Exchange rate regimes: middling through

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Abstract

The appropriate exchange rate regime, in the context of integration of currency markets with financial markets and of large international capital flows, continues to be a policy dilemma. The revealed preference for most governments is for some kind of intermediate regime, suggesting a need to study these regimes more carefully. We find that the majority of countries are moving towards somewhat higher exchange and lower interest rate volatility. Features of forex markets could be partly motivating these choices. In a model with noise trading, non-traded goods, and price rigidities we show that bounds on the volatility of the exchange rate can lower noise trading in forex markets; decrease fundamental variance and improve real fundamentals in a developing economy; and give more monetary policy autonomy to smooth interest rates. Central banks prefer secret interventions where they have an information advantage or fear destabilizing speculation. But in our model, short-term pre-announced interventions can control exchange rate volatility, pre-empt deviations in prices and real exchange rates, and allow markets to help central banks achieve their targets. The long-term crawl need not be announced. We conclude with some discussion of the regime's applicability.

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1. Introduction

The appropriate exchange rate regime is a major policy dilemma, yet the revealed preference for most emerging and small open economy (SOE) governments is for some kind of intermediate regime between a pure fixed or floating exchange rate. Therefore the properties of such regimes, in the context of integration of currency markets with financial markets and of large international capital flows, need to be more carefully studied[1].

An examination of interest and exchange rate volatility suggests that the majority of countries are moving towards somewhat higher exchange and lower interest rate volatility. Since capital mobility has been rising in the past decade, some exchange rate volatility is essential for greater independence of monetary policy. But features of foreign exchange (forex) markets can magnify exchange rate volatility, since forex transactions are many magnitudes higher than those due to trade or capital flow related transactions. In such a context, a policy of bounds on the volatility of the exchange rate lowers noise trading activity, and removes potential high volatility equilibria. Thus although monetary policy has to establish the bounds, the free lunch of lower volatility gives more monetary autonomy in equilibrium.

Jeanne and Rose (2002) combine a simple purchasing power parity based macro model with the De Long et. al (1991) model of noise trading to show that keeping the variance of the nominal exchange rate within bounds can lower entry of noise traders. We modify their model to bring in structural features of developing and import dependent SOEs, in the simplest possible ways. We allow for non-traded goods, imported and wage push pressures on the price level, price rigidities and inflationary expectations. We simplify their model in other ways, doing away with the overlapping generation structure of noise

[1] The East Asian crisis has stimulated a large literature on exchange rate regimes in developing countries. Immediately after the crisis the mainstream view was that only the extremes were feasible. An early influential such argument was Eichengreen (1994). But even he did not rule out managed floating, and Fischer, a weighty proponent of the bipolar view, has qualified his conclusions in Fischer 2001. Frankel (1999) labels "the hollowing out of the middle" as unsound, and Williamson (2000) advocates the "BBC" regime: a wide band, and a crawling central rate pegged to a multi-currency basket. Svensson (1994) argues that exchange rate bands increase monetary policy autonomy. See also Bird and Rajan (2000) and Corden (2002) for explorations of specific feasible midpoints.

trader entry. The OG assumption makes a period inordinately long and we show that it is not needed in the current context. We find that their key results continue to hold, although risk premium and exchange rate dynamics exhibit larger volatility than in their paper. Additional results are obtained on the optimal policy and its effects. Ensuring some minimum nominal exchange rate volatility encourages hedging, lowers imported price shocks, and persistent deviations of the real exchange rate that add to fundamental variance. It facilitates smoothing the nominal interest rate at the lowest feasible level, which improves real productivity related fundamentals, even in a steady-state model that focuses on the supply-side.

Central banks prefer secret interventions in situations where they have an information advantage or they fear destabilizing speculation. But in our model announced interventions allow markets to help central banks achieve some of its targets. We conclude with some discussion of the regime's applicability in the context of a typical EME forex market.

The structure of the paper is as follows: after a review, in section 2, of stylized cross country facts on exchange rate regimes and exchange and interest rate volatility, that motivates our analysis, we turn to modeling. Section 3 models the macroeconomic fundamentals bringing in aspects of a developing economy. Section 4 does the same for the microstructure of the forex market. Section 5 puts the two together to obtain the market equilibrium and demonstrate multiple equilibria due to noise trader entry. Section 6 works out the implications for monetary policy. Section 7 evaluates the results in the context of a typical EME forex market. Section 8 concludes. Derivations are in Appendix A, and tables in Appendix B.

2. Empirical Stylized Facts

Table 1 gives a broad picture of how the exchange rate regime (EER) classifications of developing countries have changed over 1995 to 2002. This is the relevant period since it has seen many changes in EERs. The immediate cause was the East Asian crisis where dollar pegs had been directly implicated as a causal factor in the crisis. The initial consensus was that only corner solutions are viable. A developing country must either adopt a completely free float or a fixed peg validated by a currency board or monetary union. Any other fixed peg is not credible and invites attack (Eichengreen 1999). Other kinds of intervention share similar problems. But have countries followed the advice? Table 1 suggests that they have not. Adding the new category "no separate legal tender"[2] to the pegged category shows almost no change in this category over the years. The share of limited flexibility and managed floats has increased. That of independent floats has actually fallen. Analysis is required to understand the value countries appear to have discovered in intermediate regimes. Moreover since the area between the corners is large, and many types of intervention are feasible, analysis is also required to further refine our understanding of these types and their optimality properties.

The corners are theoretical extremes, which are actually difficult to inhabit. Mussa (IMF 2000) acknowledges that emerging market economies do not have the deep forex markets that are required for a free float to be operational. Even countries that say they have floating exchange rates actually intervene at times. Most countries carry substantial foreign exchange reserves, and central banks use interest rates and monetary policy to affect exchange rates. As Calvo and Reinhart (2000) point out actual exchange rate variability in many countries classified as free floaters is much lower than that in true floaters such as the US.

The latter caveat must be kept in mind in reading Table 2, which shows the official IMF classification of a set of 24 countries and how it has changed over the period 1995-2002. This period is selected because it has been one of active regime change, and includes points before and after the Asian crisis. The countries are divided into the East Asian countries, a set of mature and SOEs with independent floats, and a set of other emerging market economies with mixed exchange rate regimes. The crisis directly affected Asian countries therefore the regime history of these countries is shown in detail. The second

[2] This was started in 1998 and comprises largely small island nations, Francophone Africa, and other monetary unions.

set serve as a control group to compare characteristics, and the third set also reflect the fallout of changing views on optimal exchange rate regimes for emerging and SOEs. Moreover, we will present other data with respect to this same group of countries.

Table 3 gives an estimate of exchange rate volatility for these groups. It is calculated, following Baig (2001), as the standard deviation of monthly movements (percentage changes) of domestic nominal exchange rates against the U.S. dollar. Table 4 gives a similar volatility picture for short-term interest rates[3]. As expected both interest and exchange rate volatility was high in East Asian countries during the crisis years. These countries moved from very low exchange rate volatility to very high. Post crisis exchange rate volatility fell although it remained higher than in the pre-crisis years. Under a fixed exchange rate the latter's volatility is expected to be low while since the interest rate is used to defend the exchange rate, interest rate volatility would be high. In a crisis the volatility of both would be high. In pure floats exchange rate volatility would be higher while monetary policy is free to target the domestic cycle, including smoothing interest rates. In crises periods such as afflicted the European Monetary System in the early nineties, again the volatility of both would be high. A desirable characteristic of intermediate regimes would be low volatility of both, with that of interest rates lower than that of exchange rates. The former would have some freedom to respond to domestic cycles, but its smoothing would minimize banking crises, facilitate the smooth working of the financial system, and lower the burden of government debt. Bounded volatility in exchange rates, with a market determined central rate, would make for relatively stable exchange rates, yet prevent complacency with regard to exchange rate risk and encourage hedging or otherwise managing risk in forex markets. The intermediate regime we will explore in the model developed below has precisely these features. In this context a careful examination of tables 3 and 4 suggests that most countries are moving towards regimes with these characteristics. Interest volatility has been falling for most countries (excluding Turkey) and is lower than exchange rate volatility although the latter is also bounded.

III Macroeconomic Fundamentals

A basic monetary model of the exchange rate is modified to allow for imperfectly flexible prices and relative purchasing power parity.

A simplified money market equilibrium for the domestic and foreign country (indicated by a superscript *) respectively links log-linearized real money balances inversely to the nominal interest rate. Thus *m* is the natural log of the money stock, *p* of the consumer price level and *i* the nominal interest rate, and the income variable is dropped.

$$m_t - p_t = -\alpha i_t \tag{1}$$

$$m^* - p^* = -\alpha i^* \tag{2}$$

The foreign country is assumed to be in a steady state so that m^*, p^* and i^* are constant and do not have a time subscript. The log of the foreign price level p^* is normalized to zero.

Relative Purchasing Power Parity (PPP) is satisfied on average, therefore the log domestic price of foreign exchange equals:

$$e_t = p_t - p^* + z_t + \varepsilon_t \tag{3}$$

This is an equilibrium and not an arbitrage relationship, derived below. First, in order to model non-traded goods, and other developing country trade-restrictions, in the simplest possible way, we assume, trade is marginal in final products, but trade arbitrage is perfect in intermediate products[4]. Therefore, the domestic price level (T) and the foreign currency price level (T*) of the intermediate product are linked by:

$$T_t = E_t T_t^* \tag{4}$$

Capital letters denote nominal values not measured in logs. The non-traded consumer goods prices are determined by unit costs. The technology in the production of the intermediate good is identical so that input *T* per unit output coefficient a_T is the same for the home and the foreign country.

[3] Interest rate volatility is calculated as the standard deviation of monthly money market interest rate differences (Baig (2001) performs a similar calculation over the period 1995-2000). For some developing countries where this is not available the nearest short-term substitute rate is used.

$$P_t = a_L W_t + a_T T_t; \qquad P_t^* = a_L * W_t^* + a_T T^*{}_t \tag{5}$$

Equations (4) and (5) yield

$$E_t = \frac{P_t(1 - a_L w)}{P_t^*(1 - a_L^* w^*)}; \qquad Z = \frac{(1 - a_L w)}{(1 - a_L^* w*)} = \frac{E_t P_t^*}{P_t} \tag{6}$$

Where *W* is nominal and *w* real wages, a_L the labour input per unit of consumer goods output, and P denotes the price level. When logs are taken of equation 6, and an i.i.d. normal shock ε added, equation 3 is obtained. There is no reason for z_t to equal 1, so that Purchasing Power Parity (PPP) is only relative. Monetary factors affect P_t/P^*_t, but z_t reflects, in addition, changes in real wages or technology. Since w* > w as wages in a developed country exceed those in a developing country, z >1, but if domestic real wages grow faster than foreign, *z* will fall. The domestic currency will appreciate, putting independent pressure on *e* although some adjustment will come through changes in domestic relative inflation. Thus introducing z_t is a simple way to allow real factors to affect e_t without loss of generality. The role of non-traded goods is brought in without having to use a price index that is a weighted average of traded and non-traded goods, in equation (1). There is considerable algebraic simplification in calculating real interest rates, although domestic real interest rates can differ from the world real interest as in the more general model where traded goods enter the consumer price index. The Equation (5) captures cost-push factors affecting prices. If this differs from p_t warranted by monetary factors in (1), interest rates would change. This equilibrating mechanism would work as long as shocks to money supply are not too large; we assume the latter. For example, if prices are rising, money balances would fall and interest rates would rise. Since we abstract from output, a rise in investment is assumed to directly affect technology or the labour productivity coefficient, through its effect on human capital as in the endogenous growth literature.

Since prices are imperfectly flexible, some prices adjust in the period of a monetary stimulus; others are expected to adjust in the future. Fisher's equation therefore implies:

$$i_t = \; p_{t+1} - p_t + r_t \tag{7}$$

[4] See Bruce and Purvis (1985) for a brief exposition of a related model.

That is, domestic nominal interest rate equals expected inflation plus the real interest rate r_t. The domestic nominal interest rate i_t, exceeds i* by exchange rate depreciation, and an excess return on domestic currency assets, ρ, which covers country risk. Unless this relationship holds traders will be able to arbitrage across domestic and foreign assets costlessly. Equation (8) defines the excess returns to domestic currency assets.

$$i_t = i^* + \rho_{t+1} + e_{t+1} - e_t \tag{8}$$

Substituting equations (1) and (7) in (8) gives the relationship between real interest and exchange rates:

$$r_t = r^* + \rho_{t+1} + z_{t+1} - z_t \tag*{(8)'}$$

We make assumptions about stochastic normal processes. These allow useful simplifications. For example, they allow equilibrium decision rules to take simple stable forms, despite the existence of heterogeneous agents, in a stochastic environment:

Assumption 1: Domestic money supply is identically and independently distributed around $\overline{m}$ in a pure floating exchange rate regime, and defines an average price level $\overline{p}$.

Assumption 2: In equilibrium ρ_t and i_t follow i.i.d. stochastic processes around average values $\overline{\rho}$ and $\bar{i}$ respectively.

Assumption 3: The fluctuations of e and z are i.i.d. distributed around $\bar{e}$ and $\bar{z}$ respectively.

Using equations (1) and (2) to substitute out the price variables from equation (3), e_t can be written as:

$$e_t = \left(m_t - m^*\right) + \alpha\left(i_t - i^*\right) + z_t + \varepsilon_t \tag{9}$$

In equilibrium equations (8) and (8)' imply that the average risk premium equals the average difference between domestic and foreign interest rates:

$$\overline{\rho} = \bar{i} - i^* \tag{10}$$

$$\overline{\rho} = \bar{r} - r^* \tag*{(10)'}$$

Taking expectations of equation (9) using assumptions (1) and (2), and equation (10) leads to:

$$\bar{e} = \bar{m} - m^{*} + \alpha\bar{\rho} + \bar{z} \tag{11}$$

Where $\bar{z}$ is the average value of the bracketed term in equation (6), that is, it is the real exchange rate. A depreciation of the domestic currency, or rise in $\bar{e}$, occurs with a rise in $\bar{m}$. But a higher average interest differential decreases the demand for money balances and therefore also depreciates the domestic currency.

Taking expectations of the PPP equation (3) yields another relationship for $\bar{e}$:

$$\bar{e} = \bar{p} + \bar{z} \tag{12}$$

We now turn to the forex market, which determines the risk premium, and strongly affects the exchange rate.

IV The Foreign Exchange Market

A major characteristic of the forex market is that turnover is much higher than actual balance of payments (BOP) transactions warrant (see Table 6, Appendix B). The special features of the exchange rate market are learning from order flow and sharing risks. These explain the large turnover and excess volatility independent of specific details of market microstructure. Forex dealers vary in their level of information. The order flow itself is an important source of information. Dealers keep trading in order to learn about fundamentals. The other reason for the large turnover is the unwinding of initial positions in order to share risk and achieve optimal currency portfolios. Macroeconomic fundamentals as well as market microstructure is required to understand exchange rate behaviour (Lyons, 2000, Frankel, 1996).

Information available to large banks, the main dealers in EMEs, would be very different from that with the others. Even without full capital account convertibility there is enough forex mobility to satisfy equation (8). The monetary authority decides the availability of domestic currency securities $\bar{F}$ to international investors.

A parsimonious model, which captures these aspects, is the noise trader model of De Long et.al. (1990) adapted to forex markets by Jeanne and Rose (2002). De Long et.al.

use an overlapping generations structure since their primary purpose is to demonstrate that noise traders can make more profits than informed traders. Therefore they must ensure that the horizon of informed traders is not longer than that of noise traders, so that the former cannot out-wait the latter in the market. But with continual entry of poorly informed agents in the forex market, and their ability to “infect” each other, the OG assumption is not required.

We assume that N traders consider entering the market in each period. Their decisions are made based on information available in period t, and returns are earned in period t+1. A period is defined to be long enough to complete their transactions. Traders have identical endowments and tastes, but differ in their degree of information and in their entry costs. “Informed traders” form accurate costless expectations on risk and returns. “Noise traders” have noisy expectations and have to pay an entry cost to invest in domestic markets. Of these N traders in each period, N_i are informed, j = 1,…, N_i. N_n are noise traders, j = N_i + 1,…N, with $N \equiv N_i+N_n$. Entry cost for noise traders $c_j \geq 0$ is increasing with j for j > N_i. There is a lower limit for this entry cost.

Assumption 4: The entry cost cannot be too small:

$$\forall j > N_i, c_j > \underline{c} > 0 \tag{13}$$

If trader j decides to enter, the dummy variable $\delta_t^j = 1$, otherwise it is zero. A trader will enter only if her expected utility from entering exceeds that from abstaining.

Assumption 5: All informed traders and a constant number *n* of noise traders enter domestic security markets.

U_t^j is the utility of trader j at time t, and E_t^j is her expectations operator. A currency trader, who enters the market, invests f_t^j in domestic securities so as to maximize the next period expected utility of her endowment W. Her portfolio allocation problem is:

$$\max_{f_t^j} U_t^j = E_t^j\left(-\exp\left(-aW_{t+1}^j\right)\right) \tag{14}$$

where a is the coefficient of absolute risk aversion. W_{t+1}^{j}, her next period wealth, grows as:

$$W_{t+1}^{j} = (1+i^{*})W + \delta_t^{j}\left(f_t^{j}\rho_{t+1} - c_j\right) \tag{15}$$

Her wealth grows at the safe international interest rate plus the excess return on domestic securities minus the cost of entering, if she enters the market.

The excess return ρ_{t+1} is determined in equilibrium in the domestic security market. Given assumption 1-3, this is normally distributed in equilibrium. Therefore maximizing equation (14) is equivalent to maximizing the mean-variance objective function:

$$E_t^{j}\left(W_{t+1}^{j}\right) - (a/2)\,\mathrm{var}_t^{j}\left(W_{t+1}^{j}\right) \tag{16}$$

This function is intensively used in finance, since the demand functions obtained are independent of wealth, so that it is not necessary to keep track of changes in wealth. The maximization gives trader j's demand for domestic securities as:

$$f_t^{j} = \frac{E_t^{j}\left(\rho_{t+1}\right)}{a\ \mathrm{var}_t^{j}\left(\rho_{t+1}\right)} \tag{17}$$

Traders differ in their expectations regarding excess returns:

Assumption 6: For informed traders, $j \leq N_i$, expectations are rational. That is, the expected value and conditional variance of excess returns evaluated at time *t* are equal to their actual mathematical counterparts.

$$E_t^{j}\left(\rho_{t+1}\right) = E_t\left(\rho_{t+1}\right) \tag{18}$$

$$\mathrm{var}_t^{j}\left(\rho_{t+1}\right) = \mathrm{var}_t\left(\rho_{t+1}\right) \tag{19}$$

For noise traders $j > N_i$,

$$E_t^{j}\left(\rho_{t+1}\right) = \overline{\rho} + \nu_t \tag{20}$$

$$\mathrm{var}_t^{j}\left(\rho_{t+1}\right) = \mathrm{var}_t\left(\rho_{t+1}\right) \tag{21}$$

$$\mathrm{var}\ \nu = \lambda\ \mathrm{var}\ e \tag{22}$$

Thus noise traders perception of the first moments is affected by noise unrelated to fundamentals. Their expectation of excess returns equals the unconditional mean of the excess return $\left(\bar{\rho}\right)$, and a noise term ν_t, whose variance is proportional to the actual unconditional variance of the exchange rate, where $\lambda > 0$.

V Market Equilibrium

In a rational expectations equilibrium, traders' expectations of excess returns must be consistent with excess returns determined in the macromodel. Second, securities markets must clear, given traders' demand. Third, stochastic processes for e_t and ρ_t must be consistent with traders expectations. Therefore:

Definition 1: *An equilibrium in this model consists of stochastic processes* $\langle e_t, \rho_t \rangle$ *and individual traders decision rules* $\langle \delta_t^j, f_t^j \rangle$ *such that at each period t:*

(i) $\delta_t^j = 1$ *only if benefit from entry exceeds cost of entry.*

(ii) f_t^j *solves the optimal portfolio allocation problem (14).*

(iii) The market for domestic currency securities is in equilibrium.

$$\bar{F} = \sum_{j=1,\dots,N} \delta_t^j f_t^j \tag{23}$$

(iv) A constant number n of noise traders enter the market in each period.

(v) Fluctuations of e_t, z_t *and* ρ_t *are i.i.d. around average levels* $\bar{e}$, $\bar{z}$, *and* $\bar{\rho}$ *respectively.*

Summing up individual traders demand (17) and using the market equilibrium condition (23) that demand equals supply gives:

$$\begin{aligned} \bar{F} &= N_i \frac{E_t(\rho_{t+1})}{a \operatorname{var}_t(\rho_{t+1})} + n \frac{\bar{\rho} + \nu_t}{a \operatorname{var}(\rho_{t+1})} \\ &= \frac{N_i E_t(\rho_{t+1}) + n(\bar{\rho} + \nu_t)}{a \operatorname{var}(e)} \end{aligned} \tag{24}$$

It is possible to solve for $\bar{\rho}$ by taking the expectation of (24) at t -1.

$$\bar{\rho} = a \frac{\bar{F}}{N_i + n} \operatorname{var}(e) \tag{25}$$

Average excess return on domestic currency securities, $\bar{\rho}$ increases with var (e), *F* and *a*, but falls with entry of noise traders *n*.

The next step is to obtain the equilibrium exchange rate as a function of fundamentals and noise. To do this an expression for $E_t\ \rho_{t+1}$ derived from (24) and (25) is used to substitute out $E_t\ \rho_{t+1}$ from another expression for it obtained by taking expectations of the arbitrage equation (8). This results in an expression for $i_t - \bar{i}$ which is used to substitute out $i_t - \bar{i}$ from the relative purchasing power equation (9), hence:

$$e_t - \bar{e} = \frac{1}{1+\alpha}\left(m_t - \bar{m} + \varepsilon_t + z_t - \bar{z} - \alpha \frac{n}{N_i} \nu_t\right) \tag{26}$$

The derivation of (26) is in Appendix A. Equation (26) confirms that e_t and therefore ρ_t are i.i.d. around their average values, as required in the definition of equilibrium, and just assumed earlier in assumption 3.

Using (22) to substitute for the variance of noise, ν_t, and taking the variance of (26) gives:

$$\mathrm{var}(e) = \frac{\mathrm{var}(m + \varepsilon + z)}{(1+\alpha)^2 - \lambda\alpha^2 (n/N_i)^2} \tag{27}$$

The variance of the exchange rate increased with that of fundamental components *m*, *ε*, and *z*. It also increases with the number of noise traders *n*.

An equilibrium requires that a constant number of noise traders, *n*, enter. We now show that this will hold in equilibrium. Individual trader demand (17) implies that noise trader demand rises with $\bar{\rho}$ and falls with var(e). Therefore trader's benefit from entry will also rise with $\bar{\rho}$ and fall with var(e). Entry will occur only as long as this benefit exceeds their cost of entry. We can define a smooth twice differentiable benefit function:[5]

$$B(\bar{\rho}, \mathrm{var}(e)); \qquad B'[\bar{\rho}] > 0, \quad B'(\mathrm{var}(e)) < 0 \tag{28}$$

where a superscript dash indicates a partial derivative. Trader j will enter the market as long as:

[5] See Jeanne and Rose (2002) for another derivation of this function, based on summations over normal distributions.

$$B\left(\overline{\rho}, \mathrm{var}(e)\right) \geq c_j \tag{29}$$

But both $\overline{\rho}$ and var(e) are functions of *n*. Equilibrium $\overline{\rho}$, equates demand to supply in the domestic currency security market. It is given by equation (25), which can be re-written as:

$$\overline{\rho}^* = \overline{\rho}(\mathrm{var}(e), n); \quad \overline{\rho}'(\mathrm{var}(e)) > 0, \quad \overline{\rho}'(n) < 0 \tag{30}$$

A superscript * denotes an equilibrium value. Similarly the equation for equilibrium var(e) (27), derived simultaneously from relative purchasing power parity (9), arbitrage (8), and market equilibrium (24) and (25), can be re-written as:

$$\mathrm{var}(e)^* = \mathrm{var}(e)(n); \quad \mathrm{var}(e)'(n) > 0 \tag{31}$$

In equilibrium either all noise traders will enter, or none will enter, or some will enter, so that $n \in \left[0, \overline{n}\right]$. If B( ) > c_j for all noise traders, all will enter. If B( ) < c_, given assumption 4, no noise trader will enter. In an equilibrium with interior values, (29) will hold with equality, and $\overline{\rho}*$ and var(e)* will take critical values such that the marginal noise trader is just indifferent to entering.

$$B\left(\overline{\rho}^*, \mathrm{var}(e)^*\right) = c_j \tag{32}$$

At $\overline{\rho} < \overline{\rho *}$ or var(e) > var(e)*, benefits to entry are lower than at equilibrium so *n* will shrink. Both $\overline{\rho}$ and var(e) depend on *n*. Therefore a function G can be defined, that determines entry: $G\left(\overline{\rho}(\mathrm{var}(e), n), \mathrm{var}(e)(n)\right)$. If n ≠ G ( ) it cannot be an equilibrium. Hence equilibrium entry is:

$$n^* = G\left(\overline{\rho}(\mathrm{var}(e), n^*), \mathrm{var}(e)(n^*)\right) \tag{33}$$

If B( ) > c_j then n < n*, noise trader entry will occur and *n* will rise. Since $\overline{\rho}*$ falls with *n* but rises with var(e), and var(e) rises with *n*, multiple equilibria are possible. $G'(\overline{\rho}) > 0$ and $G'(\mathrm{var}(e)) < 0$, therefore G can be falling with *n* at low *n* as $\overline{\rho}$ falls. But at high *n*, the positive effect of *n* on var(e) and therefore on $\overline{\rho}$ will dominate, $\overline{\rho}$ will rise. Hence G will also rise with *n* at high *n*. Therefore equilibria are possible both at low and at high *n*. Either a few noise traders, or a large number of noise traders will enter the forex market.

But, in each equilibrium, *n* takes a fixed value as definition 1 requires. The function G determines this value.

Noise traders create risk so var(e) rises and $\bar{\rho}$ falls with their entry (n). But they also share the risk they themselves create so that $\bar{\rho}$ rises with var(e). Figure 1, which graphs G against *n*, demonstrates the multiple equilibria. Stable equilibria are O, A, C and C′, while B is unstable. If var(e) is very low so B < C_j for all j, the dashed G curve lies everywhere below the 45° line in Figure 1, and the unique equilibrium is at O with zero entry of noise traders. This occurs if the fundamental variance, var (m+z+ε) is low.

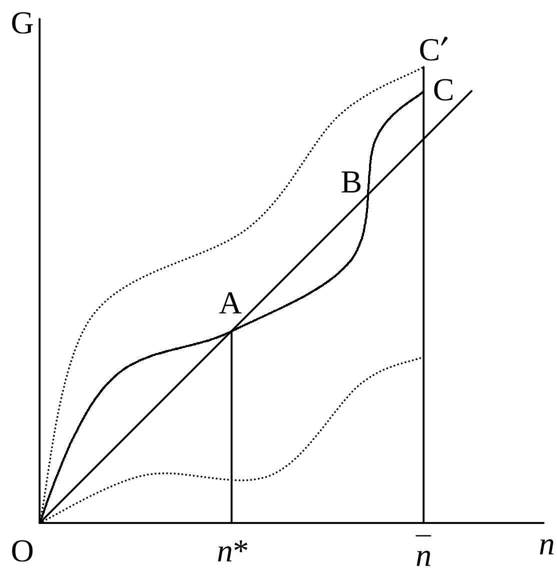

Figure 1: Multiple entry levels for traders

If var(e) is high so B > c_j for all j, the dashed G curve lies everywhere above the 45° line and there is a unique equilibrium at C′ where all noise traders $\bar{n}$ enter.

For intermediate levels of the fundamental variance, the two stable equilibria are A and C. At A var(e), $\overline{\rho}$ and *n* are all low, while C has maximum entry $\overline{n}$, and var(e) and $\overline{\rho}$ are both high.

VI Policy Consequences

The model implies that exchange rate volatility can be low if fundamental variance is low, but it can be either high or low for intermediate levels of fundamentals. Policy can improve welfare by leading to the selection of low volatility equilibria. Jeanne and Rose (2002) demonstrate that a 'stable exchange rate regime' where policy constrains var(e) to be less than or equal to *v*, leads to lower entry of noise traders and pins the economy on an equilibrium with low exchange rate variance. Thus although there is a loss of monetary autonomy in adopting the restriction on var(e), as the level of noise in the economy is decreased, the loss is of second order. Monetary policy response function is constrained out of equilibrium, but there is no sacrifice of monetary autonomy in equilibrium. These results continue to hold in our extended model, and there are further implications for the conduct of policy.

The government minimizes a weighted average of the sum of squared deviations of the price level and the nominal interest rate from their respective average levels. Its loss function is:

$$L \equiv \omega\left(p - \overline{p}\right)^2 + \left(1 - \omega\right)\left(i - \bar{i}\right)^2 \tag{34}$$

That is, the government's objective is to smooth the nominal interest rate and stabilize the domestic price level. A high ω (ω ∈ (0,1)) implies a higher relative weight on price stability compared to interest rate stability. The constraint (35) subject to which the government minimizes its loss function is the relationship between *p* and *i* resulting from macroeconomic and forex trader behaviour. Therefore (35) incorporates relative PPP, money demand and supply, trader maximization, arbitrage, and forex market clearing. To get this we substitute out $e_t - \overline{e}$ and $m_t - \overline{m}$ from equation (26) for the equilibrium exchange rate, using the deviations of the relative PPP equation (3) from its expected value equation (12), and deviations of the domestic money market equation (1) from its expected value.

$$\left(p_t - \overline{p}\right) + \left(i_t - \bar{i}\right) = X_t \tag{35}$$

The composite external shock, X_t, equals

$$X_t \equiv -\left(\varepsilon_t + z - \overline{z}_t + \left(n/N_i\right)v_t\right) \tag{36}$$

The shock is the sum of fundamental and wages related shock to PPP and an endogenous noise component. Higher levels of the shocks would imply a higher deviation of the price level and interest rate from their respective equilibrium values.

The governments' objective (O) is to minimize the loss function (34) subject to the constraints (35) and (37).

$$\text{Var(e)} \leq \text{v} \tag{37}$$

where v is a pre-announced bound set to the variance of the nominal exchange rate.

Minimization of (34) subject to (35) is done in Appendix A. The result is that the government distributes the volatility of the shock X_t over p_t and i_t as follows:

$$p_t - \overline{p} = (1-\omega)X_t \tag{38}$$

$$i_t - \bar{i} = \omega X_t \tag{39}$$

The weights are opposite to those entering the loss function. If $\omega < 1 - \omega$ equilibrium price volatility will exceed interest volatility. If the loss from price volatility if lower, more of shocks will be passed into price fluctuations. As long as var(e) < *v* the government does not have to enter the forex market. Only if a large number of noise traders enter will it have to intervene to stabilize the exchange rate, pushing some of the volatility on to p_t or i_t. But in equilibrium as *n* falls, so will X_t and the volatility to be distributed. The parameter *v* defines the width of the exchange rate band. This definition in terms of variance keeps the government's problem linear-quadratic and therefore easier to solve. It approximates the working of a passive crawl. The edges of the band are soft because the central rate $\overline{\text{e}}$ is variable and market determined.

Taking account of price rigidities and non-traded goods adds more sources of variation, but also gives the government added degrees of freedom in lowering the variance of the exchange rate.

If some prices are rigid in the short-term, they will be expected to change in the future. A reduced form expression for p_t and r_t, consistent with rational price expectations is obtained by substituting the FOCs from the government's minimization (38) and (39) in Fisher's equation (7), and solving for rational price expectations (Appendix A). This procedure gives:

$$p_t - \bar{p} = 1 - \omega(r_t - \bar{i}) \tag{40}$$

Equation (40) implies that a low r_t is associated with a low p_t. If *r* exceeds (falls short of) $\bar{i}$, the expected nominal rate, p_t will be above (below) its average level. The gap between *i* and *r* is expected price rise; if $r_t = \bar{i}, p_t = \bar{p}$. If *i* falls when there are price rigidities, some prices are expected to adjust in the future. Since future prices are expected to rise, *r* must fall to satisfy (1) and (7). Assumption 1 no longer determines money supply since the government's objective (O) is now different from a floating exchange rate regime. It turns out that money supply should smooth interest rates.

Proposition 1: *Using m to keep i to the left-hand side of* $\bar{i}$ *will achieve the government's objective O, and improve fundamentals*.

Proof: 1. A rise in *i* reduces money demand and a rise in *p* reduces real money balances. Therefore, with exogenous $\bar{m}$ and cost determined flexible prices, *i* will adjust and both *i* and *p* will move together from equation (1). It follows from (35), that both *i* and *p* may move in the same direction to absorb a given volatility shock *X*. Therefore adjusting *m* to targeting *i* will not shift *p* in the opposite direction. O will be achieved.

2. If some prices are rigid in the short-term, a rise in *m* above $\bar{m}$ will raise real balances, hence *i* must fall for money demand to adjust to supply. But these prices are expected to rise in the future, so *r* must fall below $\bar{i}$ from equation (7), to satisfy money market

equilibrium (1). Equation (40) will be satisfied with the price level below its average, and r below $\bar{i}$. There is no pressure on e to rise from equation (9), since the slight fall in i compensates for the slight rise in m. Two cases are possible with respect to wages.

First, if nominal wages are backward looking they will not rise immediately but since some prices rise, there will be a marginal fall in real wages, tending to raise z from equation (6). Second, if nominal wages are forward looking and respond to expected price, immediately in this case or with a one period lag under the first case, real wages rise, and z will tend to fall. But the fall in r will stimulate investments that raise labour productivity and lower a_L, thus raising z and back towards its equilibrium value. The fundamental variance $z-\bar{z}$, var(e), and n will all be low, and the shock X will be stable. The government's objective O of reducing deviations of e, i and p from their equilibrium values will be met. The improvements in productivity will tend to lower $\bar{p}$ from equation (5), but the rise in nominal wages will tend to raise it, keeping it constant. A consistent equilibrium will result in which average nominal interest rates tend to fall. A fall in $\bar{i}$ lowers $\bar{\rho}$ from equation (10). This is the development process during which country risk contracts. The alternative policy of raising i would set in the opposite deflationary price expectations, raise r and lower productivity growth. Since nominal wages are often more rigid in the downward direction, real wages will rise, magnifying the adverse effects effects of a fall in investment, and appreciating z, thus raising fundamental variance, var(e), X, and harming the government's objective O.

The empirical stylized facts of section 1, showed that fixed exchange rates are associated with the highest interest rate volatility. A restriction such as var(e) ≤ v, could imply fixed exchange rates if the band is narrow. A large value of v would approximate to a float. But EMEs face the problem of periods of sustained capital inflows where markets, left to themselves, would tend to appreciate the exchange rate; crisis periods of sustained outflows also occur. In inflow periods central banks buy foreign exchange tending to keep the exchange rate rigid[6], lowering perceived exchange rate risk. Therefore policy to

[6] This happened in India over the period 1993-95, when the exchange rate regime was first liberalized and inflows allowed. It also characterized many East Asian countries before the crisis.

ensure minimum two-way variability in e_t and encourage hedging is required. Such intervention can also serve another purpose.

In developing countries world oil (entering our T in equation 4) and food prices have a major impact on domestic prices and wages, and oil imports are important for many SOEs. Tariff barriers are available, but are limited due to international agreements. A pre-announced movement in E in the opposite direction to P* (equation 6) while remaining within the variance bounds, would reduce some of the pressure on domestic prices, wages and z, and therefore lower var(e). This alternative way of smoothing $\left(p_t - \overline{p}\right)$, would give the central bank more degrees of freedom in adjusting interest rates. Both the central bank and traders would gain monetarily since they would be 'leaning with the wind' selling when the domestic currency is depreciating, unlike in conventional intervention which is 'against the wind', so the central bank buys when the currency is depreciating. Traders would not be tempted to breach the bounds, and the bounds would be credible, since fundamentals would be improving.

Proposition 2: *If announced interventions link bounded two way variability of e_t inversely to key world prices of commodities dominant in the trade basket, then the central bank can (i) abort deviations in z from its equilibrium value, thus lowering the fundamental variance affecting var (e) and, (ii) lower $\left(p_t - \overline{p}\right)$ from the supply side.*

Proof: A rise in T* will raise P from equations (4) and (5). If wages are sensitive to T this will be reinforced by a rise in W. If the response changes real wages, then z will change from equation (6). The deviation of z from its average will raise var (e) from equation (27). An inverse adjustment of e to T* will abort this process[7] if it is exactly equivalent, otherwise it will at least moderate it.

Because markets are less deep in emerging market economies and in some SOEs, central bank announcements have large effects. Dominguez and Frankel (1993) argue that forex intervention is successful even in deep markets, where intervention is a tiny fraction of total transactions. It can change the exchange rate even without changing the money supply, if it makes forex traders revise their forecasts of future exchange rates. Official announcements have greater effect than information that is gleaned from central banker's quiet intervention in the market.

These issues need to be explored more fully. At present, we just note that given the trade off (35) in our current model, the government has no incentive to trick agents or display dynamic inconsistency. But the future affects the present because of traders' expectations. Announced short-term interventions that focus these expectations would, therefore, be optimal.

If trend changes in $\bar{e}$ track equilibrium values, if random but contained volatility around this level prevents banks and corporates from undertaking unhedged foreign currency borrowing, so that cumulative losses do not build up, and if policy improves real fundamentals, the likelihood of crises falls. The passive crawl and soft margins prevent the loss of face and credibility from targets central bankers' are unable to reach[8]. Scope remains for unannounced or secret longer-term interventions.

It is difficult to know the equilibrium value of $\bar{e}$, but central banks can take the help of the market. As Lyons (2001) suggests: “Fundamentals (broadly defined) are consistent with the market when there is no longer a significant imbalance between buyer-initiated and seller-initiated orders – that is, private order flow is not significantly different from zero. Pg. 230.” Inflation differentials with trading partners would also be built into the concept of $\bar{e}$.

[7] As Rogoff (1996) points out that deviations in *z* are large and persistent, with a half-life of 4.6 years. Therefore moderating this process would be very useful.
[8] Corden (2002) gives this as the major argument against any type of fixed exchange rate, target, or band. The loss of face in being forced off a fixed peg is "too sensational".

VII Emerging Market Economy Forex Markets

In this section we make a preliminary exploration to see if the policy recommendations following from the model are at all applicable given the current state of emerging market economy forex markets. Table 5 gives a comparative picture of such country currencies in global forex markets. There has been rapid change in this period; many currencies that were almost absent in global trade are acquiring some position. But it also brings out the huge difference between emerging and developed country markets. Table 6 further confirms this picture. In India for example daily forex turnover has grown from $2 billion to $3 billion over 1998-2001, and now compares favourably with many middle-income developing countries. The table also brings out how much larger forex turnover is compared to foreign exchange transactions generated by trade and foreign capital inflows. Over the same period daily trade related transactions grew only from $0.24 billion to $0.38 billion. The contribution of foreign inflows was miniscule. In a developed SOE, Australia, by contrast, turnover grew from $40 billion to $52 billion; the corresponding figures for trade were puny at 0.4 and 0.5 respectively. Foreign exchange dealers have begun trading in currencies of emerging market economies in order to diversify exchange rate risks and to profit from wider margins on interbank transactions. There are normally fewer impediments to trading in the forward segment of the exchange market relative to those affecting cash transactions in the money markets. The tentative conclusion suggested is that typical features of forex markets such as noise trading would be found in emerging markets also; but the markets are shallower and central banks can more easily dominate them. Since markets are thin, they require intervention. For example, in periods of stability in the Indian exchange rate, there is considerable decline in demand in the forward market, and forward premia fall.

Table 7 gives a picture of the institutional structure of the Indian forex market. It shows a lack of depth and a process of deepening; the dominance of financial institutions but the slow growth of other traders; the dominance of local but the presence of cross border transactions; and the still large share of central bank interventions in total turnover (8-16%). Reform in the nineties sought to consciously develop the forex market. Following the Sodhani Committee Report (1995)[9], changes have been gradually implemented from 1996 onwards. The reforms aimed at integration of domestic forex market with foreign markets, more operational freedom to dealing banks and widening and deepening of the market, and progressed with some reversals but a net positive movement. Even so, the market is still dominated by nationalized banks. Authorized dealers (ADs) are mostly banks. The list of ADs has expanded because of the entry of foreign and private banks. The State Bank of India (SBI) for example accounts for 1/3 of the transactions of the ADs. SBI and the Central Bank dominate the bid-ask spread. The Reserve Bank of India (RBI) discontinued its buy-sell quotes from 1995 in order to minimize its influence on price discovery. It gives a spot buying quotation now only for a particular deal. Inter-bank transactions account for two-thirds of forex turnover. Merchants' transactions are largely related to exports and imports. There is lack of depth also because of the regulation of instruments and imposition of limits on open positions, although these are being gradually relaxed. The ceiling on net overnight open position of ADs was removed in 1996. Banks were permitted to fix their own aggregate gap limits but had to monitor their exposures continuously and mark the mismatches to market. They were allowed to manage their foreign currency assets/liabilities through the use of derivative products, such as interest rate swaps, currency swaps, and forward rate agreements. Banks were allowed to borrow / lend in the overseas money market up to 15 per cent of their unimpaired Tier-1 capital subject to restrictions relating to gap limits. They were also allowed to arrange forex-rupee swaps between corporates, run a swap book within their open positions/gap limits, offer their customers cost-effective risk-reduction option strategies with freedom to corporates for booking and canceling the options. Foreign institutional investors have been allowed to hedge, and some derivative trade introduced. Canceling of forwards occurs to unwind hedges. Otherwise these trades would have gone to offshore markets. Since hedges are now available transacting parties should be able to tolerate bounded fluctuations.

[9] This discussion is based on information contained in the Annual Reports of the Reserve Bank of India (RBI) over 1995-2002, and Saggar (2000), who presents the results of a survey of Indian ADs.

RBI intervention is secret. It asks certain banks (SBI, Bank of India etc) to trade in forex markets when it wants to intervene. Although nothing is announced, the market finds that the banks are coming to the market to deal in forex and thereby the market and the media "guess" that the RBI is intervening. Total past interventions have been, however, reported since 1995, in the monthly bulletin (RBI), in a move towards greater transparency. In the current state of the market, the RBI and the ADs, could handle announced interventions without encouraging large-scale noise trader entry. The bounded volatility would, however, encourage more transactions and hedging, raise profits, and deepen markets[10].

VIII Conclusion

The exchange rate regime we examine in this paper satisfies the three desirable features such a regime should possess (Corden, 2002). It delivers the relatively stable exchange rates required to encourage trade, but allows policy to achieve the real targets required to improve macroeconomic fundamentals. Second, it contributes to the prevention of inflation thereby partially fulfilling a role as nominal anchor. Third, improvement in real fundamentals and the passive central crawl that maintains the exchange rate near equilibrium lowers the probability of crises. As unhedged foreign currency borrowing is discouraged the financial factors that compound currency crises are prevented from setting in. Since the regime contributes a little to each of these objectives, delivers both stability and flexibility, lies between the two corner regimes, and moreover allows the Central Bank to work with markets, it is truly a case of middling through. The bounded exchange rate is compatible with free capital inflows and some monetary policy autonomy. The negatives are that stability is not total, there is a cost of hedging, and there could be fears of announcing an indefensible position. But the passive crawl will prevent the central bank being stuck with a severely misaligned exchange rate. Since central bank objectives are met, and both traders and central banks make money, credibility is enhanced. Interest rate fluctuations, which have a much higher cost, are minimised.

[10] Two way movement encourages hedging. The Indian rupee had been moving only in one direction, depreciating. Some appreciation in 2002-03 led to a 51 % rise of activity in rupee derivatives, although it was continued to be concentrated in few players, mostly foreign banks.

A brief examination of the data suggests that developing SOEs are moving towards intermediate regimes with these features. Moreover, such regimes are well suited to the current level of development of their forex markets, and would contribute to the further deepening of these markets, while limiting noise trading.

A large amount of work remains to be done. Empirically, the hypotheses on policy and noise trading can be tested within markets and across countries. The volatility patterns and their links to forex-market developments could be further established. The incentives of the agents involved could be explored more carefully in an explicit dynamic game structure and the operational aspects of the monetary policy regime developed further. When should central bank intervention be secret, when should it be announced? The open economy inflation targeting, incorporated in a minimalist fashion in the macromodel, can be more fully worked out.

Appendix A

1. To derive equilibrium exchange rates, that is, equation (26):

Step 1: Substituting out $\overline{F}$ from (24) and (25) and solving for $E_t(\rho_{t+1})$

$$E_t(\rho_{t+1}) = \overline{\rho} - (n/N_i)v_t \qquad \text{A1}$$

Step 2: Rewrite the uncovered interest parity or arbitrage equation (8), which defines excess returns on domestic currency securities:

$$\rho_{t+1} = i_t - i^* - (e_{t+1} - e_t) \qquad \text{A2}$$

Subtract from the average risk premium (10)

$$\rho_{t+1} - \overline{\rho} = i_t - \bar{i} - (e_{t+1} - e_t) \qquad \text{A3}$$

Taking expectations of A3:

$$E_t(\rho_{t+1}) = \overline{\rho} + (i_t - \bar{i}) + (e_t - \bar{e}) \qquad \text{A4}$$

Step 3: Substituting out $E_t(\rho_{t+1})$ obtained in steps 1 and 2 implies

$$i_t - \bar{i} = -(e_t - \bar{e}) - (n/N_i)v_t \qquad \text{A5}$$

Step 4: Subtracting its expected value (11) from the relative PPP equation (9) gives:

$$e_t - \bar{e} = m_t - \overline{m} + \alpha(i_t - \bar{i}) + z_t - \bar{z} + \varepsilon_t \qquad \text{A6}$$

Step 5: Substituting out $\left(i_t - \bar{i}\right)$ in step 4 using step 3 gives the equilibrium exchange rate (26).

2. To solve the government's objective equation (34):

Minimizing the government's loss function (34) with respect to $p_t - \overline{p}$ and $i_t - \bar{i}$, subject to the constraint (35), gives the two FOCs:

$$\frac{p_t - \overline{p}}{i_t - \bar{i}} = \frac{1-\omega}{\omega} \qquad \text{A7}$$

$$\left(p_t - \overline{p}\right) + \left(i_t - \bar{i}\right) = X_t \qquad \text{A8}$$

These two can be written as:

$$\begin{bmatrix} \omega & (1-\omega) \\ 1 & 1 \end{bmatrix} \begin{bmatrix} p_t - \overline{p} \\ i_t - \bar{i} \end{bmatrix} = \begin{bmatrix} 0 \\ X_t \end{bmatrix} \qquad \text{A9}$$

Solving for $p_t - \overline{p}$ using Cramer's rule:

$$p_t - \overline{p} = \frac{\begin{vmatrix} 0 & 1-\omega \\ X_t & 1 \end{vmatrix}}{-1} = (1-\omega)X_t \qquad \text{A10}$$

Substituting this result in A8, gives:

$$i_t - \bar{i} = \omega X_t \qquad \text{A11}$$

3. To obtain a reduced form expression for p_t and r_t consistent with the government's optimization, and private price expectations:

Taking expectations, rewrite Fisher's equation (7) as:

$$i_t - \bar{i} = \overline{p} - p_t + r_t - \bar{i} \qquad \text{A12}$$

Rewrite the FOCs (38) and (39), from the government's minimization as:

$$i_t - \bar{i} = \frac{\omega}{(1-\omega)}\left(p_t - \overline{p}\right) \qquad \text{A13}$$

Substituting A13 in A12 and solving for p_t:

$$p_t - \overline{p} = 1 - \omega\left(r_t - \bar{i}\right) \qquad (40)$$

Appendix B

Table 1: Developing Countries: Officially Reported Exchange Rate Arrangements (%: in percent of total)

	1995	%	2002	%
Pegged	66	32.1	47	29.2
No separate legal tender	-	-	27	16.8
Limited flexibility	4	2.6	14	8.7
More flexible (total):	86	55.1	73	45.3
Set to indicators	3	1.9	0	0
Managed floating	35	22.4	43	26.7
Independent floating	48	30.8	30	18.6
No. of countries	156	100	161	100

Source: Compiled from International Financial Statistics (IMF), Yearbooks 1995-2001, May 2002

Table 2: IMF's Classification of Exchange Rate Regimes

Country	1995	1996	1997	1998	1999	2000	2001	2002
INDONESIA	M	M	M	I	I	I	I	M
KOREA	M	M	M	I	I	I	I	I
PHILIP	I	I	I	I	I	I	I	I
THAILAND	p	p	p	I	I	I	I	M
MALAYSIA	M	M	M	F	F	F	F	F
AUSTRALIA	I	I	I	I	I	I	I	I
CANADA	I	I	I	I	I	I	I	I
GERMANY	E	E	E	E	E	E	E	E
JAPAN	I	I	I	I	I	I	I	I
MEXICO	I	I	I	I	I	I	I	I
NEW ZEALAND	I	I	I	I	I	I	I	I
SOUTH AFRICA	I	I	I	I	I	I	I	I
SWEDEN	I	I	I	I	I	I	I	I
SWITZERLAND	I	I	I	I	I	I	I	I
UK	I	I	I	I	I	I	I	I
BRAZIL	M	M	M	I	I	I	I	I
CHILE	m	m	M	Cb	Cb	I	I	I
CZECH REP.	p	p	p	M	M	M	M	I
HUNGARY	M	M	M	Cb	Cb	Cb	Cb	Ph
INDIA	I	I	I	I	I	I	M	M
ISRAEL	M	M	M	Cb	Cb	Cb	Cb	Cb
POLAND	M	M	M	Cb	Cb	Cb	I	I
SINGAPORE	M	M	M	M	M	M	M	M
TURKEY	M	M	M	Cp	Cp	Cp	I	I

Source: Compiled from International Financial Statistics (IMF), Yearbooks 1995-2001, May 2002

Legend:
Cb= Exchange Rates within Crawling Bands
Cp= Crawling Pegs
E = Euro (No Separate Legal Tender)
F = Fixed Peg (incl currency boards & conventional pegs)
I = Independent float
M = Managed Float
m = Managed float (set to indicator)
p = Peg (other composite)
Ph = Pegged Exchange Rates within horizontal bands

Table 3: Exchange Rate Volatility: 1995-2002

Standard deviation of monthly movements (percentage changes) against the US dollar

	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
ASIA 5								
Indonesia	0.08	0.51	8.76	41.60	9.86	4.22	8.00	1.29
Korea	0.94	1.01	13.58	7.60	2.68	2.49	2.52	0.35
Philippines	1.46	0.12	5.61	5.56	1.95	3.57	2.54	0.22
Thailand	0.56	0.37	8.06	9.29	3.18	2.31	1.96	0.11
Average	0.76	0.50	9.00	16.01	4.42	3.15	3.75	0.49
Malaysia	1.14	0.72	4.78	8.87	0	0	0	0
INDEPENDENT FLOAT								
Australia	2.01	1.85	2.26	3.66	2.12	3.85	4.43	1.10
Canada	1.31	0.77	1.14	2.03	1.60	1.52	1.70	0.63
Germany	3.07	2.21	2.83	2.44	1.87	3.59	2.58	1.83
Japan	5.11	2.03	3.77	5.56	2.34	2.64	3.47	0.76
Mexico	7.92	2.22	1.48	3.74	2.88	2.77	2.02	0.67
New Zeald	1.51	1.17	2.35	4.63	2.41	4.60	4.48	2.62
S. Africa	0.94	3.21	1.69	5.22	1.84	2.35	5.33	2.66
Sweden	2.49	2.00	2.55	2.21	2.56	2.84	2.59	0.58
Switzerland	3.33	3.19	3.23	2.77	2.02	3.32	2.65	1.56
U.K.	1.69	1.83	2.40	1.68	2.03	2.50	1.49	1.87
Average	2.94	1.86	2.37	3.39	2.17	3.00	3.07	1.43
OTHERS								
Brazil	1.73	0.51	0.46	0.54	19.58	2.07	5.09	3.78
Chile	2.58	0.79	1.35	1.32	2.51	4.05	3.44	2.59
Czech Rep.	2.17	1.98	3.56	5.06	3.57	3.01	2.14	2.23
Hungary	2.15	1.42	1.79	1.91	1.94	3.68	2.33	1.51
India	1.94	1.91	1.81	1.45	0.47	0.79	0.51	0.43
Israel	1.38	1.51	1.91	3.35	1.62	1.81	1.87	
Poland	2.00	1.13	1.88	3.44	3.07	3.69	2.47	2.97
Singapore	1.14	0.36	2.12	4.00	1.41	1.18	1.78	0.83
Turkey	2.65	1.41	1.31	1.89	1.52	1.56	10.88	8.46
Average	1.97	1.23	1.80	2.55	3.97	2.43	3.39	2.53

Source: Calculated from International Financial Statistics (IFS) (IMF), Yearbooks 1995-2001, May2002.
Note: data for 2002 is till May 2002.

Table 4: Interest Rate Volatility: 1995-2002
Standard deviation of differences in interest rates

	1995	1996	1997	1998	1999	2000	2001	2002
ASIA 5								
Indonesia	1.33	1.13	16.10	13.86	3.55	0.44	4.35	-
Korea	1.26	1.30	2.27	1.99	0.29	0.08	0.12	0.04
Philippines	1.41	0.32	1.04	0.81	0.49	2.00	0.68	0.16
Thailand	2.54	1.84	5.54	4.76	0.35	0.41	0.30	0.13
Average	1.61	1.15	6.24	5.36	1.17	0.73	1.36	0.11
Malaysia	0.13	0.34	2.45	1.12	0.48	0.06	0.05	0.03
INDEPENDENT FLOAT								
Australia	0.16	0.20	0.16	0.07	0.07	0.16	0.18	0.02
Canada	0.63	0.21	0.24	0.37	0.10	0.16	0.24	0.14
Germany	0.10	0.15	0.10	0.10	0.17	0.11	0.25	0.01
Japan	0.20	0.02	0.03	0.05	0.04	0.05	0.05	0
Mexico	17.21	4.14	2.23	5.19	2.01	1.36	1.11	0.78
New Zeald	0.33	0.43	0.53	0.82	0.26	0.15	0.12	0.05
S. Africa	0.29	0.72	0.42	1.59	0.40	0.20	0.19	0.06
Sweden	0.15	0.17	0.06	0.13	0.12	0.11	0.13	-
Switzerland	0.41	0.43	0.37	0.26	0.18	0.36	0.37	0.33
U.K.	0.49	0.22	0.19	0.37	0.82	0.91	0.78	1.24
Average	1.20	0.67	0.43	0.89	0.42	0.36	0.34	0.29
OTHERS								
Brazil	6.80	1.27	6.25	6.20	4.55	0.34	0.53	0.06
Chile	0	0	0	0	0	2.32	2.78	0.14
Czech Rep.	0.29	0.29	0.72	0.87	0.45	-	0.36	-
Hungary	0.72	1.14	0.32	0.86	0.41	0.63	0.19	0.21
India	7.97	7.22	2.08	5.76	1.17	2.74	0.64	0.43
Israel	1.05	0.79	0.47	0.99	0.42	-	-	-
Poland	1.78	1.56	2.60	1.68	2.14	0.81	1.29	-
Singapore	0.51	0.51	0.69	0.78	0.44	0.36	0.28	0.04
Turkey	9.06	-	-	-	-	1.48	6.78	6.93
Average	3.52	1.83	1.88	2.45	1.37	1.09	1.61	1.3

Source: Calculated from IFS (IMF), Yearbooks 1995-2001, May 2002, RBI for Indian data.

Note: 1. Where money market rates are not available the nearest available short-rate is taken. For the Philippines, Hungary, Israel, Turkey and Singapore this is the Treasury bill rate, and for the Czech Republic it is the discount rate. 2. Data for 2002 is till May 2002 (for India till August). 3. - Indicates data not available: these entries have been excluded in averaging. 4. When there is no difference in the variables the entry is zero.

Table 5: Currency distribution of reported global foreign exchange market turnover (1)
Percentage shares of average daily turnover in April

Currency	1995	2001
US dollar	83.3	90.4
Euro	--	37.6
Deutsche mark	36.1	--
French franc	7.9	--
ECU and other EMS currencies	15.7	--
Japanese yen	24.1	22.7
Pound sterling	9.4	13.2
Swiss franc	7.3	6.1
Canadian dollar	3.4	4.5
Australian dollar	2.7	4.2
Swedish krone2	0.6	2.6
Hong Kong dollar2	0.9	2.3
Norwegian krone2	0.2	1.5
Danish krone2	0.6	1.2
Singapore dollar2	0.3	1.1
South African rand2	0.2	1
Mexican peso2	--	0.9
Korean won2	--	0.8
New Zealand dollar2	0.2	0.6
Polish zloty2	--	0.5
Brazilian real2	--	0.4
Russian rouble2	--	0.4
Taiwan dollar2	--	0.3
Chilean peso2	--	0.2
Czech koruna2	--	0.2
Indian rupee2	--	0.2
Thai baht2	--	0.2
Malaysian ringgit2	--	0.1
Saudi riyal2	--	0.1
Other currencies	7.1	6.7
All currencies	200	200

Source: BIS

Note: 1. Because two currencies are involved in each transaction, the sum of the percentage shares of individual currencies total 200% instead of 100%. The figures relate to reported "net-net" turnover, i.e. they are adjusted for both local and cross-border double counting. 2. For 1992-98, the data cover local home currency trading only.

Table 6: Forex turnover compared to other sources of currency transactions

	Forex turnover $bn (April)				Merchandise trade US $bn				Forex inflow US $bn			
	1995	**%**	**2001**	**%**	**1995**	**Daily av.**	**2001**	**Daily Av.**	**1995**	**Daily av.**	**2001**	**Daily Av.**
Indonesia	--	--	4	0.2	107.38	0.29	125.10	0.35*	5.84	0.02	-9.90	-0.03*
Korea	--	--	10	0.6	302.34	0.83	352.08	0.97	1.69	0.005	-22.40	-0.06
Philippine	--	--	1	0.1	60.11	0.17	77.93	0.21*	1.63	0.005	-8.27	-0.02*
Thailand	--	--	2	0.1	152.51	0.42	145.93	0.40	6.88	0.02	-8.06	-0.02
Malaysia	--	--	1	0.1	170.22	0.47	206.50	0.57*	9.39	0.03	-9.38	-0.03*
Australia	40	2.5	52	3.2	143.93	0.39	169.17	0.46*	18.82	0.05	166.48	0.46*
Canada	30	1.9	42	2.6	42.04	0.12	568.90	1.56	-21.22	-0.06	-3.76	-0.01
Germany	76	4.8	88	5.4	1191.1	3.26	1275.97	3.50	-27.26	-0.08	-22.11	-0.60
Japan	161	10.2	147	9.1	913.55	2.50	988.41	2.71*	-177.33	-0.49	-175.67	-0.48*
Mexico	--	--	9	0.5	171.49	0.47	372.11	1.02*	21.85	0.06	18.00	0.05*
N. Zealnd	7	0.4	4	0.2	35.31	0.10	35.17	0.10*	2.81	0.01	3.12	0.01*
S. Africa	5	0.3	10	0.6	68.06	0.19	0.65	0.00*	69.34	0.19	-0.86	-.002*
Sweden	20	1.3	24	1.5	176.67	0.48	183.59	0.50	-6.25	-0.02	-8.91	-0.03
Switzerld	87	5.5	71	4.4	232.08	0.64	229.13	0.63*	-26.07	-0.07	-32.35	-0.09*
UK	464	29.5	504	31.1	647.83	1.78	828.1	2.27*	3.2	0.01	6.27	0.02*
Brazil	--	--	5	0.3	115.93	0.32	140.20	0.38*	8.79	0.02	28.27	0.08*
Chile	--	--	2	0.1	37.66	0.10	43.30	0.12*	0.52	0.001	1.30	.004*
Czech rep	--	--	2	0.1	58.25	0.16	73.27	0.20*	-5.51	-0.02	1.69	.005*
Egypt	--	--	--	--	30.4	0.08	39.76	0.11*	6.11	0.02	7.17	0.02*
Hungary	--	--	1	0	36.96	0.10	63.57	0.17*	-2.73	-.008	0.85	.002*
India	--	--	3	0.2	86.24	0.24	136.70	0.38*	14.68	0.04	11.56	0.03*
Israel	--	--	1	0	62.71	0.17	82.16	0.23	10.19	0.03	8.71	0.02
Poland	--	--	8	0.5	69.54	0.19	103.50	0.28*	-9.73	-0.03	11.75	0.03*
Singapore	105	6.7	101	6.2	282.95	0.78	314.91	0.86*	-24.39	-0.07	-29.96	-0.08*
Turkey	--	--	1	0.1	76.79	0.21	113.34	0.31*	2.17	0.006	17.98	0.05*

Source: BIS 2001, IFS 1995 & May 2002

Note: 1. Foreign inflows are measured as the current account deficit plus reserve gains.
2. Merchandise trade is calculated as exports plus imports of goods and services (absolute values).
3. A* indicates the data for trade and inflows is for the year 2000, a -- means not available.

Table 7: Aspects of the Indian Forex Market

Sl.No.	US $ Million FCY/INR 1*	1998-99	2001-2002
1.	Total spot turnover (sales + purchases)	333746	450157
2.	Total CB intervention (sales + purchases	55650	38580.78
3.	2 as % of 1	16.67	8.57
4.	Share of 1 due to interbank(%)	66.17	64.75
5.	Share of 1 due to interbank(%)	33.83	35.25
6.	Total forward as % of total spot	27.30	20.82
7.	Total swap as % of total spot 3*	97.04	149.63
8.	Total spot (For April, 2001) 2*	13945.98	30381.87
9.	Share due to RDs (from CB survey) (%)	63.99	68.15
10.	Share due to other financial insts. (%)	12.17	5.76
11.	Share of non-financial insts.(%)	23.84	26.09
12.	Share in total spot of local transactions(%)	90.40	95.98
13.	Share in total spot of cross border tran.(%)	9.60	4.02
14.	Total forex derivatives as % of total spot	-------	0.06

Note:

(1) to (7) have been calculated from RBI bulletins. The data was collected for all the months in the given years and summed up. Each year is taken from July to June

(8) to (14) are figures for the month of April as is available in the Central Bank Surveys (BIS)

(9) to (14) are as percentage to (8); (14) which comprises currency swaps and OTC options was negligible for the year 1998-99

1* All transactions involve exposure to more than one currency

2* Excluding "tomorrow/next day" transactions

3* A swap is considered to be a single transaction in that the two legs are not counted separately. Including "tomorrow/next day" transactions

FCY: Foreign currency

INR: Indian rupees

RDs: Reporting dealers

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