

Excess Returns, Risk-Premia and Efficiency of the Foreign Exchange Market: Indian Experience in the Post Liberalisation Period

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This paper tests the market efficiency hypothesis for Indian foreign exchange market by estimating spot and forward Indian rupee – US Dollar exchange rate regressions. It also presents a dynamic model of the spot and forward exchange rates as a vector ARMA process. The sample and model-generated moments are analysed to obtain information on the behaviour of spot and forward exchange rates, including that of their transitory and permanent components. Empirical evidence suggests that: (i) the Indian foreign exchange market is not efficient, (ii) forward premiums are persistent, and (iii) the volatility of expected depreciation is larger than implied excess returns. The empirical evidence also points out that the permanent or fundamental component of the exchange rate predominates in determining its variations. This evidence implies that the stability of exchange rate in the Indian economy depends on the fundamentals.

Introduction

The counter-intuitive behaviour of excess returns encountered in foreign exchange markets has been a long-standing puzzle. Ex-ante, expected home currency returns on foreign deposits in excess of domestic deposits should be zero. Yet, empirical evidence overwhelmingly supports the presence of deviations from the uncovered interest parity (UIP), implying the existence of excess returns in the foreign exchange markets. There are many potential explanations of this observed irregularity and the issue warrants proper empirical investigation. With this objective in view, this paper attempts to model the dynamics of spot and forward exchange rates in the Indian foreign exchange (FOREX) market. Forward exchange markets have come into play only recently following the far-reaching reforms initiated in mid-1991 and phased move towards liberalisation of current and capital accounts, which led to full current account convertibility in 1993. With the convertibility of the

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rupee in 1993, the exchange rate essentially became market determined and market participants activated an otherwise dormant forward market. With significant capital account convertibility for the non-resident flows over last six years and integration of the domestic capital markets with global markets, exchange market became volatile for the first time in 1995, bringing to fore the importance of the forward market. Presently, the foreign exchange market has become closely integrated with the short-term money market. Liquidity changes are seen to spill over quickly to the FOREX markets in recent times and vice-versa. In this backdrop, the forward rates have become significantly associated, both with the spot rate of rupee and the short-term interest rates in general. The central bank has intervened time and again in both the spot and the forward markets, largely to influence the value of the currency and to a lesser extent to affect the monetary conditions. FOREX markets in India have three main segments – spot, forward and swap. Trading takes place among “authorised dealers (ADs)”, which are mainly commercial banks. They primarily trade on their own behalf or on behalf of large customers, besides conducting retail business for individuals or small business. Some ADs also buy/sell on behalf of the Reserve Bank, facilitating central bank intervention. Central bank intervenes in all three segments of the market, but not all its swap operations are conducted with a view to influence the exchange rate. Many of its swap operations are conducted with the objective of managing domestic liquidity.¹ Recently, in view of the disturbing developments in the East Asian markets, the intervention in forward market was stepped up to control the contagion effect. However, the pressures on rupee abated with the announcement of a series of monetary and credit policy measures.² The later measures were addressed at the basic demand and supply factors affecting the exchange rate. To the extent that excess returns and risk premia in the Indian foreign exchange market have become a recurrent phenomenon, the nature of the movements need a thorough examination in the context of exchange rate policy. This paper attempts to bridge the gap in the literature by modeling the spot and the forward Indian rupee-US dollar rates and examining the prevalence of excess returns and risk premia in the market over the period 1993:04-1998:01.

The rest of the paper is schematized as follows: Section I surveys the efficiency hypothesis of exchange rate and provides possible explanations for puzzles regarding the empirical regularity of excess returns, unbiasedness, market inefficiencies, systematic inefficiencies and risk premia. Section II traces the recent development in Indian foreign exchange markets, particularly the forward market and its links with money market. Section III provides the test for market efficiency. Section IV develops a model of spot and forward rates and estimating it as a vector autoregressive moving-average (VARMA) process using maximum likelihood procedure. The model provides evidence on the behaviour of excess returns and risk-premia, and the permanent and transitory components of exchange rate. Section V concludes by presenting a synoptic view of the findings in terms of its policy implications.

Section I Market Efficiency and the Excess Returns

The prevalence of excess returns in the foreign exchange markets is one of the intractable puzzles in the international finance literature. If markets were efficient, then forward rates must be unbiased predictors of future spot rates and no excess returns should exist in the markets. Traditionally, this was tested by regressing k -period ahead spot rate on the k -period forward rates prevailing at a particular time- t :

$$S_{t+k} = \beta_0 + \beta_1 f_{k,t} + u_{k,t} \quad \dots(1)$$

Where S_{t+k} is the spot exchange rate prevailing at time $t+k$, $f_{k,t}$ is the k -period ahead forward rate prevailing at time, β_0 and β_1 are parameters, while $u_{k,t}$ is the white noise term. The efficient market hypothesis was considered to hold if the joint hypothesis of $\beta_0=0$, $\beta_1=1$ and $E(u_t u_{t-i}) = 0 \quad \forall i \neq 0$ is not rejected. Bilson (1981) and Frankel (1981) may be cited as examples. In most such empirical studies this simple test yielded mixed evidence. On the one hand, when the equation was estimated after subtracting forward rates from both sides of the equation, in most cases it was not possible to reject the hypothesis of constant and slope coefficients.

But the equations were often affected by presence of serial correlation. Besides, in many cases, the slope equation of the transformed equation was closer to -1 rather than being zero indicating that forward premium may be unrelated to actual rate of depreciation. Evidence against efficient market hypothesis was also obtained by Hansen and Hodrick (1980) and Hakkio (1981), though they cautioned that rejection of the hypothesis should not be readily identified with inefficiency in the exchange market as possible statistical explanations exist for the results.³

Simple OLS regressions of the above kind suffered from problems of stationarity and inferences drawn by them were soon realised to be spurious. Cumby and Obstfeld (1984) and Fama (1984) overcame this problem by transforming the data so as to test market efficiency by regressing future depreciation on forward premiums:

$$\Delta_k S_{t+k} = \beta_0 + \beta_1 f_{k,t}^p + v_{k,t} \quad \dots (2)$$

Where $\Delta_k S_{t+k}$ denote the depreciation of the spot rate between periods t and $t+k$, $f_{k,t}^p$ denote the k -period forward premium prevailing at time t , and as before β_0 and β_1 are parameters, while $v_{k,t}$ is the error term obtained by ordinary least square (OLS) regression. Again, the efficient market hypothesis would hold if it was found that $\beta_0=0$ and $\beta_1=1$ and have t -ratios such that the constant and slope coefficients are statistically significant. Lewis (1995) points out that the regression could be analogous to testing:

$$er_{t+k} = \beta_0 + \beta_1 (f_{k,t} - S_t) + u_{k,t} \quad \dots (3)$$

Where er_{t+k} denote the excess returns of k -period future spot rate (S_{t+k}) over k -period ahead forward rate prevailing at time t ($f_{k,t}$). However, the equality of equations (2) and (3) depend on $\beta_0=0$ in (2) and the slope coefficient being equal to '1 plus the slope coefficient of (3)'. Note that excess returns are regressed on forward premiums to test for efficiency in this case, with S_t denoting the spot rate prevailing at time- t . The efficient market hypothesis is tested in this case with the null hypothesis of $\beta_1=0$. In either case of (2) or (3), it is recognised that excess returns consist of a pre-

dictable excess return component and statistical error terms, which equals the expression $(S_{t+k} - E_t S_{t+k})$, where E_t denote expectations operator denoting statistical (or expectation can be market-based) expectation prevailing at time t of spot rate at time $t+k$. Empirical evidence based on (2) or (3) have also tended to reject the efficient market hypothesis in general. This includes the findings of Cumby and Obstfeld (1984) and Fama (1984).⁴

The unbiasedness hypothesis has also been rejected using time-series evidence in a number of studies. For example, Domwitz and Hakkio (1985), model forecast errors as an autoregressive conditional heteroscedasticity (ARCH) process and obtain evidence for non-zero constant risk-premium for some countries in their sample. Kaminsky and Peruga (1990) and Baillie and Osterberg (1991) specify GARCH-in-mean models to provide evidence of non-zero risk premiums. In this paper, we model market efficiency through simple cointegrating process and employ a time-series VARMA model to provide additional information about the relationship between spot and forward rates.

Widespread evidence on existence of bias in forward premia/discount in the FOREX markets has been a puzzle, which has defied easy explanations. If agents are rational and risk-neutral and transaction costs do not matter, then forward premia/discount should be an unbiased predictor of future spot rate depreciation/appreciation. Generally this is not the case. Exchange rate literature has advanced several possible explanations for this. Existence of time-varying risk-premium is most popular of these. However, empirical models incorporating risk premia (Hodrick, 1987; Cumby, 1988; and Baillie and Bollerslev, 1990) have provided an inadequate explanation for the bias. Also, theoretically, the estimates of risk premia are much smaller than observed bias (Frankel, 1988; Engel, 1992). Alternative explanation has been provided by Rogoff (1979) and Krasker (1980) who raise the possibility of small samples and peso problem. Lewis (1989) suggests that small period can also result in absence of learning effects for the market participants. Gruen and Gizyaki (1993) propose the possibility of anchor for exchange rate expectations as one of the possible reasons for bias.

Baldwin (1990) raises the possibility of transactions costs arising such that for small interest rate differentials, it is not optimal for capital flows to operate to restore interest parity. Yet, the empirical results are generally inconsistent with market efficiency, even when we take into account these possible explanations. In any case if forward rates are biased predictors of future spot rates, there are important implications for exchange rate management and for central bank intervention.

Section II

The Spot and the Forward Rate in the Indian FOREX Markets

Across the globe, FOREX markets are found to be notorious in terms of efficiency in that the prevailing forward rates do not fully reflect the available information. In India, FOREX markets are still underdeveloped in terms of instruments and practices and market efficiency is even more unlikely to prevail. Bokil (1995) attributes the thinness of the market to regulations preventing interest arbitragers and speculators to freely operate in the market. He notes that large interest differentials prevail, but they have no relation with corresponding annualised premia. Yet, the forward market despite being thin is growing rapidly. Far-reaching changes have occurred in the 1990s and the joint dynamics of the spot and forward rate for the Indian rupee has become increasingly relevant in the conduct of exchange rate policy. The reforms of the FOREX market were initiated with a two-step downward adjustment of rupee in mid-1991. This was followed by the initiation of a system of dual exchange rates from March 1, 1992 under the Liberalised Exchange Rate System (LERMS), following the recommendation of the High Level Committee of Balance of Payments (Chairman: Dr. C. Rangarajan) (RBI, 1993). The dual exchange rate system constituted an implicit tax on exporters and on remittances and the exchange rate was quickly unified after a year by modifying the LERMS. The modified LERMS set up the system of market determined exchange rate effective March 2, 1993 and after further removing some of the remaining restrictions on current account transactions, India accepted the obligations under Article VIII of the

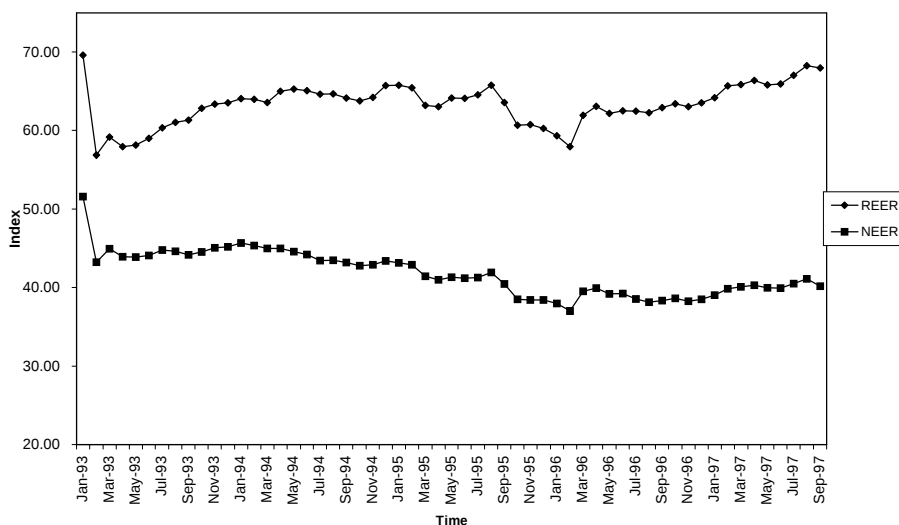
IMF's Articles of Agreement, making Rupee fully convertible on current account.

The reforms in the forward exchange market began in March 1992, with the RBI granting permission to corporates for unrestricted booking and cancellation of forward contracts for genuine exposures, both trade-related and others. Trading in forward market, however, remained thin as the nominal spot rate of Indian Rupee-US Dollar remained fairly stable till mid-1995. One of the reasons for apparent illiquidity was the lack of freedom to book cross-currency options. Customers with cross-currency exposures were permitted to split their cover through the dollar since February 1992, but it was only in December 1994 that the central bank permitted customers to take cover in a currency of their choice, which could be a currency other than one in which the payables / receivables were denominated. Cross-currency options as a hedge product was introduced in January 1994, but only on a fully covered basis. The rupee based cross-currency options are still not introduced in absence of integration of the term-structure of interest rates and a well-defined yield curve. Tarapore (1993) notes that increased interaction between domestic and international monetary policy began during this phase. During the LERMS period, the inter-bank swap premia ruled consistently above the RBI premia up to November 1992 – a period marked by tight conditions in the call money market, but the premia rates got aligned during November 1992 – March 1993. Following the unification of the exchange rate the inter-bank premia declined, specially in the period July-August 1993.

The forward market in India became active only since mid-1995. Forward premia after remaining high in early 1993, settled down and the FOREX market remained remarkably stable during the period August 1993 – September 1995. The annualised 3-month forward premia averaged 3.55 per cent, while the 6-month premia averaged 3.97. Though the premia had risen somewhat in the first quarter of 1995, it remained much below the 10 per cent mark. The 3-month forward premia, however, touched a peak of 27.06 per cent per annum in March, 1996 in anticipation of depreciation and prevailing tight liquidity conditions reflected in relatively high

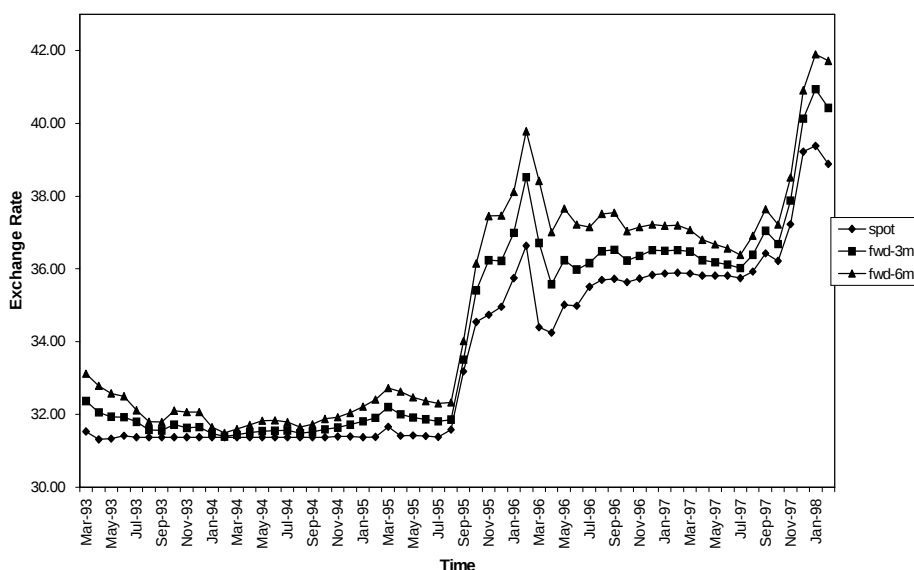
short-term interest rates. Forward premia, declined however since mid-1996, with improvement in liquidity condition and reached moderate levels of a little over 3 per cent by mid-1997. The decline in the forward premia was accompanied by wider divergence between the real effective exchange rate of rupee (REER) and the nominal effective exchange rate of rupee (NEER), indicating that the currency was becoming somewhat overvalued (Figure-1).

Figure 1 : REER & NEER



The exchange market, however, did not react to indication of currency overvaluation until quite later. The RBI responded in the later half of 1997 by further relaxing the monetary policy by a 100 basis point cut in bank rate and planned reduction in reserve requirements by 2 percentage points of net demand and time liabilities. However, excess liquidity spilled over and led to speculation of depreciation of Rupee with contagion arising from on-going financial crisis in East Asia. Large currency depreciations in East Asia generated expectations of competitive depreciation of Rupee. These sentiments resulted in forward premia rising once again and the 3-month premia crossed 15 per cent mark in early 1998. The 6-month premia has generally mimicked the 3-month premia, though the divergence between spot and forward rates has arisen, whenever the forward premia came under pressure (Figure-2).

Fig. 2 : SPOT & FORWARD INR-USD RATES
(monthly averages: spot, 3-month & 6-month forwards)



The growing forward market in India has brought about integration of the FOREX market with other financial markets, particularly the short-term money market. While the linkage of the FOREX market with the money market was weak during the pre-LERMS period the transmission mechanism got greatly strengthened once the exchange rate got market determined and forward market was activated. Two factors played an important role in this transition. First, with frequent changes in local currency reserve requirements for commercial banks, the banks resorted to frequent use of swaps to augment their level of reserves and meet their reserve requirements. Second, in events of tight money conditions reflected in high call money rates, banks took recourse to swaps acquiring spot rupees for forward dollars. The swap premia tends to rise along with call rates as a result. However, the market still remains underdeveloped due to a number of factors. First, a cautious approach requires the banks to maintain a square or near-square end-day positions. Second, banks are not permitted to take cross-currency positions overseas. Third, the rupee-based derivative market is nearly non-existent. Fourth, there is lack of depth in the market on account of moderate liquidity of money markets. Fifth, the trading base remains nar-

row on account of virtual absence of non-bank participation in trading. The Sodhani Committee Report (RBI, 1995) has made several recommendations to activate trading in forward markets. While, exchange market reforms are being pursued with caution, the role of forward markets have become central to the currency risk management for the financial institutions and corporate entities. As a result, statistical evidence on market efficiency, excess returns and risk premia have become important in the present dispensation.

Section III

A Test for Market Efficiency

As discussed in Section II, the empirical verification of efficiency of foreign exchange markets has been a subject of extensive investigation in empirical literature. Sadly, most of the research in this area pertains to the markets in developed economies and research for testing efficiency in less developed markets has been scanty. This is partly because most developing economies have only recently begun liberalising their exchange markets. Here we explicitly test the market efficiency for the Indian FOREX markets using the Indian rupee-US dollar rate using both equations (1) and (2), though for obvious statistical reasons, earlier enumerated in Section II, we base our inferences on the second equation, treating the first merely for expository purposes. The results are given in Table-I below:

The empirical estimates in Table I suggest that, even though equation (i) fails to establish cointegration between the future spot and the current forward rates, the coefficient β_0 is not significantly different from one, which establishes the existence of efficiency in the Indian exchange market. However, since not much reliance can be placed on inferences based on generic unit root tests in finite samples; the alternative is to estimate equation (ii). The estimated equation (ii), however, suggests that the hypothesis of efficiency can be rejected since the estimated β_1 turns out to be insignificant.⁵

Table I : Testing the Efficiency of Indian Foreign Exchange Market

Equation (i)

$$s_{t+k} = 0.32 + 0.90 f_{kt} \quad , k=3$$

$$(1.55) \quad (15.15)$$

$$Rbarsq = 0.80, \quad SEE = 0.03, \quad DW=0.36 \quad \text{and}$$

PP Test (residuals) = -1.208; 5% MacKinnon (1991) critical value of -3.34 against the null of random walk.

Equation (ii)

$$\Delta_k S_{t+k} = 0.0056 + 0.28 f_{kt}^p \quad , k=3$$

$$(0.45) \quad (0.69)$$

$$Rbarsq = 0.49, \quad SEE = 0.02, \quad DW = 1.31, \quad Q(11) \quad 23.74$$

Note to Table I :

- (i) The period of estimation was from April 1993 to January 1998.
- (ii) Both regressions are estimated for 3 month forward exchange rate of the rupee to US dollar.

There could be several possible explanations for rejections of the efficient market hypothesis. Under the rational expectations hypothesis (REH), ex-post excess returns should match market's true expected returns, plus a forecast error that may be unpredictable ex-ante. If this is true, then the existence of excess returns must be identical to foreign exchange risk-premia. But, excess returns could exist as systematic forecast errors and not necessarily as risk premia if market forecasts are irrational or if the distribution of errors measured statistically are different from distribution of disturbances perceived by the traders. It is also possible, that absence of a vibrant forward market with adequate liquidity and availability of hedge instruments, makes the market inefficient.

Section IV

A Time-series model for spot and forward rates

While one of the purposes of the present paper is to test for the exchange market efficiency in the Indian economy, an equally important objective is to develop a parametric time series model of the spot and forward rates so as to understand the mechanism of exchange rate dynamics including its relationship with forward rate. This model would then be employed to generate estimates of the unobserved expected currency returns and expected depreciation and the results compared with actual data to test the adequacy of the empirical exercise. The methodological approach taken here is that of Hai *et.al* (1997), who estimate a two component parametric time series model of the spot and forward exchange rates for Yen, Franc and the British Pound by setting up a vector autoregressive moving average (VARMA) model and solving it by Kalman Filter (KF) and maximum likelihood (ML) methods. In a departure from this original method, we attempt a direct estimation of VARMA through ML method and thus bypass the KF routine. This simplification is not expected to produce any significant changes in the direction of results due to the choice of a structurally uniform sample, which spans the post liberalisation era in the exchange market from April 1993 to January 1998.

The model assumes that both spot and forward foreign exchange rates can be represented as having a driftless common random walk component but with different temporary (or disequilibrium) components, each represented as a persistent stochastic process as follows:

$$\text{Spot Exchange Rate : } s_t = z_t + x_{s,t} \quad \dots(4)$$

$$\text{Forward Exchange Rate : } f_t = z_t + x_{f,t} \quad \dots(5)$$

$$\text{Common Random Walk : } z_t = z_{t-1} + \varepsilon_{z,t} \quad \dots(6)$$

where x_{st} and x_{ft} are the structural stochastic processes associated with the spot s_t and forward f_t exchange rate, respectively and z_t is

the random walk element common to both the spot and the forward rates. In addition, it is also assumed that:

$$\{\varepsilon_{zt}\} \sim N(0, \sigma_z^2)$$

$\{(x_{st} \text{ and } x_{ft})\}$ is a stationary bivariate stochastic process,

$f_t^p = x_{st} - x_{ft}$ is the implied excess returns from forward speculation and,

$$x_{st} = \theta \xi_t$$

where θ is inverse of the economy's speed of adjustment coefficient which depends on the other parameters of the model and ξ theoretically measures the state of disequilibrium in the goods market. As can easily be observed, the proposed structure is essentially a two component model of the spot and forward rates where the common random walk component is the 'implied' value of the exchange rate in the absence of nominal rigidities and can be thought of as the 'fundamental' or 'long-run equilibrium' value of the exchange rate' and can also be designated as the permanent component of the exchange rate. The fundamental component of the exchange rate is theoretically a function of domestic and foreign money stocks, income and aggregate demand shocks. On the other hand, the temporary but persistent components x_{st} and x_{ft} are deviations from their respective fundamental values of the spot and forward exchange rates and are interpreted as disequilibrium errors. As Hai *et al* (1997) indicate, the two component model is actually a stochastic generalisation of Dornbush's (1976) exchange rate overshooting model developed in Mussa (1982) where the operation of frictionless asset markets combined with commodity price adjustments lead to a two component representation for the exchange rate – a permanent value and a transitory component. The fundamental value being a stochastic trend modeled as a pure random walk.

In terms of the methodological procedure, no *a-priori* restrictions are placed on the behaviour of (x_{st}, x_{ft}) except that the process is

stationary (or I(0)). Thus if the stochastic process (x_{st}, x_{ft}) satisfies the criterion of stationarity, the model for spot and forward exchange rate disequilibrium can be set up as an unrestricted vector ARMA process. The VARMA (1,1) process in this case may be represented as:

$$\begin{bmatrix} 1-\phi_{ss}L & -\phi_{sf}L \\ -\phi_{fs}L & 1-\phi_{ff}L \end{bmatrix} \begin{bmatrix} x_{s,t} \\ x_{f,t} \end{bmatrix} = \begin{bmatrix} c_s \\ c_f \end{bmatrix} + \begin{bmatrix} 1+\theta_{ss}L & \theta_{fs}L \\ \theta_{fs}L & 1+\theta_{ff}L \end{bmatrix} \begin{bmatrix} \varepsilon_{s,t} \\ \varepsilon_{f,t} \end{bmatrix} \quad \dots(7)$$

Where the innovation vector is normally and independently distributed.

Alternatively, the model written in a complete form as:

$$y_t = \zeta z_t + x_t, \text{ where } y_t = (s_t, f_{k,t})', \zeta = (1,1)', z_t = z_{t-1} + \varepsilon_{zt}, \varepsilon_{zt} \sim N(0, \sigma_z^2)$$

ε_{zt} being i.i.d.and,

$$x_t = c + \phi x_{t-1} + \varepsilon_t + \Theta \varepsilon_{t-1}, \varepsilon_t = (\varepsilon_{s,t}, \varepsilon_{f,t})' \text{ i.i.d. } \sim N(0, \Sigma), \text{ with}$$

$$\Sigma = \begin{bmatrix} \sigma_s^2 & \rho_{sf} \sigma_s \sigma_f \\ \rho_{sf} \sigma_s \sigma_f & \sigma_f^2 \end{bmatrix} \quad \dots(8)$$

ϕ and Θ are (2x2) parameter matrices of the AR and MA terms respectively, and c is the (2x1) vector of constants and $x_t = (x_{st}, x_{ft})$ as already defined is a bivariate stochastic process and Σ is the variance-covariance matrix of the error process $(\varepsilon_{st}, \varepsilon_{ft})$.

Empirical results of the model are presented in Table-II below:

Table II : VARMA (1,1) Model of Spot and Forward Exchange Rates for India - April 1993 to January 1998

c	ϕ		Θ		σ_s^2	σ_f^2	ρ_{sf}
-0.0026 (0.00003)	-0.38 (0.029)	-0.12 (0.0003)	1.04 (0.02)	0.14 (0.02)	0.0014 (0.00002)	0.00016 (0.00003)	0.147 (0.00002)
-0.00018 (0.00084)	0.77 (0.04)	-0.88 (0.07)	0.37 (0.07)	0.76, (0.08),	Qs(13) = 6.30, p-value =0.93 Qf(13) = 6.81, p-value =0.91		

Optimized log-likelihood = -492.03

Notes to Table II :

- (i) Exchange rate is the nominal rupee equivalent of one US dollar.
- (ii) $Q_s(13)$ and $Q_f(13)$ statistics are the respective Ljung-Box χ^2 statistics for testing the whiteness of the implied random walk innovations in the spot and 3 month forward exchange rates..
- (iii) ρ_{sf} is the implied correlation between the random walk innovations of the spot and the forward exchange rates.
- (iv) Figures in parantheses are asymptotic standard errors.
- (v) The nonlinear optimisation routine of Berndt, Hall, Hall and Hausman was used to maximise the log-likelihood function.

As the empirical results in Table II, especially the estimated Box-Ljung statistics for the random walk innovations suggest the null hypothesis for both spot and the forward rates cannot be rejected, thus, validating the rationale of the choice of our specification. Of the other properties, the standard errors pertaining to the estimated coefficients are generally small, thus lending statistical significance to the empirical results. As in the case of many other studies, the exchange rate variability in the Indian market is dominated by random walk component. While the standard error of the percentage changes in exchange rate is 1.58; that of random walk innovations is estimated close to 1.68, which is not significantly different from the former. It is for the reason that the permanent component shows unpredictable changes that most macroeconomic exchange rate forecasting studies end up in failing to outperform the random walk model.

In Table III are presented a comparison of several sample and implied (model generated) information which is expected to shed a

good deal of light on the behaviour of the dynamics of the spot and the forward rates:

Table III : Sample and Model Generated Information on Exchange Rate Dynamics

	<i>Rupee/US dollar Exchange Rate</i>	
	<i>Sample Based</i>	<i>Model Generated</i>
Var (TC Innovations-Spot)	n.a	0.0081
Var (TC Innovations-Forward)	n.a	0.0087
Cov (TC Innovations Spot/Forward)	n.a	0.0079
Var (Depreciation)	0.0082	0.0088
Var (Forward Premium)	0.00017	0.00015
β_1	0.28	0.04
First Order Auto Correlation of Forward Premium	0.82	0.79
Var (3 Month Excess Returns)	0.0010	0.0012
First Order Autocorrelation of 3 Months Excess Returns	0.75	0.66

Notes to Table III :

(i) 'TC innovations' implies the innovations of the transitory components, viz., $(\varepsilon_{st}, \varepsilon_{ft})$. Var(.) implies a variance estimate.

The estimates in Table III indicate that the model performs reasonably well. Of notable significance is the higher first order autocorrelation of the implied forward premium and excess returns, both of which not only match well with their respective sample estimates but are also marked by considerable persistence. All other estimates, except the coefficient β_1 , are also found to compare adequately with their respective sample estimates. The estimated β_1 does not match very well with the traditional sample estimate even though it has a correct positive sign. Interestingly, the parametric value of β_1 is not negative as is generally obtained in empirical studies for developed foreign exchange markets. The results in Table III also suggest that the variance of implied excess returns is

less than that of implied depreciation which once again points towards the importance of fundamental factors in exchange rate dynamics and the market's failure to correctly foresee future depreciation of domestic currency.

Of critical importance in any empirical exercise is the tracking performance of the estimated model. Plots of model generated spot and forward rates and of forward premia and excess returns are presented in figures V and VI, respectively, against the sample of actual data (see Tracking Performance of VARMA (1,1) model, Figures III-VI). The visual evidence suggests that the performance of the estimated model is quite reasonable in terms of its ability to capture temporal variations of the actual data, which makes it a useful tool for foreign exchange market analysis. This is also striking in a sense that though the Indian FOREX market has not been completely deregulated, the market participants do appear to have been taking into account the importance of the fundamentals of the economy in determination of the exchange rate.

Section V

Conclusions

In terms of the empirical results presented in this paper, the Indian foreign exchange market like many others does not pass the test of efficiency implying that the forward exchange rate cannot be said to be an unbiased predictor of the future spot rate. One of the policy implications of this result is that since the events in the spot and forward markets are somewhat insulated from each other, intervention in one market needs to be supplemented by intervention in the other. The RBI intervention has generally been passive during periods when exchange rate has been relatively stable. However, on occasions the central bank has been compelled to step-up intervention, by selling dollars forward to cool forward premia, or by conducting buy/sell operations to dampen high intra-day or day-to-day volatility. It also undertakes swaps when forward premia goes out of alignment with domestic short-term interest rates or sometimes even to simply smoothen the maturity profile of forward liabilities and ensure that forward liabilities remain prudent in size. Ordinarily

swaps would not influence the forward rate, but swaps are useful not just for altering monetary conditions, but also for exchange rate management. However, there are limits to forward market intervention, specially in the long-run. A time series model of the spot and the forward exchange rate estimated as a VARMA process provided insights into the exchange rate dynamics. A notable inference is the presence of higher volatility of the permanent component of the spot exchange rate against its temporary component thus implying the dominant role played by fundamentals in determining exchange rate variations. The predominant role of the permanent component established in the paper supports the RBI strategy of concentrating on fundamentals in the economy and modulating the monetary conditions, whenever necessary for bringing orderly conditions in the exchange market. From a policy point of view, the results underscore the importance of the policy of intervention in different market segments as needed and its emphasis on continuous monitoring of the critical fundamentals of the economy to ensure their reflection on the exchange rate.

Notes:

1. Such swap operations are typically associated with the central bank selling dollar forward and supplying rupee in spot market, when forward premia and domestic interest rate comes under upward pressure, but risks pressures on domestic currency if monetary conditions ease out as a result, as indeed happened in early 1996.
2. The measures in the currency markets were successfully complemented by a set of monetary and credit policy measures. These included raising the bank rate, interest rate on fixed repo, interest rate on post-shipment rupee export-credit and the cash reserve ratio (CRR). Also, the export credit refinance to banks was sharply reduced.
3. More recently, Bansal (1997) has explained the existence of forward premium puzzle on the basis of the sign of interest rate differential which may arise from a particular term structure of interest rate.
4. Empirical findings suggesting unbiasedness is scanty. Krasker (1980) presents evidence to show that peso problem may explain rejection of efficiency in some cases. In few studies, where cointegrating relations between forward rates and future spot rates with a unit slope for forward rate in the regression have been found indicating unbiasedness, supplementary evidence on persistence from autocorrelations of forward premia indicate presence of small size risk premia showing that markets may not be as efficient as indicated otherwise. Castro and

Novales (1998) may be cited as an example.

5. These results hold even when tested for the sub-sample 95:06-98:01, i.e., for the period when the forward market became active. The results for this sub-sample are:

$$S_{tk} = 2.30 + 0.35f_k \text{ for } k=3, \quad \dots(1)$$

(5.03) (2.77)

PP test (no trend) = -0.43; 5% MacKinnon (1991) critical value of -3.90 against the null of random walk.

$$\Delta_k S_{t+k} = 0.015 + 0.042 f_{k,t}^p \quad \dots(2)$$

(0.53) (0.747)

$$Rbarsq = 0.56, \quad SEE=0.02, \quad DW=1.27, \quad Q(7) \ 6.30$$

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TRACKING PERFORMANCE OF THE VARMA (1,1) MODEL

Fig. III. ACTUAL & IMPLIED SPOT EXCHANGE RATE

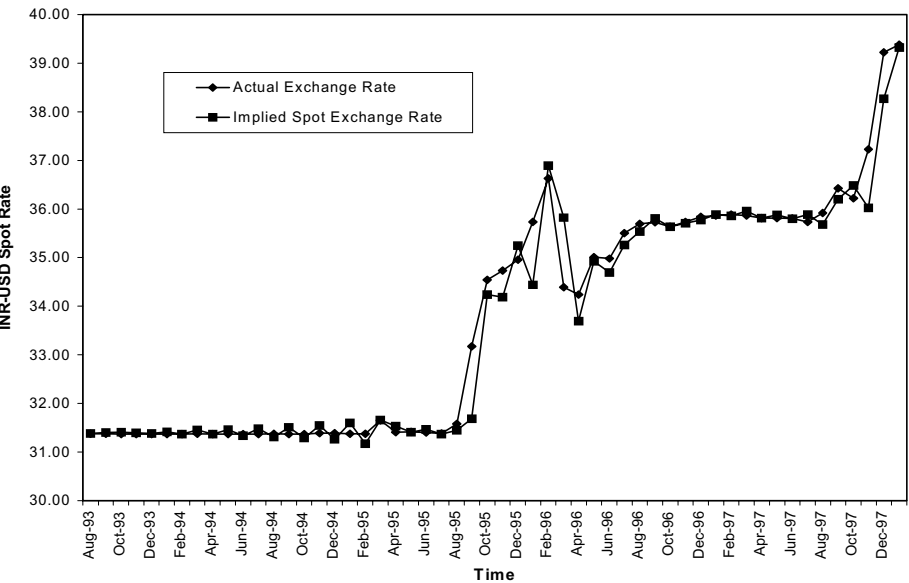


Fig. IV. ACTUAL & IMPLIED FORWARD EXCHANGE RATE

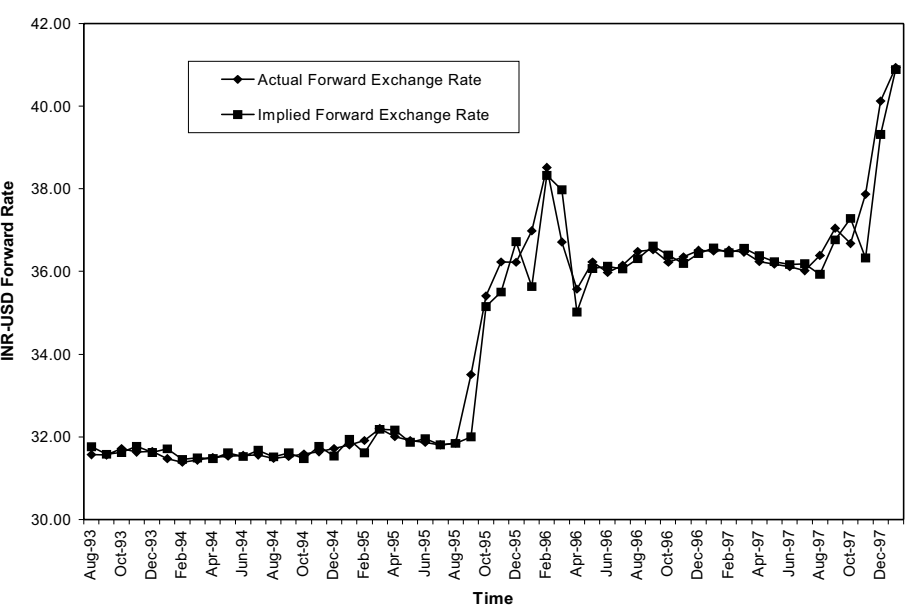


Fig. V. RISK PREMIA - Actual & Implied Forward Premia

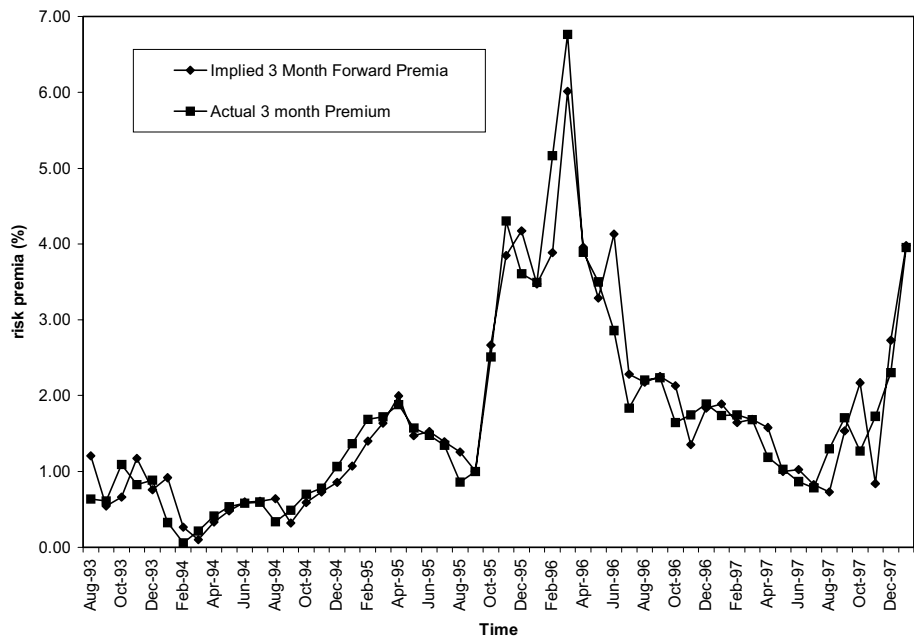


Fig. VI. ACTUAL & IMPLIED EXCESS RETURNS

