

WP-2006-015R

# Incentives from Exchange Rate Regimes in an Institutional Context

Ashima Goyal



Indira Gandhi Institute of Development Research, Mumbai  
December 2006

# Incentives from Exchange Rate Regimes in an Institutional Context<sup>1</sup>

Ashima Goyal

Indira Gandhi Institute of Development Research (IGIDR)  
General Arun Kumar Vaidya Marg  
Goregaon (E), Mumbai- 400065, INDIA  
Email (corresponding author): ashima@igidr.ac.in

## Abstract

*In a simple open economy macromodel, calibrated to the typical institutions and shocks of a densely populated emerging market economy, it is shown that a monetary stimulus preceding a temporary supply shock can abort inflation at minimum output cost, since of the appreciation of exchange rates, accompanying a fall in interest rates and rise in output. Analytic results obtained for two periods are generalized through simulations and validated through estimation. The results imply that one instrument can, in these conditions, achieve both domestic output and exchange rate objectives, since it creates correct incentives for foreign exchange traders who make profits in supporting the policy. Such a policy response is compatible with political constraints; it also imparts limited volatility to the nominal exchange rate around a trend competitive rate, thus encouraging hedging and deepening markets. But strategic interactions imply the optimal policy need not be chosen; supporting institutions are required to coordinate monetary, fiscal policy, and markets to the optimal equilibrium. The analysis gives useful degrees of freedom for Asian emerging markets migrating to exchange rate regimes compatible with more openness.*

Key words: Emerging market economy, Mundell-Fleming, monetary policy, FX market, supply shocks

JEL Code(s): F31, F41

---

<sup>1</sup>The first version of this working paper was put up in July 2005. This paper draws upon and extends parts of work done for a project on Macroeconomic Policy Challenges of Low Income Countries, coordinated by GDN. It was presented at the Claremont-IIE Workshop on the Political Economy of Intermediate Exchange Rate Regimes at IIE, Washington, and at the South and South East Asia Econometric Society Meeting, Chennai, India. I thank Pulapre Balakrishnan, Jose Maria Fanelli, Partha Gangopadhyay, Kundan Kishor, Thomas Willett, and conference participants for comments, the Fulbright Foundation for supporting the work, CIEPS, and Claremont Graduate University for warm hospitality, Ankita Agarwal, Ayan Kumar Pujari, Rijo John and Saumik Paul for research assistance, Ramkishen Rajan and Tony Cavoli for information on the simulation algorithm, Jayshree Borkar and T.S. Ananthi for help with the word processing.

# Incentives from Exchange Rate Regimes in an Institutional Context

Ashima Goyal

## 1. Introduction

The paper examines the degrees of freedom for monetary policy in a small open emerging market economy (SOEME). It seeks to discover the conditions under which monetary policy delivers both domestic cyclical and exchange rate objectives, and foreign exchange (FX) markets support the policy since they profit by helping deliver the appropriate exchange rate. The analysis is useful for Asian emerging market economies (EMEs) that are in the process of migrating to exchange rate regimes compatible with more openness.

The response of monetary policy to supply shocks, and its ability to deliver the required exchange rate, is examined in a small open economy model<sup>2</sup>. The latter has an aggregate demand function, a money demand function, a Phillips curve, and an interest arbitrage condition, but each component incorporates features of the EME. Structural features such as wage-price rigidities due to low per capita incomes and political interventions; high potential output due to high population density; but short-term bottlenecks due to frequent temporary supply shocks are built in. Forward-looking aspects come in through the exchange rate and consumer prices. Analytical results obtained in a simplified version with restrictions on parameters, are confirmed through simulations and sensitivity analysis with the full model. Estimation also justifies the chosen calibration.

The Central Bank's (CB's) optimization, given the constraints from the macromodel, affects the decisions and payoffs of market participants and vice versa. The outcome can be self-enforcing under certain parameter values, which we explore by solving for the outcome of interaction between the central bank and the market players<sup>3</sup>. The

---

<sup>2</sup> New Keynesian Economics literature has developed a number of such models, where forward looking behavior is combined with price rigidities. Svensson (2000) was a seminal paper, even though his focus was on inflation targeting. The macromodel in this paper also draws on Oudiz and Sachs (1985) and Ghosh (2002).

<sup>3</sup> Forex traders are modeled following a well-developed literature, for example Bhattacharya and Weller (1997), Lyons (2001), and Jeanne and Rose (2002).

analysis is used to construct an analytical narrative explaining actual policy choices in India's post-reform period. As suggested by Bates et.al. (1998), laying out the assumptions and the derivations allow the logic of the argument to be critiqued; suitability of assumptions and the ability to validate stylized facts provide a check for relevance.

It turns out that monetary policy can impart limited volatility to the nominal exchange rate by using shocks yet reducing their amplification. This makes a smoother and more countercyclical interest rate feasible. Intervention may not be required at all since markets deliver the required exchange rate. The resulting exchange rate regime contributes to stimulating the real sector also through encouraging trade. If deviations from the competitive equilibrium real exchange rate are minimized, external balance is maintained over the long-run. It contributes to the control of inflation by countering supply shocks, thus achieving a vital political goal. It encourages monetary policy to be forward looking rather than reactive. It also deepens and maintains stability in the FX market.

Full floating results in excessive volatility in immature markets with large foreign inflows, but some flexibility may moderate volatility. FX markets have a tendency towards excessive movement, as market participants tend to follow each other. Hedging removes the effect of currency movement in any one direction on profits by creating exposure in the opposite direction. Limited two-way movement improves incentives for hedging and therefore reduces currency risk. Since the number of agents whom a change in the nominal exchange rate affects falls, market stability rises. No hedge can cover a currency crisis, but random small movements reduce one-way bets that could otherwise magnify the movements, as happened during the East Asian crises when exchange rates were largely fixed. Currency risk aggravates systemic, liquidity and credit risk in thin EME financial markets. Global and regional measures are also required to reduce these risks, but this paper brings out the contribution of exchange rate regimes.

Under large capital inflows, facing fast growing EMEs today, accumulation of reserves and aggressive sterilization can prevent exchange rate appreciation, but interest rates rise. In the simple Mundell-Fleming (M-F) model this implies further

inflows. Monetary policy loses its independence being tied to maintaining the fixed exchange rate. The cycle can end in a crisis with a reversal of inflows and a collapse of the exchange rate. A restrictive macroeconomic policy response may harm the real sector and lead to the reversal it fears. But over appreciation of the exchange rate can harm trade, and intervention without full sterilization can cause a damaging over-expansion of the money supply, which again raises interest rates because of expected inflation. Monetary policy has to find a fine balance.

It turns out that some of the ways such an EME's structure differs from the prototype M-F model give degrees of freedom for monetary policy, despite large capital flows. The policy combination will be credible only if it improves real fundamentals in the economy. It will do this since the variation in the exchange rate allows interest rates to respond to the domestic cycle and reduces the impact of import price shocks on inflation. Since inflation is a very sensitive political issue, this will enhance the political feasibility of the policy. Inflation has been controlled in ways that have imposed large distortions and costs on society. So an exchange rate regime suited to structure and rigidities can reduce this waste and improve coordination, thus helping resolve a collective action problem to release potential surplus.

Section 2 presents the model, theoretical results, and empirical validation through regressions and simulations. Section 3 applies it to explain policy choices and outcomes. Section 4 draws out policy implications before section 5 concludes.

## 2 The Model

A standard open economy IS-LM-UIP (uncovered interest parity) model is adapted by building in the dualistic labor market, specific wage-price rigidities, the typical structure of shocks, and a simple FX market.

## 2.1. A Macro Structural Model of a Small Open Economy

The building blocks of the model are first, an aggregate demand equation where output,  $y_t$ , responds positively to the real exchange rate and negatively to the real interest rate. All variables are expressed as log-linearized deviations from a mean.

$$y_t = \delta(e_t + p_t^* - p_t) - \sigma(i_t - (p_{t+1}^e - p_t)) \quad (1)$$

The nominal exchange rate  $e_t$  is measured in units of foreign currency so that a rise implies a depreciation of the home currency. Since  $p_t$  denotes home country prices and  $p_t^*$  foreign prices, the term in the first bracket gives the real exchange rate. Expected inflation  $(p_{t+1}^e - p_t)$  subtracted from the nominal interest rate gives the real interest rate in the second bracket. Money market equilibrium gives:

$$m_t - p_t = \alpha y_t - \phi i_t - v_t \quad (2)$$

Since the money supply is assumed to target interest rates,  $v_t$  is the composite demand shock plus money supply response. A rise in  $v_t$  will reduce  $i_t$ .

Even without full capital account convertibility, mobile capital flows are assumed to be large enough to equate expected returns from deposits in domestic currency, to those from deposits in foreign currency plus country risk. Since capital account convertibility is limited<sup>4</sup>, domestic residents cannot hold foreign bonds and sovereign bonds are not floated internationally. Therefore the share of foreign bonds in portfolios does not determine the risk premium, which depends on an exogenous country risk plus FX traders' risk<sup>5</sup>, derived to be negatively related to the variance of exchange rates in section 3.4 below. With the foreign interest rate normalized to zero, arbitrage implies that expected depreciation of the exchange rate plus the risk premium  $\rho_t$ , must equal the interest differential:

$$i_t = e_{t+1}^e - e_t + \rho_t \quad (3)$$

On the supply side, producer prices are marked up on wages, so producer price inflation responds to nominal wage inflation, lagged output (through pro-cyclical mark-ups) and contemporaneous oil ( $\eta_{t+1}$ ) or productivity ( $g_{t+1}$ ) shocks to supply:

---

<sup>4</sup> This is true of both India and China.

<sup>5</sup> BIS forex market data shows that traders dominate forex transactions. Transactions due to trade or investment are a very small percentage of more than dollar trillion forex transactions. Goyal (2005) shows that the latter are much lower in EMEs compared to developed countries, but are growing rapidly.

$$p_{t+1} - p_t = (w_{t+1} - w_t) + \psi y_t - g_{t+1} + \eta_{t+1}$$

(4)

The consumer price index,  $p_t^c$ , is a weighted average of home and foreign prices.

Since  $p_t^*$  is normalized to zero,  $p_t^c$  responds directly to  $e_t$ :

$$p_t^c = \lambda p_t + (1 - \lambda) e_t \quad (5)$$

Nominal wages respond to lagged inflation in consumer prices so,  $w_t = p_{t-1}^c$ . This feature follows from characteristics of a dualistic labor market where wages may not be indexed to inflation but the low wage level is highly sensitive to food price inflation<sup>6</sup>. Substituting out wages from equation (4) and assuming that productivity is not changing gives:

$$p_{t+1} - p_t = (p_t^c - p_{t-1}^c) + \psi y_t + \eta_{t+1} \quad (6)$$

With trade liberalization food prices become more closely linked to border prices and the weight of  $e_t$  in equation (5) rises;  $p_t^c$  responds to  $e_t$ ; wages respond to  $p_t^c$ ; and producer prices are marked up on wages. If  $w$  does not rise, neither will  $p_{t+1}$ , unless there is an adverse supply shock  $\eta_{t+1}$ . The effect of border prices in stabilizing food prices, allows a potential escape from the inflation cum subsidy trap.

The dualistic labor market structure implies that if food prices are stable, supply is elastic since output is below the potential that absorbs the labor slack<sup>7</sup>. If capital is available, specific bottlenecks are alleviated and institutional reforms undertaken shocks to which the supply curve is subject can also be reduced. Foreign inflows relieve constraints on imports of food stocks, fuel oils and capital goods<sup>8</sup>. Moreover new technology makes it possible to bypass some deficiencies in infrastructure while

---

<sup>6</sup> Since there is no cost of living indexation in the large informal Indian labor market (accounting for 80 percent of the work force) nominal wage adjustment is lagged. There are political pressures to keep real wages fixed in terms of food; and pressures from well organized rural lobbies (the share of the rural population still exceeds 70 percent) for high and rising farm support prices. The compromise has been to subsidize both farmers and consumers; the latter through a low price public distribution system. Since the latter is not very effective, protection is not complete, and nominal wages rise with a lag in response to a rise in food prices.

<sup>7</sup> The Planning Commission (2006, pp.77), India, estimates that 35 million are unemployed and the labor force will increase by 52-65 million over the next five years because of population growth and more female labour force participation.

<sup>8</sup> Stable inflows tend to dominate in labour surplus EMEs. They may even relieve India's pressing infrastructure needs. The Indian Government is trying to find innovative ways to use forex reserves to raise spending on infrastructure, motivated by the Chinese Government's successful large spending in this area. The inability of the private sector to build infrastructure despite inducements has led to an emphasis on public private partnerships.

easier availability of finance funds its expansion in EMEs. Reduction in bureaucratic rationing and continuing reforms remove rigidities, shorten lags and delays, making supply more elastic. Since the real consumption wage in the informal labour market is around subsistence, firms do not gain from lowering it, since the latter makes productivity fall. The availability of labor implies that, in the short-run and over a horizon exceeding one year, which is long enough for the capital stock to rise, mean output  $\bar{y}$  would lie below potential output  $\bar{y}^*$ ; there are constant returns to capital<sup>9</sup>. In the short run we consider in the model, if food prices are constant labor cost does not rise; if there is no cost shock, intermediate inputs prices also do not rise; if mark-ups are constant, deviations from mean output are demand-determined with costs remaining constant<sup>10</sup>.

The effect of money supply on prices comes in through the money market equation (2). An excessive rise in money supply is inflationary, if short-run capacity constraints are reached but not if cost shocks have the dominant effect on prices in the short-run. To the extent money demand becomes unstable with development, money supply has to respond more frequently in order to prevent large fluctuations in interest rates, but the equilibrium condition (2) must continue to hold. Since the policy instrument may be a short interest rate, money supply  $m_t$  can be normalized to zero.

The structure of the EME and its typical shocks allow simplifying assumptions required to derive analytical results. These are relaxed in simulations later. If dualism and rigidities lower the response to price variables in an EME, price elasticities such

---

<sup>9</sup> Aghion et. al. (1999) derive this in a standard Cobb-Douglas production function  $Y = AK^\beta L^{1-\beta}$  where Y is the output level, K the capital stock, L labor employed. Normalizing the constant consumption wage  $W/P_t^c = 1$  (where W is the nominal wage and P the price level) and equating it to the marginal product of labor gives a value for L, which when substituted in the production function gives  $Y = A((1-B)A)^{(1-\beta)/\beta} K = \tau K$  or the standard AK production function with CRS. Despite rapid growth in India since the late nineties, NSS earnings data show almost constant real wage rates over 1999-2000; only graduates and above saw a sizeable rise in earnings (Planning Commission, 2006, pp. 76-77).

<sup>10</sup> Reforms allow faster labor absorption and an upward trend in mean output. Capital accumulation and organizational change over time will raise labor productivity, and increasing competition through opening out will reduce mark-ups. These factors will tend to further reduce inflation until the economy reaches a mature steady state. We abstract from them in order to simplify the analysis, but these factors further support the results.



as  $\delta$ ,  $\sigma$  may be low. But they would rise with reform<sup>11</sup>. Constant mark-ups and CRS imply that  $\psi \approx 0$ , and the large weight of food in  $P_t^c$  implies that  $\lambda$  is also low. If policy successfully implements limited volatility of the real exchange rate and induces hedging against small variations so that the exchange rate does not have a major impact on trade, we can assume  $\delta = 0$ . The first term of the real exchange rate drops out of equation (1). We assume country risk is constant, and that the central bank credibly commits to limiting the variance of the exchange rate, so that the risk premium is low. Some exchange rate variability induces hedging and reduces the impact of shocks that raise the risk premium. In the analytical derivation we restrict the horizon to 3 periods (a simulation establishes similar results for  $n$  periods). All agents including the CB have a three period horizon. No trade occurs in the FX market in period 3 since the exchange rate has stabilized. Predetermined variables are set to zero, so  $p_o^c = p_1 = 0$ . All exogenous foreign price variables are also taken to be zero. To model the frequency of supply shocks in an EME, we consider the case of the period 1 monetary policy variable  $v_1$  responding to an expected supply shock in period 2,  $\eta_2$ . As a result it is possible to set  $v_2 = 0$  and  $\eta_1 = 0$ . We drop  $\rho$  from the arbitrage equation since the risk premium is assumed not to change.

The CB has prior knowledge of the supply shock from its close following of trends and understanding of economic structure. In period 1 it learns that an adverse supply shock will impact the economy in period 2 (for example, a poor harvest due to a failure of rains). It responds by lowering interest rates (raising  $v_1$ ) in period 1. It is fully transparent and announces both the expected shock and its action.

Agents anticipate future prices and exchange rates and understand the CB's objective function. Expectations are model consistent and are realized in equilibrium. Therefore equilibrium values can be derived by the method of backward induction, starting with period 2 variables.

---

<sup>11</sup> Ghosh (2002) estimates  $\delta = 0.114$ ,  $\sigma = 0.152$ ,  $\alpha = 0.225$  and  $\phi = 1.420$ , for the US and OECD countries. Cavoli and Rajan (2004) estimate  $\delta = -0.09$ ,  $\sigma = 0.36$  for Thailand. Thus trade effects are small and of the wrong sign, and interest elasticity is large. Estimates of aggregate demand and supply functions for India, with monthly and quarterly data for the period after 1995, show  $\delta$  to be insignificant, while  $\sigma$  is large and significant. Aggregate supply shows negative effects of excess capacity and positive impact of external prices on WPI inflation (see section 3.3).

The assumptions made give  $i_2 = -e_2$ ,  $p_2 = p_1^e$  since  $e_3 = 0$  because of mean reversion in exchange rates and  $p_I = 0$ . Also using equations (1) to (5) we can solve for  $y_2$  and  $e_2$  as functions of  $p_2$  the inherited producer price:

$$e_2 = \frac{(\alpha\sigma - 1)p_2}{(\alpha\sigma + \phi)} \quad (7)$$

$$y_2 = \frac{-\sigma(1 + \phi)p_2}{\alpha\sigma + \phi} \quad (8)$$

Reverting to period 1, the aggregate demand function reduces to:

$$y_1 = -\sigma[i_1 - p_2^e] \quad (9)$$

The money market equilibrium gives:

$$i_1 = \frac{\alpha y_1 - v_1}{\phi} \quad (10)$$

Arbitrage (3) gives, using (10):

$$e_1 = e_2^e - \frac{(\alpha y_1 - v_1)}{\phi} \quad (11)$$

Price dynamics from the Phillips curve, remembering  $p_o^e = p_1 = 0$  give:

$$p_2 = (1 - \lambda)e_1 + \psi y_1 + \eta_2 \quad (12)$$

Since  $\lambda \sim 0$  and  $\psi \sim 0$ , equation (12) simplifies further to  $p_2 = e_1 + \eta_1$ . Substituting for  $e_1$  and  $y_1$  and imposing the condition that  $e_2^e = e_2$  and  $p_2^e = p_2$  so that expectations are realized gives:

$$p_2 = \frac{(\alpha\sigma + \phi)\phi(1 + \alpha\sigma)\eta_2 + (\alpha\sigma + \phi)v_1}{\phi(1 + \phi + \alpha\sigma(1 + 2\phi + \alpha\sigma))} \quad (13)$$

Substituting (13) in the equations for  $e_1$  and  $y_1$  allows us to solve for these variables as functions of the exogenous parameters and shocks. Calling the denominator of Equation (13)  $\phi D$ ,  $y_1$  can be written as:

$$y_1 = \frac{\sigma\phi(\alpha\sigma + \phi)((1 + \alpha\sigma)\eta_2 + ((\alpha\sigma + \phi) + \sigma\phi D)v_1)}{(1 + \alpha\sigma)D} \quad (14)$$

$$e_1 = \frac{-(1 - \alpha\sigma)p_2}{\alpha\sigma + \phi} - \frac{\alpha y_1}{\phi} + \frac{v_1}{\phi} \quad (15)$$

Equation (14) implies that

$$\frac{\delta y_1}{\delta \eta_2} > 0 \quad \text{and} \quad \frac{\delta y_1}{\delta v_1} > 0$$

Equation (15) implies that

$$\frac{\delta e_1}{\delta v_1} = \frac{\delta e_2}{\delta v_1} - \frac{\alpha \delta y_1}{\phi \delta v_1} + \frac{1}{\phi} < 0$$

$$< 0 \quad < 0 \quad > 0$$

$$\frac{\delta e_1}{\delta \eta_2} = \frac{\delta e_2}{\delta \eta_2} - \frac{\alpha \delta y_1}{\phi \delta \eta_2} < 0$$

$$< 0 \quad < 0$$

From equations (10) a net fall in  $i_1$  requires  $v_1$  to exceed  $\alpha y_1$  and from equation (11) this implies an expected appreciation of  $e_2$ . The condition for  $e_2$  to actually appreciate  $\alpha \sigma < 1$  is also required for  $v_1$  to rise (Appendix I). The interest elasticity of output and income elasticity of money demand must not be too large. Estimated parameters satisfy these conditions. The response of  $p_2$ ,  $e_2$  and  $y_2$  to the shocks can be readily derived from equations (13), (7) and (8). The signs are collected in Table 1.

The results imply that an anticipatory policy response ( $v_1$ ) to a supply shock  $\eta_2$  that lowers period 1 interest rates would raise  $y_1$ , appreciate exchange rates in both periods, thus lowering  $p_1^c$ ,  $p_2^c$  and moderating the rise  $p_2$  and fall in  $y_2$  due to this rise. The policy takes advantage of lags in pricing to neutralize the effect of the supply shock on consumer price inflation, thus lowering the output cost of inflation targeting. In period 2 interest rates rise to cover the expected depreciation required for mean reversion. The nominal appreciation in the exchange rate is what counters the effect of the supply shock on inflation. The exchange rate appreciates despite the rise in money supply because the rise in  $y$  raises money demand. The anticipated rise in  $p_2$  together with the fall in  $i_1$  lowers the real interest rate and stimulates  $y_1$ , but the rise in  $p_2$  is itself moderated by the anticipated appreciation.

Variables \ Shocks	$p_2$	$e_1 = p_1^c$	$y_1$	$e_2 = p_2^c$	$y_2$	$i_1$	$i_2 = -e_2$
$v_1$	+	-	+	-	-	-	+
$\eta_2$	+	-	+	-	-	+	+

It is possible to extend the results to explore how outcomes are affected if the CB does not fully share its prior information on  $\eta_2$  with the public in period 1. Then period 2 inflation may not be fully expected. But sharing information will benefit the CB if expected period 2 inflation lowers the real interest rate and stimulates output.

Expected inflation rises because producer prices adjust only with a lag. The CB does not have an inflation bias because in the labor market structure postulated, a surprise fall in real wages lowers labor productivity and therefore does not lead to a rise in labor demand and output. Moreover, in a low per capita income EME, inflation is a sensitive political issue. So the CB is strongly motivated to keep inflation low. All this implies that the full information equilibrium is sub game perfect, optimal and credible, with the private sectors' expectations of inflation fully realized.

The output cost is low for this strategy of inflation reduction since appreciation will shift down the supply curve reducing inflation, and the rise in demand will raise output, for the combination of shocks  $v_1$  and  $\eta_2$ . Interest rates rise in period 2 to cover the expected depreciation of the exchange rate back to its equilibrium value, thus negatively impacting period 2 output. But this effect will be lowered to the extent the equilibrium exchange rate itself appreciates, and the CB tends to smooth interest rates. The latter allows a small change in interest rates to have a large impact as forward looking agents factor in future movements in the same direction.

It also helps achieve one of the aims of reform to bring down the large gap that exists between domestic and world interest rates, since CBs worldwide tend to smooth interest rates. The interest gap can be further factored as  $i - \bar{i} + \bar{i} - i^*$ , with average domestic interest rates exceeding international. Exchange rate policy can contribute to shrinking the latter gap. When the economy reaches maturity  $i$  would be tied down by world inflation and real interest rate.

We put lowering the interest differential in the CB's objective function to capture its aim of reducing the deviation of output below potential, and smoothing interest rates. Inflation also reduces the CB's utility,  $U$ , and the weight  $w$ , on the loss due to inflation is high:

$$U = \text{Max}_{v_1} - \frac{1}{2} \left\{ \sum_t (i_t - i^*)^2 + wp_2^2 \right\}$$

As  $w$  rises the objective function reduces to the pure domestic inflation targeting case. Inserting equilibrium values of the variables in the CB's objective function and differentiating with reference to  $v_1$ , gives the optimal value  $v_1^*$  of the policy variable

$v_l$  (See appendix I). The optimum rises with  $\eta_2$  and falls with  $w$ , the weight on inflation in the CB's loss function<sup>12</sup>. A rise in  $v_l$  to  $v^*_1$  lowers the CB's loss, or increase its welfare.

## 2.2. Simulations

Simulations allow us to get results with the full optimization model<sup>13</sup>, without imposing any zero restrictions. They also allow us to move away from the assumption of only 3 periods. The results are similar to those from the analytical derivations documented in Table 1, but with more smoothing over time. Sensitivity analysis makes it possible to calibrate to benchmark parameter values, which turn out to be close to estimated values for India (section 3.3) and for Asian EMEs (see footnote 11).

The simulations are run for 12 periods with equal unit weights put on the variables in the loss function which are taken as  $p$  and  $y$ . Nine of the simulations (g1 to g9) are reported in Charts 1 and 2.

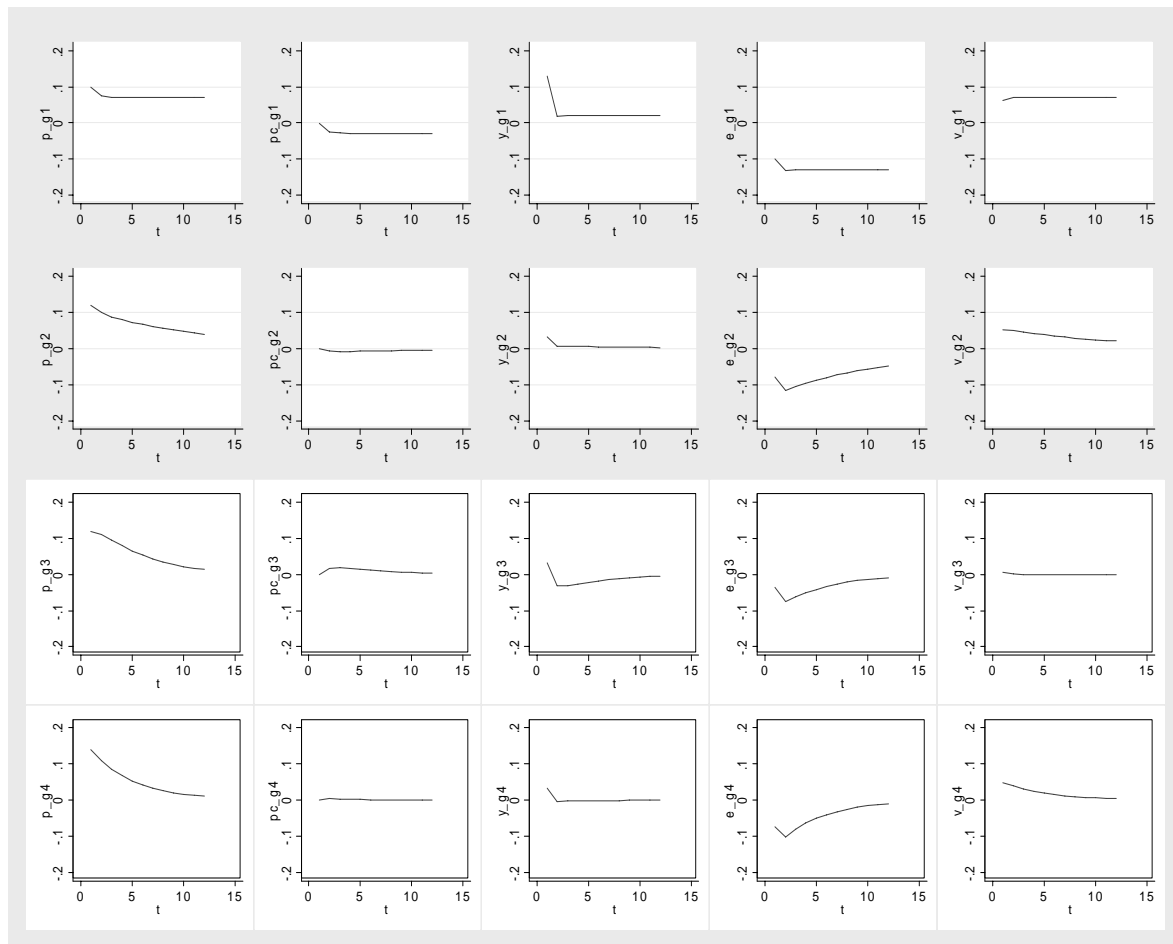
Each row in the charts reports the optimal response of  $p$ ,  $p^c$ ,  $y$ ,  $e$  and  $v$  respectively to a period one shock. Since the variables are measured in log deviations from steady state values, a shock leads to a diversion from zero with adjustment back towards equilibrium over time. In Chart 1 the range of variation on the y-axis is  $-0.2$  to  $0.2$ , and in Chart 2  $-0.1$  to  $0.1$ . For the first eight simulations, the shock is a cost shock  $\eta_1$ , and for the last simulation, it is a positive demand shock to  $y$ . Benchmark values resulting from the sensitivity analysis are  $\alpha = 1$ ;  $\sigma = 0.4$ ;  $\phi = 0.6$ ;  $\lambda = 0.5$ ;  $\psi = 0.1$ ;  $\theta = 0.1$ ;  $\delta = 0.1$ ; and the variance of the period 1 shock is taken to be  $0.1^2$ . The parameter  $\theta$  picks up the effect of lagged output on producer prices  $p$  in equation 4. Since  $v$  now adjusts gradually over the 12 periods the responses of the other variables are also smoothed over this period.

---

<sup>12</sup> Substituting  $\eta^e_{2=\theta} \eta_2$  in the CB's loss function, where  $\theta$  is the information disclosure, differentiating with respect to  $\theta$  gives the solution for  $\theta^*$  or the optimal degree of information disclosure, although we are abstracting from this by assuming full information disclosure.  $\theta^*$  falls with  $\eta_2$  and rises with  $v_l$ .

<sup>13</sup> The simulations modified a GAUSS code for solving for optimal monetary policy under discretion, made available by Paul Soderlind on his website <http://home.tiscalinet.ch/paulsoderlind>. I thank Ramkishen Rajan and Tony Cavoli for suggesting this code.

Chart 1, in g1 (row 1),  $\psi$  and  $\delta$  are 0 as in the analytical derivations. The basic pattern of a price shock leading to a rise in  $v$ , appreciation, fall in  $p^c$ , rise and then reversion in  $y$  and  $p$  is established. After the initial jump away from zero, and some adjustments in the early periods there is not much change over the course of the 12 period simulations.



**Chart 1: Impulse responses (simulations g1 to g4)**

Each row except the last (g9) reports the effect of a period one cost shock of size  $0.1^2$  on  $p$ ,  $p^c$ ,  $y$ ,  $e$  and  $v$ . In g1 (row 1) the parameter values are  $\alpha = 1$ ;  $\sigma = 0.6$ ;  $\phi = 0.6$ ;  $\lambda = 0.5$ ;  $\psi = 0$ ;  $\delta = 0$ . In g2 (row 2) the changes are  $\psi = 0.1$ ;  $\delta = 0.1$ ; g3 (row 3) changes  $\delta$  to 0.3, other parameters as in g2; g4 (row 4) has  $\psi = 0.2$ ;  $\delta = 0.1$ .

In g2 (row 2), positive coefficients for  $\psi$  and  $\delta$  moderate the rise in  $v$ , and the resulting appreciation. The rise in  $y$  and fall in  $p^c$  is less, and  $p$  rises more in the first few periods and then rises less. For all variables there is more change during the period of the simulation, and mean reversion is established. But the basic pattern remains intact in the more general model. The results are sensitive to the elasticity of export demand. In g3 (row 3), as  $\delta$  is raised to 0.2, the pattern changes. There is a fall in  $v$ , a smaller appreciation, fall in  $y$ , rise in both  $p$  and  $p^c$  in response to a cost shock.

But estimation rarely finds  $\delta$  to exceed 0.1, and for  $\delta = 0.1$  the basic pattern continues to hold.

A higher effect of  $y$  on  $p$ , or a rise in  $\psi$  and  $\theta$  to 0.2 in g4 (row 4), leads to a smaller rise in  $v$ , a smaller appreciation, a small fall in  $y$ ,  $p^c$  now remains positive through out, while  $p$  is first higher and then lower compared to the benchmark.

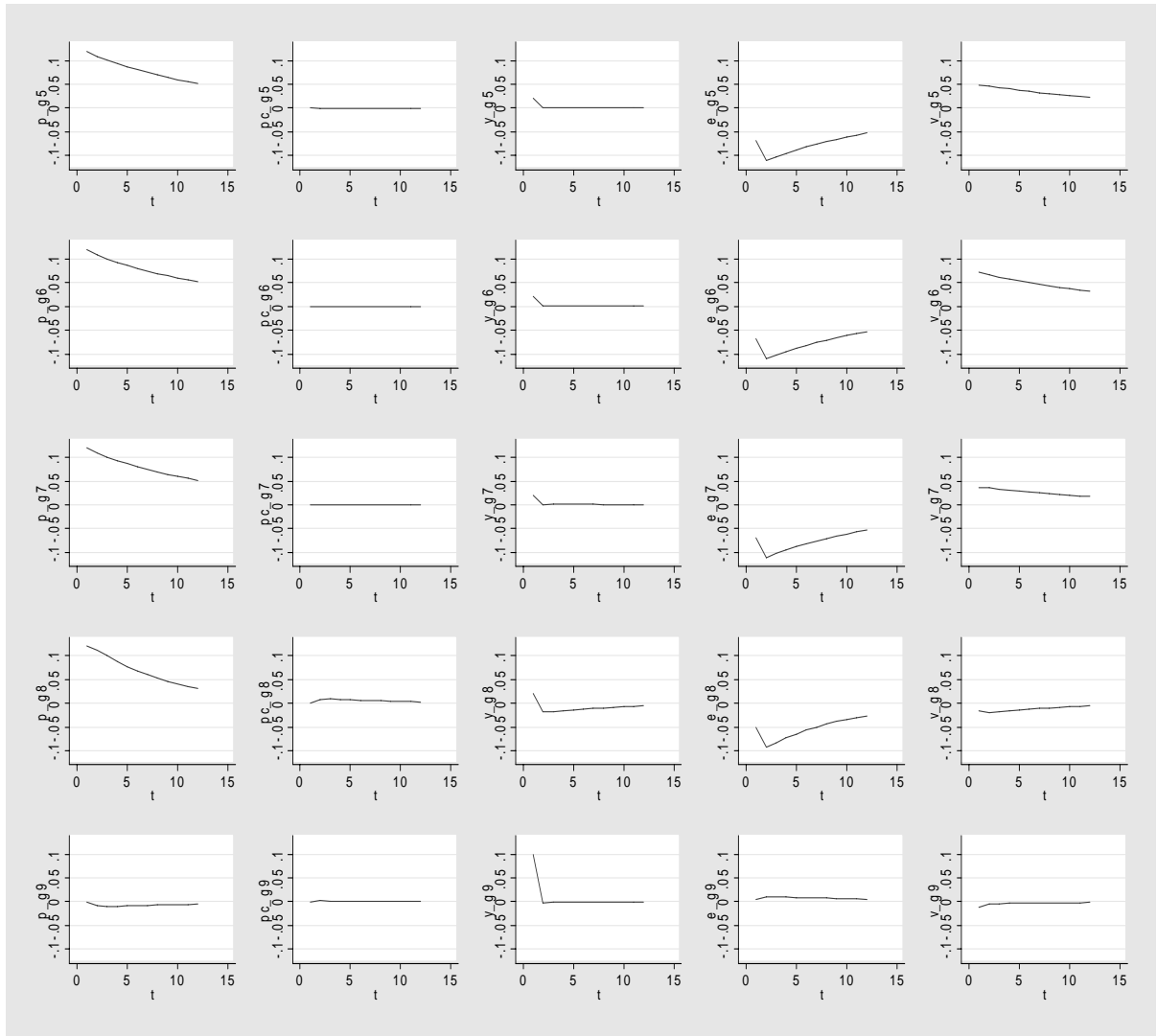
In Chart 2, g5 (row 1), a fall in the interest elasticity of aggregate demand  $\sigma$  by 0.2 to 0.4 makes  $v$  rise slightly less initially and then slightly more, with appreciation echoing this pattern. The rise in  $y$  is less;  $p^c$  is less negative, and  $p$  higher. Since the value of 0.4 is closer to empirical estimations we take this as our benchmark. The basic pattern of response to a cost shock, including initial appreciation followed by depreciation, continues to be the same.

The results are not sensitive to changes in the parameters of the money demand function, since  $v$  adjusts fully to compensate. Row 2 (g6) and 3 (g7) show the results of a change in the interest elasticity of money demand,  $\phi$ , first to 0.4 and then to 0.7. If  $\phi$  is lower,  $v$  has to rise more and is equally effective.

A simulation with no cost shock and a positive demand shock to output of standard deviation 0.1, (g9, row 5) leads to a fall in money supply leading to a fall in output after the period 1 rise. The exchange rate now depreciates;  $p^c$  is positive, and  $p$  negative. The pattern of response of variables is now different.

*We can safely conclude a rise in money supply, after a supply shock, minimizes the CB's loss function. It leads to an appreciation, which lowers prices, while output rises initially. Mean reversion occurs gradually.*

But CBs are worried about overreaction in foreign exchange markets affecting exchange rates. Therefore we analyze the response of FX traders to such a policy package in section 3.4, after seeing how far estimation with Indian data supports critical parameter values assumed in section 3.3.



**Chart 2: Impulse responses contd. (simulations g5 to g9)**

g5 (row 1) is the benchmark for all the simulations in this figure. The parameter values are  $\alpha = 1$ ;  $\sigma = 0.4$ ;  $\phi = 0.6$ ;  $\lambda = 0.5$ ;  $\psi = 0.1$ ;  $\delta = 0.1$ . The change here is a lower  $\sigma$ . In g6 (row 2),  $\phi$  is reduced to 0.4. In g7 (row 3),  $\phi$  is increased to 0.7; g7 changes  $\delta$  to 0.3, with other parameters as in g6. In g8 (row 4)  $\delta = 0.2$ ; g9 (row 5) has a positive output shock of variance  $0.1^2$ , no cost shock, and other parameters as in g5.

### 2.3 Estimation

Estimation of aggregate demand and supply for India are reported in Table 2. The data is for the period 1995-2004, sourced from the IFS (IMF) and RBI ([www.rbi.org.in](http://www.rbi.org.in)). All variables are transformed as changes in log values, except interest rates, and are all stationary. Unit root tests are reported in tables 3 and 4 in appendix II.

Parsimonious specifications as close as possible to the theoretical specifications are estimated with both monthly and quarterly data. Given this the R-squared, F and t statistics are good. To estimate aggregate supply, the log change in wholesale prices



dwpi\_t is regressed on log-lagged change in the consumer price index dcpi\_t\_2, US consumer price index duscpi, oil prices doil, a measure of potential output diippt, and a constant term, using monthly data.

**Table 2: Aggregate Demand and Supply in the Indian Economy**

	AGGREGATE DEMAND		AGGREGATE SUPPLY	
	MONTHLY	QUARTERLY	MONTHLY	QUARTERLY
	diip_t	dip_t	dwpi_t	dwpi_t
diip_t_1	-0.496****(-5.88)	-0.362*** (-2.32)	--	--
Cmr	1.464* (1.42)	-1.058*** (-2.26)	--	--
dz_t_1	-0.583 (-0.02)	-0.336 (-1.07)	--	--
drealr	1.39**** (2.67)	--	--	--
dwpi_t	-0.963* (-1.36)	-1.396* (-1.48)	--	--
constant	-.744 (-0.73)	.025 (1.15)	0.161**(1.81)	-.004 (0.45)
realcmrqr	--	1.099*** (2.33)	--	--
dcpi_t_2	--	--	0.403**(1.85)	-0.138** (-1.80)
diippt	--	--	-0.025*** (2.24)	--
doil	--	--	-0.013**(-1.90)	--
duscpi	--	--	1.026**** (4.34)	--
dgdpq_pot				-0.025** (-1.95)
No. of obs	115	37	115	36
F(5,109)	9.58	--	--	--
F(5,31)		5.94	--	--
F(4,110)	--	--	7.52	--
F(2,33)	--	--	--	4.49
Prob>F	0.00	0.0006	0.00	0.0189
R-squared	0.3053	0.4894	0.2147	0.2139
Adj.R-squared	0.2734	0.4070	0.1861	0.1662
Root MSE	4.0214	.03993	.55484	.00832

Note: t statistics in brackets; \*\*\*\*, \*\*\*, \*\*, \* indicate 1%, 2.5 %, 5%, 10% significance levels respectively

For quarterly data the potential output variable, dgdpq\_pot, is based on gross domestic output, for which data is available on a quarterly basis, rather than the index of industrial production used with monthly data. Since there are only 36 observations with quarterly data, insignificant variables are dropped so that the F statistic and the overall regression are significant. To estimate aggregate demand log change in

industrial production,  $diip_t$ , is regressed on its own lagged value,  $diip_{t-1}$ , the log change in wholesale prices,  $dwpi_t$ , the call money rate,  $cmr$ , the real long-run loan interest rate,  $reallr$ , or the  $realcmr$  for quarterly data, one period lagged real depreciation  $dz_{t-1}$ , and a constant term.

Results are similar for both data sets. They validate the assumptions made in the theoretical section. Interest rate elasticity of output demand is high and real depreciation does not significantly affect output demand. Since India's prices and interest rates are still administered to some extent the real long rate has a positive coefficient, while that on inflation is negative. This suggests that inflation is largely due to cost-push factors and has a negative effect on demand. Since long nominal rates do not adjust rapidly, real interest rates are low when inflation is high and demand is low, explaining the positive coefficient on real rates. Potential output has significant negative coefficient in both the estimated aggregate supply, suggesting that excess capacity made supply elastic in this period. Aggregate supply curve shows the effect of lagged consumer prices on wholesale price inflation, with some evidence of mean reversion in the quarterly estimate. Nominal exchange rates are not significant but may be affecting prices through the lagged CPI. Other external prices have a direct impact.

<b>Table 3: GMM Estimation, Aggregate Supply (monthly) with Forward-Looking Variables</b>		
	<b>dcpi_t-1</b>	<b>dwpi_t-1</b>
constant	-0.48 (-0.51)	0.46****(3.99)
dcpi_t	0.67****(5.57)	--
dcpi_t-2	0.36 ****(4.13)	--
dz_t-1	-16.83 ****(-2.87)	--
dwpi_t	--	-0.08 (-0.43)
dcpi_t-4	--	-0.12*(-1.50)
doil_t-2	--	0.02****(3.00)
dprod_t-1	--	-0.02****(-2.15)
No. of Observations	113	111
F(3,109)	36.21	--
F(4,106)	--	4.43
Prob > F	0.00	0.00
Centered R <sup>2</sup>	0.32	0.11
Uncentered R <sup>2</sup>	0.48	0.38
Hansen J statistic	7.52	11.44

Note: t statistics in brackets; \*\*\*\*, \*\*\*, \*\*, \* indicate 1%, 2.5 %, 5%, 10% significance levels respectively

GMM estimates of monthly aggregate supply reported in Table 3, with forward-looking variables, instrumented with a large number of lagged variables, confirm the above picture. They clearly show that while consumer prices are forward-looking, producer or wholesale prices are not as modeled in section 2. External prices and improvements in productivity impact inflation from the supply-side.

## 2.4. FX traders and strategic interaction with the Central Bank

FX traders arbitrage across currencies in response to expected profits. This can cause fluctuations in the exchange rate. Will supporting a transparent exchange rate objective of the CB be profitable for traders, after an announced policy response to a supply shock? A trader's utility is a negative exponential of wealth  $W$ , with  $\theta$  as the constant coefficient of absolute risk aversion. Their wealth is derived from trading profit and is normally distributed:

$$u(W) = -\exp(-\theta W) \quad (16)$$

It follows that their preferences, or the objective function, they maximize for period 1, can be represented as a simple function of the mean and variance of trading profit.

$$\max_{D^i} - [e_2^e - e_1] D^i - \frac{\theta}{2} \text{var}_1(e_2^e - e_1) D^i \quad (17)$$

Trading profits are given by the quantity transacted into the expected change in the exchange rate. The net demand function for period 1 obtained from maximizing (17) is:

$$D(e_1, i) = \frac{-(e_2^e - e_1)}{\theta \text{var}_1 e_1} \quad (18)$$

Thus risk aversion implies that net demand is an inelastic function the expected change in the exchange rate in that period. It rises with expected appreciation and falls with expected depreciation, and with the variance of the exchange rate. It is lower if  $\theta$  is high. Summing over  $i$  traders of measure unity gives total market net demand  $D(e_1)$  in period 1.

$$D(e_1) = \int_0^1 D(e_1, i) di \quad (19)$$

Markets must clear in equilibrium so that net demand equals net supply:

$$S(e_1) = D(e_1)$$

Substituting the values of  $e_2$  and  $e_1$  from equations (7) and (15) respectively, net demand becomes:

$$D(e_1, i) = \frac{((v_1 - \alpha y_1) / \phi)}{\theta \text{var}_1 e_1}$$

Traders expect to profit from the appreciation in period 2, which will occur if optimal monetary policy is chosen in response to the expected supply shock. Net demand for the home currency rises in period 1 and causes the expected appreciation, even without CB intervention in FX markets. Similarly expected appreciation in period 1 (equation 15) will raise net demand in period zero and cause the appreciation. Some traders who need to unwind their positions in order to rebalance portfolios will sell as the majority buy. Net sales in the next period will cause the expected reversion of the exchange rate to its mean value. If risk aversion is lower, the response will be more elastic.

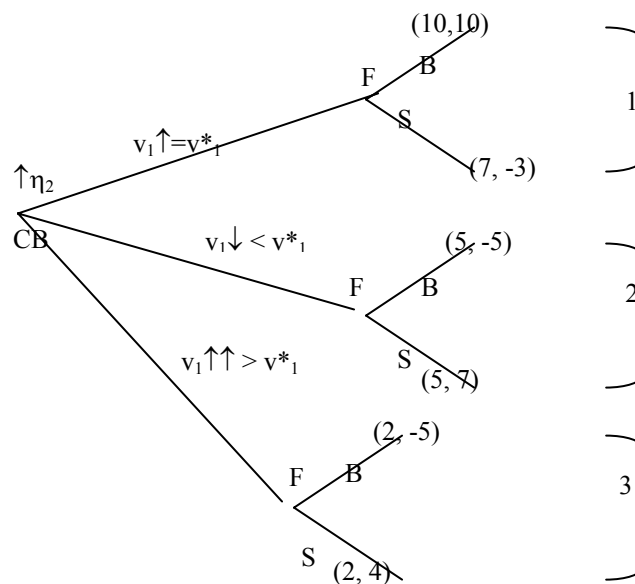


Figure 1: Payoffs to the CB and forex traders (F) under alternative strategy combinations

Since other periods can be analyzed similarly we focus on the expected period 1 payoffs. These are derived in Figure 1 by substituting solution values for  $v_1$ ,  $i$ ,  $e$ , and

$p_2$  in the CB and trader objective functions. From (19) the trader's optimal response to the CB's optimal policy  $v^*_1$  in response to a supply shock  $\eta_2$ , is net buying (B). Since both the CB and FX traders are maximizing their objective functions, payoffs are highest in the strategy  $(v^*_1, B)$  shown as (10,10) in Figure 1. It is the unique sub-game perfect Nash equilibrium. Figure 1 also shows the payoffs to all other strategy combinations. If traders sell when the CB plays  $v^*_1$  they have negative returns as the currency appreciates. The CB also incurs some cost from successful intervention so the payoffs to  $(v^*_1, S)$  are (7, -3). The other strategies available to the CB are to respond to  $\eta_2$  by increasing  $v_1$  above  $v^*_1$  to  $v_H$  or decreasing it below  $v^*_1$  to  $v_L$ . In each case FX traders decide whether to turn net buyers (B) or sellers (S) of the currency. From Table 10, if  $v_1$  is decreased, output will fall, the interest rate will rise, and the exchange rate will depreciate. The CB's payoffs will fall, and dealers will gain more from a sell strategy compared to a buy strategy. This explains the payoffs in the central section (2) of Figure 1.

However, over expansion of the money supply is possible if  $v_1$  is increased too much above  $v^*_1$ . If output is near full capacity, there is a large revenue deficit already boosting demand, the interest elasticities  $\sigma$ ,  $\phi$  are low, and the response of prices to output  $\psi$  is high even a small rise in  $v_1$  may raise it much above  $v^*_1$ . An attempt to lower interest rates would then raise inflationary expectations and result in sharp exchange rate depreciation, which may breach the variance bound making a defensive rise in interest rates necessary. The payoffs are lowest in this case (section 3, Figure 1).

Traders are willing to support the policy combination 1, delivering the appreciation required to moderate the supply shock. They act against policy in 2 and 3, enhancing volatility. Even so, the policy combination 2 of Figure 1 is most often found in practice. Conservative CBs prefer median low risk payoffs, especially when uncertainties are high, or there is fiscal fragility. If the EME is a democracy with low per capita income, even if the CB is not independent, the government will impose conservative inflation preferences. Or the Government may alternate between 1 and 3

or 1 and 2. Uncertainty in payoffs can lead to use of mixed strategies<sup>14</sup>. But then the CBs experience will be that markets create volatility, and it is necessary to intervene and otherwise repress markets. FX players will follow a *maximin strategy* in response to the CB who is the first mover. That is, they will pick the strategy that gives them the highest possible payoff given that the CB's strategy makes F's payoffs as low as possible.

The CB only has to announce that it stands ready to limit exchange rate variance within bounds, then if it implements optimal  $v^*_1$  it will be able to target the interest rate to the domestic cycle and counter supply shocks such as  $\eta$ . Operating one instrument  $v$  achieves desired movements in  $i$ ,  $e$ ,  $y$  and  $p$ . The CB may not need to intervene in FX markets at all. Intervention or signaling may be required only if the variance of  $e$  exceeds the bounds set. In thin markets and with high reserves, CB actions can be highly effective.

FX markets have a combination of informed traders who know the fundamentals, and noise traders who make systematic errors and try to derive information by observing market price and the activity of informed traders. While fundamentals based trade leads to stable mean reversion, noise traders can cause excess volatility. But the FX market differs from other markets because the CB is the largest trader. If it sets bounds on the exchange rate to limit variance, it will be sufficient keep away noise traders and prevent explosive one-way movements. Credible bounds on the variance also lower risk so that trader demand becomes a more elastic function of expected change in the exchange rate. The bounded variance will lower returns to and attract fewer such noise traders (Jeanne and Rose, 2002).

The choice between signaling and intervention is also linked to that on transparency. If the CB does not want to announce its policy response or an explicit exchange rate target, it can allow traders to infer the direction of CB actions. This will take time, so that changes will be slower. The risk of over-shooting is reduced, but the CB has to put in more effort. Traders have to distinguish between passive intervention to absorb foreign inflows, and active intervention. Their support to policy will be reduced,

---

<sup>14</sup> This occurs if small variations in each player's payoffs, known only to that player himself, determine the probability other players give to his adopting a particular strategy (Harsanyi, 1973).

together with their ability to take strategic advantage of policy as in combination 2. FX markets are dominated by bilateral trades and learning takes place from order flow.

Since the game brings out the effect of individual decisions and strategic interactions it can be used as a benchmark to analyze actual policy choices. It demonstrates the sensitivity of outcomes to monetary policy—and loss from non-optimal policy.

### 3. Analytical narrative

The analysis in section 3 gives useful insights on Indian post-reform macroeconomic episodes, and explains the stylized facts identified below. But in applying it to actual events, political and psychological factors have also to be taken into account.

A benchmark real effective exchange rate (REER) was set after the devaluations of the early nineties, in order to maintain a competitive real exchange rate, encourage exports, and allow absorption of excess labour. But the nominal exchange rate showed bursts of high volatility<sup>15</sup> following periods when it was almost static. The response was a sharp rise in interest rates, which triggered an industrial recession and sustained it over 1997-2001. Indian interest rate volatility has exceeded exchange rate volatility for much of the nineties. Limited exchange rate volatility is easier to hedge than interest rate volatility, which has a deeper impact particularly when bank loans are the dominant mode of finance. Since the reliance on bank debt is high in an EME, sharp interest rate volatility delivers a severe shock to the financial system. The impact of interest rates rose significantly in the post-reform period. Although the volatility of exchange and nominal interest rates rose post-reform that of real interest rates fell, as administrative rigidities were reduced and markets freed.

An analysis of the pattern of macroeconomic volatility across four pre- and post reform, high and low growth periods (Goyal, 2005), shows that although post reform foreign financial inflows, measured by the surplus on the capital account rose, their volatility fell. The volatility of the current account deficit (CAD), however, rose,

---

<sup>15</sup> Detailed means, volatilities, and correlations are available in a project report (Goyal, 2005). The analysis in this section is based on various bi-annual monetary policy statements issued in April and October every year by the RBI, speeches by RBI governors and data available on the RBI's website [www.rbi.org.in](http://www.rbi.org.in) and on Goyal (2002, 2004, 2005).

suggesting that policy was magnifying the volatility of the inflows, and hindering their absorption. The CAD measures the actual absorption of foreign savings allowing domestic investment to exceed domestic savings<sup>16</sup>. Although their trend was stable, short-term fluctuations of foreign portfolio inflows did contribute to exchange rate volatility.

Reversals after a period of fixed exchange rates caused over-reaction by market players as well as policy makers. Policy makers have traditionally regarded traders in Indian markets as prone to destabilizing speculative behavior<sup>17</sup>, but poor market design and predictable one-way movements in exchange rates contributed to such behavior. Recent experience suggests credible public announcements from the CB can help to focus expectations<sup>18</sup>. Although some agricultural liberalization and falling world food prices did reduce the political pressures that had raised food support prices and inflation, exchange rate policy was not systematically used to moderate the effect of the typical EME supply shocks: oil price shocks and failure of rains. Since the CB followed combination 2 its perception was that markets create volatility.

The adjusting peg type of exchange rate regime followed led to a sharp defensive rise in interest rates after shocks. This overreaction amplified volatility. In our model, low interest elasticities imply  $v^*_1$  is low, if there is a perception that interest elasticities are lower than they actually are, it would make  $v_1 < v^*_1$ . Interest rates were largely administered and had been only recently freed; interest elasticities were thought to be low. The impact of reforms on elasticities, in particular the impact of the interest rate on consumer spending, was not yet fully understood. In addition, political pressures made  $w$ , the weight given to inflation in the loss function, high. Although the Reserve Bank of India (RBI) had greater autonomy after the reforms, it was still not fully

---

<sup>16</sup> FX reserves rose to 140 billion US dollars in 2005, compared to a paltry 5 billion in 1990-91. 30 billion dollars were accumulated in just 18 months over January 2002 to August 2003. Arbitrage occurred at the short end since Indian short real rates were kept higher than US rates.

<sup>17</sup> This has often caused great trauma to traders and to certain communities that specialize in trade. See Hardgrove (2004) for a study of the Indian Marwari community, their self-understanding and sense of identity. They were said to be gamblers but for example, the traditional gambling on the rains actually served to hedge against income loss. Political rhetoric even equated foodgrain traders to the rats who eat grains and deserve to be shot.

<sup>18</sup> An example from Indian markets was the “Manic Monday” on May 17<sup>th</sup>, 2004, due to unexpected election results. Stock markets crashed and had to be shut down. The RBI made a public announcement on its website that it was ready to sell FX and to provide liquidity as required. The availability of the window meant it was not required. Since each player knew that the other knew that liquidity was available there was no need for a panic rush to be the first to draw a limited stock.



independent of the ministry of finance, which conveys the political pressures. The fiscal deficit was thought to be large. There were doubts about the durability of capital inflows and fears of a possible reversal, which would have implied a shock to the risk premium. Finally, risk aversion or the fear of being caught in policy combination 3 pushed the RBI to adopt combination 2 in Figure 1.

Pre-reform monetary policy followed a money supply targeting approach. But after the credit squeeze had a persistent effect on the level and term structure of interest rates the RBI shifted to a multiple indicator approach. A new RBI Governor, Bimal Jalan, demonstrated, through staggered placement of government debt, that it was possible for interest rates to come down despite high fiscal deficits. But there were reversals during periods of exchange rate volatility, sometimes induced by fluctuations in foreign capital inflows. The last such episode occurred, from mid-May to early August 2000. The RBI had committed to preventing excess volatility of the rupee (Jalan, 2003). A number of short-term supply shocks also occurred and as our model implies, monetary tightening in the presence of supply shocks sustained the slowdown.

Policy committed to a soft interest rate regime, since the late nineties, but steady softening of nominal interest rates occurred only after February 2001, as world interest rates fell. The liquidity adjustment facility (LAF) implemented around that time helped fine-tune domestic liquidity and short-term interest rates drifted downwards. The absence of a reversal since 2000, contributed to an upswing in activity, as benign markets expectations strengthened. Bursts of high volatility no longer occurred in exchange rates. The RBI followed policy combination 1 (Figure 1) only after 2001, whereas over 1996-2000 it repeatedly reverted to combination 2. It followed combination 1 by chance more than conscious design, because world interest rates fell. Still, Indian interest rates still did not fall as much as international and the interest differential widened.

The analysis performs well on the Bates et. al. (1998) criteria for assessing analytical narratives:

1. The modeling assumptions are chosen to closely fit our EME's structure, and the observed pattern of shocks. Estimation and structural VAR based tests

(Goyal and Pujari, 2005) support the critical assumption of long-run elastic supply.

2. The results are derived from the logic of the model. Policy choices depend on parameter values, objective functions, and the institutional environment.
3. Parameter values used in the analysis and in the simulations are validated through estimation. The analysis is able to explain actual Indian macroeconomic policy choices that led to an endogenous amplification of supply shocks. The analysis serves as a tool of empirical discovery by pointing out the fine gradations of monetary policy with their very different effects.
4. The analysis subsumes different explanations. Both demand and supply side is modeled. Macroeconomic outcomes are traced to micro decisions. It allows for the possibility of a high deficit and excessive credit creation raising inflation and therefore interest rates, but then shows why, given structure and shocks, opposite effects are more likely. Both money supply and cost-push effects on inflation are modeled.
5. The results generalize to countries that share the crucial feature of high productivity growth releasing labor thus allowing an elastic supply response<sup>19</sup>.

#### 4. Policy implications

Although the likelihood of the optimal combination 1 has risen, with higher interest elasticities and market deepening, supporting institutional changes that reduce the risk of outcome 3 would help to enforce 1. For the RBI to keep  $v_1 = v^*_1$ , restraint on revenue deficits and populist expenditure is necessary. Political and institutional features result in fiscal-monetary coordination such that the economy remains on an elastic stretch of the aggregate supply curve. Fiscal populism pushes monetary authorities towards conservatism in order to reduce inflationary expectations. But since the populism raises inefficiencies and therefore costs it shifts up the supply curve, while monetary tightening reduces demand, resulting in a large negative effect on output for little gain in reduced inflation. The Fiscal Responsibility and Budget

---

<sup>19</sup> See Goyal and Jha (2004) for a systematic comparison of macropolicy choices in China and India based on the similarities of their labor market structure and the differences in their political structure. Without democratic pressure China was able to follow a stop-go policy with large swings in inflation. The suggested exchange rate regime would help it to moderate these and deepen its financial and FX markets.

Management (FRBM) Act 2003 will put some restraint on the fiscal laxity, but it does not really address the need to change the composition of government expenditure away from consumption and towards investment in infrastructure and human capital, and reduce waste. However, more openness may aid monetary policy to break out of past traps.

Liberalization of the FX market had just begun in 1995, and markets still have a limited role in the determination of the exchange rate, and the interbank trade share is low by world standards. Even so, the analysis suggests that with policy combination 1, fundamentals strengthen and markets do the work. Intervention or signalling is additional ammunition and would be respected, because the RBI has such large reserves and size in the market. Since with high growth there is a continual inflow of foreign capital and the RBI keeps intervening to accumulate reserves, achieving  $v^*_1$  is just a matter of finding the right balance between accumulation and sterilization. As long as fundamentals improve, markets help CBs achieve their objectives<sup>20</sup>, while overreaction is moderated, and the risk premium lowered. There is evidence that while currency crises adversely affect trade, limited fluctuation in exchange rates do not have a large effect on trade (McKenzie 2004). If limited volatility helps prevent crises and lower interest rates, it may even benefit trade.

With forward looking agents a short-run tradeoff between inflation and output variability arises only if inflation is positive due to a cost shock, since excess demand can be removed without output cost. Forward-looking monetary policy can use its knowledge of structure to abort the inflationary process. During a catch-up period of rapid productivity growth potential output exceeds output. If as supply shocks are the dominant source of inflation and deviations of output from potential harm welfare, optimal policy would aim to achieve an inflation target only over the medium-term by which time temporary supply shocks have petered out, or been countered by exchange rate policy, changes in tax rates, or improvement in efficiencies. Inflation targeting itself will prevent the inflationary wage-price expectations from setting in that can imply a permanent upward shift in the supply curve from a temporary supply shock. Monetary policy has to tighten only if there is excess demand.

---

<sup>20</sup> Ito and Park (2004) find an intermediate regime, such as a basket band regime, to be compatible with other monetary policy goals, such as inflation targeting, under a variety of shocks.

Svensson (2000) points out that the lag from the exchange rate to consumer prices is the shortest. If two-way movement of the nominal exchange rate is synchronized with temporary supply shocks, and the exchange rate appreciates when there is a negative supply shock, it would lower the prices of intermediate and food prices. The competitive pressure would abate political pressures to raise farm support prices, and then to subsidize consumers or otherwise intervene to repress inflation resulting from rising nominal wages. This differs from fixing the exchange rate to bring down high levels of inflation, which often leads to real appreciation and ends in a crisis, as in Latin American exchange-based stabilization episodes. Two-way movement only pre-empt the effect of temporary supply shocks on the domestic price-wage process.

The growth revival in 2003 demonstrated the efficacy of lower interest rates and higher spending on infrastructure. Building in a rule whereby there is an automatic announced response to an expected supply shock would avoid the tendency to do nothing until it becomes necessary to over-react. But such forward-looking macroeconomic policy requires good data and estimation of macro relationships.

## 5. Conclusion

We show in a simple open economy macromodel, calibrated to the typical institutions and shocks of an emerging market economy, that a monetary stimulus preceding a temporary supply shock can abort inflation at minimum output cost, since of exchange rate appreciation, accompanying a fall in interest rates and rise in output. The policy helps to maintain some exchange rate flexibility while permitting a counter-cyclical interest rate. The optimal policy creates correct incentives for FX traders who support it, but since this can shade into lax monetary policy under uncertainty, with the worst outcomes, CB's tend to prefer the conservative policy, which is not supported by markets. Model and parameter uncertainty, status-quoism, risk-aversion, and the lack of supporting fiscal policy is the reason the opposite policy combination is often chosen. With optimal policy CB intervention in FX markets may not be required at all, or may serve as a signal. The policy is compatible with political constraints, but further institutional changes and binding rules can make it self-enforcing, deepening markets and coordinating them with macroeconomic policy towards optimal outcomes. The analysis is used to examine Indian macropolicy decisions. The economy did well when policy approached the optimal combination.

Limited volatility in exchange rates improves the structure of incentives making it possible to achieve four objectives. First, stimulate the real sector through a real exchange rate that follows its trend competitive value. Second, smooth nominal interest rates and suit them to the domestic cycle and towards achieving long-run external balance; so that eventual current account surpluses follow initial deficits. Third, an appreciation is an antidote to price shocks coming from food, oil and other intermediate inputs, which are the typical temporary supply shocks the economy faces. For example, when the underlying trend is that of nominal appreciation, a steeper short-term appreciation can reduce inflation, thus allowing interest rates to fall and contributing to control of inflation. The fourth benefit is stability in the external sector, and a fall in the likelihood of currency crises. Limited two-way movement of the exchange rate, creates incentives to hedge, reduces noise trader entry, and contributes to the deepening of FX markets.

Further work can compare consumer price and domestic inflation targeting, explore CB secrecy and commitment, and derive aggregate demand and supply from microfoundations in the context of the EME modeled.

## Appendix I

The value of optimal  $v^*_1$  is  $v^*_1 = -\left(\frac{\Lambda\phi D + \Omega(\alpha\sigma + \phi)\phi(1 + \alpha\sigma)\eta_2}{(\alpha\sigma + \phi)(\Gamma + \Omega)}\right)$

Where  $\Lambda = \frac{(\alpha\sigma - 1)^2}{(\phi(1 + \alpha\sigma))^2}$

$$\Omega = \Gamma + X\left(\frac{\alpha\sigma + \phi}{\phi D}\right)$$

$$\Gamma = \frac{(\alpha\sigma - 1)\alpha\sigma\phi}{(\phi(1 + \alpha\sigma))^2}$$

$$X = \frac{(\alpha\sigma\phi)^2}{(\phi(1 + \alpha\sigma))^2} + \left(\frac{\alpha\sigma - 1}{\alpha\sigma + \phi}\right)^2 + w$$

The denominator of  $v^*_1$  is positive since it reduces to  $\frac{X(\alpha\sigma + \phi)}{\phi D} > 0$ . Therefore  $v^*_1 > 0$  if

the numerator of  $v^*_1$  is positive. This requires  $\alpha\sigma < 1$  so that  $\Gamma < 0$  and

$|\Gamma| > X\frac{(\alpha\sigma + \phi)}{\phi D}$  so that  $\Omega < 0$  and  $|\Omega(\alpha\sigma + \phi)\phi(1 + \alpha\sigma)\eta_2| > \Lambda\phi D$ .

## Appendix II

VARIABLE	ADF TEST	PPERRON TEST
Cmrqr	-2.99**(.0350)	-2.872**(.0487)
Dip	-7.810***(.000)	-14.231***(.000)
Dwpi	-5.671***(.000)	-5.669***(.000)
Dcpi	-5.210***(.000)	-5.156***(.000)
Dz	-5.580***(.000)	-5.589***(.000)
dgdpq_pot	-6.539***(.0000)	-16.689***(.000)
Realcmrqr	-2.979**(.0369)	-2.812*(.0566)

VARIABLE	ADF TEST	PPERRON TEST
Cmr	-5.464***(.000)	-5.407***(.000)
diip_t	-17.097***(.000)	-17.253***(.000)
dwpi_t	-9.856***(.000)	-9.807***(.000)
dcpi_t	-6.799***(.000)	-6.678***(.000)
Duscpi	-7.923***(.000)	-7.532***(.000)
Doil	-9.660***(.000)	-9.631***(.000)
Reallr	-6.985***(.000)	-6.832***(.000)
Diippot	-17.097***(.000)	-17.253***(.000)
Dz	-8.134***(.000)	-8.027***(.000)

- Notes: 1. Superscript \*\*\*, \*\*, \* indicate 1%, 5%, 10% significance level respectively  
 2. Figures in parenthesis indicates Mackinnon P-value  
 3. All the regression equations include one lagged difference term and constant

## References

Aghion, A., Banerjee, A., and Piketty, T., 1999, "Dualism and Macroeconomic Volatility", *Quarterly Journal of Economics*, November, 114 (4), 1359-1397.

Bates, R. H., A. Greif, M. Levi, J.-L. Rosenthal, and B. R. Weingast, 1998, *Analytic Narratives*, Princeton, N.J.: Princeton University Press.

Bhattacharya, U. and P. Weller, 1997, "The advantage of hiding one's hand: speculation and central bank intervention in the foreign exchange market", *Journal of Monetary Economics*, 39, pp. 251-77.

Ghosh, A.R., 2002, "Central Bank Secrecy in the Foreign Exchange Market", *European Economic Review*, 46, 253-272.

Goyal, A., 2005, "Reducing Endogenous Amplification of Shocks from Capital Flows In Developing Countries", Report for the GDN Coordinated Project on Macroeconomic Policy Challenges of Low Income Countries, available at [http://www.gdnet.org/pdf2/gdn\\_library/global\\_research\\_projects/macro\\_low\\_income/Goyal.pdf](http://www.gdnet.org/pdf2/gdn_library/global_research_projects/macro_low_income/Goyal.pdf).

Goyal, A., 2004, "Rupee: Changing Trends" commentary piece in *Economic and Political Weekly*, 39, 23, 2335--2337, June 5.

Goyal, A., 2002, 'Coordinating Monetary and Fiscal Policies: a Role for Rules?', chapter 11 in *India Development Report 2002*, K. S. Parikh and R. Radhakrishna (ed.), New Delhi: IGIDR and Oxford University Press.

Goyal, A. and Jha A.K., 2004, "Dictatorship, Democracy and Institutions: Macro Policy in China and India" *Economic and Political Weekly*, 39, October 16.

Goyal, A. and A. K. Pujari, 2005, "Identifying Long-run Supply Curve in India", *Journal of Quantitative Economics*, 3, 2, July.

Hardgrove, A. 2004, *Community and Public Culture*, Oxford University Press, New Delhi.

Ito, T. and Y. C. Park, 2004, "Exchange Rate Regimes in East Asia", in Asian Development Bank (ed.) *Monetary and Financial Integration in East Asia: The Way Ahead*, Palgrave, Macmillan: UK.

Jalan, B., 2003, "Exchange Rate Management: An Emerging Consensus?" Keynote address at the 14th National Assembly of Forex Association of India, Mumbai, August 14.

Jeanne, O., and A.K. Rose, 2002, "Noise Trading and Exchange Rate Regimes," *The Quarterly Journal of Economics*, CXVII (469), 537-570.

Lyons, R.K., 2001, *The Microstructure Approach to Exchange Rates*, Cambridge, MA: MIT Press.

McKenzie, M. D., 2004, "The Effects of Exchange Rate Volatility on Trade", in G. de Brouwer and M. Kawai (eds.) *Exchange Rate Regimes in East Asia*, RoutledgeCurzon: London and New York.

Oudiz, G. and J. Sachs, 1985, "International Policy Coordination in Dynamic Macroeconomic Models", in W.H.Buiter and R.C.Marston (eds.), *International Economic Policy Coordination*, Cambridge: Cambridge University Press.

Planning Commission, 2006, 'Towards Faster and More Inclusive Growth: An Approach to the 11<sup>th</sup> Five year Plan', Government of India: Planning Commission, November.

Svensson, L.E.O, 2000, "Open Economy Inflation Targeting", *Journal of International Economics*, 50, 155-183.