"Incentives from Exchange Rate Regimes in an Institutional Context"

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Abstract

In a simple open EME macromodel, calibrated to the typical institutions and shocks of a densely populated emerging market economy, a monetary stimulus preceding a temporary supply shock can lower interest rates, raise output, appreciate exchange rates, and lower inflation. Simulations generalize the analytic result with regressions validating the parameter values. Under correct incentives, such as provided by a middling exchange rate regime, which imparts limited volatility to the nominal exchange rate around a trend competitive rate, forex traders support the policy. The policy is compatible with political constraints and policy objectives, but analysis of strategic interactions brings out cases where optimal policy will not be chosen. Supporting institutions are required to coordinate monetary, fiscal policy and markets to the optimal equilibrium. The analysis contributes to understanding the key issues for countries such as India and China that need to deepen markets in order to move to more flexible exchange rate regimes.

Key words: exchange rate, hedging, supply shocks, EMEs, incentives, politics

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1. Introduction

We examine the incentive properties of the exchange rate in the context of the institutional structure of an emerging market economy (EME) with high population density[1]. The analysis contributes to understanding the key issues for countries such as India and China that need to deepen markets in order to move to more flexible exchange rate regimes.

Exchange rates have to adjust to changes in the economy, but excessive movements unrelated to fundamentals cause problems. Equally a rigid nominal rate has adverse effects. While variability is all right excess volatility is not. We will argue that some variability may prevent excessive volatility. Specifically we will explore if monetary policy (i) can impart limited volatility to the nominal exchange rate (ii) its potential to reduce the endogenous amplification of the effects of volatile capital flows and (iii) and allow a smoother and more countercyclical interest rate that makes it possible to better utilize capital flows.

Forex 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 exposure to currency risk. No hedge can cover a currency crisis, but if participants are hedging irregular small movements, one-way bets that could otherwise magnify the movements will reduce. Since the number of agents whom a change in the nominal exchange rate affects falls market stability rises. The incentives created for forex market players may reduce endogenous amplification of exchange rate volatility.

The policy combination will be credible if it improves real fundamentals in the economy. It will do this if the variation in the exchange rate allows interest rates to respond to the

[1] See Willett (2004) for an argument that a fixed nominal exchange rate cannot successfully constrain or discipline macroeconomic policy, as it was expected to in Latin America. But incentives from exchange rate regimes are important in the context of domestic politics. In this paper we explore the incentives the exchange rate generates for market players, and its compatibility with political imperatives.

domestic cycle and contributes towards lowering inflation through affecting the price of imports. Since inflation is a very sensitive political issue and it has been controlled in ways that have imposed large distortions and costs on society, this function will enhance the political feasibility of the policy. Although politics is about power, conflicts and re-distribution, it is also about solving the collective action problem to yield a potential surplus. An exchange rate regime suited to structure and rigidities can reduce waste and improve coordination.

The strategic interaction, payoffs and incentives of market players and the central banker are carefully examined in a market microstructure model plus a small open economy model[2]. 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, high potential output but short-term bottlenecks are built in. Forward-looking aspects come in largely through the exchange rate. Forex traders are modeled in a market microstructure model following Bhattacharya and Weller (1997), Lyons (2001) Ghosh, A.R. (2002) and Jeanne and Rose (2002). While Jeanne and Rose focus on the entry decisions we focus on the actions and incentives of the traders. Analytical results obtained in a simplified version with restrictions on parameters, and are confirmed through simulations and sensitivity analysis with the full model. Some estimation also justifies the chosen calibration.

The Central Bank's optimization, given the constraints from the macromodel, is an input into the micro market participant optimization 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. The outcome of the strategic interactions suggests macro policy rules or institutions that may bring about optimal outcomes in the context of the economic structure.

[2] 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 analysis makes it possible to construct an analytical narrative about actual policy choices in India's post-reform period and is evaluated according to the criteria suggested by Bates et.al. (1998). Laying out the assumptions and the derivations allow the logic of the argument to be critiqued; the suitability of the assumptions and the ability to validate stylized facts ensure the analysis is relevant.

The suggested exchange rate regime contributes to stimulating the real sector through encouraging trade, ensuring external balance over the long-run, maintaining stability in the forex market, and contributing to the control of inflation by countering supply shocks. Limited variability is consistent with maintaining a competitive real effective exchange rate to encourage exports, and can also be used to moderate supply side inflationary shocks. The latter function helps the Central Bank maintain low inflation and further increases its ability to adapt interest rates to the domestic cycle and achieve vital political goals.

The models allow us to explore the tradeoff between interest and exchange rate volatility in the intermediate regimes found in most EMEs today. In a regime of large capital inflows, accumulation of reserves and aggressive sterilization can prevent appreciation, but interest rates rise. Such 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. Currency risk, which we focus on, can aggravate systemic, liquidity and credit risk in thin EME financial markets. Global and regional measures are also required to reduce these risks, but in this paper we focus on a feasible country initiative.

Macrovolatilities reported in Section 2 lay out Indian stylized facts the analysis aims to reproduce and brings out the importance of the exchange rate. Section 3 gives an overview of reform in Indian exchange rates and forex market microstructure. Section 4 describes relevant aspects of institutional structure. Section 5 presents the model, theoretical results and empirical validation through regressions and simulations. Section 6 applies it to explain policy choices and outcome. Section 7 concludes.

2. Shocks and volatilities

In order to identify potential causes of the Indian growth slowdown over 1997-02, and the recovery that followed, the pattern of macroeconomic volatility is examined across four pre- and post reform, high and low growth periods[3].

Since India continues to be a monsoon and imported oil dependent economy, it is relevant to ask if the typical shocks were active. Agriculture's average rate of growth did fall and volatility was higher over the low growth period, 1997-2003. And inflation in fuel products was higher in the nineties, and its volatility was higher in the low growth periods.

But reform offered new opportunities to smooth the traditional shocks, particularly as the severe foreign exchange constraint was removed. Moreover, fluctuations in foreign inflows and exchange rates can themselves be a source of shock. Policy can contribute towards smoothing these shocks or, if poorly designed, can magnify the shocks. Post reform foreign financial inflows, measured by the surplus on the capital account rose, but their volatility fell. The volatility of the current account deficit (CAD), however, rose, suggesting that policy was magnifying the effect of the inflows. The CAD measures the actual absorption of foreign savings in domestic investment. Although their trend was stable, short-term fluctuations of foreign portfolio inflows did impact exchange rates.

The volatility of exchange and nominal interest rates rose post-reform while that of real interest rates fell, in line with the philosophy of reducing administrative rigidities and allowing markets to discover equilibrium values. Lending interest rates fell less than interest rates on government securities and deposit rates. All nominal interest rates fell substantially, although all real interest rates did not, the exchange rate appreciated and its volatility rose, in the recovery phase of 2002-04.

[3] The detailed means, volatilities and correlations are available in a project report (Goyal, 2005).

The impact of interest rates rose significantly in the post-reform period. The correlation of private investment with lagged nominal interest rates became high and negative while it was positive with real interest rates. Nominal rates were fixed pre-reform therefore could not have much impact. Nominal interest rates turn out to be positively correlated with both currency depreciation and inflation.

Since the economy was steadily and in some periods explosively accumulating reserves[4] post reform and there was active sterilization, the rate of growth of reserve money was lower, but broad money was unchanged and its volatility fell indicating more efficient financial intermediation. The rate of growth of money supply and credit/GDP ratio is low compared to world averages.

Volatility of output and consumption growth in India is low compared to other developing countries and has not changed much across the period. Therefore the focus has to be on investment fluctuations to understand variations in growth. Fluctuations in total investment rose while public investment fell steadily.

Government deficits tended to fall in the high growth post reform period and rise in the low growth period. There have been attempts to restrain the Central Deficit, but States' deficits rose. But there was no excess demand despite a fiscal deficit, and a current account surplus appeared in the balance of payments.

Fluctuations in investment were linked to exchange and interest rate volatility, which are subject to policy influence. Indian exchange rates showed bursts of high volatility following periods when the nominal exchange rate was almost static. Interest rate volatility exceeded exchange rate volatility for much of the nineties. This was contrary to most EMEs, which, after the Asian crisis moved to middle exchange rate regimes; their

[4] Forex reserves rose to 120 billion US dollars in 2004, 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.

interest volatility has been falling and is lower than exchange rate volatility, although the latter is also bounded.

3. Reforms in the Exchange Rate and Market Microstructure

Although in the short-term market perceptions and policy can affect the exchange rate, in the longer-term it cannot depart from equilibrium rates determined by macroeconomic fundamentals including relative productivity.

In India 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 and encourage exports. The REER, which gives weights according to major trading partners and corrects for relative inflation, was not allowed to appreciate. This is a valid strategy as long as India, like China, has large reserves of labor that need to be absorbed into higher productivity employment to which exports can contribute. An economy at full employment requires an appreciation of the exchange rate to absorb foreign inflows since a rise in domestic absorption occurs through a rise in imports. But in an economy with excess capacity the rise in absorption can occur at unchanged real exchange rate, through output and capacity expansion.

The nominal effective exchange rate (NEER) continued to depreciate, since Indian inflation rates were higher than those of trading partners. There was some appreciation in both REER and NEER from 2003. But it was not large enough to imply a major appreciation over the lowest value reached 1992-93[5]. Some appreciation could occur without making exports costlier because of productivity improvements and a fall in inflation. Export growth was impressive despite the appreciation. Both the global recovery and productivity improvements helped exporters beat the depreciating dollar, suggesting that limited nominal appreciation may be feasible without harming exports.

[5] Different indices range from 10 percent depreciation to a 28 percent appreciation.

But the nominal exchange rate showed bursts of high volatility[6] following periods when it was almost static. Such reversals cause over-reaction by market players as well as policy makers. Indian interest rate volatility has exceeded exchange rate volatility for much of the nineties. Policy makers have traditionally regarded traders in Indian markets as prone to destabilizing speculative behavior, but as in other areas, poor market design and price structure induced such behavior[7]. A trend one-way movement in a currency induces one-way bets.

Thus exchange rate policy, in its own way, distorted incentives. Usually either importers or exporters covered their currency exposure; with two-way movement both would have an incentive to do so. During the period of steady depreciation only importers used to buy forward cover. Over 2003 as the rupee appreciated only exporters were hedging. Importers also rushed for cover[8] when the rupee started depreciating in May 2004. Thin markets raise the cost of formal hedging, and a high interest differential raises the cost of informal hedging. If an importer holds a dollar deposit as an informal hedge he sacrifices domestic high interest. If he has to borrow in rupees he pays an additional much higher interest at home. Similar considerations affect banks acting on behalf of retail trade. Banks will not hedge, but unless open exposure is strictly limited banks would arbitrage: take dollar deposits and make high interest domestic loans. If zero or low exposure is enforced, banks contribution to the forex market and to discovering the value of the rupee is limited. The CB is forced to intervene to set the exchange rate.

Although there are still some restrictions on hedging indirect currency risk, the reverse of the trend depreciation in 2002-03 led to a 51 per cent rise of activity in rupee derivatives.

[6] These results and also variations in the REER and NEER are available in Goyal (2004).

[7] 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 and 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 equated foodgrain traders to the rats who eat grains and deserve to be shot.

[8] There were reports that Infosys and Wipro would not be able to gain from the depreciation because of the forward cover they had taken. The point is precisely that with hedging they can stop worrying about the impact of the rupee on their profits, and trying to make money from rupee movements. Instead they can concentrate on what they are good at—producing better and more productive software.

It continued, however, to be concentrated in few players, mostly foreign banks. But new technology and regulatory market design is enhancing market activity yet lowering destabilizing speculation. Electronic market making is being applied to forex markets and has reduced turnover.

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. Other policies such as transparency, prudential regulation, and liquidity enhancement are required for a healthy financial system. But since limited ability to borrow in one's own currency is a major source of financial instability, lowering currency risk will reduce financial instability.

Another reason for instability and crises in currency markets is the tendency of traders to over-react. In times of trouble, market participants are thinking not about what the correct value of the exchange rate is; but about guessing correctly what other people think it is. Uncertainty about what a small section is going to do can lead to cumulative movements. In situations where fundamentals are not strong, or some shocks have occurred, and market participants are nervous, credible public announcements from the CB can help to focus expectations[9].

4. Institutional structure

In an EME concerned to maintain a competitive exchange rate in order to encourage exports, rapid capital inflows imply a rapid accumulation of reserves in order to prevent a nominal appreciation. But because inflation is a highly political issue when wage indexation is very limited, there is a high degree of sterilization. In the simple Mundell-Fleming (M-F) model this implies rising interest rates and further inflows. Monetary

[9] An example from Indian markets was the "Manic Monday" on May 17th, 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 forex 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.

policy looses 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. But there are degrees of freedom for monetary policy from the many ways such a developing country's structure differs from the prototype M-F model. These differences include limits on capital account convertibility, specific wage-price rigidities and dualistic labor markets.

The large informal labor market, accounts for 94 percent of the work force. There is no cost of living indexation so that nominal wage adjustment is lagged, but there are political pressures to keep real wages fixed in terms of food; and pressures from a well organized farm lobby (more than 50 percent of the population) for high and rising farm support prices. The compromise has been to subsidize farmers and consumers, the latter through a low price public distribution system. Since the protection is not complete, nominal wages rise with a lag in response to a rise in food prices leading to inflation.

In a more open economy, the effect of border prices on food prices, allows an escape from this inflation cum subsidy trap. The larger trade in agricultural commodities, added to oil imports, gives the exchange rate a greater impact on the inflationary process. Therefore exchange rate policy can help moderate the effect of the typical EME supply shocks: oil price shocks and failure of rains. 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 normally led to real appreciation and ended in a crisis in the countries where such exchange-based stabilization was tried. Two-way movement only pre-empts the effect of temporary supply shocks on the domestic price-wage process.

Since keeping inflation low and real wages constant in terms of a basic consumption basket are political imperatives, an exchange rate policy that furthers these objectives is politically feasible. If it reduces the necessity for subsidies and administered prices that distort incentives and lower efficiency, it would lower waste in the system.

A dualistic labor market structure implies that if food prices are stable, capital is available, specific bottlenecks are alleviated and institutional reforms undertaken; supply will not be a constraint on output, which is below potential. If flexible inflation targeting, with some help from the exchange rate, anchors nominal wages and inflationary expectations, a rise in credit can finance an expansion in output, capital and capacity. Since the foreign exchange constraint is relieved, so are constraints on imports of food stocks, fuel oils and capital goods[10]. Moreover new technology makes it possible to bypass deficiencies in infrastructure. Reduction in bureaucratic rationing and continuing reforms shorten lags and delays, making supply more elastic.

There is evidence that fluctuating exchange rates do not have a large effect on trade; it is currency crises that adversely affect trade (McKenzie 2004). If limited volatility helps prevent crises and lower interest rates, it would actually benefit trade.

CBs have a problem in that they have more targets—output, inflation, exchange and interest rates, than instruments. We demonstrate in the section below that with policy that suits EME structure and typical shocks discussed above, markets may help CBs achieve their objectives[11], while overreaction is moderated, and the risk premium lowered.

5 The Model

We build in the dualistic labor market, the structure of shocks identified in the stylized facts, and a simple forex market in a standard open economy IS-LM-UIP (uncovered

[10] It may even relieve India's pressing infrastructure needs. The Indian Government decided in 2004 to issue bonds against the reserves in order to fund spending on infrastructure, motivated by the Chinese Government's successful large spending in this area, and the inability of the private sector to deliver despite inducements. There is a focus on public private partnerships.

[11] 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.

interest parity) model, in order to examine if macroeconomic policy can implement counter-cyclical interest rates that strengthens fundamentals and moderate shocks.

5.1. 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.

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

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. All variables are expressed as log-linearized deviations from a mean.

Money market equilibrium gives:

$$m_t - p_t = \alpha y_t - \phi i_t - v_t \tag{2}$$

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

Uncovered interest parity (UIP) arising from arbitrage implies that expected depreciation of the exchange rate plus the risk premium ρ_t, must equal the interest differential:

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

Next we turn to the supply side:

$$p_{t+1} - p_t = (w_{t+1} - w_t) + \psi y_t - g_{t+1} + \eta_{t+1} \tag{4}$$

Producer prices are marked up on wages. Therefore producer price inflation responds to nominal wage inflation, lagged output (through pro-cyclical mark-ups) and contemporaneous oil (η_{t+1}) or productivity (g_{t+1}) shocks to supply. Nominal wages respond to lagged inflation in the consumer price index, p_t^c, which is a weighted average of home and foreign prices. Therefore $w_t = p_{t-1}^c$. Since p_t^* is normalized to zero, p_t^c responds directly to e_t:

$$p_t^c = \lambda p_t + (1-\lambda)e_t \tag{5}$$

Substituting out wages from equation (4) and assuming that productivity is not changing gives:

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

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 η_{t+1}.

The dualistic labor market structure with large numbers willing to work at a low constant real consumption wage implies constant returns to scale to capital[12]. The real consumption wage is around subsistence so firms do not gain from lowering it, since productivity falls commensurately. The availability of labor implies that, 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 $\bar{\bar{y}}$.

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, and if mark-ups are constant, deviations from mean output are demand determined at constant cost. Subsistence commodities, especially food, have a high weight in the consumption basket and therefore in P_t^c. If dualism and rigidities lower the response to price variables in an

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[12] It is easy to show 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 capital P indicates the price level, equating this 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.

EME, price elasticities such as δ, σ may be low, but rising with reform[13]. To the extent money demand becomes more 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 money supply m_t is itself not the policy instrument, it can be taken to be zero. Constant mark-ups and CRS imply that $\psi \simeq 0$, and the large weight of food in P_t^c implies that λ is also low. Therefore, the exchange rate plays a major role in price determination. If it responds inversely to a terms of trade shock or rise in P_t^*, P_t^c and therefore W will not rise.

Reforms allow faster labor absorption and an upward trend in the mean output $\bar{y}$. 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 would support the policy combination we explore below. 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.

Simplifying assumptions, common in the literature, further adapt the model to the structure of the EME, its typical shocks, and the focus on the response of monetary policy to shocks. If the limited volatility of the real exchange rate does not have a major impact on trade, we can assume δ = 0 and the first term or the real exchange rate drops out of equation (1). Hedging reduces internal shocks to the risk premium and we abstract from external shocks. In the analytical derivation we restrict the horizon to 2 periods. All agents including the CB have a two period horizon. No trade occurs in the forex market

[13] Ghosh (2002) estimates δ =0.114, σ = 0.152, α = 0.225 and ϕ = 1.420, for the US and OECD countries. Cavoli and Rajan (2004) estimate δ =- 0.09, σ = 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 δ to be insignificant, while σ is large and significant. Aggregate supply shows negative effects of excess capacity and positive impact of external prices on WPI inflation (see the Appendix).

in period 2 since the exchange rate has stabilized. Since predetermined variables are set to zero, $p_o^c = p_1 = 0$. All exogenous foreign price variables are also taken to be zero. In accordance with our stylized facts, we consider the case of the period 1 monetary policy variable v_1 responding to an expected supply shock in period 2, η_2. As a result it is possible to set $v_2 = 0$ and $\eta_1 = 0$.

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. 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.

Under the assumptions made which give $i_2 = -e_2, p_2 = p_1^c$ and using equations (1) to (5) we can solve for y_2 and e_2 as functions of p_2 the inherited producer price:

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

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

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

$$y_1 = -\sigma\left[i_1 - p_2^e\right] \tag{9}$$

The money market equilibrium gives:

$$i_1 = \frac{\alpha y_1 - v_1}{\phi} \tag{10}$$

UIP gives, using (10):

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

Price dynamics from the Phillips curve give:

$$p_2 = (1-\lambda)e_1 + \psi y_1 + \eta_2 \tag{12}$$

Remembering $p_1 = 0$, since $\lambda \underset{\sim}{} 0$ and $\psi \underset{\sim}{} 0$ equation (12) simplifies further. 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:

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

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. We drop ρ from the UIP equation since the risk premium is assumed not to change.

$$y_1 = \frac{\sigma(\alpha\sigma + \phi)((1+\alpha\sigma)\eta_2 - (1+2\alpha\sigma)v_1)}{(1+\phi+\alpha\sigma(1+2\phi+\alpha\sigma))} + \frac{\sigma v_1}{(1+\alpha\sigma)} \tag{14}$$

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

It is clear that

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

since the second v_1 term dominates in equation (14).

Equation (15) implies that

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

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

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 η_2 that tends to reduce interest rates can raise y_1, moderate or reverse the fall in y_2 and neutralize the effect of the supply shock on inflation. Moreover, such a policy package would appreciate the exchange rate in period one with some reversion to the mean in the second period. The appreciation in the exchange rate is what counters the effect of the supply shock on inflation. The anticipated rise in p_2 together with the fall in i_1 lowers the real interest rate and stimulates y_1, but this rise is moderated by the anticipated appreciation.

Table 1: Response of variables to shocks

Shocks \ Variables	P_2	e_1	y_1	e_2	y_2	i_1	i_2
v_1	-	-	+	+	+	-	-
η_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 η_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 of lags in the adjustment of producer prices. CB cannot gain from reducing expected appreciation even if it lowers expected inflation, if as we see below, forex market expectations help it to achieve the required appreciation.

The CB does not have an incentive to create 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 price rise fully realized.

When the supply curve is elastic but inflation rises due to a temporary cost shock, reducing demand will only reduce output and not inflation. Appreciation will shift down the supply curve reducing inflation, and the rise in demand will raise output. Thus there is no output cost of this strategy of inflation reduction for the combination of shocks v_1 and η_2. By reducing reliance on monetary tightening and administrative distortions to reduce inflation, output can actually rise.

Given the surplus labor and high productivity of capital, lowering real interest rates raises demand and also encourages capital formation, which raises mean output levels. Lowering nominal interest rates can also encourage investment because of the effect on the net worth of firms (Stiglitz and Greenwald, 2003). One of the aims of reform is to bring down the large gap that exists between domestic and world interest rates. This gap is partly due to differential inflation, to administrative rigidities, higher risk premium and expected depreciation. Reducing the interest gap not only stimulates output, but also, over time may help to reduce these other distortions. 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. At maturity *i* would be tied down by world inflation and real interest rate.

The deviation of output below potential (or the interest differential which influences it) and inflation both reduce the CB's utility, U. The weight *w*, on the loss due to inflation in the CB's objective function is high:

$$U = Max_{V_1} - \frac{1}{2}\left\{\sum_t (i_t - i*)^2 + wp_2^2\right\}$$

Inserting equilibrium values of the variables in the CB's objective function and differentiating with reference to v_1, gives the optimal value of the policy variable v_1.

$$v_1^* = \frac{(1+\alpha\sigma-\alpha)(1+\phi+\alpha\sigma(1+2\phi+\alpha\sigma)}{w(1+\alpha\sigma)(2\alpha\sigma+1)^2(\alpha\sigma+\phi)^2} + \frac{\phi(1+\alpha\sigma)\eta_2}{(2\alpha\sigma+1)}$$

$v*_1$ rises with η_2 and with the interest elasticity of money demand, ϕ, and falls with *w* the weight on inflation in the CB's loss function[14].

Remembering that $i_2 = -e_2$, it is easy to see that:

[14] Substituting $\eta^e{}_2 = \theta\,\eta_2$ in the CB's loss function, where θ is the information disclosure, differentiating with respect to θ 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 η_2 and rises with v_1.

$$\frac{\delta i_1}{\delta v_1} < 0, \frac{\delta i_2}{\delta v_1} < 0 \quad and \quad \frac{\delta p_2}{\delta v_1} < 0$$

A rise in v_1 upto v^*_1 lowers the CB's loss, or increase its welfare.

5.2. Empirical Results

Estimates of Aggregate Demand and Supply are reported in the Appendix. 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. Moreover, results are similar for both data sets. They validate the assumptions made in the theoretical section. Interest rate elasticity is high and the real depreciation variable is not significant. 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.

The aggregate supply curve shows the effect of lagged consumer prices on wholesale price inflation, with some evidence of mean reversion in the quarter. Nominal exchange Rates are not significant but may be affecting through the CPI, and other external prices have a direct impact. Potential output tends to decrease prices.

Simulations allow us to get results with the full optimization model[15], without imposing any zero restrictions. They also allow us to move away from the assumption of only 2 periods. The results are similar to those from the analytical derivations documented in Table 1, and sensitivity analysis makes it possible to calibrate to benchmark parameter values, which turn out to be close to estimated values 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 are reported in Charts 1 and 2 (g1 to g9). Each row in the charts reports the effect on p, p^c, y, e and v respectively

[15] 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.

of a period one shock of size 0.1^2. 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 –0.1to 0.1. For the first eight simulations, the shock is a cost shock η_1, and for the last simulation, it is a positive demand shock to *y*.

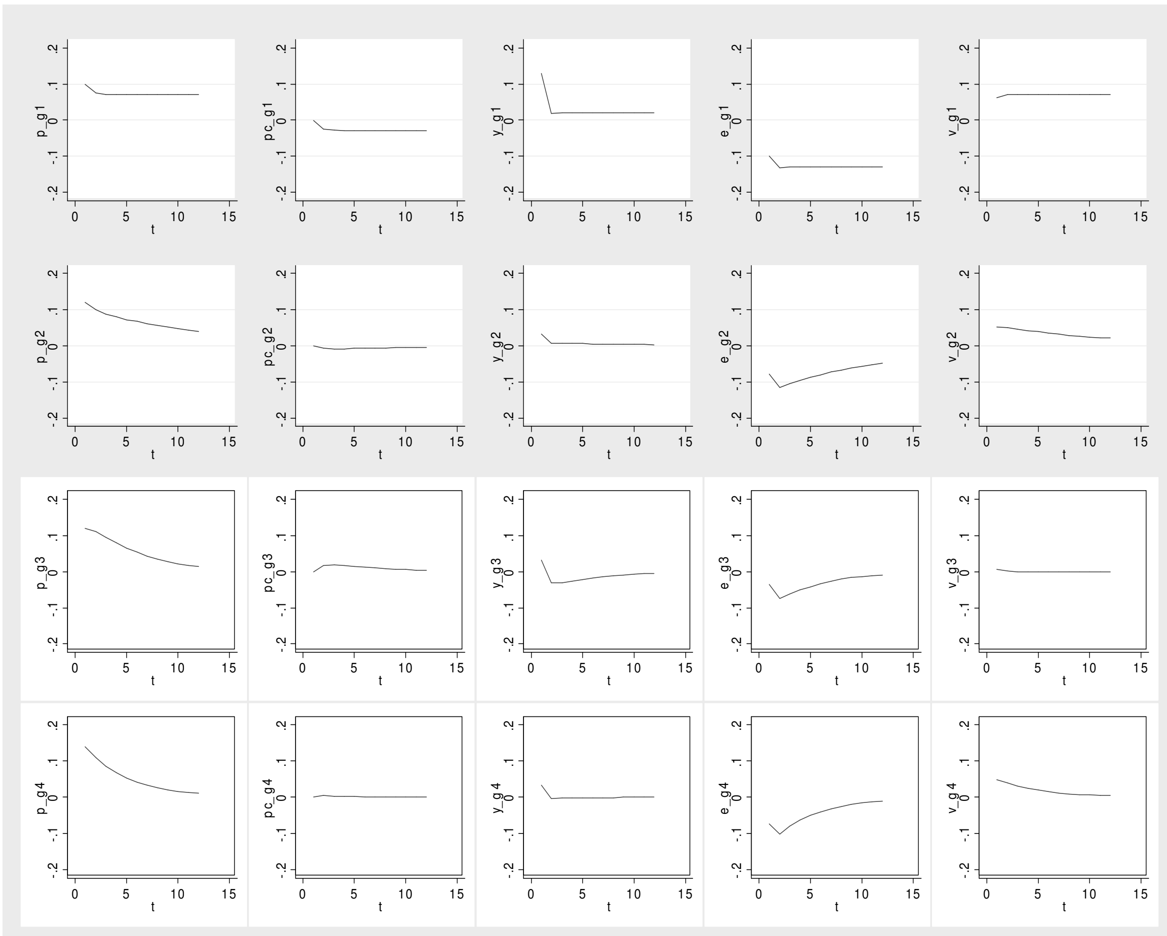

Chart 1: Impulse responses (g1 to g4)
Each row reports the effect on p, p^c, y, e and v respectively of a period one cost shock of size 0.1^2. In Row 1 the parameter values are $\alpha = 1$; $\sigma = 0.6$; $\phi = 0.6$; $\lambda = 0.5$; $\psi = 0$; $\delta = 0$. In Row 2 the changes are $\psi = 0.1$;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

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 θ picks up the effect of lagged log output on the log of producer prices *p* in equation 4.

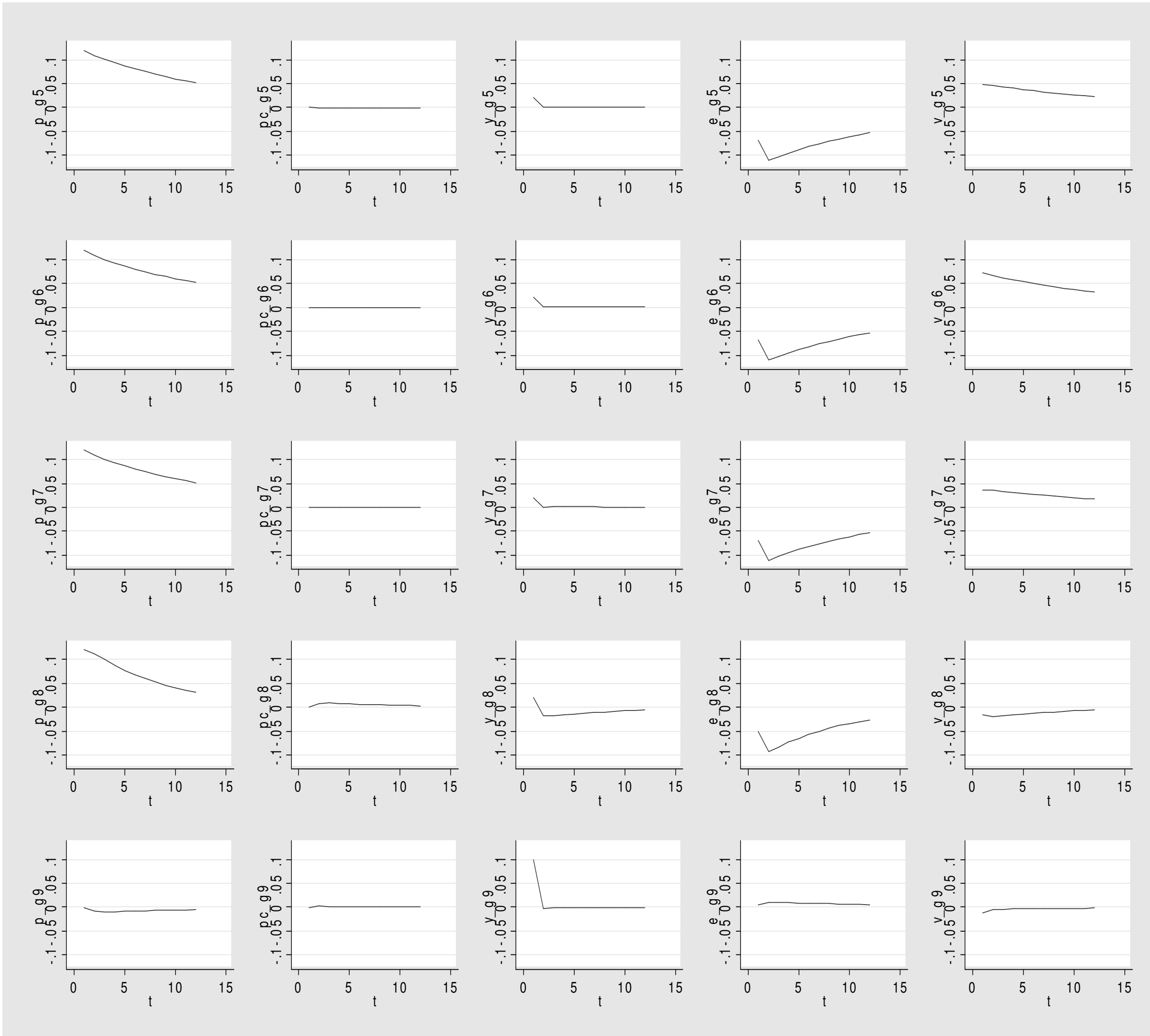

Chart 2: Impulse responses contd. (g5 to g9)

Each row reports the effect on p, p^c, y, e and v respectively of a period one cost shock of variance 0.1^2. In the last row the shock is a positive demand shock to output. 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 the fall in σ. In Row 2, ϕ is reduced to 0.4. In Row 3, ϕ is increased to 0.7. Row 3 changes δ to 0.3, with other parameters as in Row 2. Row 4 has $\delta = 0.2$. Row 5 has a positive shock to output of variance 0.1^2, no cost shock, and other parameters as in Row 1.

Chart 1, Row 1, ψ and δ 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 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.

In Row 2, positive coefficients for ψ and δ moderate the rise in v and resulting appreciation. The rise in *y* and fall in p^c is less, and *p* rises more in the first few periods and then less. For all variables there is more change during the period of the simulation. But the basic pattern remains intact in the more general model.

The results are sensitive to the elasticity of export demand. In Row 3, as δ 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 δ 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 ψ and θ to 0.2 in 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, Row 1, a fall in the interest elasticity of aggregate demand σ 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 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 and 3 show the results of a change in the interest elasticity of money demand,ϕ, first to 0.4 and then to 0.7. If ϕ is lower *v* has to rise more to be equally effective.

A simulation with no cost shock and a positive demand shock to output of standard deviation 0.1, 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. Since the variables are all log deviations from steady-state levels, money supply is contracted to bring output back towards its steady-state value.

Therefore 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.*

We examine how the forex market can contribute to this policy package in the section below.

5.3. The Forex Market

Fluctuations in the exchange rate occur as a consequence of arbitrage across interest rates by forex traders who buy or sell the home currency. Forex 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. The forex market differs from other markets because the CB is the largest trader and normally has more information than any other player.

In our simple illustration the CB is fully transparent so that we can restrict our analysis to informed traders – we assume all traders are fully informed. Summing over *i* traders gives the total market demand $D(e_t)$ in period *t*.

$$D(e_t) = \int_0^1 D(e_t, i)di \tag{16}$$

Markets must clear in equilibrium so that demand equals supply:

$$S(e_t) = D(e_t) \tag{17}$$

In our example we assume the CB does not need to intervene, therefore some traders who need to unwind their positions must be selling for others to buy. A trader's utility is a negative exponential of wealth W, with θ as the constant coefficient of absolute risk aversion. Their wealth is derived from trading profit and is normally distributed:

$$u(W) = -\exp(-\theta W) \tag{18}$$

This implies that their preferences or the objective function, which they maximize, can be represented as a simple function of the mean and variance of trading profit.

$$\max_{D^i} \left[e_t^e - e_{t-1}\right] D^i - \frac{\theta}{2} \operatorname{var}_t \left(e_t^e - e_{t-1}\right) D^i \tag{19}$$

The demand function obtained from maximizing (19) is:

$$D(e_t, i) = \frac{\left(e_t^e - e_{t-1}\right)}{\theta \operatorname{var}_t e_t}$$

Or demand rises with the mean or expected appreciation and falls with the variance of the exchange rate. It is lower if θ is high. Expectations will be mean reverting if policy is strengthening fundamentals. If the CB is able to use exchange rate expectations and the forex market to limit exchange rate variance within bounds, but at the same time, ensure some variance within those bounds, it will be able to target the interest rate to the domestic cycle and counter supply shocks such as η.

In our simple model the CB does not need to intervene in forex markets at all. Operating one instrument v achieves desired movements in i, e, y and p. Intervention or signaling may be required if the variance of e exceeds the bounds set. In thin markets and with high reserves, CB intervention can be highly effective. Even allowing for traders without knowledge of fundamentals, the bounded variance will lower returns to and attract fewer such noise traders (Jeanne and Rose, 2002). The stimulus for hedging will also reduce trader entry into forex markets and panic one-way movements. Deepening forex markets will facilitate an eventual move to a floating exchange rate.

5.4. Outcomes

In the above model (Section 5.3) since traders expect to profit from the appreciation in period 1 net demand for the home currency will rise and cause the expected appreciation; net sales in the next period will cause it to revert to mean. This reversion and the bounds the CB sets on the exchange rate limit the variance. The reversion prevents extended explosive one-way movements.

Consider the CB's optimal policy v^*_1 in response to a supply shock η_2. From (19) the trader's optimal response to this policy is net buying (B). Since both the CB and forex 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 η_2 by increasing v_1 above v^*_1 to v_H or decreasing it below v^*_1 to v_L. In each case forex 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.

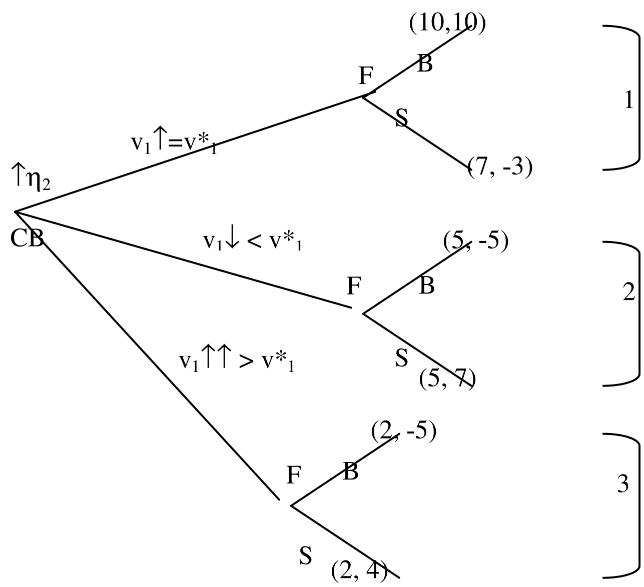

Figure 1: Payoffs to the CB and forex traders (F) under alternative strategy combinations

However, over expansion of the money supply is possible if v_1 is increased too much. This becomes more likely if output is near full capacity, there is a large revenue deficit already boosting demand, the interest elasticities σ, ϕ are low, and the response of prices to output ψ is high. An attempt to lower interest rates would then raise inflationary expectations and result in an uncontrollable 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).

The structure of payoffs explains why the central policy combination 2 of Figure 1 is most often found in practice. Conservative CBs may prefer the median low risk payoffs, when parameter values are at the margin, 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. Some uncertainty in payoffs can explain use of mixed strategies as in Harsanyi (1973). 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.

Since the game brings out the effect of individual decisions and strategic interactions it can be used as a benchmark to understand actual policy choices. It demonstrates the sensitivity of outcomes to monetary policy—excess volatility results from non-optimal policy. But in applying it to the real world, political and psychological factors have to be taken into account.

6. Events, feasibility and politics

The analysis above, applied to explain actual policy choices and outcomes, yields an analytical narrative[16]. Rational choice theory from the analysis is section 5 gives a deeper understanding of Indian post-reform macroeconomic episodes by highlighting the actors, their decision points, choices and outcomes that followed.

Why were optimal choices not made? What were the perceptions of the agents involved in making crucial decisions, what was their view of the constraints they faced, and the strategies that would benefit them? How have these changed over the years?

In the post-reform period, the severe credit squeeze and rise in interest rates that followed the first episode of exchange rate volatility in 1995-96 helped trigger off a sustained

[16] Bates et.al. (1998) develop a methodology of analytical narratives and apply it to case studies.

industrial slowdown[17]. 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 $v_1 < v^*_1$. Since reforms were recent, their impact on elasticities was not fully understood. In addition, political pressures made w, the weight given to inflation in the loss function, high. Although the RBI had greater autonomy after the reforms it was still not fully independent of the ministry of finance, which conveys the political pressures. Finally, risk aversion or the fear of being caught in policy combination 3 pushed the RBI to adopt combination 2 in Figure 1.

The country was growing faster than it ever had before and the RBI was nervous in its first encounter with a gyrating exchange rate. Interest rates were largely administered and had been only recently freed; interest elasticities were thought to be low. Liberalization of the forex market had just begun in 1995, and markets still had a limited role in the determination of the exchange rate. 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.

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[18]. The Bank Rate, which had been frozen, was activated as a benchmark for interest rates, and gradually brought down from 11 percent in 1997 to 6 percent by 2003. 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, when the rupee depreciated by about 3 per cent against the dollar, along with a net outflow by foreign

[17] 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 and on Goyal (1997, 2002, 2005).
[18] The then RBI Governor Dr. Rangarajan announced the new policy in a release function for IGIDR's India Development Report, 1997, which had analyzed monetary policy actions and outcomes (see Goyal 1997).

institutional investors. The bank rate, the CRR and short-term repurchase rates were all increased in July.

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) was implemented and domestic short-term interest rates drifted downwards. This spread to long-term rates, which fell relatively more, and flattened the yield curve by 2003. The Bank Rate was reduced steadily from 8 per cent to 6 per cent in 2004. Markets see what the RBI does, not only what it says, so the softened tone, together with the absence of a reversal since 2000, contributed to an upswing in activity. The RBI followed policy combination 1 (Figure 1) only after 2001, whereas over 1996-2000 it repeatedly reverted to combination 2. A number of short-term supply shocks occurred and as our model implies, monetary tightening in the presence of supply shocks sustained the slowdown.

After the reforms and devaluation of the early nineties the nominal exchange rate was kept more or less fixed; but the RBI said it was a market determined rate even as it kept buying forex to keep the Rupee from appreciating as foreign inflows began to flood in. After the disturbances in the mid-nineties it said that while the level of the exchange rate was market determined, it was intervening in order to lower volatility. Only in 2004 did the Policy Statement declare officially that India had a managed float. Long periods of a stable exchange rate, with uni-directional changes, encouraged bursts of over-reaction and high volatility from markets. Sharp defensive changes in short-term interest rates further disturbed financial markets.

The RBI had been holding the exchange rate fixed and then reacting to market volatility if it occurred. Dr. Jalan had noted in a monetary policy statement (Jalan, 2002) that such sustained one-way movement did encourage market players to bet on that movement and enhance it further, and he remarked in his farewell address as RBI governor, to the Indian Forex Association in 2003, that in view of the ballooning reserves, there should be some rethinking on exchange rate policy.

Current international research is supporting managed exchange rate regimes compared to the earlier emphasis on pure floats or extreme fixes. To that extent the RBI's "middling" regime, is validated; Indian exchange rate management earned high praise for avoiding the fallout from the East Asian crisis and managing the pressures of gradually opening the economy without major trauma. Interventions did successfully quell excess volatility but led to a steady accumulation of reserves and to one-way movement of the rupee. The RBI did not maintain regular limited volatility, or use the exchange rate to counter supply shocks. But a middling regime gives some flexibility to achieve other targets.

The RBI is open to ideas and welcomes a debate on exchange rate regimes, but there is a genuine fear of excess volatility in shallow Indian forex markets (Jalan, 2003). But our analysis suggests that with policy combination 1, fundamentals strengthen and markets do the work. Forex markets are now deep enough to be effective. Intervention or signalling is additional ammunition and would be respected, because the RBI has such large reserves and size in the market.

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 make it self-enforcing. For the RBI to keep $v_1 = v^*_1$, restraint on revenue deficits and populist expenditure is necessary. If fiscal responsibility acts, with good incentive features, bind the Centre and the States, and a weak form of inflation targeting stabilizes inflationary expectations, the RBI will be willing to be less overcautious and more transparent. It will have more credibility with markets. Better coordination between markets and fiscal and monetary policy would result.

When there is excess capacity, a short-run tradeoff between inflation and output variability arises only if there is positive cost-push inflation. As long 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. The policy complex identified can contribute to reducing fiscal deficits as interest rates fall and growth rates rise, if the primary deficit is reduced while spending on infrastructure and human capital formation is maintained.

The suggested combination is politically feasible since in India there is a general consensus about maintaining a competitive exchange rate and keeping inflation low while attempting to reach potential growth levels. The RBI's explicit objectives, stated in the Bi-annual Monetary Policy Statement, are to maximize growth and minimize inflation. The policy contributes to both these. Policy authorities have a reluctance to take a public position on the exchange rate, but their desire to lower inflation and improve growth may push them to do so. 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 there is a crisis. Better data and estimation of macro models are required to provide firmer estimates of the sensitive parameters.

Since many explanations can be consistent with an outcome, and it is not always possible to test alternative hypotheses for historical events, Bates et. al. (1998) give criteria using which an analytical narrative based on explicit theorizing can be subject to critical appraisal.

1. Do the assumptions fit the facts? Our 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. Do conclusions follow from premises? Once the assumptions are validated, the results follow from the logic of the model and are demonstrated in tight algebraic derivations. A set of outcomes is derived from policy choices, and choice among them depends on parameter values, objective functions, and the institutional environment.
3. Do its implications find confirmation in the data? The parameters used in the analysis and simulations are validated through regressions. The analysis explains actual Indian macroeconomic policy choices that led to an endogenous

amplification of supply shocks. Estimation of structural demand and supply shocks from the VAR model also demonstrates an amplification of supply shocks through reductions in demand, during growth slowdowns. The analysis serves as a tool of empirical discovery by pointing out the fine gradations of monetary policy with their very different effects.

4. How does the analysis compare with alternative explanations? Subsuming different explanations are strengths of the model. 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. Do the results generalize to other cases? In countries that share the crucial feature of high productivity growth generating excess capacity, a set of policies similar to the ones advocated has worked. Goyal (2002), Goyal and Jha (2004) argue that policies suited to structure, that built in good incentives, coordinated monetary and fiscal policy, and made possible a countercyclical smoothing of interest rates can help to explain high growth episodes in America and China.

7. Conclusion

We show in a simple open economy macromodel, calibrated to the typical institutions and shocks of an emerging market economy, a monetary stimulus preceding a temporary supply shock can lower interest rates, raise output, appreciate exchange rates, and lower inflation, supported by trader action that maximizes their profits. This helps to maintain the required exchange rate regime while permitting a counter-cyclical interest rate. CB intervention in forex markets is required only if the exchange rate overshoots the bounds set. 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. Deepening in markets has made optimal policy feasible, and it is compatible with political constraints and policy objectives, but further institutional changes and binding rules can make it self-enforcing, coordinating markets and macroeconomic policy to optimal outcomes.

The analysis is used to examine Indian macropolicy decisions in a narrative. The economy did well when policy followed the optimal combination.

With limited volatility in exchange rates the CB can 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. This will contribute towards achieving long-run external balance; eventual current account surpluses should follow initial deficits.

Second is inflation control. 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, and allow interest rates to fall.

Fourth 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 forex markets.

Appendix

The data is for the period 1995-2004, sourced from the IFS (IMF) and RBI (www.rbi.orb.in). All variables are transformed as log changes except interest rates.

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 diippot, and a constant term using monthly data. 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 wit 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 zdepre_t_1, and a constant term.

The Stata output is presented below.

Monthly

Aggregate Supply

```
      Source |       SS       df       MS                  Number of obs =     115
-------------+------------------------------               F(  4,   110) =    7.52
       Model |  9.25677214     4  2.31419303               Prob > F      =  0.0000
    Residual |  33.8634049   110  .307849136               R-squared     =  0.2147
-------------+------------------------------               Adj R-squared =  0.1861
       Total |  43.1201771   114  .378247167               Root MSE      =  .55484

------------------------------------------------------------------------------
      dwpi_t |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     dcpi_t_2 |    .403094   .2182774     1.85   0.067    -.0294806    .8356686
     diippot |  -.0251534   .0112391    -2.24   0.027    -.0474267   -.0028801
        doil |  -.0132506   .0069817    -1.90   0.060    -.0270867    .0005855
      duscpi |   1.025468   .2362588     4.34   0.000     .5572584    1.493678
       _cons |   .1605756   .0884998     1.81   0.072    -.0148102    .3359615
------------------------------------------------------------------------------
```

Aggregate Demand

Source	SS	df	MS		
Model	774.479554	5	154.895911	Number of obs =	115
Residual	1762.68982	109	16.1714662	F(5, 109) =	9.58
				Prob > F =	0.0000
				R-squared =	0.3053
				Adj R-squared =	0.2734
Total	2537.16937	114	22.2558717	Root MSE =	4.0214

diip_t	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
diip_t_1	-.495983	.0843416	-5.88	0.000	-.6631452	-.3288207
cmr	1.463654	1.030982	1.42	0.159	-.5797199	3.507027
zdepre_t_1	-.5829627	29.68394	-0.02	0.984	-59.41557	58.24965
reallr	1.390563	.5211541	2.67	0.009	.3576524	2.423473
dwpi_t	-.9630594	.7075006	-1.36	0.176	-2.365302	.4391837
_cons	-.7436415	1.01833	-0.73	0.467	-2.761939	1.274656

Quarterly

Aggregate Supply

Source	SS	df	MS		
Model	.000621606	2	.000310803	Number of obs =	36
Residual	.002284842	33	.000069238	F(2, 33) =	4.49
				Prob > F =	0.0189
				R-squared =	0.2139
				Adj R-squared =	0.1662
Total	.002906449	35	.000083041	Root MSE =	.00832

dwpi	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
dcpi_2	-.1376692	.0765234	-1.80	0.081	-.2933572	.0180187
dgdpq_pot	-.0251811	.0129287	-1.95	0.060	-.0514847	.0011225
_cons	-.0044554	.0099833	-0.45	0.658	-.0247666	.0158558

Aggregate Demand

Source	SS	df	MS
Model	.047375432	5	.009475086
Residual	.049430515	31	.001594533
Total	.096805947	36	.002689054

Number of obs = 37
F(5, 31) = 5.94
Prob > F = 0.0006
R-squared = 0.4894
Adj R-squared = 0.4070
Root MSE = .03993

dip_t	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
diip_t_1	-.3621648	.1563349	-2.32	0.027	-.681012	-.0433177
cmr	-1.057666	.468229	-2.26	0.031	-2.012626	-.1027071
zdepre_t_1	-.3369933	.316414	-1.07	0.295	-.9823239	.3083372
realcmr	1.099056	.4716428	2.33	0.026	.1371346	2.060978
dwpi_t	-1.395587	.9426332	-1.48	0.149	-3.3181	.5269261
_cons	.0250204	.021818	1.15	0.260	-.0194776	.0695185

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