CHAPTER 2
REVIEW OF SELECT EMPIRICAL LITERATURE

2.1. Introduction

The literature on foreign exchange reserves have developed enormously with special focus on estimating demand for reserves, optimality and various motives and risks. The works on foreign exchange reserves with respect to exchange rate and foreign exchange intervention are aplenty and this has also developed with special focus on exchange rate volatility. Since this work attempts to identify the beneficial effect of accumulating reserves focusing on whether accumulation of foreign exchange reserves can help reduce exchange rate volatility, this chapter makes an effort to expound the empirical works done relevant for the analysis carried out in Chapter 4. Hence, this chapter deals with the empirical works done related to foreign exchange reserves, central bank intervention and exchange rate volatility in foreign countries in general and India in particular.

2.2. Literature on foreign exchange reserves

There has been a tremendous amount of theoretical and empirical literature on international reserves explaining reserves accumulation. Traditional views focused on the main role of three variables: i) the benefit of accumulating reserves stocks which is measured by the reciprocal of the marginal propensity to import; ii) the opportunity cost of accumulating reserves which is the difference between interest earned by reserves and the alternative use of these resources for productivity; and iii) the volatility of balance of payments, in order to account the degree of synchrony between external flows. In this respect, a huge body of literature has been developed on the demand for international reserves to empirically verify the determinants of the reserve accumulation.

Triffin (1947a) is generally considered of as being the first to systematically argue that the demand for reserves might grow in line with trade growth suggesting that reserves are positively associated to average propensity to import and hence the ratio
of reserves to imports (R/M) became a good measure of reserve adequacy. Heller (1966) has been instrumental for the entire discourse on foreign exchange reserves and is the first to formalize the demand for reserves and analyzed the necessary levels of reserves in terms of optimized level in which a simplified but intuitive model is developed to show optimal reserves as an increasing function of uncertainty (average yearly imbalances) and a decreasing function of the cost involved in holding it and of the marginal propensity to import (a alternative measure for reciprocal of the marginal cost of balance-of-payments adjustment). The benefit in holding reserve is avoiding a circumstance of output loss that occurs due to a balance of payment crisis. Heller’s results are more general, but varying sub-optimal reserves for developing countries. Subsequently, Clark (1970a, 1970b), Kelly (1970), Hamada and Ueda (1977) and Frenkel and Jovanovic (1981) modified Heller (1966) and showed that the quantum of optimal level of reserves increases with volatility and decreases with propensity to import and the opportunity cost. Moreover, the most important aspect of these works has been the focus on stochastic time series properties of reserves thereby showcasing the dynamic nature of reserves level adjustments. The most important paradox to be noted is the assumption of Heller’s model that reserve holdings are inversely associated to the marginal propensity to import, while the Triffin (1947a) hypothesis emphasize that reserves are positively associated to average propensity to import. Despite visualizing an ambiguous and opposite interpretation, the import based ratio has been highly popular. Conventionally, the measure based on trade is R/M, i.e., reserves should cater at least three to four months of imports, is the most commonly cited benchmark as recommended by international institutions. Though the import cover ratio has been highly popular, theoretical rationalization for this approach has not been strong enough; the central problem is one of defining the optimum value of the R/M ratio. Moreover, unless the incidence of deficits increases in a linear relationship with that of value of imports, it cannot be considered that any definite value of ratio will be appropriate over time as trade grows.

Machlup (1966), after analyzing few measures of international reserves, found that the prevailing holding patterns could not be justified by explanations offered either by “theoreticians or practitioners” and concluded that monetary authorities’ hoarding of international reserves can be motivated by factors that are non-fundamental in
nature. According to Machlup, no level of reserves was ever enough and stated a metaphor to illustrate the monetary authorities’ acquisitive characteristics of adding to their reserves resembled those of his wife’s desire for clothes which is popularly known as the “Mrs. Machlup’s Wardrobe Theory”.

The Triffin dilemma\textsuperscript{11} has highlighted a paradoxical condition associated with using the US dollar as international reserve currency since in effect it was expected to play the role of a “weak” and a “strong” currency simultaneously. Weak in the sense that the US is expected to create externally held dollar liabilities in order to supply international liquidity, and strong in the sense that the confidence in it to be maintained. The variable international reserves came to limelight as a consequence of the collapse of Bretton Woods system and it was considered as a major milestone in international finance. Before the abandonment of Bretton Woods agreement, there existed an essential debate pertaining to liquidity creation that eventually led to the creation of Special Drawing Rights (SDRs). The idea behind this was to detach liquidity dependence from dollar supply that emanates from US balance of payments deficits so as to avoid Triffin paradox. Once the Smithsonian Agreement of December, 1971 and February, 1973 devaluation could not help, currencies began to float in March, 1973 and it was believed at that time that demand for international reserves will diminish. That is, the embracing of generalised floating exchange rates in 1973 implied that balance of payments disequilibria would lead to changes in the relative values of currencies rather than changes in the reserve levels and the expansion of international capital markets make it easy for countries to augment their reserves via international borrowing. On the contrary, reserve accumulation began to rise at a faster rate under flexible exchange rate arrangement. This puzzling phenomenon was first pointed out by Frenkel (1983).

Frenkel (1978), by presenting evidence on the stability of demand argued that, a high (low) import to gross domestic product (M/GDP) ratio denotes a high (low) openness of an economy reflecting the vulnerability to external shock. Also, Frenkel

\textsuperscript{11} The argument was that if the US tries to correct its balance of payments deficit it would cause a liquidity crisis. If the deficit is allowed to continue, other countries would lose confidence in dollar’s status as reserve currency and start converting their dollar reserves into gold.
and Jovanovic (1981) developed a framework for optimal level of reserve using the R/M ratio approach allowing for trend movements that guides international payments and receipts, the mean rate of net payments and stock adjustments to justify greater theoretical sophistication to the R/M ratio. It is argued that the demand for reserves is a function of benefits acquired from smooth external transactions (trade) and a negatively related to opportunity cost (forgone earnings) involved in holding them.

2.3. Reserve accumulation in the era of capital mobility

Motives behind holding foreign exchange reserves were explained in terms of, precautionary and mercantile motives. Precautionary motive for holding reserves is similar to the concept of the demand for money as it can be positively linked to wealth and the cost of covering unplanned deficit, and negatively linked to the return from several other alternative assets. Reserves provide self-insurance against run-type behavior in international financial markets.\textsuperscript{12} This phenomenon is perceived to be particularly associated with economies having fixed or pegged exchange rates, though is not entirely restricted to these countries alone. Even for countries having flexible exchange rate arrangement, the sudden unwillingness of international lenders to renew credit lines could lead to a sudden excessive depreciation of the exchange rate or a significant reduction in imports.

2.3.1. Precautionary view against sudden stops/capital reversals

Currently the precautionary view can be approached by classifying literature in three related areas. The first research area is related to the precautionary motive behind accumulation of reserves considered as an insurance against sudden stops and capital reversals. The surge in foreign exchange reserves of EMEs is largely attributed to increase in the volatility of capital flows across frontiers which is subject to sudden stops/reversal (Calvo, 1998 and Edwards, 2004).

\textsuperscript{12} See, for example, Sachs, Tornell, and Velasco (1996) and Lee (2004).
Indeed, with the dearth of a true lender of last resort, holding foreign exchange reserves could be one alternative for financially open economies to be able to dampen the effect of output loss caused by sudden stop in capital inflows. In certain circumstances, hoarding reserves might also help avert the probability of certain types of crisis from occurring, for instance, by deterring speculative attacks against currencies or by making capital reversal less probable. However, the emerging market economies started accumulating large reserves unusually high in the aftermath of the Asian Financial Crisis of 1997. This phenomenon is, widely perceived and supported by academic research, reflects the lack of confidence in the international financial system.

Precautionary motive (Aizenman and Marion, 2003b; Kim et al; 2005; Aizenman and Lee, 2005) deals with the desire for insurance against exposure to sudden shocks that can possibly occur in the future which takes into account both crisis prevention and crisis management. A sudden capital outflow or reverse capital flow will create unrest in the forex market which will cause heavy movements in the country’s exchange rate which may lead to possible depletion of foreign exchange reserves.

Aizenman and Lee (2005) compared the significance of precautionary and mercantilist motives in holding of reserves by developing countries. The objectives are to quantify the relative importance of different alternative approaches explaining reserves accumulation, and modeling precautionary demand for reserves with a view of self-insurance against output loss as a result of sudden stops and capital reversals. This approach is employed to provide a welfare evaluation of the costs and benefits of accumulating reserves and the optimal level of precautionary demand. The first set of variables deals with the factors related to mercantilist view, i.e., lagged export growth and deviations from predicted purchasing power parity (PPP). The second set of variables helps to estimate precautionary adjustment in the aftermath of unexpected sudden stop crisis, with dummy variables. Specifically, the 1994 Mexican crisis and the 1997 AFC are the two major events. Both occurred after greater financial integration took place with the relaxing capital controls. The empirical results applying to the data period from 1980 to 2000 provide only a little support for mercantilist view. While the variables connected with the mercantilist view are statistically significant, their economic importance with respect to reserves
holding is close to zero and is shrunk by other variables. Specifically, trade openness, measured in terms of GDP share of imports, and crises variables have played a more significant role in accounting for reserves holding than lagged export growth and PPP deviations. This result applies to all countries, including China. In all specifications, a more liberal capital account policy is found to rise the level of reserves. This by itself forms evidence favouring precautionary motive, for open capital account will enhance the precautionary purpose than the mercantilist motive. Moreover, the addition of capital control variables reduces the statistical significance of deviations from PPP, one of the two mercantilist variables, while having little impact on statistical significance of crisis variables. Moreover, the results support precautionary view; in particular, a more liberal capital account regime increases reserve holding. Theoretically, large precautionary demand for exchange reserves comes as a self-insurance against costly liquidation of long-term projects when the economy is susceptible to sudden stops. The welfare gain from the optimal level of reserves is of a first-magnitude, lowering the welfare cost of liquidity shocks from a first-order to a second-order magnitude.

Gosselin and Parent (2005) compared the extent of the existing level of reserves from that predicted by the standard macroeconomic determinants. The analysis is carried out using Pedroni’s (1999) panel cointegration tests as the base for modeling long-run reserve demand function in a panel of eight Asian EMEs. The data are yearly and period starts from 1980 and ends in 2003. It is an important innovation compared to the existing literature on reserves modelling: although the data are typically I(1), the work ignores this and attempts to statistically infer based on unadjusted standard errors. Although the results show evidence of positive structural break in the demand for international reserves by central banks of Asian EMEs in the aftermath of 1997-98 crisis, it indicate that the actual level of reserves accumulated in 2003-04 is still in excess compared to that predicted by the model.

Aizenman and Marion (2004) investigated whether political considerations play a major role in determining holding of international reserve over and above the standard explanatory variables in EMEs. The study evaluated a two-period economy that experienced productivity shocks and can borrow abroad up to a limit due to the existence of some probability of default in the second period. The important idea is
that reserves provide insurance as long as there is a difference between first period and second period marginal utility when there is default and there is no reserve cushion. In this way, international liquidity helps the economy to smooth consumption intertemporally even in the default scenario. A buffer stock model is estimated to show how optimal level of reserve holdings is sensitive to both efficiency and political economy factors. The results show political instability and political corruption decreases the optimal level of buffer stocks. Also, it indicates that greater attention should be shown to the role of political-economy issues in studying the reserve demand and functioning of buffer stocks. It is found that the probability of leadership change and political corruption influenced the reserve demand even after controlling for main determinants and country specific factors. Theoretical underpinnings show that external threats should raise reserve demand whereas internal political polarization should lower them.

Jeanne and Ranciére (2005) have also worked in this field estimating a model for optimal level of reserves in EMEs. A model of the optimal international reserves is calibrated for a small open economy that is susceptible to sudden stops in capital flows. This study derives a simple formula for the optimality, based on the assumption that the main benefit of reserves is to cushion domestic absorption against the disturbance caused by sudden stops in capital flows. An important aspect of the model is the different maturity of private (short) and public (long) financing. In the margin, reserves have to be financed with long-term debt since short positions are very difficult to roll over in a crisis scenario. A formula is derived for the optimal level of reserves to show that plausible calculations that can give explanation for the order of magnitude of reserves that is observed in many EMEs. However, the huge buildup of reserves in Asia after AFC seems to be in excess of what would be perceived as an insurance motive against sudden stops.

### 2.3.2. Precautionary view with focus on trade and currency crisis

The second research area about international reserves is with the literature on trade and currency crisis. Few recent literatures on reserves has studied possible trade-related and crisis-vulnerability-related aspects that might have impact on reserve accumulation trends, showing evidence of a self-insurance motive of holding
reserves. Much of the studies for countries’ reserve holding patterns do not yet untie
the possible reasons behind the precautionary motive which could vary across
countries. Different countries may have distinctive underlying weaknesses, which
in turn portrays their reserve holding patterns to the extent that this could reduce the
occurrence of crises and/or tone down their effects.

The empirical works of Flood and Marion (2002), Aizenman and Lee (2007) provide
evidence supporting the view that rising volatility of external transactions and
increased frequency and the intensity of banking and financial crises have
significantly led to increased precautionary demand for reserves. In particular,
Aizenman and Lee (2007) in the process of analyzing reserve demand have explored
the possible trade-related and crisis-vulnerability-related factors that might have an
effect on reserve holding patterns, showing evidence that reflects a self-insurance
motive for accumulating reserves. A comparison is made empirically to verify the
significance of precautionary versus mercantilist strategies for reserve accumulation
for a sample of 49 industrialized and developing countries during the period 1980-
2000. In comparison between two sets of variables – one representing precautionary
(e.g. capital account openness, crisis dummies, etc.) and the other representing
mercantilist view (e.g. export growth, trade openness, etc.) – it is found that the
variables related to mercantilist view are statistically significant but they explain a
very small portion of total reserve holding. It also shows that the reserve
accumulation has strengthened by international capital flows, and that the variables
associated with precautionary strategy are both statistically and economically
significant in depicting reserve hoarding patterns.

Also, Mendoza (2010) examined the empirical association between reserve holding
trends and vulnerability related factors, comparing the pre- and post-AFC periods of
1997-1998 focusing on the self-insurance motivation. As it is envisaged that some of
the empirical relationships between reserves and the indicators of macroeconomic

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13 Aizenman and Lee (2007) and Hashimoto (2008) are notable exceptions. Aizenman and Lee
attempt to analyze possible differences in the reserve holding patterns of Asian and Latin American
countries as distinct groups, while Hashimoto examines specific crisis-hit countries in Asia as well as
Mexico and the Russian Federation.

14 Bahmani-Oskooee and Brown (2002) and Mendoza (2004) provide a comprehensive review of the
theoretical and empirical literature on reserve holding, including the possible motivations behind it.
vulnerability may have changed ever since 1997, the potential structural breaks in reserve holding behavior has also been examined. A data set of group of 51 developing countries is taken for the period from 1982 to 2004 for analysis. The reserve demand function used for analysis incorporates the indicators based on literature on crisis forecasting and early warning system, i.e., variables centering on current account balance, hot money flows and external debt. The dependant variable is the ration of foreign exchange reserves to GDP and the explanatory variables for reserves are crisis vulnerability indicators, real exchange rate volatility (or foreign exchange intervention), financial development, economic openness and money supply. It is found that the elasticity of reserves of developing country in relation to vulnerability indicators like external liabilities and foreign debt service seems to be higher in post-AFC period, showing that policymakers’ responsiveness by holding more reserves has increased on precautionary grounds. Countries in a group based on the type of vulnerability (commodity, debt or sudden stop related), countries prone to sudden stops because of capital inflows also seem to have managed and adjusted their strategies towards higher levels of precautionary base. Also, it is found that, in general, China’s holding pattern appears to be consistent with that of developing countries’ self-protection strategy.

International liquidity is considered to be a fundamental asset in second generation type model that could play an important role (in triggering or not a currency crisis) when underlying fundamentals are in an “intermediate” zone. Li and Rajan (2005) developed an optimizing model to determine the optimal level for a country looking to minimize the net costs of holding reserves. In this process an effort is made to determine the validity of Sachs et al. (1996) contribution that a country that has sufficiently high stocks of reserves can offset weak fundamentals. However, if fundamentals of the country are sufficiently weak, no level of reserves will be able to compensate this structural problem existing in the economy. This idea largely in line with the escape clause based second-generation models of currency crisis. Moreover, the recent high level of reserve build up in Asian economies has been associated with exchange rate motivations (i.e., mercantilist motives or adherence to pegged exchange rate regimes basically kept undervalued) instead of a conscious effort to accumulate for insurance purpose.
2.3.3. Precautionary view associated with financial risk

The third channel highlighted by precautionary view of reserves is associated with financial risk. There exists two-way relationship between these variables of reserves and risk. On the one hand, credit rating agencies observe and monitor reserve levels, among other variables, in order to evaluate and assign ratings to debt instruments of sovereign nations. Since such ratings tend to influence investor sentiments there exists a significant signalling effect of reserves. On the other hand, when a more risky environment prevails more reserves will be essential. The emerging market economies with less liquidity, a managed or dirty floating exchange rates and unsure market access will have significant benefits like less risk, less impact of current account crises or capital account shocks from large foreign exchange reserves. Whereas the advanced economies which have high liquidity, stable access to financial market using domestic currency and floating exchange rates are unlikely to significantly gain from large precautionary reserve holdings.

The crises that afflicted many middle-income developing countries in the 1990s till date are predominantly due to the crises of the capital account, which could have been averted or reduced the intensity by sensible management of asset and liability position. The capital account route cause of crises has forced some sophisticated policy makers, governments and central banks to develop pertinent rules of thumb for reserve adequacy based on different varieties of international liabilities. As the main cause of uncertainty for EMEs now linked with the capital flows and not trade flows, the conventional current account-based metrics determining the reserve adequacy (such as import cover) may sternly undermine the actual amount of reserves that should be accumulated.

This broad acceptance in a world of huge capital mobility has made the conventional indicators of reserve adequacy with respect to trade, in general and imports, in particular, of limited value. Hence the inherited notion of operational metrics such as ratio of reserves to imports approach to quantify adequacy levels may no longer be

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15 For instance, Hviding, Nowak and Ricci (2004) dealt in next section of this chapter.
16 The Bank of Korea (BOK) and the Reserve Bank of India (RBI) are more suitable examples. For details on reserve management in India, Korea and other selected countries, see IMF (2001).
suitable. This may be useful for poorer economies (Bird and Rajan, 2003), which cannot access and attract private capital and may have a highly concentrated export base. However, for EMEs which carries huge short-term debt, this ratio may not match optimally to reserve adequacy phenomenon and the R/M ratio may not help capture capital account shocks. Hence, Greenspan (1999) came out with an idea and suggested that it is therefore required to take into account the capital flows and level of reserve to a country’s short-term debt to evaluate reserve adequacy for EMEs.

With respect to the important role played by short-term debt, many suggestions were made to express reserve level of a country in relation to the short-term debt it has. The idea of ratio of reserves to short-term debt (R/STED) is not new. Already some explorations have been carried out on this issue by Ben-Bassat and Gottlieb (1992b) and Jung (1995) hypothesizing that the reserves help to avoid default costs, i.e., reserves are proposed to be a related to debt that is coming due.

For instance, Ben-Bassat and Gottileb (1992) developed a framework to emphasise the cost of earlier defaults on demand for reserves which means that the cost and probability of reserve reduction may be explained similar to the cost and probability of default on debt. A combination of the standard optimality approach focusing on country-risk phenomenon has been used to link default risk to certain macroeconomic variables like ratios of reserve to imports and the external debt to exports and per capital GNP. This model emphasizes the role of potential cost of default as an important determinant. An analysis is done to estimate this cost in a model comprising 13 countries which have defaulted in the past. In addition, this model is empirically tested for Israel for the period starting from 1964 to 1988 and a comparison is done with other models. Moreover, the simulation technique for optimal level of reserves is carried out to calculate and compare with actual data. It is found that a defaulting record would necessitate proportionally more reserves.

Bussière and Mulder (1999) found that a higher stock of reserves with respect to short-term debt significantly lowers the probability of occurrence of BoP/currency crisis. The ratio of R/STED is found as supreme predictor of crisis compared to any other reserve adequacy indicator and conclude that, as a rule of thumb, in countries which run moderate level of deficits in current account and has a real exchange rate
which is not much misaligned at medium term, the ratio of R/STED is expected to avoid contagion. In a similar fashion, Mody and Taylor (2002) found that for countries like Mexico, Brazil, Korea and Thailand, the ratio of R/STED helps to determines the supply of foreign capital and that a high R/M ratio reduces the demand for foreign capital. Manasse et. al, (2003), show that high level of reserves helps reduce risk of sovereign default. In addition, Caramazza et. al. (2004) found a high R/STED ratio helps reduce occurrence of financial contagion across borders.

Aizenman and Marion (2004) argue that reserves are held to mitigate any financial crises or shocks that may occur in future. Though reserves are play a role of buffer but it cannot play a role as an alternate to policy reforms at domestic level. The buffer role is in line with the modern second generation (escape clause-based) currency crises models (Obstfeld, 1994; 1996 and Rajan, 2001). These models stresses the plausible multiple equilibria in the environment of huge capital mobility where the payment position of a country is neither “quite strong” nor “hopelessly weak”, i.e., if the country is placed in a vulnerable range. When such conditions exists a country’s reserve stocks helps not only to finance speculative runs against its currency but can help mitigate such disturbance from occurring.

Further, Kim et al. (2005) identified three functions of precautionary motives: (i) the capacity to finance essential payments imbalances; (ii) the ability to supply liquidity at times of capital flight; and (iii) the preventive role in lowering the possibility of an occurrence of speculative attack against the currency. Also, a study is done on additive coverage ratios used by some central bank authorities and reports new benchmarks for assessing reserve adequacy in relation to the behavior of various types of capital flows, for instance, short-term debt flows, portfolio flows etc. In addition, different measures based on the “size” of crises and their implications on adequacy indicators for Asian economies are discussed. Initially, a brief overview is dealt about the “inadequacies” of recent coverage measures in account of capital account related crises that surfaced from 1990. Further, an analysis is done on the ratios of reversals of capital flows during AFC of 1997 to find explanation if there is any strong justification for accumulating different levels of “reserve backing” in place of various types of capital flows. Experiences from various episodes indicate that the precautionary holding represents larger in the policy of Asian EMEs to
hoard such huge levels of reserves. The results of the employing new benchmarks to select Asian economies infer that all five countries examined have accumulated excessive reserves by 2003. Since there does not exist any one pertinent method to evaluate optimum level of reserves, it has proved difficult to show distinction between precautionary and mercantilist basis for reserve holding. Moreover, the smoothing of market disorderliness may be an important motive for extended periods of accumulation.

Aizenman and Riera-Crichton (2007) evaluate the impact of foreign exchange reserves, terms of trade shocks (ToT) and capital flows on real exchange rate (REER). It evaluates the extent to which reserve accumulation and economic structure affected the REER and its adjustments to ToT, capital flows, and different other shocks. A comparison is done in the REER trends of developing and OECD economies. Further, this study examines the degree to which reserve accumulation does offset the impact of ToT shocks on the REER. The analysis is done for the period covering 1970 to 2004 for 60 developing economies and 20 industrialized economies in a panel regression framework. It is observed that reserve accumulation comforts and cushions against the impact of ToT shocks on REER and this effect is considered important for developing countries and not for industrialized economies. As a result, countries which are vulnerable to ToT shocks may gain from cautious reserve management that may be way beyond traditional policies of central bank. This effect gained from buffer is significant for Asian economies, and for economies which export natural resources. The buffer role of reserve holding is lowered by the financial deepness in developing countries. Financial integration of markets might have raised the financial flows’ responsiveness to ToT volatility. The REER of developing economies are more responsive to reserve stock changes, whereas there exists a significant association between REER and capital flows in industrialized economies. The ToT improvement realized through higher returns on domestic side would stimulate inflows of capital, which might force REER to appreciate. In the same way, the deterioration in ToT would induce disorderly outflows of capital, where the speed of flight is forced by the extent of capital losses. In general the results are robust to control variables of monetary policy, financial openness, capital flows and exchange rate management.
Mishra and Sharma (2011) studied demand for exchange reserves for India’s data with focus on national monetary disequilibrium and have presented different benchmarks for evaluating reserve adequacy measures. India’s reserve adequacy position has been assessed with standard rules of thumb. In addition, the assessment of excess reserve holding and opportunity cost considers many vital factors like portfolio flows, short-term debt and country risk measures. The volatility measure of exchange rate used to model reserve demand is estimated from GARCH model. Further, based on Badinger (2004), in order to include the role of national monetary disequilibrium in reserve demand function the study estimates and incorporates the national monetary disequilibrium into the vector error correction (VECM) model. The quarterly data from January 1991 to February 2009 is used so as to cover the reform period of post-1991 crisis and adherence to flexible exchange rate regime. It is found that India is well positioned and has sufficient reserve stock to meet its commitments. The results also suggests that the excess accumulation of reserves and the associated opportunity cost of 1.5% of GDP seems to be substantial. The results of reserve demand estimates shows the magnitude of foreign trade, profitability and uncertainty are the factors significantly determining policies of reserve demand in India. The results also validates the monetary approach to BoP indicating that the national monetary disequilibrium play an important role in explaining reserve movements in short-run. The excess money supply (demand) stimulates outflow (inflow) of reserves stock with a responsiveness of 0.56 indicating that the RBI responds by correcting the money market disequilibrium existing in the country; and did not allow completely to be taken care by reserve inflows.

2.3.4. Developments on reserve adequacy metrics

In the aftermath of various financial crises that engulfed 1990s certain indicators developed based on reserves levels to overcome such risks. These indicators evolved as a rule of thumb for central bank authorities in order to assess the metrics of comfort levels. As mentioned earlier, the short-term debt emerged as an important scaling variable to measure reserve adequacy in the wake of various crises that engulfed 1990s. The R/STED ratio has been popularized by Pablo Guidotti, the former Deputy Minister of Finance of Argentina and is attributed to have stated that EMEs should manage their external assets and liabilities without foreign borrowings
for at least one year (Wijnholds and Kapteyn, 2001). This has been popularly known as “Guidotti-rule.” This indicates that the usable reserve stock should exceed the following external amortization for at least one year.

There are also criticisms made against R/STED ratio, stating that while it provides a measure of risk of an “external drain”, it does not reveal the risk of an “internal drain” reflecting the capital outflows by domestic residents (Wijnholds and Kapteyn, 2001). Therefore, both Guidotti-rule and Greenspan’s modifications of R/STED ratio fail to incorporate the risks of internal drain occurring in stock of reserves caused by risk of capital outflow by residents. There always exists a potential for domestic currency holders to exit (“internal drain”) when economy’s vulnerability to currency runs is largely affected by the extent of foreign capital in the country specifically by highly liquid foreign capital (“external drain”). This impact may be captured by including the variable, broad money (M2) (Flood and Marion, 2002). This measure is based on the quantity of money – reserve holding held with respect to a portion of money base, which can be followed by countries facing a risk of capital flight. A low R/M2 ratio capturing the extent to which the liabilities are backed by reserve stocks will show an indication of a currency crisis (Kaminsky and Reinhart, 1999). For instance, it shows the vulnerability exhibited by the domestic residents running from deposits into foreign currency denominated assets more worried about the depreciation of the domestic currency thinking that the central bank’s reserve stock will not be sufficient to cover the exchange of domestic deposits for foreign currency. According to Wijnholds and Kapteyn (2001), reserve stock held up to 5-20% of M2 can be held as an appropriate buffer depending on the exchange rate regime that a country operates with, though there is no conventional minimum reserve adequacy level as it is very difficult to measure the exact capital flight. This helps in bringing confidence on the value of local currency.

In addition, the ratio of reserves to GDP also finds a place in this discussion. Generally, the ultimate lender/guarantor of last resort happens to be the government. Governments generally have to take over the significant amounts of liabilities held by private sector in crises and have to employ counter-cyclical fiscal policy in order to stimulate the economy during steep downturns. So the sovereign balance sheet of a country must be stronger in order to either buy private liabilities or to implement
fiscal stimulus. But when the sovereign balance sheet is shaky during a crisis, the burden of providing macroeconomic stimulus packages will be forced on monetary policy because the state of public finances is dried. Therefore, a country should maintain a robust balance sheet to be able to increase public liabilities of huge amounts in a short time period, say, up to 10%-20% of GDP. This implies that a debt to GDP ratio of no greater than 30%-40% of GDP in good times (Subramanian, 2009).

Moreover, there is no universally accepted precise amount of reserves that is adequate or optimal as the character and conditions differ from one country to another. Hawkings and Turner (2000) highlights the impracticality in ascertaining a general adequacy condition implying that reserves should be similar among countries which are of similar character to avoid a negative opinion of financial markets.

2.3.5. Reserves as a by-product of exchange rate intervention

There is a branch of literature on exchange reserves that depicts reserve hoarding as a by-product of real exchange rate targeting. This view is supported by Dooley and Garber in few works. It has been argued that the increase in reserve level is a by-product of a desire to smooth exchange rate movements. The phenomenon that reserves stocks are being built up continuously explains that the intervention operation in the foreign exchange market is largely asymmetric in nature, i.e., the sale of domestic currency whenever there is appreciating tendency but limited intervention during depreciating tendency. A more well-known argument behind accumulation of reserves by EMEs is that it stems from a strong mercantilist motive to maintain an undervalued exchange rate to enhance the domestic employment via improved export competitiveness.

2.3.6. Literature focusing on mercantile motive

Mercantile motive, (Calvo and Reinhart, 2002; Rajan, 2002; Dooley et al, 2003; Aizenman and Lee, 2005) enhances the growth by promoting export and FDI through huge reserve accumulation. This reserve holding can be used to maintain the
exchange rate favourable for export growth and it does encourage domestic employment. Implicitly or overtly, and to varying degrees, the East Asian countries made self-insurance an important policy objective after the AFC. The countries that have an enormous foreign reserve do have a relatively stronger version of self-insurance, a kind of Powell doctrine\footnote{The Powellian self-insurance implies a counter-cyclical macroeconomic strategy of moderate/serious mercantilism with a country aiming to run current account surplus in order to accumulate reserves steadily and thereby also keeping its net foreign indebtedness manageably small. It certainly means avoiding currency appreciation.} for financial crises: a financial crisis like war requires vast firepower to mount an effective response so that the battle is won even before it begins.

Two clear reservations to mercantilist policy must be noted. Mercantilism might work for few countries but mercantilism by all would lead to beggar-thy-neighbour outcomes and international frictions. The first-best option to get rid of this of course would be to create pooled liquidity at international level that could make some or many crisis hit countries to get access to liquidity as easier and quicker as possible. If that option is not practically viable – and nothing about the recent crisis will engender confidence that that option is on the horizon – the pursuit of self-insurance by some or many countries will be an unavoidable second-best option. Secondly, there lies a problem of over-dependence on export-led growth strategy at the country level. Mercantilism and the associated self-insurance protect a country against financial contagion. But this policy will also increase too much reliance on exports and foreign markets for sustaining growth. As a consequence export to GDP ratio will increase. This will ultimately force a country to greater vulnerability of trade contagion.

\subsection*{2.3.7. Various other literatures on foreign exchange reserves}

A large literature on reserves has focused on the theoretical costs and benefits of accumulating reserves and has studied by comparing those predictions with actual level of reserve accumulation (Grubel, 1971; Lizondo and Mathieson, 1987; Ben-Bassat and Gottlieb, 1992b). One such important benefit is acquired through lowering the cost of external borrowing. Christofides, Mulder, and Tiffin (2003)
show evidence for this through its impact on credit ratings. Economically this effect has broader consequences as low risk spread is likely to reduce cost of domestic borrowing which may occur due to arbitrage. Also, reserves are used as a suitable instrument for government purchases of goods and services, servicing foreign debt, insurance against disturbances, and in some cases, as a means of income.

Also, there is substantial literature on the need for holding an optimal level of international reserves which is considered mandatory so that governments and central banks are able to carry out intervention operations to maintain a pegged or managed exchange rate and to ensure stability in the balance of payments. The most popular approach stems from the buffer stock model propounded by Frenkel and Jovanovic (1981). If a country holds inadequate amount of reserves, the central bank will have to opt for stringent policy measures to build the reserves which otherwise might result in output loss. The cost attached with such reserve restocking is called the macroeconomic adjustment cost. Such adjustment cost tends to decline as reserve holding increases. On the contrary, reserve accumulation increases the income foregone in other investments; hence, there is a rise in the opportunity cost with increase in reserve holdings. The optimal level of reserves is determined at a point where the expected sum of adjustment cost and opportunity cost is minimized.

The proponents who favour the holding of reserves against the opportunity cost involved in it argue that the cost incurred is relatively small when compared to the steep devaluation of the currency that generally culminates in to financial crisis resulting in a huge output loss. This devaluation increases the cost of debt-servicing, soars inflation and makes foreign goods more costly. The negative effects of devaluation can be neutralized by intervening in the foreign exchange market by buying domestic currency. This can be done if the central bank holds sufficient level of reserves as a policy when the aim is to maintain stable exchange rate. A detailed exposition of works done on central bank intervention is provided in next section.
2.4. Literature on central bank intervention

Reserves help to uphold confidence in the currency and helps carry out intervention in the foreign exchange market mainly to influence the exchange rate. In economies with floating exchange rate regimes, authorities often worry that a steep fall of the currency could have political and credit risks and resort to intervention in order to defend the rate or to reduce the pace of depreciation. That is, whenever there is upward pressure on the exchange rate exerted by private investors’ buying of domestic assets the central bank attempts to restrain that pressure by selling domestic assets and buying foreign currency assets. Similarly, whenever there is downward pressure exerted by outflows of private capital the central bank resort to selling of foreign currency assets and buying of domestic assets. However, it is not clear in the literature that for how long a country can prevent crisis using foreign exchange reserves if macroeconomic fundamentals are weak. If central banks of EMEs do not offset the foreign capital inflows with official outflows— that is, reserve purchases - their exchange rate would strengthen, lowering the competitiveness of their firms in world markets.

The concern is also about excessive short-term volatility and log-term movements in exchange rate that leads to overshooting in terms of the values justified by fundamental economic conditions vis-à-vis capital flows as well as international trade. Such movements can complicate the attainment of price stability and have adverse effects on employment and output — mainly in small, open economies. In addition, the central banks generally keep both objectives in mind while reserve accumulation is done

In floating exchange rate arrangements, the timing and quantum of intervention and whether to intervene or not itself, have become important policy decisions. Central banks generally have more concern about effectiveness of intervention as it impacts central bank’s repute and brings financial risks. In many economies, intervention happens to be crucial policy even after adopting managed and freely floating exchange rates arrangements from different types of pegs (Bubula and Otken-Robe, 2002, and Reinhart and Rogoff, 2003). Though intervention prevails in EMEs, the empirical works with respect to its effectiveness is inadequate. It reflects the lack of
data available in the public domain on intervention in EMEs. In addition to this, there is difficulty in controlling for changes in policy reaction functions and incorporate the credibility of central bank in high frequency time series models. A select review on the literature relating to central bank intervention is attempted, in the following.

Bonser-Neal (1996) examined whether intervention can reduce volatility of exchange rate by preventing speculative forces against a currency or this would lead to increase in volatility in place of intervention contributing to market uncertainty by promoting speculative forces act against the currency. The empirical model used in the study links exchange rate volatility to intervention measure to evaluate the impact of intervention on deutschmark/dollar and yen/dollar exchange rate volatilities on daily data from 1985 to 1991. The volatility measure is estimated employing implied volatility method using foreign currency option prices. The empirical model used includes the US macroeconomic variables in order to make sure that volatility changes ascribed to intervention in fact does not imply as an effect of some other macroeconomic cause of volatility. The macroeconomic variables of US are the change in volatility of “Standard & Poor’s”, the announced money supply values, consumer price index, trade deficit, producer price index, industrial production and unemployment rate, and the unexpected components of these announcements. Other variables employed in this model are lagged exchange rate volatility to control for feedback effects from volatility to intervention, and a variable to capture any differences in volatilities as a result of the break in trading over holidays and weekends. The results report that, in general, intervention does not reduce volatility of exchange rate. But it shows a little effect on volatility.

Dominguez (1998) explores the effects of intervention on the behavior of exchange rates, i.e., the effects of US, German and Japanese monetary and intervention policies on dollar/mark and dollar/yen exchange rate volatility for the period, 1977 to 1994. The central banks of G-3 countries have carried out a number of coordinated as well as unilateral intervention actions in this period. The exchange rate volatility in short-run is modeled using both time series econometric analysis of ARCH and GARCH models, and also implied volatility method using market-based option prices. In the GARCH model, the dependant variable in the mean equation is
the log change in dollar/mark or dollar/yen spot exchange rates. The explanatory variables include dummy variables to control for the effects of day of the week and holidays, variables to capture reported Fed intervention operations, reported Bundesbank intervention operations, ‘secret’ intervention actions of the Fed and Bundesbank, dummy variables to capture reported Band of Japan intervention operations and exchange rate policy news (excluding intervention) and a variable to capture the spread between German or Japanese and US overnight interest rates. In addition, the spread between the German or Japanese interbank interest rate and the US federal funds rate is incorporated in both volatility models to capture relative contemporaneous monetary policies in the three countries. The specification of implied volatility model estimated is similar to the conditional variance equation in the GARCH model, excepting the lagged implied volatility that swaps the lagged conditional variance, with the omission of lagged sample variance. The results show that changes in monetary and intervention policy regularly influence volatility of exchange rate. The reverse causality tests suggest that there is no causation from volatility to intervention. Also, intervention actions have generally amplified exchange rate volatility particularly when secret interventions are carried out. Further, it shows that intervention is not required to be known to public so that volatility can be influenced. This evidence supports the hypothesis that “the more ambiguous are signals, the more likely they are to increase volatility”. Overt interventions in mid-1980s are found to have reduced volatility, but in periods mainly between 1977 to 1994, interventions has generally increased volatility of exchange rate.

Neely (2000) addressed the issue of considering changes in foreign exchange reserves as a proxy variable for official intervention. Nonetheless, reserves are considered as an imperfect alternative to intervention in various studies previously done arguing that reserve levels changes not only when intervention operations are conducted but also because of other reasons, i.e., when government makes payment of foreign currency denominated debt. To understand this aspect, graphs of time series data, seasonal adjustment, correlations, and other statistical procedures are used for the intervention series obtained from reserves data of the US, Switzerland and Germany. It is also checked whether any small modifications can lead to make reserves a better substitute for intervention. Further, the motives for reserve
accumulation and intervention in currency markets are briefly discussed. While the study addresses the issue of why reserve changes as a variable may not for a perfect substitute for intervention it also makes comparisons of reserve changes to intervention data for three countries employing time series techniques, rolling and static correlations. It is concluded, though considering the three countries only and not making generalization for other countries, that it is due to the data constraints on official intervention many research works have employed reserve changes as proxy for intervention variable. It is verified that reserve changes are positively associated with intervention action although not strongly. The instruments of foreign exchange used for conducting domestic monetary policy by Switzerland and Germany significantly reduce the correlation. The extent to which reserve changes can be used as a proxy for intervention depends on the specific aspect that is researched. Moreover, the usage of various techniques to filter the data such as seasonality and intra-Exchange Rate Mechanism realignments (ERM) can increase the correlation between reserve change and intervention which will make it a better substitute. The correlation between German dollar intervention and reserve changes increases after filtering for months of ERM realignments is done and valuation changes are adjusted. Also, there is an increase in correlation between seasonally adjusted Swiss reserve stock along with approximating valuation changes and Swiss franc intervention. But no adjustments to US reserves data improved the correlation both with in-market and with-customer intervention.

Unnikrishnan and Mohan (2001) explore the effectiveness of central bank intervention on US dollar/Indian rupee exchange rate and to check whether RBI adopts a ‘leaning-against-the-wind’ policy at least at the macro level. Initially, before proceeding to econometric analysis, the correlation between exchange rate return and net dollar purchases is checked. Further, to analyse the effectiveness of central bank intervention on exchange rate volatility the GARCH model is used. The total market purchase and sale on a monthly basis is used as intervention data; this is inclusive of forward and swap market operations on value date basis. Independent variables considered in the model are nominal effective exchange rate (NEER), real effective exchange rate, net purchases and open market operations by the central bank and the dependent variable in the GARCH framework is log return on exchange rate of Indian rupee. It is found that the central bank adopts a policy of
‘leaning-against-the-wind’ at macro level, as reflected in negative correlation between exchange rate return and net dollar purchases by the central bank and it is further reinforced from the results of GARCH models. This cannot be interpreted as a policy against appreciation or depreciation of the domestic currency but reflects a stand against volatility in the market. The GARCH model effectively captures the central bank policy of volatility containment, indicating that RBI is successful in achieving the objectives of intervention policies. It is also found that log-differenced NEER has significant effect on return; besides, movement of NEER is indicative of the direction of US dollar/Indian rupee exchange rate in the sense of long-term relationship captured through cointegration.

Pattanaik and Sahoo (2001) assess empirically the effectiveness of intervention operations in the foreign exchange market in India. The analysis follows the approach adopted by Edison (1993) and Pilbeam (1991) to approximate the profit figure by separately estimating the exchange rate related profit/loss and the interest rate related profit/loss. The monthly data for the period from June 1995 to January 2002 is used to test the objective. Also, recognising the problem of simultaneity highlighted by Almekinders and Eijffinger (1994), the volatility equation estimated again in a simultaneous framework along with an intervention reaction function of the central bank. This framework is more realistic in the sense that volatility not only responds to intervention operations but also triggers intervention action by the central banks. The results of Two-Stage Least Square (TSLS) regressions found that volatility often triggers intervention actions but such interventions may not always be effective in reducing volatility. The estimated results indicate that intervention operations may not be very effective in influencing the exchange rate levels. India’s stated exchange rate policy fully recognises these aspects and as a result, intervention operations are not used either for driving the exchange rate to any particular level or for keeping the exchange rate contained within any pre-decided range of volatility. Such an intervention strategy reflects the commitment to a market determined exchange rate regime where the central bank normally does not interfere with the market dynamics as long as the range of factors that influence the level and volatility of exchange rate do not give rise to disorderly conditions in the market. Hence it is found that intervention actions of the RBI have been effective in
reducing exchange rate volatility of the rupee, though the extent of impact does not show it to be very strong.

Égert and Komárek (2006) studied the impact of daily official interventions on the Czech koruna’s exchange rate with respect to the euro (the German mark prior to 1999) for the period, 1997 to 2002. The application of event study approach has accounted for the role of official interest rate moves, and then has employed GARCH models to estimate the influence of intervention on mean and variance of koruna’s exchange rate with respect to German mark before 1999 and the euro after 1999. This approach shows that the intervention operations of Czech National Bank is not specifically effective after the crisis from 1997-98. The koruna purchases seemed always ineffective, whereas koruna sales resulted in smoothing of exchange rate or followed “leaning against the wind” in short-run. The GARCH results confirm these, as koruna purchases are generally not associated with appreciation but with depreciation of koruna. In fact, koruna sales neither had impact nor were linked with appreciation of exchange rate from 1997 to 1998, signaling a failure. However, in the period mid-1998 to 2002, the intervention – mainly koruna sales – reversed the appreciation in short-run and smoothed the exchange rate at longer period of up to 60 days. The results of econometric analysis shows that koruna sales was linked positively to exchange rate in the period, mid-1998 to 2002. The analysis also indicates that the effectiveness of intervention operations is closely associated to interest rate policy, as different episodes of intervention excluding key policy rate changes became statistically ineffective. Moreover, a similar results is derived interest rate episodes adjusted for effects of interventions. The results show that intervention and interest rate policies may provide healthy outcomes when they are well organized, rather than when relied on isolated manner. As a whole, the Czech authorities were successful in altering the exchange rate levels, specifically against appreciation (rather than against depreciation) in the second half of study period. Still, it required well coordinated approach between intervention and interest rate policies.

Ramachandran and Srinivasan (2006) empirically investigate the asymmetric exchange rate intervention and the resultant accumulation of foreign exchange reserves in India, for the bilateral exchange rate, Indian rupee vis-à-vis US dollar.
The argument is that, the asymmetric intervention prompted, maybe, due to concerns about export competitiveness in foreign markets might have contributed to huge accumulation of reserves. In such scenario, the central bank’s reaction to appreciating pressure on rupee is likely to be more powerful than to depreciating pressure of the same scale. Such policy action aimed at enhancing exports performance, results in high stockpile of reserves. The buffer stock model of Frenkel and Jovanovic (1981) to illustrate the increasing reserve demand is used to empirically analyse whether there exist any asymmetries. The analyses of reserve demand equations are estimated for weekly data starting from 05 January 2001 to 12 August 2005. This period is selected as it constitutes accumulation of more than three-fourth stock of reserves (US$ 139.51 billion as on 13th January 2006). The reserve measured as foreign currency assets and the implicit yield on 91-day Treasury bill at cut-off price as a proxy for opportunity cost is used for estimation. Also, the conditional standard error of reserve increment is used from appropriate ARCH model (Engle, 1982) by which the conditional volatility is constructed based on Ljung Box test statistic using ARCH (1) process. The results indicate that the intervention operation is asymmetric in nature which is in line with the concern about export competitiveness that has resulted in high level of reserve accumulation. The results from the autoregressive distributed lag (ARDL) models of Pesaran et al. (1996) indicate that precautionary motive does not explain large reserve accumulation in this period. Instead, asymmetric exchange rate intervention is the main reason behind large stockpile of reserves.

Behera. et. al. (2008) empirically explored the relationship between foreign exchange intervention by RBI and exchange rate behavior in India. The effects of central bank intervention on both exchange rate level and volatility are investigated. The study uses monthly data from June 1995 to December 2005. The variables used are Indian rupee/US dollar bilateral exchange rate, net FII inflows, net dollar purchases of RBI, Treasury bill rates of India and the US over the post-reform period. The study uses GARCH (1,1) model to relate RBI intervention to exchange rate level and its volatility. The results from GARCH model confirms that the intervention operation by RBI is effective in containing volatility in the Indian exchange market. However, the result is not supporting the theoretical positive association between exchange rate return and RBI intervention. Thus, the Reserve
Bank intervention has been reducing the extent of fluctuations of the exchange rate rather than changing the direction of the rupee movement against the US dollar.

Vadivel (2009) has examined whether the RBI’s exchange rate intervention policy is effective or not. Also the impact of intervention on the volatility of exchange rate has been evaluated along with checking for asymmetric behavior of intervention of the RBI using only the impact of official purchase/sale of foreign currency on the level of exchange rate. This is because direct purchase/sale of foreign exchange is predominantly resorted to for stabilizing the exchange rate during the market determined exchange rate arrangement. This study has uses weekly data for the period, April 2, 1993 to September 22, 2006 and has been chosen on account of market based exchange rate regime adopted since March 1993. The exchange rate is measured as rupee per US dollar and intervention is measured as percentage change in foreign currency assets. The difference between the interest rate on 91 days treasury bills of US and India is used as a variable when it is required in the model. The ordinary lease square and instrumental variables methods are used to investigate the effect of intervention on exchange rate. The autoregressive conditional hetroskedasticity (ARCH) models of Engle (1982) and generalised autoregressive conditional hetroskedasticity (GARCH) models of Bollerslov (1986) are deployed to examine the impact of intervention on exchange rate volatility. Appropriate dummies are used to investigate structural breaks in the model and asymmetry in exchange rate intervention. The RBI’s intervention has been asymmetric in nature where the response to appreciating rupee is more forceful than the response to depreciating rupee which has been triggered by the fear of export loss due to appreciating domestic currency.

Nagaraju (2009) has measured the contribution of RBI in moderating volatility of exchange rate in India. Besides, the study also tries to concretely establish RBI’s model of exchange market intervention. The study builds hypothetical scenarios under a range of possible assumptions on the nature of forex market to seek the insights on exchange rate and its volatility when RBI’s intervention is absent. Though the possible scenarios are conditional upon the strength of assumptions, has been used to highlight important aspects and develop more understanding of India’s forex markets. The analysis is done to formulate alternative series of exchange rates
if intervention was absent in the forex market. This derived exchange rate series is then used to estimate volatility which is then compared with actual exchange rate to make inference on the effect of the RBI’s intervention operation. The variables used are the original exchange rate, the total volume of purchase and the volume of net intervention of RBI. Also, the functional relations like demand function and supply function have been used. Since the parameters of demand and supply functions are unavailable, assumptions are made about the elasticity coefficients and different scenarios are built, which gives the broader corner scenarios within which true elasticities lie. In all of these assumptions the derived exchange rates that could have prevailed in the absence of RBI’s intervention are devised through which the judgemental assessment is made of RBI’s intervention on the volatility dampening. The result of this analysis shows that there exists definitely a contribution made by RBI in terms of volatility dampening in the exchange rate.

Goyal and Arora (2010) have empirically studied the effect of different types of intervention actions (verbal and actual) including monetary policy instruments on India’s exchange rate level and volatility. Though research on monetary policy has evolved tremendously, yet there exists challenging tasks with respect to experiences in emerging markets which are still unexplored. The ARCH and GARCH models of exchange rate volatility have been employed for both daily and monthly data, from November 1, 2005 to December 31, 2008 and from January 2002 to December 2008, respectively. The monthly data sample starts with the embracing of liquidity adjustment facility (LAF) and the daily data sample covers a period of large exchange rate volatility, when the LAF had attained greater maturity. There are few policy dummies inserted to study the impact of traditional monetary policy instruments such as interest rates, intervention and other quantitative measures, and of central bank communication, on exchange rate volatility. Moreover, as India has adopted market determined exchange rate, the effect on level of exchange rate has also been tested. In addition, rapid development is experienced in Indian markets, institutions and in instruments of monetary policy since 1993. As this is a period of potential market instability from volatile capital flows due to the movement towards freer markets in emerging economies, alternative instruments are used to analyse their effectiveness which can give valuable degrees of freedom to the authorities.
2.5. Literature focusing on exchange rate volatility

Although there is no unanimity in the literature on the factors affecting and determinants of exchange rates and their volatility, empirical works have been done on different context on the basis of different theoretical approach. Most of the existing literature have centered on the levels (the first moment or mean) and volatility (the second moment or variability/standard deviation) of exchange rates. The empirical literatures focusing on exchange rate volatility that provide useful insights for the present thesis are illustrated below.

Canales-Kriljenko and Habermeier (1999) have studied the factors determining nominal exchange rate volatility for a group of 85 developing countries in a cross-section panel data framework. The structural variables like adherence to IMF Article VIII restrictions, \textit{de jure} exchange rate arrangement, and a wide range of measures on exchange restrictions are used in the cross-section framework with little or no time variation. Using a model selection algorithm the macroeconomic variables like trade openness, fiscal deficit in percent of GDP, real GDP growth and inflation are found to be the determinants of nominal exchange rate volatility. But none of the reserve adequacy measure have been neither chosen nor retained in the model.

Hau (2002) studies the relation between the volatility of real effective exchange rate (based on trade weights) and the extent of trade openness of a country for which a sample of 48 countries with a more homogeneous OECD subsample of 23 countries is chosen and tested for the period, January 1980 - December 1998. Theoretically and empirically it is argued that the economic openness and volatility of real exchange rate are inversely linked to each other and in the economies which are more open the volatility of real exchange rate should be lower as a result of quicker adjustment of domestic aggregate price level when imported goods are more. The theory section explains an intertemporal monetary model of a small open economy consisting of nominal rigidities. Moreover, monetary and aggregate supply shocks both are shown to induce (ceteris paribus) smaller movements in real exchange rate if the economy is more open to cross border trade. In addition, the role of non-tradables in explaining real exchange rate volatility is examined. Non-tradables induces the degree of aggregate price rigidity to increase unlike tradables which
facilitate the adjustment of relative price level via exchange rate pass-through effect. The main contribution of this work is the measurement of volatility of real exchange rate at low frequency which provides evidence that those economies which are more open have low real exchange rate volatility. Empirical findings confirms this theory that the differences in trade openness provides explanation for major portion of cross-country variation in real effective exchange rate volatility.

Devereux and Lane (2003) develop an empirical model of bilateral exchange rate volatility across countries. This is done on the basis that, in developing economies, financial integration via debt or portfolio liabilities, i.e., credit constraints, plays an important role on volatility of desired bilateral exchange rate in addition to the factors portrayed by Optimal Currency Area (OCA). But for industrial countries which are not constrained in accessing international capital markets the factors related to financial linkages are of less importance. A theoretical framework is developed which incorporates the tightening of financial constraints by outstanding debt thereby reducing the response of exchange rate efficiency on external shocks. In addition, the factors determining volatility of bilateral exchange rate are explored. The monthly data from January 1995 to September 2000 is used to test the theoretical results of industrial and developing countries. The variables taken here are related to OCA considerations: bilateral trade as a percent of GDP, the standard deviation of bilateral growth rate differentials, and the log of the product of two countries’ GDP. Also, the variables that measure the size of the domestic financial sector, GDP per capital with respect to purchasing power parity (PPP) and bilateral external debt are taken. It is found that the above mentioned variables have a significant role to play in establishing the determinants of bilateral volatility of exchange rate. Further, the external debt stock negatively affects the bilateral exchange rate volatility of developing countries. For industrial countries, external debt does not significantly affects bilateral exchange rate volatility but OCA variables are found to be more impotent.

Hviding, et al. (2004) studied the role of higher levels of reserves in reducing exchange rate volatility in EMEs. It is done for 28 countries in a panel data framework for the period, 1986 to 2002. The system-generalized methods of moments (difference-GMM), and identification through heteroscedasticity (IH) are
employed to account for country specific effects and to deal with endogeneity bias. The regression includes various control variables to check the factors impacting volatility of exchange rate which would encompass monetary aspects, external indicators and macroeconomic fundamentals. The analysis eliminates endogeneity caused by exchange rate regime, as it affects both exchange rate volatility and reserve levels. In few specifications, a proxy for exchange rate intervention is employed to capture policy responses that is undertaken to stabilize exchange rate for intermediate exchange rate regimes. The results shows that adequate level of reserve tends to reduce volatility of exchange rate. This effect is nonlinear and robust and seems to operate via a signaling mechanism.

Morana (2009) studied the second moment’s implications of theories of exchange rates determination finding long-run fundamental relations between macroeconomic and exchange rate volatility. This relationship for both the short- to medium-term and the long-term has been empirically tested for G-7 countries in float period, 1980-2006. An accurate modeling of the persistence properties of the data is performed in the framework of a new fractionally integrated factor vector autoregressive (FI-F-VAR) model. This model allows investigating the linkages across variables and countries involving both common deterministic and stochastic components, pointing to the presence of both structural change and stationary long memory in the volatility of financial asset returns and macroeconomic variables. The long-term (cobreaking) as well as medium-term (fractional cointegration) associations have been investigated. It is found that there is clear cut indication of significant long-term relations and trade-offs between macroeconomic and exchange rate volatility, mainly linking output and inflation volatility, and volatility of money growth volatility to a lesser extent. In addition, although causation exist in both directions, the association is very stronger from macroeconomic volatility to exchange rate volatility than through other direction. This has provided support for the short- to medium term, and fresh evidence for the long-run case as well which has been neglected. It also provides indirect empirical support for the basic models of exchange rate determinations in the long run. The two policy inferences are (i) in the long-term, focus on macroeconomic stability may certainly be essential to reduce excessive volatility in exchange rates, (ii) the systemic volatility cannot be reduced
by fixing exchange rates, since the latter arises only at the cost of macroeconomic uncertainty.

Reinhart and Reinhart (2008) made two observations; firstly, about the tools available for the central banks in EMEs to offset pressure on appreciating of exchange rate and secondly, about the measures that the authorities adopt to tide of large capital inflows, since one of the most exciting factors of the pressure on exchange rate comes from capital inflows. Here, the interest-parity link has been used to locate the possible forces of upward pressure on exchange rate and identify the various policy actions to damp exchange rates in principle. Further, an illustration is provided on the practice by considering the degree to which the reserve accretion has been sterilized effectively and illustrates key policy actions connected in order to force appreciation of exchange rate in 100 countries over the last two decades. The experience shows that authorities seem unwilling to be bound by the “impossible trinity” of international finance that makes possible only two phenomena to be achieved out of three objectives, namely, open capital account, fixed exchange rates, and independent monetary policy. The increasing vigor of capital mobility has forced central bank authorities to search for different methods to train instruments for monetary control coupled with delivering exchange rate stability. Moreover, the capital flowing in to the economy necessitates authorities to hoard reserve in order to deliver stable exchange rate.

Caporale and Doroodian (1995) examined the change in exchange rate uncertainty between the Bretton Woods era and floating exchange rate periods. Both the unconditional variance and the conditional variance of the deutschmark/dollar (DM/US) exchange rate are estimated under each exchange rate regime. Although it is argued that the conditional variance is the correct measure of currency volatility, the unconditional “variability” is computed for comparing with conditional variance. To estimate the conditional variance of DM/US dollar exchange rate the GARCH model is used and the coefficient of variation to assess unconditional variance of the deutsche mark/US dollar exchange rate is used for both fixed and flexible regimes. The data for the fixed exchange rate and flexible exchange rate regime ranges from 1957:Q2 to 1973:Q1 and 1973:Q2 to 1993:Q4 respectively. It is found that the GARCH estimate of the conditional variance of exchange rates measures the
uncertainty, in contrast to variability, of the series. The results show that the traditional use of various measures of unconditional variance has downplayed the increase in uncertainty of exchange rate ever since the collapse of the Bretton Woods regime.

Singh (2002) estimates the GARCH model and present the conditional variance as a measure of volatility of exchange rate in India. The work employs a broad set of weighted (trade and export) and unweighted (official and black market) real exchange rate data on quarterly frequency from 1975:Q2 to 1996:Q3 and from 1960:Q1 to 1996:Q3 respectively, to analyse the response of outcomes to different exchange rate used. It also deals with another issue of regime neutrality of volatility of exchange rate in India. The series of trade and export weighted REER are based on 36 country bilateral weights. The unweighted nominal exchange rate is converted into the real series by using the world consumer price index relative to the domestic wholesale price index (WPI). As a major portion of black market transactions is carried out in US currency, the US consumer price index (CPI) relative to domestic WPI is used to convert nominal into the real series of black market exchange rate. The results show the presence of weak and statistically insignificant (or significant at lower levels of significance) ARCH effects when compared to GARCH effects in all exchange rate series, apart from “unweighted nominal series of official exchange rate that is transformed into the real series” which shows contrasting results during, 1975:Q1 to 1996:Q3. The dimensionally weak and statistically insignificant ARCH estimates show the weak response of conditional variance to shocks, whereas the dimensionally stronger and statistically significant GARCH estimates indicate persistence is strong in conditional variance. In addition, the estimates of GARCH model are not responsive to the exchange rate series used. Further, the GARCH effects stayed unchanged to the sample period chosen, and this confirms the regime neutrality of volatility of exchange rate in India.

Carrera and Vuletin (2003) examined the association between exchange rate regimes and volatility of the REER. A sample of 92 countries is considered to evaluate this for the period, 1980 to 1999. In addition, it also attempts to show evidence the impact of other variables on REER volatility and examines the persistence of shocks in REER. The period of study is exclusively based on flexible exchange rate regime
guided by the classification done by Eichengreen (1994). It facilitates to examine the impact of the exchange rate regimes on the REER volatility excluding the impact of change in properties exhibited by different international monetary arrangements. The de jure exchange rate regimes classified and complied by IMF alongside with new additions that classify countries based on the observed behavior are used. A new classification of regime is also proposed based on the existing classifications. Here, the de jure and de facto regimes are combined to check the inconsistencies observed between the authorities’ commitment and the actual behavior. As the objective is to relate major links mainly examining the effect of exchange rate regime on REER volatility the dynamic panel approach is employed. The dynamic panel models of estimation (Generalised Method of Moments) of Arellano and Bond (1991) is employed which allows for endogeneity and unobserved specific effects and analyse persistence of shocks in REER. The results validate the non-neutrality of regime with regard to REER volatility. The de jure peg and intermediate arrangements increase volatility than the flexible regimes. In view of the new classification, the hard peg or pure float exhibits similar real volatility, whereas other regimes exhibit increased real exchange rate volatility. The results also show that more openness, high acceleration in per capita GDP growth and terms of trade reduce volatility whereas positive monetary shocks and growth in capital inflows and in public expenditure increase real volatility. Moreover, the study confirms that in an analysis the exchange rate regimes should be distinguished with respect to developed and developing economies.

Dua and Sen (2006) studied the relationship between the real exchange rate, fiscal and monetary policy measures, capital flows, volatility of flows and the current account surplus for India’s data from 1993:Q2 to 2004:Q1. The variables, namely, the REER and its volatility, net capital inflows and its volatility, fiscal and monetary policy measures, and real current account surplus, are employed. 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 net capital inflows is taken as total of foreign institutional investment (FII) flows and foreign direct investment (FDI) flows. Nominal capital flows are deflated by consumer price index (CPI) to calculate real net capital flows. The volatility of real net capital inflows is computed by 3-period
moving standard deviation. The measures of fiscal and monetary policy incorporated are government expenditure and high-powered money respectively. Each variable in nominal terms are deflated by CPI to convert them into real terms. The estimated results show that REER is cointegrated with the level of capital flows, volatility of flows, government expenditure, high-powered money and current account surplus. This association is statistically significant and all these determinants Granger causes the REER. The results of generalized variance decompositions indicate that the factors determining REER are net capital inflows and its volatility (together), government expenditure, current account surplus and the money supply. In addition, preliminary study suggests that a study can be undertaken for foreign exchange reserves in a similar fashion.

Stancik (2007) analyzes the key factors contributing to euro exchange-rate volatility in the new EU members, i.e., for five Central and Eastern European Countries (CEEC-5). As these countries are expecting to fulfill the criteria indicated by EU which includes exchange rate stability, the study examines the source of it. Also, exchange-rate stability is not merely a criterion considered to enter into Economic Monetary Union (EMU) but also a considered essential for economic development. The data used are of daily frequency ranging from January 1, 1999 to December 31, 2004. The factors considered are the openness of an economy, the exchange rate regime and the “news” factor as the movements in exchange rate are primarily affected by these variables. The volatility of exchange rate is estimated using TARCH (threshold autoregressive conditional heteroskedasticity) model. Although each country is considered separately, the results show that economic openness has reduced exchange-rate volatility, “news” significantly impacts volatility and volatility is more in flexible exchange rate regimes. However, the magnitude of these effects differs across country.

Fišer and Horváth (2010) estimates volatility of exchange rate using GARCH model to examine its responsiveness to the Czech National Bank communication, macroeconomic news and interest rate differential. The analysis uses daily data from 3rd January 2005 to 14th February 2007, which sums to a total of 536 observations. The results suggest that central bank communication have a tendency to reduce exchange rate volatility, i.e., this shows evidence to the idea that the central bank’s
objective is to reduce the disturbance in the financial markets. The exact timing of communication is more important as financial markets react more to the communication prior to policy gathering than post-meeting. The variable, macroeconomic “news”, reduces volatility of exchange rate. This indicates that there exists greater uncertainty in EMEs. While the variable, “news” calms down the markets, the interest rate differential makes volatility of exchange rate to increase.

Kumar (2010) attempt to identify the determinants of real exchange rate (RER) in India using quarterly data series for the period, 1997:Q2 to 2009:Q2. The study illustrates theoretical backdrop on real exchange rate determination and employs autoregressive distributed lag (ARDL) model to estimate the long-run and short-run relationship. The variables used are real exchange rate of Indian rupee vis-à-vis US dollar, growth rate differential of India and the US, government final consumption expenditure as percentage of GDP, terms of trade, foreign exchange assets and external openness. The RER is calculated taking nominal exchange rate of rupee against US dollar, producers’ price index of the US and wholesale price index of India. The results show in the variables identified a priori on account of theoretical perspectives to be determinants of RER, external openness, productivity differential, terms of trade and net foreign assets exhibits statistical significance. The signs of short-run dynamic effect show consistency with long-run coefficients whereas error correction term is negative and statistically significant indicating convergence towards long-run equilibrium. As the fitted RER is closer to the actual RER behaviour, the variables chosen with some lags may serve as important indicator to show the behavior of RER. Based on the results, it is understood that RER appreciation should not be considered always as decline in competitiveness of trade as some factors that forces appreciation of RER are linked to higher growth which leads to enhancement in competitiveness.

Sharma (2011) has analysed the impact of introduction of currency futures in 2008 on exchange rate spot market in India. To moderate the risk that occurs due to excess volatility, currency futures were launched which is seen as a major structural change. Moreover, it is expected that currency futures will help hedge against exchange rate exposures to unfavourable conditions. Since the ambit of derivatives has increased in recent times, this study has focused on the relationship between spot
market exchange rate volatility and currency futures trading activity. The analysis has been done on the USD-INR exchange rate data on daily basis from April 02, 2007 to February 11, 2010. The Granger causality test is employed to examine the association between futures trading activity and the spot exchange rate volatility. The ARCH and GARCH models are also used. The results indicate a bi-directional causality between the volatility in the spot exchange rate and currency trading activity in futures market. In addition, the study suggest to incorporate the effect of financial crisis as developing economies are more prone to speculative attacks and adverse consequences.

Pontines and Rajan (2011) attempt to investigate the likely asymmetric foreign exchange intervention on account of de facto exchange rate regimes in Asia to establish the fact that Asia’s exchange rate regimes in the 2000s are characterized as due to “fear of appreciation” or “fear of floating in reverse” (Levy-Yeyati and Sturzenegger, 2007). Prior to this, Calvo and Reinhart (2002) characterized the exchange rate policy of EMEs in the 1990s as due to “a fear of floating”. Apart from the important rationale cited for reserve accumulation, namely, precautionary view, mercantilist policy and reducing exchange rate volatility, it is to be noted that the reserve accumulation done on regular basis indicate that intervention involved more than just reducing exchange rate volatility. The estimating equation is a reaction function of intervention action which is derived in a model of optimal behavior of central bank. The estimation of model is carried out for six emerging Asian countries which follows different managed floating regimes, viz., India, Philippines, Korea, Thailand, Singapore and Indonesia, for the period, January 2000 to July 2009. This period is characterized as the one where huge reserves were built up. The study confirms the presence of asymmetric intervention of central banks of chosen economies. It also shows that the intervention is stronger against appreciation than depreciation and the authorities respond to changes in nominal effective exchange rate than nominal bilateral exchange rate changes. This results of asymmetric exchange rate intervention against a trade-weighted basket is suggestive of stable exchange rate and huge reserve hoarding.
2.6. Conclusion

As the focus of the thesis is to investigate one of the major beneficial effects of accumulation of foreign exchange reserves, namely, reserves accumulation tends to reduce exchange rate volatility, the literature on various issues that has been developed on reserves, central bank intervention and exchange rate volatility has been the interest of this chapter. Though there are plenty of works done on motives and benefits of holding foreign exchange reserves the literature with respect to exchange rate volatility has been focusing on central bank intervention and its effectiveness.

More recently, the theoretical insights of Guha (2008) to understand exchange rate movements in developing country keeps foreign exchange reserves at the centre stage and illustrates that the changes in reserve stock, which portrays the potential of central bank’s intervention, tends to impact exchange rate volatility. Moreover, this perspective has not yet been tested in the existing literature so far. Hence, this has been one of the frameworks which have been taken up for empirical investigation in this thesis which may provide an addition to the existing literature.

Also, there has been a class of literature that evolved dealing with the beneficial effects of “comfort” portrayed by the adequacy levels of reserves, viz., a high level of reserve adequacy tends to reduce the likelihood of currency crises or a “sudden stop” and higher reserve adequacy tends to be associated with lower external borrowing costs. One such beneficial effect is that, a high level of reserves adequacy tends to reduce exchange rate volatility for which the literature is meager and Hviding, et al. (2004), which show evidence for this effect is studied for a group of countries and considered to lack empirical sophistication. As this aspect has not been investigated for a specific country, this framework is also considered to be investigated for India which will provide an addition to the existing literature.