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REAL EXCHANGE RATE STABILISATION AND MANAGED FLOATING: EXCHANGE RATE POLICY IN INDIA, 1993-99

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Foreword

The role of exchange rate and monetary policies has undergone a qualitative change since 1993, underscoring the need for fresh academic enquiries on these issues. This study, part of the larger project at ICRIER on Capital Account Convertibility and Macroeconomic Management, is an attempt to address this gap. It examines the exchange rate management strategy of the Reserve Bank of India after the floating of the rupee in 1993. A policy reaction function is modelled to test for central bank response to contemporary exchange rate movements and its deviation from purchasing power parity. The impact of exchange rate changes upon foreign exchange reserves is thereafter traced within a vector auto-regression framework.

The study finds empirical support for a significant intervention response to contemporary changes in the nominal rupee-dollar spot rate and its deviation from relative Indo-US prices. The results suggest that the central bank stabilised the real exchange rate during 1993-99 along with moderating market pressures upon the exchange rate.

I hope that the empirical analysis in this study will help throw some light on the exchange rate policy in India and contribute to a larger understanding of its links with monetary policy in the evolving financial sector environment.

Isher Judge Ahluwalia
Director & Chief Executive
ICRIER, New Delhi

December, 2000

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Renu Kohli

I. Introduction

Economic theory predicts that a floating exchange rate will automatically adjust balance of payments deficits through variations in the market price of foreign exchange and insulate the domestic economy from external shocks. Since the authorities do not have to intervene in the foreign exchange market, monetary policy can be assigned exclusively to domestic objectives, giving complete monetary policy autonomy. These propositions however, have been belied by the post-Bretton Woods' experience with freely floating exchange rates. Increased exchange rate volatility, misalignment from equilibrium levels for long periods, prolonged current account imbalances and a rise in capital mobility underscored the need to 'manage' exchange rates. This consensus emerged by 1985 and instances of intervention by respective central banks in support of weak currencies, or to prevent exchange rate instability, have become fairly common since. For instance, the Bank of Japan, from mid-1986 onwards rigidly tried to hold on to the prevailing exchange rate level of the yen and prevent it from sliding downwards; so did the United States in the 1980s.

The Bank of England has been known to systematically counter depreciation of the effective exchange rate of the pound and its depreciation vis-à-vis the US dollar. More recent examples include practically all 'emerging market' economies in Latin America and Asia that have shifted to floating exchange rate regimes and the European Central Bank.

Likewise, India too is no exception to the concept of 'dirty' floating. It switched to a floating exchange rate regime in 1993 after a transitional phase of dual exchange rates for two years. The post-float period is distinguished by remarkable exchange rate stability, which is contrary to commonly observed experience, as countries that switch from fixed to floating exchange rate regimes typically experience a rise in exchange rate volatility. The floating of the rupee has also been accompanied by a rise in the frequency and scale of intervention by the central bank in the foreign exchange market. These features inspire the central question that this paper addresses, viz. the exchange rate management strategy of the central bank. This question is addressed in the paper by modelling a simple policy reaction function that tests for the intervention strategy of the

Reserve Bank of India between 1993-99. Explicit exchange rate policy objectives, viz. exchange rate stability and preserving the international competitiveness of the domestic economy, indicate a real targets approach to exchange rate management by the central bank. We therefore test for two intervention strategies – leaning against the wind and minimisation of deviations from a target level for the exchange rate. Using purchases & sales of foreign currency by the RBI as proxy intervention data, we find its intervention behaviour is characterised by a significant effort to lean against the wind, tempered with purchasing power parity considerations.

The paper is organised as follows. Section II reviews India's exchange rate policy, placing the floating exchange rate regime in perspective with preliminary statistics. Section III formulates an implicit reaction function for the RBI and estimates it using single-equation (2SLS) methods. Section IV demonstrates the impact of exchange rate movements and intervention response upon foreign exchange reserves within a vector auto-regression framework. An impulse response analysis is then conducted on the estimated VAR. Section V concludes.

II India's Exchange Rate Policy in Perspective

Between 1947-75[1] the rupee was pegged to the pound sterling after which there was a shift to a multi-currency basket link arrangement.[2] This shift was precipitated by the breakdown of fixed parities and free floating of major world currencies in the early seventies, continuous third currency fluctuations which affected the external value of the rupee and trade diversification. Frequent adjustments through the basket link helped in moderating variations in the rupee exchange rate, making it an "implicit adjustable NER peg" (Joshi, 1984). Between 1983-85, the rupee was devalued enough so as to keep the real exchange rate constant. Between 1986-90, a policy of active rupee devaluation was followed to produce a real depreciation which helped export growth (Joshi & Little, 1994: 277).
The switch to a floating exchange rate regime in 1993-94 was amidst a precarious macroeconomic environment following a balance of payments crisis in 1991. The rupee was devalued by 9 and 11 per cent in two stages

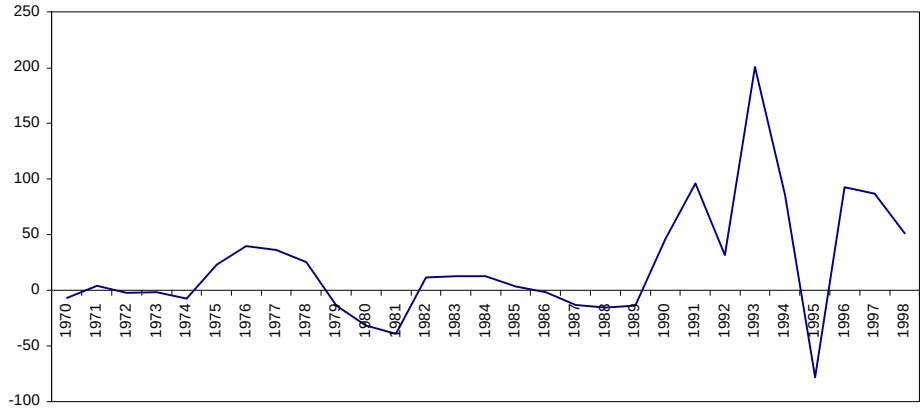
[1] The external value of the rupee was maintained within a band of 1 per cent on either side. After the realignment of parities of major currencies following the Smithsonian agreement, the rupee was re-linked to the pound with a widened margin of 2.25 per cent on either side.

[2] The exchange value of the rupee was determined with reference to the daily exchange rate movements of a select number of currencies that were India's major trading partners The exchange rate was maintained within a band of 2.25 percent on either side of the base value being widened to 5% later to allow for more flexibility.

between July 1 and 3, 1991. A new system of exchange rate management in 1992-93, LERMS (Liberalised Exchange Rate Management System),[3] made the rupee partially convertible on the current account through a dual exchange rate. A downward adjustment in the official exchange rate was effected in December 1992 and the two rates were unified in March 1993 with the floating of the rupee.

A notable feature of the post-float period has been a significant rise in intervention by the central bank. Fig. 1 plots yearly changes in foreign reserves (deflated by the wholesale price index at 1990 prices). It is apparent that annual reserve changes are higher in the floating exchange rate period than in the adjustable peg regime, suggesting that the size of central bank interventions in the foreign exchange market has increased.

Fig. 1 Movements in Reserves, 1970-98



yearly change

The mean absolute change in foreign exchange reserves during 1970-90 is merely Rs 0.03 billion which increases to 0.73 billion rupees after the rupee started to float in March 1993 (the average size of intervention for the transition period, 1991-92, which saw major exchange rate adjustments, is Rs 0.64 billion).

A perusal of the central bank's annual reports during 1993-99 reveals that the Reserve Bank uses both direct and indirect intervention to manage the exchange rate. The most frequently used tool is direct intervention in the foreign exchange market through purchases and sales in the intervention

[3] Under this arrangement, 40 per cent of foreign exchange earnings were to be converted at the official rate (to be utilised for import of essential items) and 60 per cent at market rates (available to finance all other imports). Demand and supply factors and free access for all foreign exchange transactions determined the market rate and the official rate was determined by the RBI and had restricted access.

currency (i.e. US dollars) in both spot and forward markets. This is often combined with indirect intervention, viz. quantitative restrictions, reserve requirements and interest rate changes to smoothen temporary mismatches between demand and supply of foreign currency. A summary of these measures over the study horizon is given in Appendix I.

Table 1 presents some facts about the central bank's intervention activity after 1993. The heavy dollar purchases observed in the beginning of the period are related to the inward capital surge that accompanied the free price convertibility of the rupee.

Table 1
Interventions[a] by RBI during 1993-98

(US $ million.)

	Purchases	Sales	Gross Intervention	Net Intervention
1993	11287	4021	15508	7266
1994	15238	1	15239	15237
1995	1987.6	4799.5	6787.1	-2811
1996	10058.5	5837	15895.5	4221.5
1997	13182.5	6671	19853.5	6511.5
1998	28180	27903	56.83	277
1999	19910	17439.5	47349.5	2470.5

Source: RBI Bulletin, Various Issues. Gross intervention is the sum of purchases and sales, irrespective of sign. Net intervention is the same, except that the sum takes account of the signs.

The central bank absorbed these inflows during 1993-97 (excluding 1995 when capital inflows subsided) to counter appreciation pressures upon the exchange rate, augmenting its international reserves in the process. Note that gross intervention equals net intervention in 1994, pointing to one-way intervention effort to oppose appreciation and rebuild reserves.
Official accounts of this period indicate that the Reserve Bank's exchange rate management strategy focused upon stabilising the exchange rate and keeping it aligned to fundamentals. Consider, for example, the following statements: "…it will be important to maintain a stable REER…to prevent an erosion in the incentives available to exporters"[4]; the Reserve Bank of India stands ready to intervene to maintain orderly market conditions and

[4] Economic Survey, 1993-94, GOI: 85.

to curb excessive speculation"[5] and "…exchange rate management continues its focus on smoothing excessive volatility in the exchange rate…to ensure that the exchange rate remains consistent with economic fundamentals."[6]

It can be inferred from these statements that the central bank reacts to exchange rate volatility with the objective of stabilising the nominal exchange rate. They also suggest a 'real targets' approach under which central banks typically insulate the level of the real exchange rate to either keep it constant, or achieve a different level. For instance, many developing countries follow the 'real targets approach' to achieve a depreciated level of the exchange rate to make their exports more competitive.[7] The nominal exchange rate is therefore the policy tool that is varied to attain real targets to maintain internal and external balance.

The monthly intervention activity of the Reserve Bank during this period is plotted in Fig. 2, along with changes in the nominal exchange (spot) rate. A prima facie association between intervention and exchange rate movements can be observed from the plotted values. Intervention is mainly unidirectional between 1993-95; i.e. an appreciation is countered through intervening purchases by the Reserve Bank. The period immediately following the floating of the rupee, 1993-95, is a period of relative calm in terms of exchange rate movements. A closer look at the data reveals extensive intervention by the central bank with the nominal exchange rate (spot) being held almost constant between 31.23 – 31.81 rupees per US dollar. This is confirmed by the central bank's own account of this period when it describes its intervention strategy (1993-95) to be directed at "…protecting the export competitiveness and consolidating the foreign exchange reserves."[8] Clearly, a rigid defence of the exchange rate (averting an appreciation) led to very large interventions during these two years. Table 2 (Cols. 2 & 3) presents some measures of exchange rate volatility during periods of exchange rate pressure between 1993-98.

The last column of the table provides evidence of central bank response, i.e. intervention. The idea here is to tease out a preliminary association between exchange rate policy objectives and intervention behaviour.

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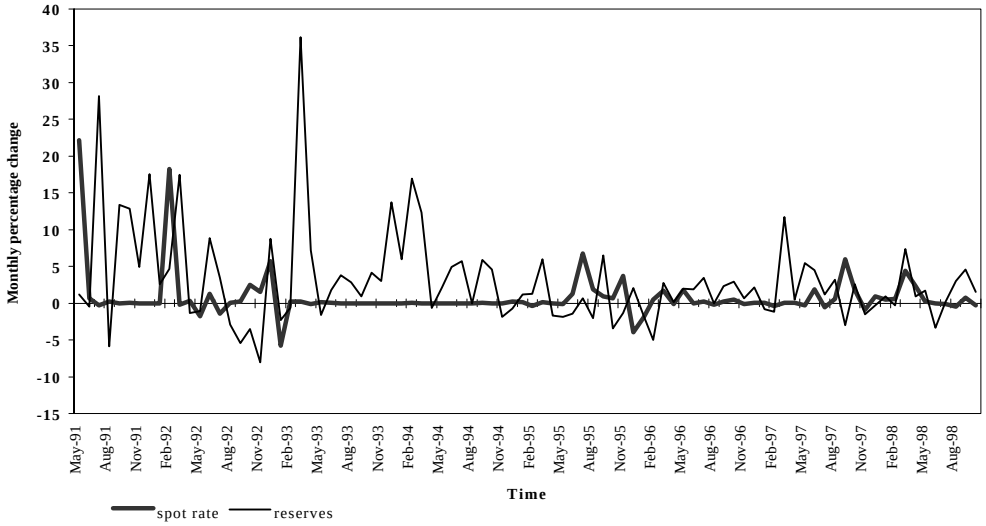
5 Economic Survey, 1995-96, GOI: 103.

6 Economic Survey, 1997-98, GOI,: 92

7 The normal assumptions underlying a 'real targets approach' are that domestic prices, i.e. wages and the prices of non-tradeables, are inflexible (or sluggish); a real devaluation will lead to increases in international competitiveness and that the country is subject to asymmetric shocks (Corden, 1993: 198-99).

8 Report on Currency & Finance, 1994-95, RBI: X-17.

Fig. 2 Intervention and movements in the spot rates



A close positive relationship can be detected between intervention and exchange rate volatility, for example, the co-movement between intervention and volatility between July-Sept. 1995, Jan.-March 1996 and April-June 1998. A second feature is that intervention is often preceded by, or follows, an exchange rate adjustment even though exchange rate movements might not have been extraordinarily volatile. For example, the period July-Sept. 1995, Jan-Mar 1996, Jan-Mar 1998 and July-Sept 1998, suggesting thereby that intervention has been directed at changing or sustaining a particular value of the exchange rate. The central bank's own account of the depreciation in the quarter Aug.-Sept. 1995, viz. "…due to the policy guided correction in the exchange rate of the rupee in the second half of 1995-96, the rupee remained stable during 1996-97", buttresses this observation.[9]

[9] Report on Currency & Finance, 1995-96, RBI: X-12.

Table 2
Exchange Rate Volatility and Intervention in Periods of Pressure

Period	Nominal exchange rate variability vis-àvis US dollar		Interventions
April-June 1995	0.21[1]	-0.14[2]	5.80[3]
July-Sept. 1995	3.59	1.28	10.30
Oct-Dec 1995	0.66	9.85*	7.88
Jan-Mar 1996	3.95	0.29	12.11
April-June 1996	0.92	0.10	5.21
July-Sept 1997	1.30	1.06	7.69
Oct-Dec 1997	2.80	6.61*	4.55
Jan-Mar 1998	0.99	1.88	10.61
April-June 1998	1.90	5.59*	8.03
July-Sept 1998	0.17	2.56*	10.42

[1] standard deviation of absolute percentage change in the bilateral rupee/dollar exchange rate;

[2] percentage change of the median value of the exchange rate in the current quarter over the median value of the preceding quarter;

[3] quarterly averages expressed as a percentage of the yearly average of gross intervention undertaken *Intervention leading to realignment of the exchange rate

Elsewhere, the intervention intended to "…even out volatility and correct misalignment in relation to the fundamentals".[10] Another account of the policy response reports an intervention (dollar sales) in October 1995 in the spot and forward exchange markets to "…prevent further depreciation and to guide the rupee along a course consistent with macroeconomic fundamentals".[11] Note also that intervention activity subsides after the readjustment. This evidence strongly suggests that these adjustments were implemented by the central bank.

In the second period of exchange rate pressure (Oct.-Dec. 1997 onwards) the Reserve Bank's intervention activity again rises with volatility in the foreign exchange market. Between Jan-July 1998, substantial interventions took place, when the Reserve Bank resisted further

[10] *Ibid.* X-6.

[11] *Ibid.* X-12.

pressures upon the exchange rate. Despite the direct as well as indirect[12] intervening measures, further realignments of the market rate were accepted as indicated by Col. 3 of Table 2.

The following inferences can be made from this analysis. One, the central bank is averse to excessive fluctuations and aims to moderate exchange rate movements when there is volatility in the foreign exchange rate market. Second, the exchange rate appears to be periodically adjusted by discrete percentages, with the adjustments being 'guided' by the central bank. This suggests an exchange rate 'rule' guiding the periodic realignments that are managed by the central bank. Finally, the observation that intervention is usually directed at averting an appreciation or achieve a more depreciated level, is consistent with real exchange rate targeting by the central bank. Section IV aims to confirm these insights through a formal investigation of the Reserve Bank's intervention strategy.

III Intervention Strategy

This section estimates an implicit reaction function that relates central bank response to exchange rate movements to test for its intervention strategy. We assume two intervention strategies on the part of the central bank– leaning against the wind and directing the rate to a certain pre-decided value, i.e. an exchange rate target. Leaning against the wind implies resistance against market forces for a prolonged period and is aimed at sustaining the exchange value of the currency in an aggressive manner. This exchange rate rule, formally due to Wonnacott (1965), is expressed as

$$\Delta F_t = a\,(S_t - S_{t-1}) \qquad (1)$$

where ΔF_t is the change in foreign exchange reserves and symbolises intervention. It responds automatically to changes in the nominal exchange rate, S_t and S_{t-1}, which is end of the period (month) spot rates (rupee per US dollar) for the current and the past month respectively. Past levels of the exchange rate can also be thought of as a target level for the current exchange rate in a leaning against the wind strategy (Almekinders & Eijffingers, 1991: 648)

This strategy was practised by the Canadian authorities in the sixties and seventies, but lost currency in the post-Bretton Woods period when the

[12] This refers to trade and interest rate restrictions imposed by the Reserve Bank to complement its direct intervention. See Appendix I.

major problem with exchange rates was not just volatility but a tendency to be misaligned in relation to their long-run equilibrium value.[13] Note that this strategy "…does not require the authorities to take a view on where the exchange rate ought to be…" (Williamson, 1993: 191). It is also distinct from a strategy directed at maintaining orderly market conditions, which aims at prevention or moderation of sharp and disruptive fluctuations. The latter strategy counters short-term exchange rate movements; i.e. day to day or week to week fluctuations in the exchange rate whereas leaning against the wind seeks to maintain the exchange rate in a particular direction, implying intervention for a longer period.[14]

An alternate hypothesis we consider is that intervention is directed at maintaining a particular target level of the exchange rate. Under this approach, the authorities take a view on what the exchange rate ought to be or where they would like it to be (*Ibid*. 194). The choice of the target rate thus involves calculation of an equilibrium rate and a choice whether the target rate should be changed and if so, then how.[15] The intervention strategy here can then be described as minimising deviation of the spot rate from a 'target' rate and can be represented as

$$\Delta F_t = a_1(S_t - S^*_t) \qquad (2)$$

where S^* is the central bank target exchange rate for the rupee. We assume two hypothetical exchange rate targets here. One, the target is set so as to maintain constant domestic and world relative prices at 1993[16] level as in Artus (1976). The second formulation is a moving target that changes with monthly changes in relative prices. The target rate is calculated as

$$S^* = S_t\left[1 - \%\Delta P_h / P_w\right] \qquad (3)$$

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13 Another reason was that leaning against the wind, when the wind is blowing in the right direction ends up magnifying the problem (See Williamson, 1993).

14 This distinction implies that empirically, leaning against the wind can be tested through data of longer duration (e.g. monthly frequency) while an intervention response to short-term exchange rate movements can be picked up by daily or weekly frequency data (Quirk, 1976: 646).

15 Kenen (1988). Cited in Williamson (1993).

16 The base of March 1993 is reported to have been notionally established as an 'equilibrium' rate for the rupee by the official authorities. See "Money Market Review" EPW Research Foundation, Economic & Political Weekly, Sept. 13, 1997: 2306.

where P_h and P_w are domestic and US consumer price levels, and S_t is the nominal exchange rate (end of the month rupee-dollar spot rate). $\Delta\% P_h / P_w$ is *a)* the deviation from the March 1993 base; and *b)* the monthly percentage change in wholesale prices in the home and foreign country respectively.

Thus the equilibrium exchange rate would increase or decrease by the varying inflation differential between domestic and world wholesale prices respectively. This basically tests for the existence of a PPP rule, where the nominal exchange rate is adjusted by discrete percentages depending on the inflation differential. The underlying assumption here is that the monetary authority is committed to a real exchange rate target. It must then either change the nominal exchange rate at any given price level or change internal prices at any given level of the nominal exchange rate. The nominal exchange rate would then be manipulated in terms of the intervention currency, i.e. the dollar, to either maintain a constant real exchange rate or change it in relation to some 'fundamental' determinants, which we assume to be the price level.

Empirical Estimation

The period of analysis, 1993:03 to 1999:05, covers the maximum period of floating that could be covered given the availability of monthly data; the small number of observations this allows us therefore, is an obvious constraint. All variables have been taken from various issues of the Report on Currency and Finance & RBI bulletin of the Reserve Bank of India. For estimation of the reaction function, purchases and sales of US dollars by the RBI have been used as intervention proxies.[17]

Both time series, viz. net intervention (i.e. purchases less sales of US dollars) and the spot rupee-dollar rate, were found to be I (1) processes. All other estimation details are reported in Appendix II. Corresponding to the reaction function modelled earlier, three versions were estimated using two-stage least squares. This was preferred to control for the simultaneity problems that may arise due to the effects of intervention upon exchange rate changes during that period.

[17] Regressions of change in foreign currency assets (foreign exchange reserves excluding SDRs and gold) as the intervention variable, instead of purchases/sales of foreign currency yielded very similar estimates (not reported here), confirming it to be a very good proxy for intervention. The results are obtainable from the author on request.

Equation 1 relates intervention to changes in log spot rate (with and without lags), equation 2 adds ΔS^{*93} (target set to maintain constant relative prices from March 1993 base) to the basic specification, which is replaced by ΔS^{*} (target moving with monthly changes in relative prices) in equation 3. Several variants of these basic three specifications were tested and the results are presented in Table 5. All the estimations yield a significant coefficient on ΔS_t, are correctly signed and of almost similar magnitude, confirming the robustness of the stimates**.** The 2SLS regressions perform well in terms of standard goodness-of-fit measures like tests on the residuals for autoregressive conditional heteroskedasticity (LM) and autocorrelation (Ljung-Box statistic). A Chow forecast test conducted by splitting the sample in the middle, i.e. 1996:1, shows that the null of parameter instability is strongly rejected.

Table 5
Estimated ECM and 2SLS estimates

	(1)	(2)		(3)	
	$\Delta F_t = a + b\Delta S_t$	$\Delta F_t = a + b_1\Delta S_t + b_2 S_t^{*93}$		$\Delta F_t = a + b_1\Delta S_t + b_2 S_t^{*}$	
C	89.3	110.3	81.3	96.3	73.7
	1.47	1.88	1.11	1.25	0.01
ΔS_t	-216.4*	-482**	-495.5**	-216.9*	-323.9**
	-2.71	-4.20	-3.17	-2.24	-3.18
ΔS_{t-1}		231.9**	229.1**		279**
		3.53	3.68		3.06
ΔS^{*93}			-1.22		
			0.59		
ΔS^{*}_{-1}				9.80*	8.43*
				2.31	2.31
Adj. R^2	0.20	0.04	0.09	0.03	0.08
LM	0.01	0.21	0.21	0.002	0.14
ARCH	0.19	0.24	0.28	0.30	0.26
Chow Forecast	1.39	1.00	0.99	1.18	1.03

** and ** indicate 5 and 1 per cent significance levels respectively*

Equation 1, which relates intervention to contemporary rate of change in the spot rupee/dollar exchange rate, i.e. 'leaning against the wind' strategy, suggests that the data is consistent with this view of central bank behaviour. On an average, a one per cent fall (rise) in the exchange rate leads to a sale (purchase) of US $ 216 million by the Reserve Bank.

This result remains unaltered with the addition of one-period lagged rate of exchange rate change, though the coefficient is now of a higher magnitude and significance. This equation indicates an intervention (purchase/sale) of the order of 482 million dollars for every percentage contemporary rise/fall in the exchange rate. The positive sign on the coefficient on the one-period lagged exchange rate possibly reflects that subsequent response of the central bank is concentrated upon rebuilding reserves in the next period. Subsequent lags of log exchange rate were found to be insignificant and, therefore, dropped from the final estimation.

Equation 2, which reflects the assumption that the central bank seeks to minimise deviations of the spot rate from a March 1993 base value of relative Indo-US prices, does not bear any support for this hypothesis. The coefficient on the target rate adjusted to the March 1993 value, contemporary as well lagged one-period were both found to be insignificant. This suggests that there was no attempt by the Reserve Bank to vary the nominal exchange rate to attain this particular exchange rate target.

The final set of regressions, equation 3, which corresponds to the model positing intervention response to minimising deviations of the spot rate from a moving nominal exchange rate target set to changes in Indo-US relative prices, captures central bank behaviour most significantly. There is substantial empirical support for the moving relative prices' target hypothesis as witnessed by the significant coefficient on the target rate. Two variants of this model, with and without the one-period lag of the spot rate were tested. In each specification, the coefficient on the target rate is statistically significant, suggesting an intervention response from the Reserve Bank to deviation of the spot rate from the target rate.

These results indicate that the central bank's intervention behaviour reflects mixed considerations. It responds significantly to the current rate of change in the exchange rate, but this response is also tempered by factors based upon relative price movements. On an average, a one per cent change in the spot rate invokes an intervention response of approximately US $ 216-323 million from the Reserve Bank. We can infer from this that the intervention strategy is targeted at moderating market pressures upon the spot rate as well as keeping the nominal exchange rate in some kind of alignment with prices. This suggests that the central bank follows a PPP rule, or that the real exchange rate appears to be periodically adjusted to compensate for increases in inflation relative to that of its trading partners. The small size of the coefficient, however, suggests the magnitude of intervention on this account, to be quite small, i.e. 8-10 million dollars.

IV Error-Correction Model and Impulse Response Analysis

How do reserves respond to disequilibrium and exchange rate shocks? We address this question by estimating the intervention equation within a vector auto-regression framework. The estimated adjustment coefficients from the vector error-correction model are reported in Table 6.[18]

Table 6
VECM Adjustment Parameters

Model	Adjustment Coefficient z_{t-1}
F_t, S_t	1.35**
	(2.43)
F_t, S_t, S^{*93}	0.74*
	(3.21)
F_t, S_t, S^{*}	1.90*
	(3.31)

- *and ** indicate significance at 1and 5 per cent levels respectively.*

The vector error-correction estimation is done by imposing the error-term obtained from the cointegrating regression in levels, as a restriction upon the VAR, which is estimated in first-differences. The coefficient estimated for the cointegrating equation, or the adjustment parameter, reflects the intervention response of the central bank at time-period *t* to past period's disequilibrium, i.e. *t-1*. The size of this coefficient reflects the speed of response. The VECM representation of the intervention equations reveals that intervention response, or alternately, accretion or depletion of foreign exchange reserves, is always significant, suggesting an adjustment to restore equilibrium. No matter which specification we choose, this result remains unaltered. The magnitude of this parameter lies in the range of -1.3-1.9, suggesting a fast convergence of reserves to their long-run equilibrium.

The impact of exchange rate changes upon reserves can be depicted more clearly, using impulse response functions, which we construct next.

[18] We do not report the entire vector error-correction model. This was estimated with sixteen, eleven and sixteen lags respectively, corresponding to the three basic specifications of Section III and IV. The detailed VECM is obtainable from the author on request.

These trace the effect of a one standard deviation shock to the exchange rate upon current and future values of foreign exchange reserve changes (intervention) by the Reserve Bank. In the VAR model we considered above, (F_t, S_t), a shock to the exchange rate would affect itself and all other endogenous variables in the VAR system. A change in the error term e_{1t} will immediately change values of current as well future values of the variables, i.e. the exchange rate and reserves. The impulse response function for e_{1t} measures the effect of an unanticipated one-unit change or standard deviation shock upon current and future values of the two variables in the VAR.

We thus reordered the VAR arranged originally for the error-correction modelling, attributing the common component of the two error terms wholly to the error term of the exchange rate equation.[19] A surprise innovation to the exchange rate can then be transformed to eliminate the common component through the Cholesky decomposition, which decomposes the original VAR innovations. The resulting covariance matrix is then diagonal and calculates the consequences for current and future values of reserve changes due to a one standard deviation surprise element in the exchange rate, holding all other shocks constant.

Table 6 presents the point estimates for the impulse responses of reserve changes resulting from *a)* a one standard deviation (0.11) unanticipated increase, i.e. a depreciation, in the exchange rate and *b)* a one standard deviation (39.04) surprise increase in the target exchange rate adjusted for monthly changes in relative prices. The impulse responses indicate that unanticipated exchange rate shocks have their maximum impact on foreign exchange reserves in the first and second month. For example, an innovation results in decline in reserves through sales of US $ 150-260 million and oscillates for about a month after the shock. The effect of the shock then wears out and there is no significant effect thereafter.

[19] Since the two error terms e_{1t} and e_{2t} are likely to be correlated and hence carry an inseparable common component, a common (but arbitrary) method of dealing with this problem is to attribute the entire effect of any common component to the variables that features firs tin the VAR system (Hamilton, 1994).

Table 6
Impulse response of Foreign Exchange Reserves

Period (months)	Effect of one S.D. exchange rate Innovation upon reserves	Effect of one S.D. target exchange rate innovation upon reserves
1	-156.5*	16.39
2	-258.6*	-123.1*
3	-0.98	-109.5*
4	123.4	-80.8
5	7.21	-20.2
6	-29.9	-145.4

***indicates significance at one per cent level. Figures in columns are changes in the levels of foreign exchange reserves resulting from a one standard deviation increase in the shock variable.**

Figs. 3 and 4 display these responses derived from the table. Fig 3 shows that an unexpected depreciation in the exchange rate reduces reserves temporarily for two months *after* the shock, leaving the level of reserves lower than what it would have been. Subsequent impacts upon reserves are insignificant. Fig. 4 that displays the impulse response of reserves to a moving relative prices target shows a significant response of reserves in the second and third month. The two period lags suggests that some deviation from parity is tolerated before intervention takes place to align the exchange rate to price levels.

Fig. 3 Cumulative Response of Reserves to Exchange Rate Shock

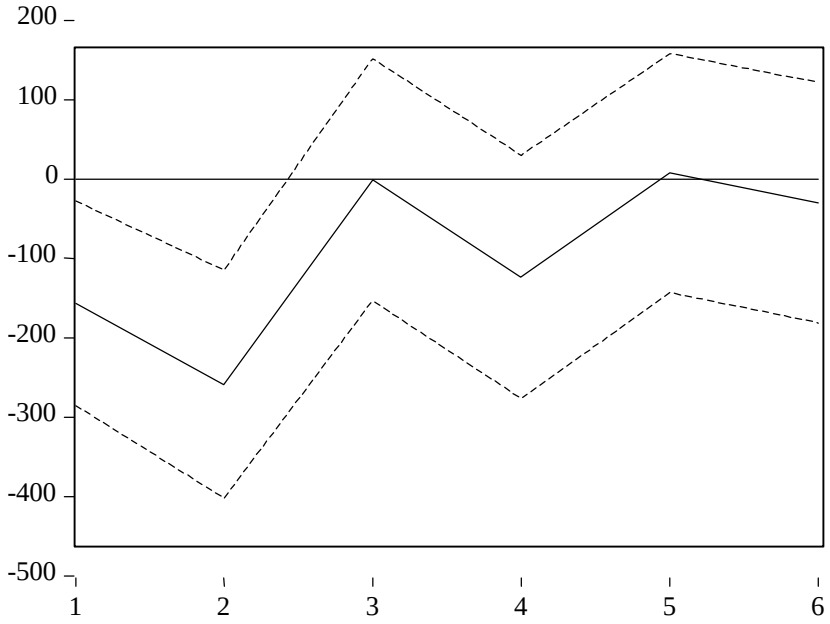
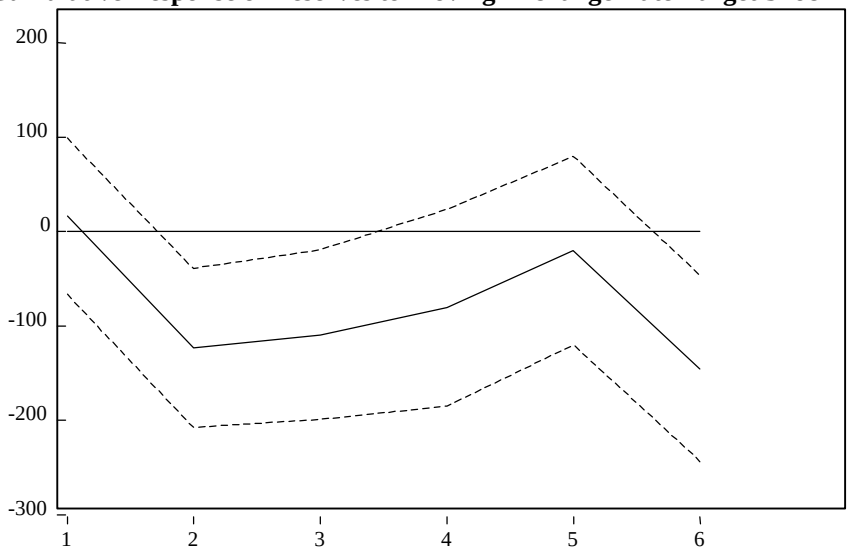


Fig. 4 Cumulative Response of Reserves to Moving Exchange Rate Target Shock



This is perfectly plausible since it is expected that the central bank takes into account whether the currency is overvalued or undervalued, i.e. the exchange rate is moving away or towards purchasing power parity. Since this involves computation of actual inflation rates, which are

available only with a certain lag, it is contemporarily not known whether the exchange rate is over or undervalued (Honegger, 1989). This response is consistent with the view that intervention responds periodically to price differentials, or the PPP rule, with occasional deviations. Nominal exchange rate adjustments therefore, appear to be brought about through intervention, when realignment is desired by the central bank.

An interesting implication of this result is that if the central bank has indeed been aligning the exchange rate to prices, then purchasing power parity ought to hold, at least for this period. This is confirmed by the PPP tests that we conducted on the data for the corresponding period. The results are reported in Appendix II. The ratio of wholesale prices (India-US) validates PPP for the 1993-99 period. The data also provides support for the hypothesis that parity with foreign price level holds for a more aggregate class of goods and to a large extent, for tradable goods. This is tested by substituting the ratio of wholesale to consumer price levels as proxies for the hypothesis that only the prices of tradable goods should be equalised across the two countries. In our knowledge, this is the only study that tests PPP for the floating exchange rate period; previous studies on this subject use the black market exchange rate for testing this hypothesis.[20] These results confirm the results of our earlier regressions and give additional support to the finding that the RBI stabilised the real exchange rate during this period.

V Conclusion

This paper has tried to assess which objectives the RBI pursued with its interventions in the foreign exchange market between 1993-98. It tested for the intervention strategy of the Reserve bank of India through a policy response function relating changes in foreign exchange reserves to variations in the nominal rupee-dollar exchange rate. We find a significant effort by the Reserve Bank to lean against the wind along with maintaining the spot rate in alignment with a moving relative (Indo-US) prices' target. We have been able to relate the interventions to the deviation from a target level for the rupee/dollar exchange rate. Additional support for this finding is provided by the fact that PPP holds for the market-determined exchange rate for the estimation period.

[20] Berg & Jayanetti (1995) test PPP for India, using the official and black market exchange rates for the period 1957-87. PPP holds according to this hypothesis as the three series are found to be cointegrated; the coefficient on relative prices (Indo-US) is > 0. Bagehstani (1997) finds similar evidence, using quarterly data for the period 1973:1-1991:2.

The results suggest a 'real targets' approach followed by the central bank, where the exchange rate is periodically adjusted to keep it aligned to inflation differentials between India and its trading partners. Thus the RBI appears to have tried to move the exchange rate close to purchasing power parity over the period 1993-98. The central importance of the real exchange rate in exchange rate management suggests that pronounced deviations from PPP are either not sustainable or not tolerated by the official authorities. This behaviour points towards specific objectives that the central bank wanted to attain, viz. exchange rate stability and improved competitiveness of the domestic industry. This also indicates consistency of the central bank in adhering to its stated exchange rate policy stance. These results must however, be interpreted with caution as a stable reaction function during the period of estimation does not necessarily imply similar future responses by the central bank since policy regimes are likely to change as has been pointed out by Lucas (1976).

One policy implication of this result is that economic agents, including speculators and market analysts, could be expected to attach considerable weight to PPP as a fundamental determinant of the exchange rate. As a consequence, agents' expectations could be built around deviations from PPP when the central bank might be expected to effect an 'adjustment' in the exchange rate through intervention. It is debatable however that this strategy will continue into the future as the economy undergoes further reforms in the external sector, particularly when the capital account is liberalised. International experience has shown that increased capital mobility exposes the economy to higher exchange rate volatility caused by speculative, destabilising capital flows rather than the fundamental determinants of exchange rates. Empirical evidence also shows the random walk model of exchange rate behaviour outperforming the 'fundamentals' model for short horizons. Intervention strategy in such a scenario is more likely to be focused on smoothening extremely short-term exchange rate fluctuations, and perhaps preserving some potential exchange rate flexibility to allow for exogenous shocks.

Indeed, signals on current exchange rate policy (December 1999) by the Reserve Bank confirm this view to some extent. To quote "…Reserve Bank's intervention is to be viewed as ensuring orderly market conditions…while allowing market forces sufficient flexibility to determine exchange rate in alignment with fundamentals…exchange rate policy is guided by the need to reduce excess volatility, prevent the emergence of destabilising speculative activities, help maintain adequate level of

reserves and develop an orderly foreign exchange market…"[21], indicates that maintaining international competitiveness is no longer a policy objective. This is confirmed by the admission that "…in an increasingly open capital account, the price competitiveness of exports arising out of exchange rate movements cannot be the sole criterion of exchange rate intervention."[22]

[21] Report on Currency and Finance, 1998-99: X-12, RBI, Mumbai, December 1999.

[22] *Ibid:* X-18.

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Appendix I

Monetary Measures used by RBI to Counter Exchange Rate Movements: 1994-98

	Cash Reserve/Statutory Liquidity Ratio Changes	Interest Rate changes	Other Direct Measures
Oct. 1995	Increases in NRER, NR(NR)RD a/cs over their outstanding levels on Oct. 27, 1995 exempted from CRR requirements.	Rise in interest rate on NRER deposits; interest surcharge on import finance; reduction in interest rate concessions on export finance between 3-6 months	
Jan-Feb 1996	CRR requirements for all FCNR (B) and NR(NR) Deposits relaxed; average CRR on NRER liabilities reduced from 14 to 12 per cent.	Interest rate surcharge on import finance raised from 15 to 25 per cent; interest rates on post-shipment export credit freed to expedite exports payments into the country.	
Apr 1996	NRER deposits exempted from CRR requirements; SLR on NRER reduced from 30 to 25 %.	Interest rates on NRER term deposits over two years freed.	
Nov-Dec 1997	CRR increased by 0.5 %; incremental CRR of 10 % on	Interest rate on post-shipment export credit increased from 13	

	NR(E)RA and NR(NR) removed;	to 15 %; interest rate on fixed rate repos increased by 0.5 %;	
Jan. 1998	Bank rate raised from 9 to 11 %; CRR raised from 10 to 10.5 %; general refinance limit reduced from 1 to 0.25 % of fortnightly average outstanding aggregate deposits; export refinance limit reduced from 100 to 50 % of the increase in outstanding export credit eligible for such refinance over the level of such credit as on Jan 16, 1996;	Interest rate on fixed rate repos increased from 7 to 9 %;	Banks barred from offering forward contracts based on past performance; declaration of exposure suspended;
June 1998		Lowering of interest rate on export credit on 'incremental exports' over the base year level of exports in 1997-98;	Merchants advised to monitor credit utilisation to meet genuine foreign exchange demand but not unanticipated import requirements beyond a reasonable period to discourage inventory build-up; domestic financial intermediaries to buy back their won debt or other Indian paper from the international market; Banks acting on behalf of FIIs allowed to but foreign exchange directly

			from the RBI at the prevailing market rate.
Aug 1998	CRR maintained by banks raised from 10 to 11 %; CRR – cash reserve ratio; NRER, NR(NR)RD, FCNR(B) etc. –various categories of Non-resident accounts ADs – authorised dealers	Interest rate on fixed rate repos hiked from 5 to 8 %;	ADs allowed to offer forward cover directly to FIIs upto 15 % of their investment as on June 11, 1998; rebooking of cancelled import contracts forbidden; facility for splitting forward and spot leg for a commitment withdrawn; extension of time limit for realisation of export payments allowed only in exceptional circumstances; ADs advised to report their peak intra-day positions.

Appendix II

Two-stage least squares estimation

Estimates of equations 1-3 in Table 5 were obtained using 2SLS with LIBOR, redemption yield rate on government securities (Indian), the money market rate (Indian), industrial production index (India and US) serving as first-stage instruments for the endogenous nominal exchange rate. Plots of the autocorrelation and partial autocorrelation functions of the residuals, together with the Ljung-Box Q-statistics were used to test for the presence of significant serial correlation. All equations showed a significant low-order autoregressive error process. The data was then transformed to correct for AR (1) error process in all three equations. The equations were found to have no significant serial correlation once the data had been transformed

VAR estimation

The ADF regressions assumed a random walk process with a drift and a deterministic time trend. Specification tests for order of the VAR suggested a VAR (16, 11, 16) process for the three respective specifications. Tests for the presence of an intercept term in the data generating process of all models showed an insignificant c^2 test statistic, justifying the presence of an intercept in the cointegrating vector. Testing for a long-run equilibrium relationship, i.e. cointegration, amongst the I (1) variables was done using the econometric methodology due to Johansen and Juselius (1990). Table 3 presents the results of the cointegration analysis along with the trace statistic (l_{trace}) for these three models.

Table 1
Cointegration Analysis of models 1-3

		Model 1(F_t, S_t)	**Model 2**(F_t, , $_*$)	**Model 3**(F_t, , $_{*93}$)
H_0	H_1	l_{trace}	l_{trace}	l_{trace}
R=0	r>0	16.65*	49.44	35.65
R=1	r>1	0.18	20.80	20.04
R=2	r>2	-	4.96	6.65

*** and * indicate significance at 1 and 5 per cent levels respectively.*

The results indicate that the hypothesis of one cointegrating rank of the matrix is accepted (r>1 rejected) at the 1 per cent level, but r=0 is clearly rejected, leading to the conclusion of one cointegrating vector in a stationary VAR process of models 1 and 3. For model 3, the hypothesis of r=1 and r>2 is rejected at one per cent level of significance, pointing to the existence of two cointegrating vectors in the data generating process. The maximum likelihood estimation of the cointegrated system was done in the next stage in an error correction model (ECM) format. The long-run relationship was imposed as a restriction upon the VAR, so that the system was just identified.

PPP Tests

PPP was tested using monthly data for 1993:03-99:12, choosing the United States as the base country. Absolute purchasing power parity requires that the exchange rate equalise the price level in the two countries. Table 2 presents the results of tests for absolute purchasing power parity.

Table 2
Tests for Absolute PPP

$s_t = b\left(p_t - p_t^*\right)_t + u_t$

Series	Cointegrating Vector	CPI	WPI	WPI/CPI	Adjustment Coefficient
S	Yes	-0.478			-0.203
		(0.043)			(0.087)
S	Yes		1.048*		0.016
			(0.370)		(0.092)
S	Yes*			1.662*	-0-009
				(0.518)	(0.105)

All variables are in logarithms. Figures in parentheses are standard errors.
** indicates significance at 1%.*

Column 2 of the table reports that the null of no cointegration is rejected significantly in all the cases confirming an equilibrium relationship between the price of foreign exchange and the foreign and domestic price levels,

i.e. PPP holds in the long run. The estimated long-run equilibrium relationships, which test for absolute PPP, are reported in the next three columns. PPP requires that the coefficient on $b = 1$. The value of the coefficient with respect to the ratio of wholesale prices validates PPP for the 1993-99 period. Consistent with empirical evidence on PPP from numerous other studies, the results are sensitive to choice of price index. When the log of nominal spot rate is regressed on the relative ratios of wholesale/consumer price levels in India and US respectively, we find a positive and statistically significant exchange rate response to this variable. The ratio of wholesale to consumer price levels proxies for the hypothesis that only the prices of tradable goods should be equalised across the two countries The magnitude of the coefficient on this price variable exceeds its predicted value of unity though. The data thus provides support for the hypothesis that parity with foreign price level holds for a more aggregate class of goods and to a large extent, for tradable goods.