuous growth in the post-reform period (1991-2009) after its shocking decline at the onset of the balance of payment crises in 1991 (see figure 1). In 1991 India's total stock of international reserve depleted to such an extent that it was not sufficient to finance even one three months of import. On international front, the issue of reserve adequacy has gained widespread attention in the aftermath of the Mexican tequila (1995), Asian crisis (1997-98), Russian default (1998) and a series of crises that hit Brazil (1999) and Argentina (2002). And now, the recent global experiences are sufficient enough to conclude that the level of reserves can be an important factor in explaining and predicting currency crisis (Fischer, 2001). The precautionary benefits of keeping huge stockpiles of international reserves are numerous, since it provides a comfortable cushion against financial crisis and speculative attacks on the domestic currency. However, reserve accumulation also involves incurring some opportunity cost of holding international reserves beyond a certain limit (see Ben-Bassat and Gottlieb, 1992; Rodrik, 2006). Moreover, in the case of a developing country like India, where the demand for financial resources to finance developmental projects is always greater than the available supply, it is not completely justified to keep these precious funds unemployed for a longer period, that too in huge quantity. Therefore, it has become a challenging task in the hands of policy makers to strike a balance between benefits and costs to keep the stock of international reserves at the optimal level and, at the same time, to ensure a safe passage for the rapidly growing economy from any unwanted movements in financial market.

Figure 1: India's international reserve in the post-reform era



Source: International Financial Statistics (IFS).

2.1 International Reserves in Months of Import

In the related literature, there are various measures of reserve adequacy. In this study, we consider three conventional rules of thumb for reserves adequacy to investigate India's position in during the independent floating exchange rate regime. In the earlier studies, the ratio of reserves-to-import is considered to be a standard way to quantify reserves adequacy because of its operational simplicity and other merits. It is argued that where instability in balance of payment originates from the current account, it seems more logical to judge reserves adequacy against the size of trade flows using the value of imports as a proxy (Bird and Rajan, 2003). Using this measure as a rule-of-thumb for reserves adequacy, it is recommended that the stock of reserves should be sufficient enough to finance at least three to four months of imports (Fischer, 2001) or the ratio of reserves to imports should be equal to 0.25 according to the three-months-of-import rule (see Jeanne, 2007). Figure 3 reveals that the stock of India's international reserve crossed the benchmark of 3 months of imports in 1992 and since then it stayed continuously above the minimum required level. The level of reserves touched the maximum of 12 months of import value in 2003. Therefore, using this rule it can be concluded that India has sufficient reserves to meet the minimum adequacy requirements.

Figure 2: Reserve adequacy- total international reserves in months of import

Source: World Development Indicators, World Bank.

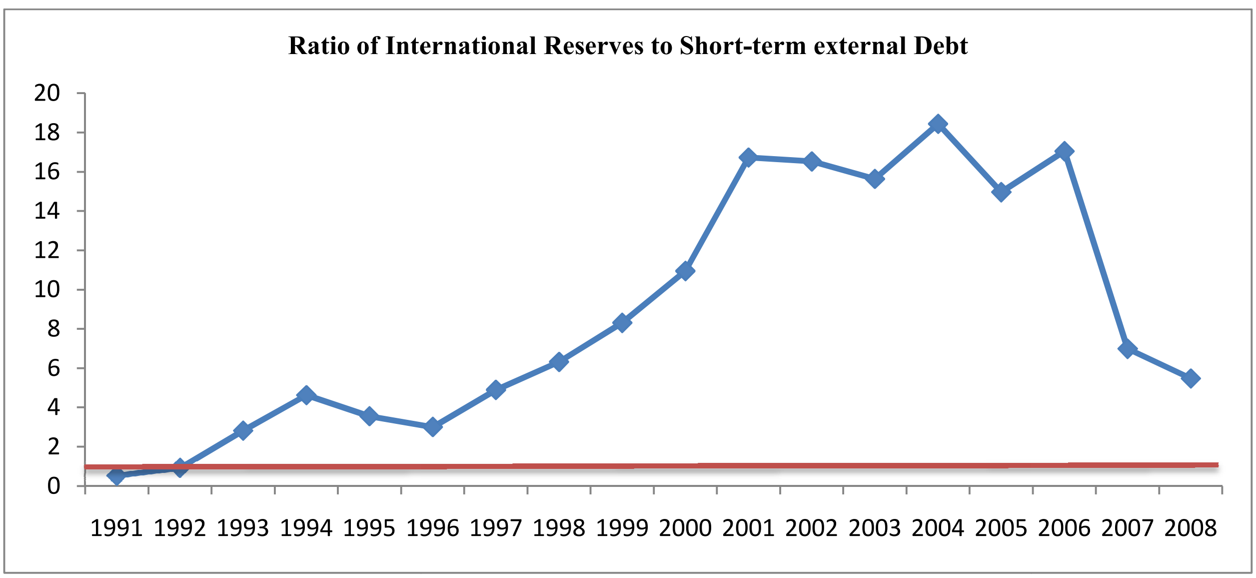
2.2 International Reserves and Short-term External Debt

The rule-of-thumb based on the ratio of reserves to imports was suitable when inflow and outflow of international capital was highly restricted. The Indian economy has witnessed massive inflows of international capital in the post reform era mainly because of the economic reform and liberalization of the external sector. On international front, after the devastating economic consequences of the Asian financial crisis, the size of short-term external indebtedness has been considered to be a prime indicator of liquidity and a reliable predictor of financial crisis (see Bussiere and Mulder, 1999; Greenspan, 1999; Rodrik and Velasco, 1999). In this context, Bussiere and Mulder (1999) argued that the availability of higher liquidity can significantly reduce countries' vulnerability to unwanted external shocks under the conditions of weak domestic fundamentals. The ratio of international reserves-to-short term debt is now assumed to be the most relevant single indicator of reserves adequacy for countries that borrow heavily in international financial market. The extreme reversibility of short-term external debt increases the exposure of borrowers to liquidity runs and systemic crisis during a negative shock. Therefore, the ratio of reserves–to-short-term external debt offers an important indicator of the minimum point at which foreign investors lose confidence (Bird and Rajan, 2003). The Greenspan-Guidotti rule suggests that the ratio of international reserves to short-term external debt should be equal to 1. The fundamental idea behind this benchmark is that the existing stock of reserves should allow a country to live without any foreign borrowing at least up to one year (De Beaufort Wijnholds and Kapteyn, 2001; Jeanne, 2007).[7] Figure 4 reveals that India crossed this minimum benchmark rule of thumb in 1993 when the ratio of reserves to short-term external debt became 2.81. It is noteworthy that during the severe balance of payment crisis in 1991 it was 0.51 and with a little improvement in economic situation after the launch of core economic reform it increased to 0.9 in the year 1992. Thereafter, owing to the massive inflow of foreign capital and liberalization of the external sector, the stock of reserve remained sufficiently high to comfortably avoid foreign

[7] In his proposal Greeenspan (1999) suggested two extensions over the Pablo Guidotti's minimum benchmark rule. First, the average maturity of a country's external debt should be greater than a threshold level, such as three years. Second, there should be a "liquidity-at-risk" standard to assess a country's external liquidity position while taking into account the full set of external assets and liabilities. The minimum benchmark level of reserves would then be one that ensures a sufficient level of liquidity to avoid new borrowings for one year.

borrowing up to one year in the event of a crisis. It is also clear from figure 3 that there has been a massive decline in the ratio mainly after 1996. The main possible reason behind this decline seems to be the substantial growth in the size of short-term external debt compared to stock of international reserve. For instance, the stock of international reserves witnessed an increase of 144.9% during the period 2006-08 whereas the growth in short-term external debt was 451.7% during the same period. The decline in the stock international reserves during 2008-09 was a result of the global financial crisis and the strengthening of the US dollar vis-à-vis other national currencies. The valuation loss (US billion) alone accounted for 65.2% of the total decline in international reserves during 2008-09 (Economic Survey, 2009-10). Nevertheless, even after this recent decline in the stock of reserves, India seems to be in the safe zone using the short-term debt based reserves adequacy measure.

Figure 3: Reserve adequacy- ratio of international reserve to short term debt

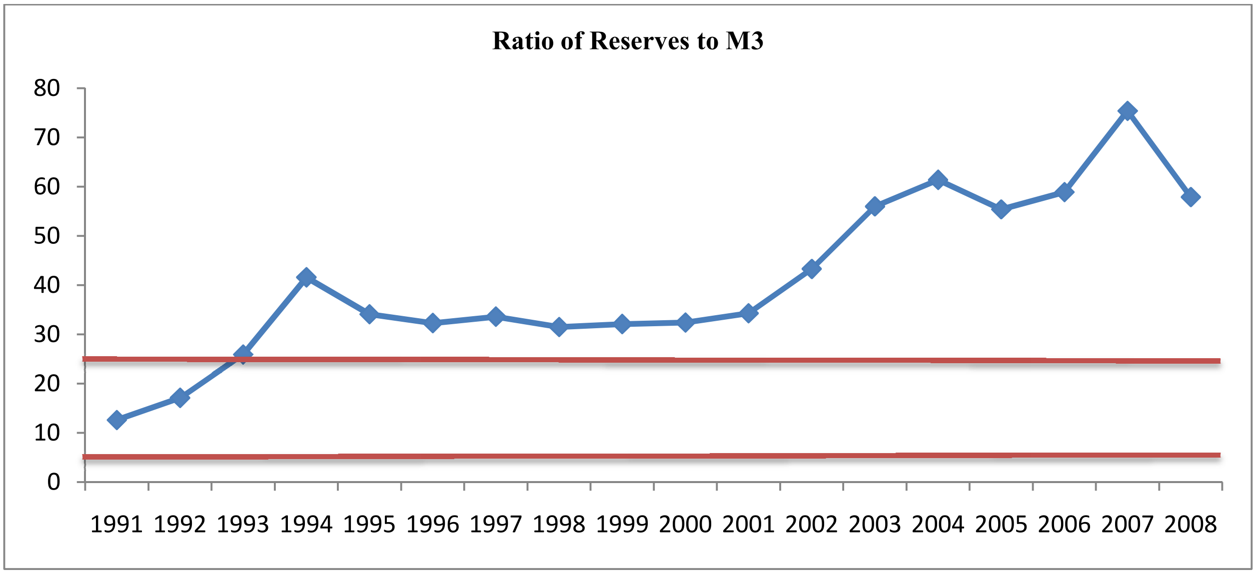


Source: World Development Indicators, World Bank.

2.3 International Reserve and Broad Money

Although the ratio of reserves to short-term external debt is a useful indicator of currency crisis and investors' confidence, but this indicator has also been criticized on several grounds. For instance, it has been argued that while the ratio of international reserves to short-term debt offers a better indication of the vulnerability to an 'external drain', it fails to capture the risk of an 'internal drain' associated with capital flight by residents (De Beaufort Wijnholds and Kapteyn, 2001; Bird and Rajan, 2003). The issue of capital flight and the associated risk of 'internal drain' are best captured by an indicator constructed based on broad money supply (M3 in the Indian case). Calvo (1996) emphasized that a country's vulnerability to financial crisis should be assessed, in part, by the size of its money supply, since broad money reflects a country's exposure to the sudden withdrawal of assets. A low and falling reserves-to-broad money ratio is said to be a leading indicator of a currency crisis and a conventional range for this ratio is said to be 5 to 15% (Kaminsky and Reinhart, 1999). Empirical crisis prediction models have shown that the size of short-term external debt relative to the stock of international reserves was a key indicator of a country's vulnerability to crisis in the 1990s (see Radelet and Sachs, 1998). Figure 4 reveals that there has been significant improvement in the ratio of reserves to M3 in the post-reform era. In short, all the three standard measures of reserve adequacy indicate that India's stock of international reserves is much higher than the minimum limit any conventional rule of thumb would prescribe. Nevertheless, this analysis of reserves adequacy also indicates that there is a need to assess the size of opportunity cost imposed on the country because all the indicators of reserve adequacy suggest that existing stock has crossed the minimum required level by a huge margin.

Figure 4: Reserve adequacy- ratio of international reserves to M3



Source: Reserve Bank of India, Handbook on Indian Economy.

3. Data description

The data used in this study are quarterly observations and the sample period spans from 1991:01 to 2009:02. The primary reason behind taking 1991 as a starting point is that Indian economy faced a severe balance of payment crisis in 1991 and the level of international reserves depleted to such a low level that it was not sufficient enough to finance one month of imports. After that the core economic reform process was initiated and as a result India's international reserve holding touched the height of USD 283.6 billion. This development has changed India's reserves holding pattern completely and that is why we consider 1991 as the starting year in the study. The data on Gross domestic product (GDP) at factor cost (base 1999-2000) are taken from Virmani and Kapoor (2003) and the Handbook on Indian economy published by Reserve Bank of India (RBI).[8] Further, the data on Short-term external debt and Foreign Portfolio Investment (FII) and broad money (M3) are also collected from RBI's Handbook on Indian economy. The data on international reserves (total reserve minus gold)[9], imports and Federal fund rate are collected from International Financial Statistics (IFS) online database provided by International Monetary Fund (IMF). All variables, except the opportunity cost, are converted to logarithms before any econometric analysis.

4. Reserve Demand Function and the Role of National Monetary Disequilibrium

Earlier empirical studies on the demand for international reserves have mainly focused on measures of reserves adequacy by analyzing various ratios, for example reserves to import (see Bahmani-Oskooee and Brown, 2002). However, during the period between mid 1960s to mid 1970s a more elaborate theory of optimal reserves was developed. This new theory advocated the inclusion of a scale variable (transactions motive), measure of uncertainty (precautionary motive), measure of adjustment and opportunity cost in the reserve demand function. Recently, some studies have accommodated a large number of variables highly associated with capital account of the Balance of Payment (e.g. Jeanne and Rancière, 2006) and some indicators to capture the mercantile motive (e.g. Aizenman and Lee, 2007) in the reserve demand function. In this study, we consider a set of explanatory variables to capture various motives of demand for international reserves in India. The growth of Indian economy in the post-reform era (1991-2008) has been spectacular and the GDP growth rate during 2008-09 was 6.7 despite the fact that growth rate across countries has declined substantially because of the global crisis of 2008. To

[8] This is mainly because RBI's Handbook on Indian economy provides quarterly data on GDP only from 1996 onwards. RBI's online database on Indian economy is also available at http://rbi.org.in.

[9] Following Ramachandran (2006), we do not include the gold stock and SDRs in the stock of international reserves. This is mainly because of the reason that they constitute a very small proportion of international reserve and gold is not considered as an intervention asset by the central bank in India.

account for the overall economic growth and a measure of international transactions, we include GDP and Average propensity to import (API) in the reserve demand function respectively.

Further, over the last decade, Indian economy has witnessed massive inflows of foreign capital mainly because of its consistent growth performance. Net capital flows to India was US $ 29.6 billion in April-September 2009. Similarly, Portfolio investment also witnessed large net inflows of US $ 17.9 billion during the same period which indicates towards the revival of global investors' confidence in Indian economy (Economic Survey, 2009-10). However, it is noteworthy that foreign portfolio investment is said to be highly volatile in nature and any sudden outflow is possible and highly likely event. This demands sufficient reserves backup to avoid any unwanted major financial turmoil. Therefore, to account for this risk we include this variable in the reserve demand function. Many recent studies have blamed to short-term external debt (STED) as one of the major reasons for financial crises (see Furman and Stiglitz, 1998 and Radelet and Sachs 1998). As explained earlier, now the size STED is considered as a good indicator of crisis. More importantly, in India it is taken as an important indicator of reserve adequacy and movements in STED is very closely monitored by the Reserve Bank of India (RBI). Therefore, we include the relative size of STED (ratio of STED/GDP) in the reserve demand function. Further, as discussed earlier, we also include opportunity cost (OC) of holding reserves (interest rate differential between India's short term interest rate- call money rate- and the federal fund rate of USA). Finally, we include the volatility of US dollar based Indian exchange rate (EXVOL) in the reserve demand function. To model India's demand for international reserves, we construct the following standard long-run reserve demand function:

$$RES_t = \beta_0 + \beta_1 API_t + \beta_2 OC_t + \beta_3 STED_t + \beta_4\, GDP_t + \beta_5 EXVOL_t + \beta_6 FPI_t + \varepsilon_t \qquad \text{………………………….. (1)}$$

where *RES* is the level of international reserves (total reserve minus gold), *API* is the average propensity to import, *OC* is the net opportunity cost of holding international reserves (the difference between short-term domestic interest rate and the yield on foreign reserve proxied by federal fund rate of USA), *STED* is the short-term external debt, *GDP* is the real gross domestic product, *EXVOL* is the volatility of exchange rate taken as a measure of uncertainty. The volatility included in the reserves demand function is the estimated conditional variance of the exchange rate from a univariate GARCH (1, 1) model explained in the next section. *FPI* is the foreign portfolio investment and $\boldsymbol{\varepsilon_t}$ is the stochastic error term. All the variables, except OC, are in log form. Theoretically, it is very difficult to establish the sign of the estimated coefficient of API in advance. One the one hand, it may proxy to the marginal propensity to import and therefore one would expect a negative sign. On the other hand, as derived by Frenkel (1974) one would expect a positive sign of *API* when it acts as a porxy for the openness of an economy (see Badinger, 2004). The sign of estimated coefficient of opportunity cost or interest rate differential between India and the USA is expected to be negative. The main reason for this is that with the increase in opportunity cost of holding international reserves the demand for international reserves will decline. The measure of uncertainty, i.e. exchange rate volatility proxied by conditional variance, is expected to enter in the demand function with a positive sign. Further, as established in the literature, a larger size of both *FPI* and *STED* indicates for high probability of liquidity at risk and therefore one would expect a positive sign of the estimated coefficients under the precautionary motive of reserves holding.

Further, in addition to modeling India's demand for international reserves in the long-run, following Badinger (2004), we also focus on the role played by national monetary disequilibrium in determining reserve demand. In fact, we are mainly interested in the approach to reconciling reserve demand theory with the monetary approach to the balance of payment. [10] The monetary theory postulates that a country's balance of payments disequilibrium is directly associated with a disequilibrium in its domestic money market. In short, if there is an excess demand for (or supply of) money, it must be satisfied by an increase (decrease) in international reserves holdings of a country's central bank (see Bilson and Frenkel, 1979; Frenkel, 1983; Edwards, 1948 and Bahmani-Oskooee and Brown, 2002). The monetary approach to balance of payment asserts a short-run impact of national monetary disequilibrium on demand for international reserves. Therefore, we did not include this variable in the long-run reserve demand function estimated using cointegration technique. Instead we attempt to model the impact of monetary disequilibrium on reserve demand by incorporating it in the Vector Error Correction Model (VECM) as an exogenous variable (see Badinger, 2004 and Huang, 1995).

4.1 Money demand function and Estimation of monetary disequilibrium

As discussed above, one of the main objectives of this study is to investigate the role of national monetary disequilibrium as a factor that determines India's demand for international reserve in the short-run. For this purpose, in the first stage, we estimate India's demand for money function and then following Badinger (2004), we estimate national monetary disequilibrium for further analysis. In the literature on demand for money, there exist a number of estimable functions based on the monetary aggregates used in the formulation. Among other, we estimate a simple, but fairly standard, empirical model by forming the long-run demand for money function as given below:

$$M3_t = \varphi_0 + \varphi_1 GDP_t + \varphi_2 R_t + \varphi_3 EX_t + \varepsilon_t \qquad \ldots\ldots\ldots\ldots\ldots (2)$$

[10] Studies by Edward (1984) for developing countries, Elbadawi (1990) for Sudan, Ford and Huang (1994) for China, Huang and Shen (1999) for Taiwan and Hunag (1995) for China, Badinger (2004) for Austria have already attempted to reconcile the reserve demand theory with monetary approach to balance of payments and tested the role of monetary disequilibrium in reserve demand.

where *M3* is the real money supply, *GDP* is the real gross domestic product, R is the nominal short-term interest rate, EX is the exchange rate (units of domestic currency per unit of US dollar) and $\boldsymbol{\varepsilon}$ is the stochastic error term. All variables, except the interest rate, are included in their logarithmic form. As explained and established by macro theory, an estimate of φ_1 is expected to be positive whereas an estimate of φ_2 is expected to be negative. As far as the estimated value of φ_3 is concerned, it could be negative or positive. If an increase (or depreciation) in EX is taken as an increase in wealth (foreign assets in terms of domestic currency) then the estimated coefficient will be positive. However, if an increase in EX leads to the expectation of further depreciation, then an estimate of φ_3 is expected to be negative.[11] We consider two traditional unit root tests, namely Augmented Dickey-Fuller test (ADF) and Phillips–Perron test (PP) to confirm the stationarity of variables. The result of unit root tests is presented in Table 1. As expected, all variables included in the model are found to be integrated of order one, i.e. $I(1)$.

Table 1: Results of Unit Root Test: Money Demand Function

	ADF		PP	
Variable	At Level	At 1st Difference	At Level	At 1st Difference
M3	-1.514521	-7.148307*	-1.156842	-18.51118*
GDP	-1.949347	-4.401041*	-0.679690	-21.15536*
R	-2.405164	-10.81670*	-2.516799	-10.71651*
EX	-1.918306	-3.549022*	-3.215649**	-7.200741*

Note: (i) * and ** indicates significant at 5% and 10% critical level (ii) Optimal lags for ADF is determined based on AIC and for PP test it is Newey–West bandwidth selection using Bartlett kernel. (iii) Probability values for ADF and PP test is as per MacKinnon one-sided p-values.

[11] See Arango and Nadiri (1981), Bahmani-Oskooee and Pourheydarian (1990) for a detailed discussion on the expected sign of this coefficient.

Under this circumstance it is not justified to estimate equation (2) using ordinary least squares (OLS) because the estimated results may be spurious. Therefore, we apply the cointegration technique developed by Johansen (1988) and Johansen and Juselius (1990) to investigate the presence of long-run relation among variables.[12] The results of Johansen cointegration, presented in Table 2, show that the null hypothesis of no cointegration is strongly rejected in favour of one cointegrating relation with plausible (normalized) coefficients. This implies that all variables share a common stochastic trend and do move together in the long-run.

Table 2: Results of Johansen Cointegration: Money Demand Function

Trace test			Max-eigenvalue test		
Rank	Eigenvalue	Trace-Stat.	Rank	Eigenvalue	Max-Stat.
r = 0	0.654547	113.5124*	r = 0	0.654547	75.46587*
r ≤ 1	0.122528	15.46172	r = 1	0.272467	22.58485
r ≤ 2	0.122528	15.46172	r = 2	0.122528	9.280424
r ≤ 3	0.083378	6.181301	r = 3	0.083378	6.181301
Cointegrating Vector					
	M3	GDP	R	EX	C
Unrestricted	-20.48161	-42.30075	0.549924	-20.47941	
Normalized (β_{11} = 1)	1.000000	2.065304*	-0.026850*	0.999892*	-0.050417

Note: (i) * indicates significant at 5% critical level. (ii) VAR specification: Optimal lag length (4) selected using AIC (iii) deterministic trend assumptions of the cointegration test: intercept and trend in cointegrating relationship and no trend in VAR (iv) *r* denotes the assumption about the number of cointegration vectors.

The estimated long-run cointegrating relationship of the money demand function is given below

$$M3_t = -0.05 + 2.06GDP_t - 0.03R_t + 0.99EX_t \qquad \text{..................} (3)$$

[12] Johansen cointegration methodology is highly discussed in the literature. Therefore, keeping the space constraint in mind, we do not discuss the methodology in details. However, it noteworthy that compared to other procedures the Johansen methodology provides more robust results when there are more than two variables in the system (Gonzalo, 1994).

Using the long-run relation given in equation (3) and following Badinger (2004), we estimate the following model to compute monetary disequilibrium, hereafter (M_t^{Dis}):

$$M_t^{Dis} = (M3_{t-1} - M3_t^*) \quad \text{.............................. (4)}$$

where $M3_t^*$ is the equilibrium value of money demand. The calculated negative (positive) values of M_t^{Dis} indicates an excess demand for (excess supply of) money. The computed national monetary disequilibrium using the relationship expressed in equation (3) is used in the error correction model.

4.2 Estimation of ARCH model for Exchange rate volatility

After computing monetary disequilibrium, now we discuss the methodology used for constructing the volatility series of exchange rate to be included in the long-run reserve demand function. The volatility series utilized in the reserve demand function is the estimated conditional variance of the exchange rate from Generalized Autoregressive Conditional Heteroscedastic (GARCH) model developed by Bollerslev (1986). As explained earlier, the main advantage of GARCH model, as compared to traditional volatility estimation method such as rolling standard deviation etc. is that it helps to model the volatility clustering features of the data and incorporates heteroscedasticity into the estimation procedure (Bollerslev, 1986). Another advantage of the GARCH specification is that it allows us to model the variance of exchange rate changes as time dependent. This is not the case when estimating a moving average process which asserts that the error term has a constant variance. Further, this specification also allows us to exploit the existing patterns and persistence in the behavior of volatility (Pozo, 1992). The GARCH (p, q) model specification is given by:

$$EXVOL_t = \mu + \varepsilon_t \quad \text{....................... (5)}$$

where $\varepsilon_t/\Omega_{t-1} \sim N(0, h_t)$

$$h_t = \omega + \sum_{j=1}^{p} \alpha_j \; \varepsilon_{t-j}^2 + \sum_{j=1}^{q} \beta_j \; h_{t-j} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

given that $\omega > 0$; $\alpha_1, \ldots\ldots. \alpha_p \geq 0$. Equation (5) is the conditional mean equation, where μ is the mean of EXVOLA. ε_t is the error term conditional on the information set Ω_{t-1} and is normally distributed with zero mean and variance h_t and quation (6) is the variance equation. The inequality that $\omega > 0$, $\alpha_j \geq 0$, and $\beta_j \geq 0$ are imposed to ensure that the conditional variance (h_t) is positive. It is noteworthy that he size and significance of α_j indicates the presence of ARCH process or volatility clustering in the series. The estimated result of GARCH (1, 1) model is given below.

$$\underset{}{EXVOL_t} = \underset{(15.529^*)}{47.448} + \underset{(45.129^*)}{0.93}\, EXVOL_{t-1} + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots.. (7)$$

$$h_t = \underset{(0.74)}{0.2} + \underset{(1.21)}{0.26}\varepsilon_{t-1}^2 + \underset{(2.13^*)}{0.67}h_{t-1} \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

(diagnostics: *t*-values in parenthesis; * indicates significant at 5% critical level; ARCH = 0.427 (p-value 0.51); $Q(10)$= 11.29; Q^2 (10) = 2.92; Log likelihood = -123.216).[13]

The quarterly changes in the exchange rate are modeled as a first-order auto-regressive. It is clear from the estimated model that ARCH effect is not significant in the conditional variance. However, significant GARCH effects appear to exist in the data as the coefficient of h_{t-1} in the variance equation is statistically significant at traditional level of significance. Further, it is noteworthy that the sum of the coefficients of ARCH and GARCH terms is not above unity

[13] ARCH = LM test for ARCH effects in the residuals, $Q(10)$ represents the Ljung-Box statistics for up to 10th order serial correlation in the standardized residuals ($\boldsymbol{\varepsilon}/\boldsymbol{h_t^{1/2}}$) and Q^2 (10) represents the Ljung-Box test statistics for up to 10th order serial correlation in the standardized squared residuals ($\boldsymbol{\varepsilon^2}/\boldsymbol{h_t^{1/2}}$).

(inverted AR Roots 0.93). This implies that variance process seems to be mean reverting. Further, the model residuals do not indicate serial correlation in the standardized residuals or the presence of ARCH effect. We use the estimated conditional variance of this model as a proxy of exchange rate volatility in the long-run reserve demand function.

5. Estimation of the long-run reserves demand function

We next, proceed further to estimate the reserve demand function. In the first stage, we test the stationarity of variables included in the reserve demand function. For this purpose we utilize two time series unit root test namely Augmented Dickey-Fuller (ADF) and Phillips-Perron test (PP) and the results are reported in Table 3. As expected, all variables are found to be integrated of order one, i.e. *I*(1).

Table 3: Results of Unit Root Tests: Reserve Demand Function

	ADF		PP	
	At Level	At 1st Difference	At Level	At 1st Difference
RES	-0.736852	-8.364175*	-2.017870	-8.211285*
OC	-2.732313	-3.697138*	-1.824845	-6.746932*
STED	-3.097233	-5.357146*	-1.839684	-12.03666*
EXVOL	-2.971814	-11.70568*	-3.037023	-14.51578*
API	-0.417234	-4.394741*	-0.351009	-12.03829*
FPI	-2.327000	-10.98414*	-2.220405	-11.14999*

Note: (i) RES, OC, STED, EXVOL, API, FPI, MDIS indicates for International Reserve, Opportunity Cost, Short-term External Debt, Exchange Rate Volatility, Average Propensity to Import, Foreign Portfolio Investment, respectively (ii) * indicates significant at 5% and 10% critical level respectively (iii) also see the notes given under Table 1.

Given that variables are non-stationary, it is not justified to estimate the reserve demand function using ordinary least square estimator (OLS). Therefore, in the next stage we apply the Johansen cointegration methodology to establish the presence or absence of cointegration among variables and to estimate the parameters of the cointegrating vector. The results of Johansen cointegration test is presented in Table 4. It clear from the results that the null hypothesis of no cointegration is strongly rejected by both the trace and maximum eigenvalue test. The rejection of null hypothesis implies that variables do share a common stochastic trend and move together in the long-run.

Table 4: Results of Johansen Cointegration Test: Reserve Demand Function

Trace test			Max-eigenvalue test		
Rank	Eigenvalue	Trace-Stat.	Rank	Eigenvalue	Max-Stat.
r = 0	0.777706	242.1307*	r = 0	0.777706	103.7590*
r ≤ 1	0.449554	138.3716*	r = 1	0.449554	41.19478**
r ≤ 2	0.436250	97.17686*	r = 2	0.436250	39.54698*
r ≤ 3	0.293951	57.62989	r = 3	0.293951	24.01688
r ≤ 4	0.244877	33.61301	r = 4	0.244877	19.38035
r ≤ 5	0.142975	14.23266	r = 5	0.142975	10.64591
r ≤ 6	0.050654	3.586746	r = 6	0.050654	3.586746

Note: (i) * and ** indicates significant at 5% and 10% critical value (ii) VAR specification: Optimal lag length (4) selected using AIC (iii) deterministic trend assumptions of the cointegration test: intercept and trend in cointegrating relationship and no trend in VAR (iv) *r* denotes the assumption about the number of cointegration vectors.

Further, based on the estimated normalized cointegrating vector, the long-run relationship between international reserves and its determinants is expressed below:

$$RES_t = \underset{}{17.57} + \underset{(4.469^*)}{0.75GDP_t} - \underset{(-5.608^*)}{0.03OPC_t} + \underset{(1.993^*)}{0.08STED_t} + \underset{(3.013^*)}{0.70API_t} \quad \ldots\ldots\ldots\ldots$$

$$+\underset{(5.569^*)}{0.05EXVOL_t} + \underset{(1.011)}{0.01FPI_t} + \varepsilon_t$$

The estimated results of the reserve demand function indicate that real national income proxied by GDP, short-term external debt, average propensity to import and exchange rate volatility measure have statistically significant and positive impacts on the demand for international reserves, which agrees with a priori reasoning.[14] Further, all estimated parameters, except foreign portfolio investment, are significant at the 5% level. Further, the signs of all the coefficients are

[14] The model diagnostic tests, not reported in the study but available upon request, indicate that the model is adequately specified, as the tests results of normality, serial independence and homoscedaticity show that residuals do not violate the standard classical assumptions.

consistent with the theoretical explanations. For example, the results show that in Indian case the measure of opportunity cost of holding international reserves is found to be negative and highly significant. It indicates that a 1%increase in opportunity cost will result in 20% decline in international reserves holding. This finding is in line with the findings of Prabheesh et al. (2009) and Ramachandran (2006) for India, Huang (1995) for China and Badinger (2004) for Austria. This also an important finding because most empirical studies generally fail to find any significant role of opportunity cost in reserve demand function.[15] In this context, Ben-Bassat and Gottieb (1992) argued that if the opportunity cost of holding reserve is measured correctly, it can be a key determinant of reserve demand. Similarly, short-term external debt, average propensity to import and exchange rate volatility enter into the reserve demand function with positive coefficients. In short, a 1% increase in short-term debt will increase demand for international reserve by 8%. Further, our results show that foreign portfolio investment is not an important determinant of reserve demand in India. The insignificant role of foreign portfolio investment in determining reserve demand in India is somewhat surprising. It seems that the size of the short-term external debt relative to the stock of international reserves have not yet reached to the level where it can significantly influence the reserves demand. Nevertheless, the significant role of short-term external debt in determining reserve demand is another important finding because many previous studies have not included it in the demand function.

6. Vector Error Correction Model: The Role Monetary Disequilibrium in Reserve Demand

As explain earlier, in this study, along with other long-term determinants of reserve demand, we also focus on the role played by national monetary disequilibrium. We did not include this variable in the long-run reserve demand function because the monetary approach to balance of

[15] However, few exceptions in this category include Edwards (1984), Landel-Mills (1989), Karfakis (1997).

payment asserts that monetary disequilibrium influences reserve demand in the short-run. Therefore, to study its short-term impact on reserve demand we include it as an exogenous variable in the error correction model. The estimated results of dynamic error correction model for international reserves are given below

$$\underset{}{\Delta RES_t} = \underset{(-1.8)}{-0.74} - \underset{(1.10)}{0.232\Delta RES_{t-1}} - \underset{(2.24^*)}{0.32\Delta\, RES_{t-3}} - \underset{(-2.08^*)}{0.06\Delta STED_{t-1}} - \underset{(-0.86)}{0.106 API_{t-1}} \ldots..$$

$$\underset{(-2.21^*)}{-0.316\Delta API_{t-3}} + \underset{(2.31^*)}{0.034\Delta FPI_{t-2}} + \underset{(2.199^*)}{0.026\Delta FPI_{t-3}} - \underset{(-0.25)}{0.001\Delta OPC_{t-1}} \ldots\ldots$$

$$+ \underset{(0.06)}{0.028\Delta GDP_{t-1}} + \underset{(0.50)}{0.003\,\Delta EVOLA_{t-1}} - \underset{(2.76.^*)}{0.561\Delta M_{t-1}^{Dis}} - \underset{(3.71^*)}{0.482 ECM_{t-1}}$$

(diagnostics: *t*-values in parenthesis; R^2 = 0.78; F-test= 2.67*; standard error = 0.026; LM_{AR}= 64.01; Jarque-Bera residual normality test = 2.02; White= 1618.95; RESET= 3.61).

The R^2 of the estimated model is convincingly high and all reported model diagnostics suggest that reserve demand equation fits the data suitably. In short, the Jarque-Bera residual normality test, LM test of auto-correlation and White's heteroscedasticity test show that the residuals are well behaved. From the above equation it is clearly evident that changes in short-term external debt have an immediate negative impact on reserves whereas the impact of average propensity to import becomes significant in the second quarter. It is also clear that changes in opportunity cost and gross domestic product do not play any significant role in the error correction mechanism. Nevertheless, while the study failed to find any long-run association between demand for international reserves and foreign portfolio investment, positive and statistically significant impacts in third and fourth quarter were clearly visible in the short-run. This is indeed an important finding because it implies that FPI has strong positive and significant impact of reserve demand in India. The coefficient of *ecm* term indicates the percentage of the last period deviation from the estimated long-run relationship that has been corrected this period. As can be seen from the model around 48% of the deviation from equilibrium was corrected within one quarter. The relatively high speed of adjustment coefficient of the error correction term indicates towards a somewhat active reserve management of the Reserve Bank of India (RBI). More importantly, the national monetary disequilibrium enters significantly in the correction mechanism with the expected sign. We have used one period lag of monetary disequilibrium in the model because only this term is found to be significant when both lagged and contemporaneous variants are included in the model. The results show that the excess demand for (supply of) money results in an increase (decrease) in international reserve with an elasticity of 0.35. This is indeed an important finding in the case of India because none of the previous studies have so far considered the role of domestic monetary disequilibrium in reserve demand. The small coefficient of monetary disequilibrium indicates that RBI takes measures to clear the money market by making appropriate changes in both interest rate and domestic credit, and did not leave any disequilibrium in money market completely on the market forces such as induced reserve flows to restore equilibrium.[16]

7. Conclusions and Policy Implications

India's stock of international reserves has been increasing continuously since the launch of economic reform in 1991. It is a known fact that along with several benefits, the huge stock of international reserve also imposes some costs on the country. Therefore, it has become a crucial policy issue in the hands of policy makers and monetary authority to strike an optimal balance between the stock of international reserve and the opportunity cost of holding it in one hand and reserve adequacy to satisfy various precautionary motives and developmental requirements of

[16] See Badinger (2004) for a details and discussion on the plausible size of monetary disequilibrium coefficient.

the economy, in the other hand. Contrary to the theoretical explanations, India's stock of international reserve witnessed massive and continuous increment during the independent floating exchange rate regime. Theoretically, a country needs relatively less international reserves under flexible regime because central banks were not compelled to defend their parities against any international currency through frequent interventions. Nevertheless, the practical experience in the Indian case has been just opposite for the flexible regime.

The main objectives of this paper were to study reserve adequacy and to investigate what determines India's demand for international reserves over the period 1991 to 2009. In the first stage, we have discussed the issue of reserve adequacy and made an effort to assess India's position using various standard benchmarking measures of minimum reserve requirement deemed to be necessary to avoid unnecessary financial catastrophe. Using three measures of reserve adequacy, we find that India has adequate stock of international reserves to fulfill the minimum requirements and therefore it stands in a somewhat comfortable zone with the existing stock of reserves. In the next stage, we estimated a reserve demand function for India and an error correction model to investigate the role of national monetary disequilibrium. Estimates of reserve demand function suggest that precautionary motive is clearly playing a significant role in determining India's demand for International reserves and RBI's reserve policy in the long-run. The results show that the scale of foreign trade and overall economic growth (imports and GDP), uncertainty (exchange rate volatility), profitability considerations (opportunity cost of holding reserves) and precautionary motive (short-term external debt) have been guiding India's long-run reserve policy. Contrary to the theoretical explanations, we failed to find any significant impact of foreign portfolio investment in the Indian case. Nevertheless, there is sufficient evidence to conclude that reserve management is rather active in India as, on average, some 48% of the deviation from the long-run equilibrium was corrected within one quarter.

Further, our results show that national monetary disequilibrium plays significant role in reserve movements in the short-run as suggested by the monetary approach to the balance of payments. This is indeed a significant finding since many earlier studies have failed to find any role of monetary disequilibrium. The results from error correction model show that an excess demand for (supply of) money in the domestic money market leads to an inflow (outflow) of international reserve with time delay of one quarter. The size of the monetary disequilibrium coefficients is less than one which suggests that the RBI is responding actively to domestic monetary disequilibrium through appropriate measures and not leaving it completely on the mercy of reserve flows to correct the existing disequilibrium in domestic money market. Further, the significant and positive impact of short-term external debt is another important finding of the study because many previous studies, for example Prabheesh et al. (2009) for India, did not consider this variable as one of the key determinants of reserve demand in India.

The results of this study have some major policy implication for India and other emerging countries. First, it is true that an emerging economy like India needs to keep sufficient amount of international reserve to avoid any unnecessary financial calamity, to meet its external debt obligations, to ensure a healthy rating of its creditworthiness and overall macroeconomic stability. However, it is also true that there is a high cost of holding massive international reserves. It has been observed that India has surpassed the all three standard benchmarks of reserve adequacy by a high margin. Therefore, it seems desirable that there is a need to manage the reserve stock in a more efficient way to minimize the opportunity cost of holding international reserves. Because for a developing country like India where the available financial resources to meet the rapidly growing developmental requirements are terribly scarce, every increase in the stock of unemployed international reserves increases the real opportunity cost considerably, if not exponentially. Second, the significance of opportunity cost coefficient in the reserve demand function also indicates towards the presence of a trade-off between adjustment policies and reserves holding policies for correcting balance of payments disequilibrium. This further indicates that there is need for an optimal coordination between payments imbalance adjustment policies and reserve holding polices to determine the optimal level of required international reserve. Third, although the central banks (RBI) is responding actively to the disequilibrium in domestic money market, but the size of response is relatively small and still more than half of the disequilibrium is corrected by the inflows of international reserves. It seems advisable that the RBI should increase the size of its operation to correct domestic disequilibrium. The main reason behind this is that it does seem reasonable to leave the domestic monetary disequilibrium on the mercy of highly volatile international inflows. Finally, the favourable evidence for the monetary approach to the balance of payments is very important for a country with managed floating exchange rate regime. Because it is possible that persistent monetary disequilibrium in the domestic money market may neutralize the serious efforts of the central bank to restore payments equilibrium.

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