The Optimal Level of International Reserves – The case of India

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Abstract

The study analyzes the optimal reserve holding for India during an era of flexibile exchange rate and high capital mobility using the buffer stock model of Frenkel and Jovanovic(1981). The evidence derived from the ARDL approach of Pesaran, Shin and Smith (1996) support the fact that the scale variable,opportunity cost variable and the volatility variable all have significant effects on the reserve demand. The evidence also shows that exchange rate flexibility does not have any significant impact on the reserve demand .

JEL classification: E 58; F 31

Key Words: reserve demand, buffer stock model, volatility, opportunity cost

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Global holdings of International Reserves have increased rapidly in the recent years. At the end of 2006, the world non gold reserves as weeks of imports has reached to 21.6. In industrial countries this stood at 10.1 whereas in developing countries it was 39. (Table 1). Among the developing countries it is the emerging economies which have significantly increased their reserve holdings in the last five years (Choi, Sharma & Stromqvist 2007). This massive holdings of reserves in emerging economies is at odds with the prediction of the standard reserve holding model (IMF 2003).This increased holding of reserves has led to widespread discussions in the academic circles as to the reasons behind this increased preference for holding reserves by these countries.

In the era of increased capital mobility and cross border transactions, reserve management constitutes a vital aspect of macroeconomic policy. Increased financial integration often makes a country vulnerable to a financial crisis due to sudden reversals in capital flows. So holding a huge stockpile of precautionary reserves can be an effective strategy for emerging economies given their restricted access to international capital markets. (Aizenman &Marion 2002). In this regard this is analogous to corporate liquidity holding as they help in coping with uncertain income streams and cash flows. Financially weak firms have high levels of liquid assets in the face of external finance premia (Choi & Kim 2001).Analogously , with increased financial account transactions, emerging economies may find external financing expensive during capital flow reversals which has increased the option value of holding reserves.

Holding large levels of reserves also entail a cost for the economy as the resources could have been better used to step up investment in the economy or to repay a part of the external debt which a country has incurred with the rest of the world. However the authorities feel that these costs are small relative to the economic cost of a crisis which results from currency depreciation, a aftermath of a currency crisis causing substantial loss of output. (Frenkel 2005).

Reserves can also be held to manage the exchange rate. It is seen that reserve holdings are high for some countries because their shift to greater exchange rate flexibility is just an illusion. Self identified floaters and managed floaters look more like peggers on the basis of the probability that the monthly percentage change in their nominal exchange rate fall within a narrow band (Calvo and Reinhart 2000).Furthermore in developing countries, reserve accumulation the Central bank can be a strategy to protect external competiveness. This is especially true for Asian countries as exporting to the US is a major concern. (Dooley, Folkerts – Landau & Garber 2004).

It has also been argued that holding high level of reserves may be a cover up of loose fiscal policy or other macroeconomic fundamentals (Kapur & Patel 2003). Due to political compulsions, a less developed economy cannot easily bring about the necessary reforms in their macroeconomic management. In such a case holding a high level of reserves may be an insurance cover to counter the resulting enhanced risk perceptions of the economy.

Domestic political instability may at times, reduce desired current reserve holdings below the optimal level as the present administration may think that there is a high probability that the future administration may be 'soft' and grab these reserves for favoured insiders (Aizenman & Marion 2004). In the same way, political corruption acts as a tax on the return to holding reserves and reduces optimal holdings.

Reserves further allow a country to achieve intertemporal smoothening of the tax burden especially when the country faces adverse productivity shocks. This is especially true for developing countries where the tax base cannot be broadened within a short period (Aizenman & Marion 2002). Also holding assets in foreign currencies may constitute a reasonable investment strategy especially when the value of foreign currency assets are negatively correlated with that of domestic investments (Choi, Sharma & Stromqvist 2007).

The rest of the paper is organised as follows. In section 1 we discuss the two recent contrasting views about the optimal reserve holdings for India. Section 2 provides the empirical literature on the optimal level of reserve holdings. Section 3 provides a brief discussion on the basic buffer stock model and its extensions to be used in the estimation. In Section 4 we have explained the variables, data sources.Section 5 explains the methodology adopted in the study. Section 6 discusses the results and the last section draws the conclusion of the study.

1. Diverse Views on India's Optimal Reserve holdings

India has steadily accumulated reserves in the last 15 years. In March 2007, the total reserve holdings were $199.1 billion, an enormous increase compared to $5.8 billion in March 1991. Reserves accounted for about 23.2 % of the GDP in 2007 compared to 2.2 % in the early1990s. Reserves were 11.5 months of imports by March 2007, a remarkable increase from 3.1 in March1991.Reserves as a share of M_3 was 29.3% by March 2007 compared to 4.5% in March 1991 (Table 1a).

This large holdings of international reserves have elicited different views on what constitutes the optimal reserves for India. The Reserve Bank of India (RBI) in their Report on Foreign Exchange Reserves (2007) says that India's reserve holdings were adequate, measured either in terms of import cover or as a ratio of short term debt. This view has been challenged by Chandra(2008) who feels that the RBI report misses out the other types of volatile capital entering the economy.This includes non resident deposits which are prone to sudden stops at the time of a financial crisis. Also foreign institutional investments(FII) in stock markets constitutes another aspect of volatile capital inflows. Here the RBI grossly underestimates this liability by relying on historical data on net purchase of equities. The correct measure would be the market capitalisation of the FII holdings of securuties at a point of time. This measure takes into account the stock price appreciation. Chandra(2008) calculates the market value of FII investments in equities and compares this with the reserve holdings by the RBI. He finds that upto 2004, reserves were far in excess of the former but thereon the gap started to narrow. At the end of 2006, FII investments were 73% higher than quoted in the RBI report and if NRI deposits are also added it amounts to nearly 93% of the official reserves. In 2007, the sum of FII investments in equities and NRI deposits exceeds reserves by over 7.7%. Also if FII trading in equity derivatives is added, India's external net liability becomes much more that what is recorded in the official statements.

From the above discussion it seems that the desire to protect the Indian economy from sudden reversals in capital flows is one of the main reasons behind the rapid accumulation of reserves. The fact that the RBI has increased its reserve holdings by almost $138 billion during 2006 and 20007 while the FII stock (by the RBI measure of net purchases) increased by only $25 billion suggests that the RBI is taking cognizance of the increased value of FII holding in equities in Indian stock markets (Chandra 2008).

2. Empirical Evidence

To explain optimal international reserve holding, traditionally the buffer stock model has been used. The model says that the authorities demand reserves as a buffer to absorb fluctuations in external payment imbalances. In the absence of adequate reserves, the authority is often forced to implement expenditure damping policies to rebuild reserves which may result in loss of output. This is defined as the macroeconomic adjustment cost. So the demand for reserves increases with a rise in the adjustment cost. However reserves yield negligible return and therefore incurs an opportunity cost. This is measured as the difference between what the reserves could have earned and what they actually earn.Reserve demand increases with a fall in opportunity cost. The empirical studies arrive at an optimal level of reserves that minimize the expected sum of these costs.

The buffer stock model is widely used in the literature.Hellar(1966) determines the optimal stock of reserves in terms of a rational optimising decision that involves equating the marginal cost and benefit of holding reserves. He then compares actual reserves with his calculation of each country's optimal reserves to check for reserve adequacy. Frenkel and Jovanovic(1981) extended Hellar's idea and developed a theoretical model based on the principles of inventory management to determine the optimal stock of reserves.They estimated reserve demand elasticities with respect to macro economic adjustment cost (measured as fifteen years rolling standard deviation of change in trend adjusted reserves) and opportunity cost (measured in terms of yield on government bonds) using pooled time series for the period1971-75 with a cross section of twenty two developed countries. The estimated elasticities were close to their theoretical predictions.

Flood and Marion(2002) in their study find that buffer stock model works as well in the modern floating exchange rate period as they did during the Bretton Woods regime period.However with greater exchange rate flexibility and financial openness, the explanatory power of the model can be significantly increased if these variables are also included in the original model. Disyatat and Mathieson(2001) estimate a Frenkel Jovanovic type reserve holding equation for fifteen Asian and Latin American countries and find that the financial crises in 1997-98 produced no structural break. They also find that the volatility of the effective exchange rate is an important determinant.

The IMF(2003) study on the emerging economies in Asia, uses a standard buffer stock model and comes to the conclusion that the rapid accumulation of reserves in emerging markets between 1997 and 2001 was broadly in line with the fundamentals of the model but the surge in reserves in 2002 and 2003 was above the level predicted by the model. The surge in reserves were driven by increases in current account and to a lesser extent by capital flows.

Aizenman and Marion (2004) carries out the same exercise on 64 countries over the period 1980-96 and find that the standard variables included in the literature explain about 70% of the variation in observed reserve holdings without country fixed effects and 86% with country fixed effects. They also investigated whether political uncertainity and corruption influences optimal reserve holdings and find that they have negative and significant effects on reserves even after accounting for trends.

Ramachandran (2005) uses the buffer stock model in the Indian context covering the period from 2 April 1993 to 5 December 2003. This period was characterised by a flexible exchange rate system and a high level of capital inflows. He finds that the standard measure of volatility defined as the fifteen years rolling standard deviation of change in trend adjusted reserves used by Frenkel Jovanovic (1981) produces biased estimate.He thus derives an alternative measure of volatility from an appropriate GARCH model and finds that the estimated coefficients are close to their theoretical prediction. Higher K mobility did not increase the value of the volatility coefficient which may be due to the fact that capital outflows were not as free as capital inflows in India and there has also been a steady and sharp decline in external debt during 1990s.

The available empirical studies confirm that the buffer stock model is useful to analyze the optimal level of reserves in a regime of capital mobility.

3. The Buffer Stock Model

The buffer stock of Frenkel and Jovanovic (1981) defines reserve movements in continuous time period as a Weiner process:

$$dR(t) = -\mu dt + \sigma dW(t) \; ; \qquad (1)$$

where R_t is reserves held in time t and W(t) is the standard Weiner process with zero mean and variance t. At each point of time the distribution of reserve holdings R(t) is characterized by-

$$R(t) = R^* - \mu t + \sigma W(t) \qquad (2)$$

Where R* denotes the optimal stock of reserves, μ denotes the deterministic part of the instantaneous change in reserves and σ is the standard deviation of the Weiner increment in reserves. The optimal stock of reserves is obtained by minimizing two types of costs viz, (1) the cost of adjustment which is incurred once reserves reach an undesirable lower bound and (2) foregone earnings on reserve holdings. The optimal stock of reserves is obtained by minimizing these two costs and it is yields an expression:[1]

$$R^* = \sqrt{\left[\frac{2c\sigma^2}{(2r\sigma^2)^{0.5}} \right]} \qquad (3)$$

where c,r and σ are fixed cost of adjustment, opportunity cost of holding reserves and standard deviation of change in reserves respectively. The estimating equation can be written as:

$$\text{Log } R_t = b_o + b_1 \log \sigma_t + b_2 \log r_t. + u_t \qquad (4)$$ where u_t is white noise error.

Equation (4) is taken as the benchmark reserve demand equation in most of the empirical studies. The theoretical predictions suggest $b_1 = 0.5$ and $b_2 = -0.25$ and the equation estimated by Frenkel and Jovanovic (1981) had the estimated elasticities close to the theoretical predictions of the model.However past studies for eg Flood & Marion (2002), Ramachandran (2004) have obtained different values of the elasticities. The reason is these estimates are highly sensitive to the proxy used to represent opportunity cost, model specification, estimation methods and additional variables included in the original equation.

[1] A detailed explanation can be found in Frenkel and Jovanovic(1981)

The benchmark buffer stock model has to be extended to incorporate some additional variables which are important in the determination of the level of reserves for an emerging economy like India. This is highlighted in some of the recent studies in this area.In our empirical exercise, in addition to the variables included in the benchmark buffer stock equation we have added a scale variable and a variable representing the flexibility of the exchange rate. The justification of including the scale variable is that reserve holdings are positively correlated with the size of international transactions (Aizenman & Marion 2004). This has increased significantly in the last ten years as the Indian Economy has become integrated with the rest of the world. The scale variable measures the size of international transactions. The rationale for incorporating a variable representing exchange rate flexibility is that the exchange rate has become market determined in India from March 1993 and with that, the policy regarding exchange rate management is aimed at ensuring a credible value of the rupee in line with sustainable current account deficit and maintaining adequate amount of reserves.

The sign of the exchange rate variable is however ambiguous.The reason is, as argued in the literature that greater exchange rate flexibility reduces the demand for reserves as the Central bank does not have to keep a large stockpile of reserves to maintain a peg (Flood and Marion 2002). However countries may keep a high level of reserves even in the face of a flexibile exchange rate in a regime of high capital mobility. Fluctuations in the exchange rate can be curtailed to a prescribed band by maintaining a high level of reserves even when the capital flows exhibit volatility. This is particularly true for developing countries where the growth in exports is linked to the exchange rate maintained by the Central bank.So the Central bank may dampen the fluctuations in the exchange rate for the sake of export competitveness (Dooley, Folkerts-Landau and Garber 2003).

Thus our modified buffer stock equation is written as :

$$\text{Log } R_t = b_o + b_1 \log y_t + b_2 \log \sigma_t + b_3 \log r_t + b_4 \log e_t + u_t \qquad (5)$$

where R_t is reserves, σ_t is volatility of international transtactions, r_t is the opportunity cost variable, y_t the scale variable and e_t is the exchange rate flexibility. u_t is the white noise error component.

Equation (5) is estimated for the period from April 1996 to March 2007 for India. The reason for choosing April 1996 as the starting point is that data for all the variables in the estimation are available from April 1996 onwards..

4. Variables and Data

International reserves include (a) foreign currency assets of the monetary authority (b) Special Drawing Rights (c) Reserve position in the Fund & (d) Gold. We use the International Financial Statistics definition of total Reserves of the monetary authorities minus gold. (Edwards1985,Landell & Mills 1989). Gold is excluded because there is some question whether central banks consider gold to be as liquid as say foreign currency holdings to be used as an intervention asset. Central Banks seem to regard gold as a reserve that is truly ‘ of last resort’ to be sold only as a last measure..

The common scale variables used in the estimation of a reserve demand equation are GDP, population, GDP per capita, imports. Data for all these variables are available on yearly basis.As our study is based on monthly data, we use the index of industrial production (base 93-94) as a measure of the scale variable.

The volatility of international transtactions is usually measured by the standard deviation of the trend adjusted changes in reserves over some period (Frenkel and Jovanovic 1981,Landell & Mills 1989, Ford & Huang 1994,).However as shown by Flood and Marion (2002) that such a measure produces upwardly biased estimate due to restocking of reserves and downward bias due to sharp fall in reserves in times of financial crisis. To avoid this we use an alternative measure of volatility (Edwards1985, Aizenman and Marion 2004) ie, volatility of export receipts measured as the standard error of the regression of log of exports over time for the previous twelve months.

The opportunity cost plays an important role in the determination of international reserves. However most empirical studies have been unable to find a significant opportunity cost effect. Ben- Bassatand Gottlieb(1992 a &b) takes the opportunity cost variable as the difference between the real rate on capital and the yield on reserves.The logic behind this is that opportunity cost of holding reserves is the difference between the highest possible marginal productivity foregone from an alternative investment and the yield on reserves. The real rate of return on capital is calculated as the ratio of profits to gross capital stock of the business sector and the yield on reserves as the real interest on short term deposits.He finds that when opportunity cost is measured in this manner, there is a significant negative relationship between the opportunity cost variable and reserves.We have tried to use this approach in our analysis. As monthly data on profits and gross capital stock are not available from the published sources, we have taken the differential between India's yield on long term Govt. securities and the interest rate on three month treasury bills. However we did not find a significant effect on reserve demand. The reason may be that this proxy for opportunity cost does not properly capture the true opportunity cost of holding reserves (Aizenman and Marion 2004). So we use the monthly yield on cut off price of 91 days treasury bills as a proxy for opportunity cost.(Ramachandran 2004, 2005).

Exchange rate flexibilty is measured as the rolling standard deviation of the previous 12 months of the percentage changes in the nominal exchange rate against the US dollar.(Aizenman and Marion 2004, IMF 2003).

All the variables are converted into logs.Data for all the variables is obtained from RBI- Handbook of Statistics for the Indian economy, and International Financial Statistics , various issues.

The estimating equation now becomes:

$$\text{Ln } R_t = b_o + b_1 \ln y_t + b_2 \ln\sigma_t + b_3 \ln r_t + b_4 \ln e_t + u_t \qquad (5a)$$

Where ln represents log and the other symbols have the same meaning as explained in eqn (5).

5. Methodology

In the empirical research on time series data, there is a problem of nonstationarity which renders the traditional tools of econometrics like OLS, 2SLS inappropriate. To overcome this problem, the cointegration approach has been developed (Engle & Granger 1987 and Johansen1990,1992). However the basic condition for cointegration analysis is that the variables in the system should be non-stationary at levels and stationary of the same order. The unit root tests that exist in the literature can be used to determine the order of integration of the variables. Here the results derived from the existing unit root tests may differ depending on the power of the test. This may lead to a bias in choosing the unit root test that gives the same order of stationarity for all the variables in the system. There is also another problem ie, the variables in the estimating equation may have different orders of integration which renders the traditional cointegration techniques useless.

To overcome this problem, Pesaran, Shin & Smith (2001) developed a bounds testing autoregressive distributed lag (ARDL) procedure that ignores the order of integration of variables. The ARDL bounds testing method can be applied for testing any long run relationships irrespective of whether the variables are stationary at the same or different order. The procedure is explained briefly as follows.

We have eqn (5a) as:

$$\text{Ln } R_t = b_o + b_1 \ln y_t + b_2 \ln\sigma_t + b_3 \ln r_t + b_4 \ln e_t + u_t \qquad (5a)$$

The above equation can be written in an error correction format as-

$$\Delta \text{ Ln } R_t = b_o + \sum_{i=1}^{n} a_i \Delta\ln R_{t-i} + \sum_{i=1}^{n} b_{1i} \Delta\ln y_{t-i} + \sum_{i=1}^{n} b_{2i} \Delta\ln\sigma_{t-i} + \sum_{i=1}^{n} b_{3i} \Delta\ln r_{t-i} + \sum_{i=1}^{n} b_{4i} \Delta\ln e_{t-i} +$$
$$\gamma_1 \ln R_{t-1} + \gamma_2 \ln y_{t-1} + \gamma_3 \ln\sigma_{t-1} + \gamma_4 \ln r_{t-1} + \gamma_5 \ln e_{t-1} + u_t \qquad (6)$$

Pesaran and Shin (2001) set up a two step procedure to estimate eqn (6). In the first step, the null hypothesis of the non existence of the long run relationship among R_t, y_t,σ_t, r_t & e_t is defined by $H_o : \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = 0$. H_o is tested against the alternative of H_1: not H_o. Rejecting the null hypothesis indicates that there exists a long run relationship among R_t, y_t, σ_t,r_t &e_t irrespective of the integration properties of the variables. The relevant test statistic to test the null hypothesis is the familiar F statistic with the critical values tabulated by Pesaran , Shin & Smith (2001). They have tabulated two sets of critical values. One set assumes all variables are I(1) and another assumes all variables are I(0). This provides a band covering all possible classifications of the variables into I(1) and I(0) or fractionally integrated. If the calculated F statistic lies above the upper level of the band, the null is rejected indicating cointegration. If the calculated F statistic falls below the lower level of the band, the null cannot be rejected supporting lack of cointegration. If, however it falls within the band, the result is inconclusive.

If the variables have a long-run relationship, we can estimate the long run coefficients and the corresponding lagged error correction term to see the long run impact of the dependent variables and the speed of adjustment.

6. Results

In Table (2) & (2a) we have presented the Phillips Perron(PP) and the Augmented Dickey Fuller(ADF) statistics for all the variables respectively. From the two tables we can see straightaway that based on the PP tests, Lny_t is stationary while the other four variables namely LnR_t, $Ln\sigma_t$, Lnr_t,and Lne_t are nonstationary. The ADF test however show that LnR_t is stationary and Lny_t, $Ln\sigma_t$, Lnr_t and Lne_t are non stationary. These results restrict us from the use of the standard cointegration techniques developed by Engle & Granger (1987) and Johansen (1990). In such cases the ARDL bounds testing approach of Pesaran & Shin (2001) is useful in testing for the long run relationships among the variables.

In table(3) we have presented the ARDL results following the Akaike information criteria (AIC) for the selection of lag length. The calculated F statistic lies above the upper bound critical value tabulated in Pesaran & Shin (2001) suggesting a long run relationship among all the variables. The lagged error correction term has the expected negative sign and is significant. Coming to the estimated long run coefficients we see that all the variables have the signs as expected from their theoretical predictions. From the respective p values we see Lny_t and Lnr_t are significant at the 10% level, $Ln\sigma_t$ is marginally insignificant and Lne_t is highly insignificant. All the variables have the signs as expected from their theoretical propositions.Moreover the intercept term and the time trend are also significant.

Table(4) gives us the results using the Schwarz Bayesian criteria (SBC) for lag length selection. Here the calculated F statistic lies within the two bounds indicating that the test for cointegration among the variables is inconclusive. The other results are approximately the same except that here both $Ln\sigma_t$ and Lne_t are highly insignificant.

Given the above results, we have decided to drop the insignificant variable ie, Lne_t from the analysis and carry out the same exercise. The insignificance of the exchange rate flexibility variable may be due to the reason that this variable may not properly capture the exchange rate flexibility for the Indian Economy and suitable modifications must be made to this variable so that it measures the exchange rate flexibility accurately. This is an area for further research. Also it is to be noted that the exchange rate, although being market determined, is actively managed by the RBI for most of the estimating period in order to maintain export competitiveness and stability in the exchange rate.(Baig, Narsimhan & Ramachandran 2003).This may render the flexibility variable insignificant.The results are tabulated in table 5 (using AIC) and 6 (using SBC) respectively. From table (5) we see that the calculated F statistic strongly suggests a long run relationship among all the variables. All the variables have the expected signs and are significant at the 10% level of significance. The results are corroborated using the SBC criteria (table 6), except that the variable $L\sigma_t$ turns insignificant at 10% level of significance.

The diagonistic checks are carried out on the ARDL equation of table (5). The results based on the LM tests (table 7) show that there is no serial correlation or heteroscedasticity and the functional form is properly specified.However it fails the test of normality of the residuals at the 5% level of significance but given the significantly large sample size, we can still use the normal distribution of the estimates asymptotically by relying on the Central Limit Theorem (Theil 1978). Lastly the cumulative sum and cumulative sum of squares plots based on the recursive residuals (Figures 1&2 respectively) show no evidence of statistically significant breaks.

From the above exercises, it is reasonable to take the results reported in table (5) as our baseline ARDL results indicating a stable relationship among reserves, index of industrial production, volatility of export receipts and 91 day treasury bills.

7.Conclusion

We have estimated the buffer stock model for reserve demand for India in a regime of high capital mobility and flexible exchange rates. The empirical evidence shows that the reserve demand is positively related to a scalar variable, a variable measuring the volatility of international transtactions and negatively related to the opportunity cost measure. It has been shown elsewhere (Ramachandran 2005) that the standard measure of volatility ie, the rolling standard deviation of reserve increment scaled by imports produces bias in the coefficient. So we have used an alternative measure of volatility ie, volatility of export receipts used by Edwards(1985) and Aizenman & Marion(2004) and found that it improves the overall performance of the model.

The results however indicate that exchange rate flexibility is not a significant variable influencing reserves in India. This may be due to the reason that officially exchange rates in India may be flexible but in reality they are highly regulated by the Central bank through direct intervention and indirect methods which has lowered the magnitude of the fluctuations. This to some extent has lowered the impact of this variable on reserve demand.

The results show that the other variables considered in the model are significant and have the correct signs as specified in the theory. The model passes most of the specification tests. Also the stability test does not provide evidence in favour of a structural break in the reserve demand during the later periods when the country witnessed high levels of capital inflows.

<u>Table 1</u>

Non gold foreign exchange reserves as weeks of imports

Year	World	ICs	DCs
1995	15.2	11.5	21.8
1996	16.2	12.1	23.3
1997	15.7	11.2	23.9
1998	16.4	10.7	27.9
1999	16.9	10.7	29.8
2000	16	10.2	27.2
2001	17.6	10.8	30.5
2002	19.9	12.2	34.3
2003	21.4	12.8	36.8
2004	21.4	12.5	36.4
2005	20.7	10.7	36.6
2006	21.6	10.1	39.0

Note - ICs = Industrial countries

DCs = Developing countries

Source – International Financial Statistics

Table 1 (a)

Reserve holdings in India

Year	90-91	99-00	02-03	04-05	06-07
Reserves (Billion Dollars)	5.8	38.0	76.1	141.5	199.1
Reserves as % of GDP	2.2	9.2	16	21.6	23.2
Reserves as months of Imports	3.1	7.8	12.8	11.4	11.5
Reserves as % of M_3	4.5	15.7	22	29	29.3

Source – RBI Handbook of Statistics for the Indian Economy

Table 2

Unit Root Tests

Phillips Perron Test

Variable	Test Stat	CriticalValue (10%)
LnR_t^{NT}	-1.16	-2.57
Lny_t^{T}	-4.85	-3.13
$Ln\sigma_t^{T}$	-2.99	-3.13
Lne_t^{NT}	-2.14	-2.57
Lnr_t^{NT}	-2.14	-2.57

^{T} denotes trend significant
^{NT} denotes trend not significant

Table2a

Unit Root Tests

ADF Test

Variable	Test Stat	CriticalValue (10%)
LnR_t^{T}	-3.58	-3.13
Lny_t^{T}	-1.99	-3.13
$Ln\sigma_t^{T}$	-2.97	-3.13
Lne_t^{NT}	-2.39	-2.57
Lnr_t^{NT}	-2.02	-2.57

^{T} denotes trend significant
^{NT} denotes trend not significant

Table 3

ARDL approach to cointegration

Estimated long run coefficients using AIC

Dependent variable LnR_t

Variable	Coeff	T ratio	pvalues
Lny_t	.96	2.50	(.01)
$Ln\sigma_t$	.14	1.52	(.12)
Lne_t	-.008	-.35	(.72)
Lnr_t	-.34	-5.21	(.00)
Inpt	7.08	4.17	(.00)
T	.01	6.74	(.00)
Ecm(-)	-.19	-4.35	(.00)
Fstat	4.68		

AIC criteria suggested ARDL order of (1,2,1,0,0). The critical bounds for the 10% significance level for 4 variables with intercept and linear trend are 3.03-4.06.

Inpt – Intercept, T- Time trend

Table 4

ARDL approach to cointegration

Estimated long run coefficients using SBC

Dependent variable LnR_t

Variable	Coeff	T ratio	pvalues
Lny_t	.79	2.31	(.02)
$Ln\sigma_t$	.07	.77	(.43)
Lne_t	.006	-.02	(.97)
Lnr_t	-.36	-4.82	(.00)
Inpt	7.68	5.00	(.00)
T	.01	7.68	(.00)
Ecm(-)	-.17	-3.93	(.00)
Fstat	3.98		

SBC criteria suggested ARDL order of (1,0 ,0 ,0,0). The critical bounds for the 10% significance level for 4 variables with intercept and linear trend are 3.03-4.06.

Table 5

ARDL approach to cointegration

Estimated long run coefficients using AIC

Dependent variable LnR_t

Variable	Coeff	T ratio	pvalues
Lny_t	.91	2.65	(.01)
$Ln\sigma_t$	.12	1.58	(.10)
Lnr_t	-.35	-5.47	(.00)
Inpt	7.29	4.74	(.00)
T	.01	7.56	(.00)
Ecm(-)	-.19	-4.68	(.00)
Fstat	5.47		

AIC criteria suggested ARDL order of (1,2,1,0). The critical bounds for the 10% significance level for 3 variables with intercept and linear trend are 3.47 -4.45.

Table 6

ARDL approach to cointegration

Estimated long run coefficients using SBC

Dependent variable LnR_t

Variable	Coeff	T ratio	pvalues
Lny_t	.79	2.46	(.01)
$Ln\sigma_t$	.07	.83	(.40)
Lnr_t	-.36	-4.48	(.00)
Inpt	7.70	5.32	(.00)
T	.01	8.08	(.00)
Ecm(-)	-.17	-4.22	(.00)
Fstat	4.81		

SBC criteria suggested ARDL order of (1,0 ,0 ,0). The critical bounds for the 10% significance level for 3 variables with intercept and linear trend are 3.47 -4.45.

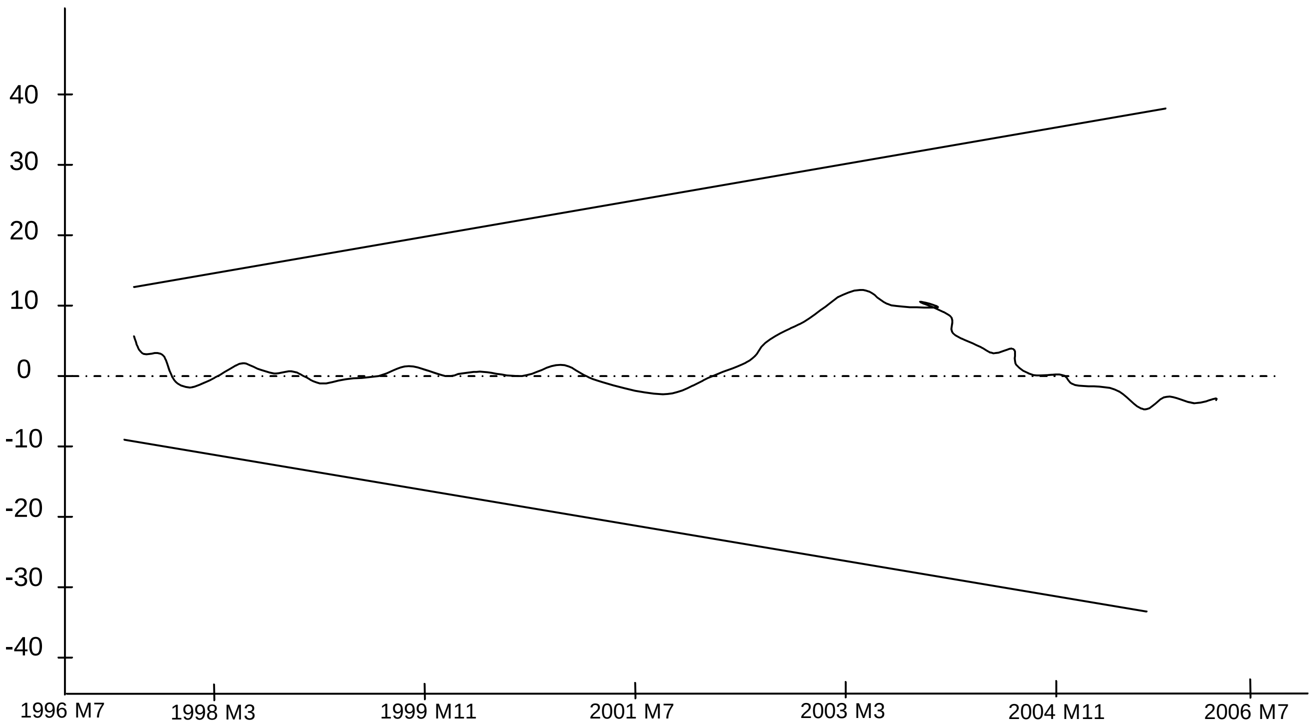
Table 7

Diagonistic tests

LM Test	χ2(calculated)	p value
Serial correlation	13.34	(.34)
Functional form	1.27	(.25)
Normality	18.86	(.00)
Heteroscedasticity	.25	(.61)

FIGURE -1

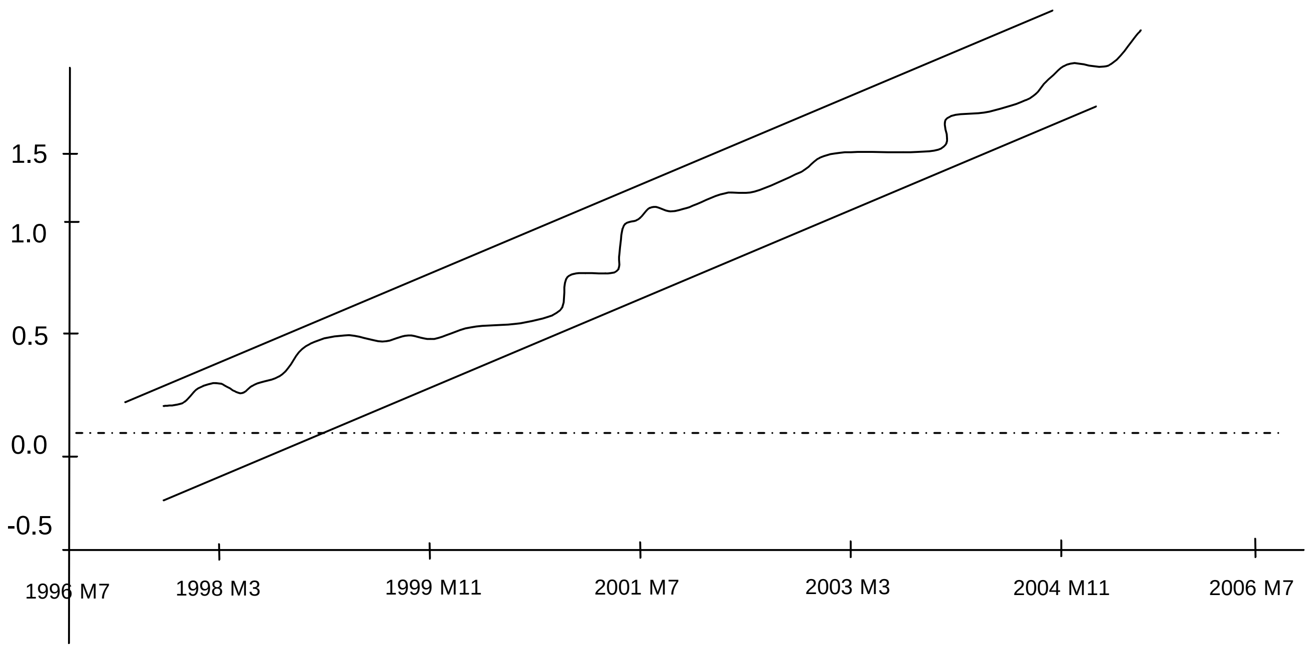
PLOT OF CUMULATIVE SUM OF RECURSIVE RESIDUALS



STRAIGHT LINES ARE CRITICAL BOUNDS AT 5% SIGNIFICANCE LEVEL

<u>**FIGURE -2**</u>

PLOT OF CUMULATIVE SUM OF SQUARES OF RECURSIVE RESIDUALS



STRAIGHT LINES ARE CRITICAL BOUNDS AT 5% SIGNIFICANCE LEVEL

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