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Commitment, Discretion and Fixed Exchange Rates in an Open Economy.*

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Abstract

Within a small open economy we derive a tractable framework for the analysis of the optimal monetary policy design problem as well as of simple feedback rules. The international relative price channel is emphasized as the one peculiar to the open economy dimension of monetary policy. Hence flexibility in the nominal exchange rate enhances such channel. We first show that a feature of the optimal policy under commitment, unlike the one under discretion, is to entail stationary nominal exchange rate and price level. We show that this property characterizes also a regime of fixed exchange rates. Hence, in evaluating the desirability of such a regime, this benefit needs to be weighed against the cost of excess smoothness in the terms of trade. We show that there exist combinations of the parameter values that make a regime of fixed exchange rates more desirable than the discretionary optimal policy. When the economy is sufficiently open, this happens for a high relative weight assigned to output gap variability in the Central Bank's loss function and for high values of the elasticity substitution between domestic and foreign goods. We draw from this interesting conclusions for a modern version of the optimal currency area literature.

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1 Introduction

The aim of this work is to provide a tractable framework for the analysis of monetary policy in a small open economy, both in terms of optimal design problem as well as of simple feedback rules[1]. The discussion is framed within the so called New Open Economy Macroeconomics (NOEM) paradigm. It draws insights from both the two streams that currently characterize such literature. The first (seminal) one dates back to the contribution by Obstfeld and Rogoff (1995) and is for the most part surveyed in Lane (2000).[2] The second stream of the NOEM literature is even more recent. In its core it emphasizes a continuity with the closed-economy New-Keynesian synthesis exemplified in the work of Rotemberg and Woodford (1999), Woodford (2002) and Clarida, Gali and Gertler (2000). Three are the main features of this latter line of work, although strongly complementary to the former. The first is the adoption of the Dynamic Stochastic General Equilibrium framework as the workhorse of analysis. The second feature is the specification of the price setting mechanism. Typically such literature makes use of a staggered price-setting structure, which allows for richer dynamic effects of monetary policy than those found in the models with one-period advanced price-setting that are common to the earlier strand. Third, and most importantly, monetary policy is modelled as endogenous, with a short-term interest rate being the instrument of that policy. This approach to the specification of monetary policy seems to accord well with the general consensus reached by roughly twenty years of VAR literature on the effects of monetary policy shocks on the business cycle.[3] In a nutshell such literature de-emphasizes the role of the unanticipated component of monetary policy as a source of business cycle fluctuations, placing instead a lot of emphasis on its systematic component. Incidentally such approach seems to accord much better with the practice of modern central banks of setting interest rates as the instruments of policy by reacting to the current state of the economy.

The open economy dimension lends it self as an ideal ground of application of such an approach. In an open economy, in fact, exchange rate regimes matter. And if indeed the specification of the monetary policy conduct is best represented in terms of

[1] This work relies heavily on previous joint work of mine with Jordi Gali whom I thank for unvaluable insights. It also draws from earlier work by Clarida, Gali and Gertler (2001) who in turn draw on Gali and Monacelli (2000) in the specification of their model.

[2] See, e.g., Obstfeld and Rogoff (1995, 1999), Corsetti and Pesenti (2001), Betts and Devereux (2000), and Bacchetta and Van Wincoop (1999). For an updated series of recent contributions see Bryan Doyle's New Open Economy Macroeconomics Homepage at http://www.geocities.com/brian_m_doyle/open.html and the Benigno-Benigno-Ghironi page on open economy interest rate rules at http://www.geocities.com/monetaryrules/mpoe.htm.

[3] For an excellent contribution see Christiano, Eichenbaum and Evans (2001).

systematic behavior, this holds a fortiori for the description of exchange rate regimes. Fixed exchange rate regimes or, alternatively, currency areas, are in fact extreme cases of pure endogeneity of monetary policy.

In this work we start by characterizing the benchmark setup, whose basic features are complete pass-through of exchange rate movements to (import) prices and perfect international risk-sharing. We then proceed by comparing a scenario in which the monetary authority can commit to a certain future course of action with another in which such commitment is unfeasible and the same monetary authority acts under discretion. At first we recover a basic (well-known) result of this framework, namely that, relative to the optimal policy under discretion, gains from commitment arise in equilibrium as an effect of the purely forward-looking nature of inflation.[4] In addition, the open economy dimension allows us to characterize the dynamic behavior of the nominal exchange rate under the alternative regimes. We show that, in such a context, the properties of the nominal exchange rate tend to mimic closely the ones of the (producer) price level. In particular, and in response to a cost push shock, the optimal solution under commitment entails a stationary exchange rate and price level, while the same is not true under the time consistent policy.

After characterizing the optimal behavior of policy, we move on to a comparison with an alternative regime, in which the authorities of the small open economy peg their currency to the one of the rest of the world. We are interested in the following point. If, on the one hand, the terms of trade channel of monetary policy is enhanced by allowing the maximum exchange rate flexibility, it holds true that a regime of fixed exchange rates requires per se some type of commitment. We first show that fixed exchange rates entail the key property that characterize the optimal commitment regime, namely stationary nominal exchange rate and price level. However, under the baseline parameterization, it turns out that an exchange rate peg is dominated by the optimal time consistent policy.

We then analyze in more detail the comparison of the fixed exchange rate regime with the optimal benchmark. An exchange rate peg corresponds to the highest degree of monetary integration. Hence it reproduces the situation of a small economy relinquishing its monetary independence upon joining a currency area. We therefore explore whether the cost of relinquishing monetary independence varies with the degree of openness of the economy. One key feature of our framework is that the equilibrium volatility of international relative prices (the terms of trade) depends inversely on the degree of openness. This follows crucially from the source of deviations from PPP in our model. Namely, the fact that preferences of the home and the foreign (world) representative consumers are asymmetric, with the latter holding only

[4] Woodford (2002), Clarida, Gali and Gertler (2000).

a negligible share of small economy's goods in their consumption basket. Therefore the degree of openness, from the view point of the small economy, is also an inverse measure of the degree of asymmetry in preferences. It follows that the higher the degree of openness the lower the terms of trade volatility required along the equilibrium, and the lower the loss stemming from relinquishing the exchange rate as an adjustment tool.

While under our baseline parameterization the optimal time consistent policy always dominates fixed exchange rates, we show that, interestingly, the loss from relinquishing monetary independence is sensitive to two other key parameters: the relative weight attached to output gap variability in the policy authority's loss function and the elasticity of substitution between domestic and foreign goods. In particular, we analyze two deviations from the baseline case: a case in which the output gap weight is high and a case of high international elasticity of substitution. In such cases we show that, when the economy is sufficiently open, an exchange rate peg can outperform the optimal policy under discretion. We draw from this interesting conclusions for a modern version of the optimal currency area literature.

The remainder of this paper is organized as follows. Section 2 contains the outline of the model. Section 3 describes the optimal monetary policy design problem. Section 4 analyzes the equilibrium dynamics implied by alternative monetary regimes. Section 5 concludes.

2 A Small Open Economy Model

The domestic (small) economy is populated by infinitely-lived households, consuming Dixit-Stiglitz aggregates of domestic (C_H) and imported (C_F) goods, and by domestic firms producing a differentiated good. All goods are tradeable. In the following, lower case letters indicate log deviations from steady state and capital letters indicate levels.

Let's define C as a composite consumption index:

$$C_t = \left[(1-\gamma)^{\frac{1}{\eta}} \; C_{H,t}{}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} \; C_{F,t}{}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{1}$$

with C_H and C_F being indexes of consumption of domestic and foreign goods.[5] Notice

[5] Such indexes are in turn given by CES aggregators of the quantities consumed of each type of good. The optimal allocation of any given expenditure within each category of goods yields the demand functions:

$$C_{H,t}(i) = \left(\frac{P_{H,t}(i)}{P_{H,t}} \right)^{-\varepsilon} C_{H,t} \qquad ; \qquad C_{F,t}(i) = \left(\frac{P_{F,t}(i)}{P_{F,t}} \right)^{-\varepsilon} C_{F,t}$$

for all $i \in [0,1]$, where $P_{H,t} \equiv (\int_0^1 P_{H,t}(i)^{1-\varepsilon} di)^{\frac{1}{1-\varepsilon}}$ and $P_{F,t} \equiv (\int_0^1 P_{F,t}(i)^{1-\varepsilon} di)^{\frac{1}{1-\varepsilon}}$ are the price in-that under this specification η measures the elasticity of substitution between domestic and foreign goods. The optimal allocation of expenditures between domestic and foreign goods implies:

$$C_{H,t} = (1-\gamma)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t \qquad ; \qquad C_{F,t} = \gamma\left(\frac{P_{F,t}}{P_t}\right)^{-\eta} C_t \tag{2}$$

where $P_t \equiv \left[(1-\gamma)\ {P_{H,t}}^{1-\eta} + \gamma {P_{F,t}}^{1-\eta}\right]^{\frac{1}{1-\eta}}$ is the consumer price index (CPI).

We assume the existence of complete markets for state-contingent money claims expressed in units of domestic currency. Let $h^t = \{h_0, ...h_t\}$ denote the history of events up to date t, where h_t is the event realization at date t. The date 0 probability of observing history h^t is given by ψ_t. The initial state h^0 is given so that $\psi(h^0) = 1$. Henceforth, and for the sake of simplifying the notation, let's define the operator $E_t\{.\} \equiv \sum_{h_{t+1}} \psi(h^{t+1}|h^t)$ as the mathematical expectation over all possible states of nature conditional on history h^t.

The problem of the domestic household is to maximize

$$E_t \sum_{t=0}^{\infty} \beta^t U(C_t,\ N_t)$$

subject to a sequence of budget constraints which, after considering the optimality conditions in (2), can be written in units of domestic currency as

$$P_t C_t + \sum_{h_{t+1}} \nu_{t,t+1} B_{t+1}(h_{t+1}) = W_t N_t + B_t + \tau_t \tag{3}$$

In equation (3) B_{t+1} is the market value (in units domestic currency) of a portfolio of state contingent securities held at the end of period t, $\nu_{t,t+1} \equiv \nu(h^{t+1}|h^t)$ is the pricing kernel of the state contingent portfolio, N is labor hours, W is the nominal wage and τ are net lump-sum transfers/taxes. After ruling out Ponzi schemes the first order conditions of the above problem can be described as follows. The efficiency condition for the consumption-leisure choice is given by

$$U_{c,t} \frac{W_t}{P_t} = -U_{n,t} \tag{4}$$

where $U_{c,t}$ and $U_{n,t}$ denote the marginal utility of consumption and disutility of work respectively. The price of the state contingent asset (for any state of the world) must satisfy

dexes for domestic and imported goods respectively, both expressed in home currency. The elasticity of substitution between goods within each category is given by $\varepsilon > 1$.

$$\nu_{t,t+1} = \psi_{t,t+1} \frac{U_{c,t+1} P_t}{U_{c,t} P_{t+1}} \tag{5}$$

where $\psi_{t,t+1} \equiv \psi(s^{t+1}|s^t)$. By assuming a separable period utility of the form $\frac{1}{1-\sigma} C_t^{1-\sigma} - \frac{1}{1+\varphi} N_t^{1+\varphi}$ and recalling that the (gross) nominal interest rate can be pinned down via the arbitrage condition $R_t = \left(\sum_{s_{t+1}} \nu_{t,t+1} \right)^{-1}$ one can characterize the above first order conditions in the convenient log-linearized form:

$$w_t - p_t = \sigma\ c_t + \varphi\ n_t \tag{6}$$

$$c_t = E_t\{c_{t+1}\} - \frac{1}{\sigma}\ (r_t - E_t\{\pi_{t+1}\}) \tag{7}$$

In the rest of the world a representative household faces a problem identical to the one outlined above. Hence a set of analogous optimality conditions characterize the solution to the consumer's problem in the world economy. As in Gali-Monacelli (2002), however, the size of the small open economy is negligible relative to the rest of the world, an assumption that allows to treat the latter as if it was a closed economy.

2.0.1 Pass-through, the Real Exchange Rate, and Deviations from PPP

Log-linearization of the CPI formula around the steady state yields:

$$p_t \equiv (1-\gamma)\ p_{H,t} + \gamma\ p_{F,t} \tag{8}$$

Producer inflation–defined as the rate of change in the index of domestic goods prices- and *CPI-inflation* are linked according to

$$\pi_t = \pi_{H,t} + \gamma\ \Delta s_t \tag{9}$$

where $s_t = p_{F,t} - p_{H,t}$ denotes the (log) terms of trade, i.e., the relative price of imports. The treatment of the rest of the world as an (approximately) closed economy (with goods produced in the small economy representing a negligible fraction of the world's consumption basket) implies that $P_t^* = P_{F,t}^*$, and $\pi_t^* = \pi_{F,t}^*$, for all t, i.e., an equivalence between producer and CPI inflation holds in the world economy.

This allows the change in the terms of trade to be written as:

$$\begin{aligned} \Delta s_t &= \pi_{F,t} - \pi_{H,t} \\ &= \Delta e_t + \pi_t^* - \pi_{H,t} \end{aligned}$$

In this context the real exchange rate and the terms of trade are related by a simple expression:

$$q_t = e_t + p_t^* - p_t \quad (10)$$
$$= (1-\gamma)s_t$$

Equation (10) deserves some comments. It stands clear that the source of deviation from aggregate PPP in our framework is due to the heterogeneity of consumption baskets between the small economy and the rest of the world, an effect captured by the term $(1-\gamma)s_t$, as long as $\gamma < 1$. For $\gamma \to 1$, in fact, the two aggregate consumption baskets coincide and relative price variations are not required in equilibrium. This will become more clear below when we illustrate risk sharing.

2.1 Producers

In the market of the domestic goods, there is a continuum of monopolistic competitive firms (owned by consumers), indexed by $i \in [0,1]$. They operate a constant return to scale technology: $Y_t(i) = Z_t N_t(i)$, where Z is a total factor productivity shifter. Cost minimization typically leads to the following efficiency condition for the choice of labor input :

$$mc_t = (w_t - p_{H,t}) - z_t \quad (11)$$

where mc indicates the real marginal cost (which is common across producers). In the following, domestic (log) productivity is assumed to follow a simple stochastic autoregressive process:

$$z_t = \rho z_{t-1} + \zeta_{z,t} \quad (12)$$

where $0 \le \rho \le 1$ is a persistence parameter and $\zeta_{z,t}$ is an i.i.d shock.

2.1.1 Pricing of domestic goods

Domestic firms are allowed to reset their price according to a standard Calvo-Yun rule, which implies receiving a price signal at a constant random rate θ. Let then θ^k be the probability that the price set at time t will still hold at time $t+k$. Firm i faces domestic and foreign demand. This kind of pricing technology leads to the following log-linear equation for newly set domestic prices:

$$p_{H,t}^{new} = (1-\beta\theta)\sum_{k=0}^{\infty}(\beta\theta)^k \; E_t\{mc_{t+k} + p_{H,t+k}\} \quad (13)$$

The domestic aggregate price index evolves according to:

$$P_{H,t} = [\theta(P_{H,t-1})^{1-\varepsilon} + (1-\theta)(P_{H,t}^{new})^{1-\varepsilon}]^{\frac{1}{1-\varepsilon}} \tag{14}$$

By combining (13) with the log-linearized version of (14) one can derive a typical forward-looking Phillips curve:

$$\pi_{H,t} = \beta E_t \{\pi_{H,t+1}\} + \lambda mc_t \tag{15}$$

where $\lambda \equiv \frac{(1-\theta)(1-\beta\theta)}{\theta}$.

2.2 Risk Sharing and Uncovered Interest Parity

The existence of complete markets for nominal state contingent securities has implications for consumption risk sharing. Formally the marginal utilities of consumption must be equalized across economies in equilibrium. This implies a log-linearized condition:

$$\begin{aligned} c_t &= c_t^* + \frac{1}{\sigma} q_t \\ &= c_t^* + \frac{(1-\gamma)}{\sigma} s_t \end{aligned} \tag{16}$$

where σ is the intertemporal elasticity of substitution in consumption. Under complete international asset markets it also possible to derive a standard log-linear version of an uncovered interest parity condition

$$r_t - r_t^* = E_t\{\Delta e_{t+1}\} \tag{17}$$

It is easy to show that such an equation results from combining efficiency conditions for an optimal portfolio of bonds by both domestic and foreign residents.

2.2.1 Labor Market Equilibrium and Domestic Real Marginal Cost

By combining (7), (11) and (16) one obtains, after aggregation, an equilibrium equation for the domestic real marginal cost (or inverse of the domestic markup), which also expresses the equilibrium in the labor market:

$$\begin{aligned} mc_t &= (w_t - p_{H,t}) - z_t \\ &= (w_t - p_t) + \gamma s_t - z_t \\ &= \sigma y_t^* + \varphi y_t - (1+\varphi) z_t + s_t \end{aligned} \tag{18}$$

Equation (18) shows that the domestic real marginal cost is increasing in domestic output (through its effect on employment and therefore the real wage) and decreasing in domestic technology (through its direct effect on labor productivity). However, open economy factors as well affect the real marginal cost: world output (through its effect on labor supply) and the terms of trade (through both its direct effect on the product wage, for any given real wage, and the indirect labor supply effect on consumption and the real wage).

2.3 Goods Market Equilibrium

It is first useful to consider log-linearized versions of the isoelastic demand functions. In particular local and foreign demand for domestic goods can be written respectively:

$$\begin{aligned} c_{H,t} &= -\eta(p_{H,t} - p_t) + c_t \\ &= \eta\gamma s_t + c_t \end{aligned} \tag{19}$$

$$\begin{aligned} c^*_{H,t} &= -\eta(p^*_{H,t} - p^*_t) + c^*_t \\ &= \eta(p_{F,t} - p_{H,t}) + c^*_t \\ &= \eta s_t + c^*_t \end{aligned} \tag{20}$$

Finally, the demand for imports will read

$$\begin{aligned} c_{F,t} &= -\eta(p_{F,t} - p_t) + c_t \\ &= -\eta(1-\gamma)s_t + c_t \end{aligned} \tag{21}$$

Goods market clearing implies $y_t(i) = (1-\gamma)\ c_{H,t}(i) + \gamma\ c^*_{H,t}(i)$ for any good i,and by aggregating:

$$y_t = (1-\gamma)\ c_{H,t} + \gamma\ c^*_{H,t}$$

By substituting the above demand functions we can rewrite the previous goods market clearing condition as:

$$y_t = (1-\gamma)c_t + \gamma c^*_t + \gamma\eta(2-\gamma)s_t \tag{22}$$

Hence one notices that, in the case of $\gamma = 0$, namely the one of a closed economy, such condition reduces simply to $y_t = c_t$, i.e., to the typical resource constraint linking (in the absence of investment and capital accumulation) aggregate output to aggregate consumption.

Rearranging the previous condition by substituting (16) one obtains a relation between relative output and the terms of trade:

$$y_t - y_t^* = \frac{\omega_s}{\sigma} s_t \tag{23}$$

where $\omega_s \equiv 1 + \gamma(2-\gamma)(\sigma\eta - 1) > 0$. Hence a rise of domestic output relative to foreign output requires, in equilibrium, a real depreciation (i.e., a rise of s_t). Notice also that, if $\sigma\eta > 1$,

$$\frac{\partial \omega_s}{\partial \gamma} > 0; \quad \frac{\partial \omega_s}{\partial \eta} > 0 \tag{24}$$

Hence the higher the degree of openness and the higher the elasticity of substitution between domestic and foreign goods, the *smaller* is the equilibrium adjustment in relative prices required to absorb a given change in relative output. Consider now a small economy joining a currency area. Such monetary arrangement implies the relinquishment of the nominal exchange rate as a macroeconomic stabilization tool. The implication of (24) is that such cost should be lower the more open the economy and the more substitutable her goods with the ones produced in the rest of the currency area.

Finally, it is useful to notice that, by substituting (16) into (22), the market clearing condition can in turn be written as:

$$y_t = \frac{\omega_s}{(1-\gamma)} \ c_t + (1 - \frac{\omega_s}{(1-\gamma)}) \ c_t^* \tag{25}$$

2.4 Policy Target in the Rest of the World

Let's first describe how the equilibrium looks like in the rest of the world. The equilibrium real marginal cost is given by:

$$mc_t^* = (\sigma + \varphi) y_t^* - (1+\varphi) z_t^* \tag{26}$$

which is simply the closed economy (i.e., obtained for $\gamma = 0$) version of equation (18). Therefore the natural (flexible-price) level of output easily obtains by imposing $mc_t^* = 0$ (which implies $\pi_t^* = 0$):

$$\overline{y}_t^* = \frac{(1+\varphi)}{(\sigma+\varphi)} z_t^* \tag{27}$$

As in a canonical sticky price model with Calvo price staggering, under fully flexible prices the output gap will be completely stabilized, i.e.,

$$\widetilde{y}_t^* = y_t^* - \overline{y}_t^* = 0 \tag{28}$$

Throughout it will be assumed that the monetary authority in the rest of the world aims at replicating the flexible price allocation by simultaneously stabilizing inflation and the output gap. It is well known that such a policy also coincides with the first best outcome.[6]

2.5 Flexible Domestic Prices

Let's proceed by assuming, at first, that in the small open economy *domestic producer* prices are flexible. In such a case the domestic pricing equation (13) implies a constant markup. Therefore it can be assumed, without loss of generality, that domestic prices remain fixed at their optimal level, as firms would have no incentive to deviate from that state of affairs. By imposing a constant markup in equation (18) and substituting equation (23) one obtains an expression for the flexible price (or *natural)* level of output:

$$\overline{y}_t = \left(\frac{\omega_s(1+\varphi)}{\sigma+\varphi\omega_s}\right) z_t + \left(\frac{\sigma(1-\omega_s)}{\sigma+\varphi\omega_s}\right) y_t^* \tag{29}$$

By using equation (23), and noticing that $\overline{s}_t = \frac{\sigma}{\omega_s}(\overline{y}_t - y_t^*)$, the nominal exchange rate can be written as

$$\overline{e}_t = \frac{\sigma}{\omega_s}(\overline{y}_t - y_t^*) \tag{30}$$

$$= \frac{\sigma(1+\varphi)}{\sigma+\varphi\omega_s}(z_t - z_t^*) \tag{31}$$

This expression shows that, under flexible prices, a rise in domestic productivity relative to the rest of the world causes the nominal exchange rate to depreciate.

2.6 The Supply Block

Let's define the output gap as the percentage deviation of current output from the natural level of output, i.e.,

$$\widetilde{y}_t \equiv y_t - \overline{y}_t \tag{32}$$

[6] Goodfriend and King (2001), Clarida, Gali and Gertler (1999). Woodford (2002) discusses under what conditions such a policy corresponds also to maximizing a second order approximation of households' welfare.

Equation (23), in turn, implies that the output gap is proportional to the terms of trade gap:

$$\widetilde{y}_t = \frac{\omega_s}{\sigma}\widetilde{s}_t \tag{33}$$

Therefore the equilibrium real marginal cost (18) can be written, after combining with (33), as

$$mc_t = \left(\varphi + \frac{\sigma}{\omega_s}\right)\widetilde{y}_t \tag{34}$$

Hence we see that the proportionality relationship between the real marginal cost and the output gap, which is common to the prototype sticky price model with imperfectly competitive markets, survives in this open economy context. Clearly the sensitivity of the real marginal cost to movements in the output gap is affected by parameters that are typical of the open economy, namely the degree of openness γ and the elasticity of substitution between domestic and foreign goods η.

Equation (33) implies that the terms of trade and the output gap are strongly correlated in this context. Hence the choice of the underlying exchange rate regime, by affecting the dynamics of the terms of trade, also heavily affects the behavior of the output gap. This result, however, depends strictly on the assumption of complete exchange rate pass-through, which prevents deviations from the law of one price.[7]

By replacing (34) in (15) one obtains

$$\pi_{H,t} = \beta\ E_t\pi_{H,t+1} + \kappa_y\widetilde{y}_t \tag{35}$$

where $\kappa_y \equiv \lambda\left(\varphi + \frac{\sigma}{\omega_s}\right)$. Hence the degree of openness affects only the slope (via its effect on ω_s) but not the specification of the Phillips curve. Notice also that this happens if and only if $\sigma\eta \neq 1$, which in turn implies that $\omega_s \neq 1$. In the empirically plausible case of $\sigma\eta > 1$, we have that a higher γ rises ω_s and hence lowers the slope of the Phillips curve. In particular, via equation (23) which is an alternative way of rewriting the market clearing condition, an increase in openness lowers the size of the adjustment in the terms of trade necessary to absorb a change in domestic output (relative to world output), thus dampening the impact of the latter on marginal cost and inflation. The slope of the Phillips curve is also decreasing in η, the elasticity of substitution between domestic and foreign goods. The intuition is similar. The larger such elasticity the smaller the variation in the terms of trade required to absorb a variation of domestic output relative to the foreign output.

By solving (35) forward we obtain:

[7] See Monacelli (2003) for a model that allows for deviations from the law of one price.

$$\pi_{H,t} = E_t \left\{ \sum_{k=0}^{\infty} \beta^k \kappa_y \widetilde{y}_{t+k} \right\} \tag{36}$$

which shows that domestic inflation depends on both current and expected future values of the output gap. As such inflation is a typical forward-looking variable in this context.

2.7 The Demand Block

To complete the description of the model it is useful to rewrite also the aggregate demand equations in a more compact form. By substituting (25) into (7) and making use of the definition of the output gap and of equation (9) we can write the following aggregate demand equation:

$$\widetilde{y}_t = E_t\{\widetilde{y}_{t+1}\} - \frac{\omega_s}{\sigma}(r_t - E_t\{\pi_{H,t+1}\} - \overline{rr}_t) \tag{37}$$

where $\overline{rr}_t \equiv \sigma \left(\frac{\varphi(\omega_s - 1)}{\sigma + \varphi\omega_s} \right) E_t\{\Delta y^*_{t+1}\} - \left(\frac{\sigma(1-\rho)(1+\varphi)}{\sigma + \varphi\omega_s} \right) z_t$ is the *natural real interest rate.* Notice that the natural real rate depends not only on domestic productivity, but, as long as $\omega_s > 1$, also on the expected growth in world output. Besides this the effect of openness on the shape of the typical optimizing IS equation is reflected in the parameter ω_s affecting the sensitivity of the output gap to real interest rate movements.

2.8 The Equilibrium in Compact Form

It is easy to rewrite the equilibrium conditions for the domestic small economy in a more compact form. By combining (16) and (22) with (18) one can write the following expression for the real marginal cost

$$mc_t = \Phi s_t + (\sigma + \varphi) y^*_t - (1 + \varphi) z_t \tag{38}$$

where $\Phi \equiv \left(1 + \frac{\varphi\omega_s}{\sigma}\right) > 1$. By combining with (15) domestic inflation can be easily related to the terms of trade by the following first order difference equation

$$\pi_{H,t} = \beta E\{\pi_{H,t+1}\} + \lambda\Phi s_t + \lambda[(\sigma + \varphi) y^*_t - (1 + \varphi) z_t] \tag{39}$$

Furthermore the real version of the uncovered interest parity condition (17) can be written as:

$$r_t - E_t\{\pi_{H,t+1}\} = rr^*_t + E_t\{s_{t+1}\} - s_t \tag{40}$$

where $rr_t^* \equiv r_t^* - E_t\{\pi_{t+1}^*)$ is the foreign real interest rate.

Hence, *conditional to the definition of a monetary policy rule* for the monetary authority and for any given exogenous path $\{z_t,\ rr_t^*,\ y_t^*\}$, a rational expectations equilibrium for the small open economy is a pair of processes $\{\pi_{H,t}, s_t\}_{t=0}^{\infty}$ that solves the system of equations (39) and (40).

3 Monetary Policy, Interest Rate and the Exchange Rate

In this section we will characterize alternative monetary policy regimes for the small open economy. We will first analyze the optimal policy design problem, both when the monetary authority can commit to a certain future path of inflation and output gap (and therefore interest rates) and when such commitment is not feasible. We will then compare the outcome under the optimal policy with the one obtained when the small economy pegs its exchange rate vis a vis the rest of the world (or equivalently decides to join a currency area).

Let us first postulate that the monetary authority of the small economy tries to minimize the following loss criterion

$$\frac{1}{2}E_0\{\sum_{j=0}^{\infty}\beta^j(\pi_{H,t+j}^2 + b_w\widetilde{y}_{t+j}^2)\} \tag{41}$$

where b_w is the relative weight attached to output gap variability. Furthermore, as in Clarida,Gali and Gertler (2001), it is assumed that the presence of an exogenous cost-push shock u_t does not allow the monetary authority to reach the flexible price allocation, namely an equilibrium such that $\pi_{H,t} = \widetilde{y}_t = 0$ for all t. The role played by such shock is crucial to generate a trade-off between the conflicting goals of stabilizing domestic inflation and the output gap. This of course is necessary to generate a non-trivial analysis of the optimal policy problem.[8]

3.1 Optimal Policy under Discretion

Let us now assume that the monetary authority cannot have access to a commitment technology and can only reoptimize period by period. In this case, and given the

[8]The fact that this model generates no conflict between policy objectives depends crucially on the fact that the law of one price is assumed to hold throughout. In Monacelli (2003) the presence of incomplete pass-through on import prices determines endogenously a tradeoff between the stabilization of domestic inflation and of the output gap.

vector of exogenous variables $\{u_t,\, \overline{rr}_t,\, z_t^*,\, rr_t^*\}$, the monetary authority chooses $\pi_{H,t}$ and $\widetilde{y}_{H,t}$ to

$$\max -\frac{1}{2}\{\pi_{H,t}^2 + b_w \widetilde{y}_t^2\} \tag{42}$$

subject to

$$\pi_{H,t} = F + \kappa_y \widetilde{y}_t \tag{43}$$

where $F \equiv \beta E_t\{\pi_{H,t+1}\} + u_t$ is a term which is taken as given by the policy authority in her maximization problem. Notice that in so doing the monetary authority recognizes that future private sector's expectations cannot be manipulated

The first order condition of this static problem reads:

$$\widetilde{y}_t = -\Theta\ \pi_{H,t}, \text{ for } all\ t \tag{44}$$

where $\Theta \equiv \frac{\kappa_y}{b_w} > 0$. This condition typically suggests that the monetary authority contracts real activity in response to a rise in inflation above the target. The parameter Θ measures the magnitude of the implied optimal adjustment of the output gap, which is increasing in the sensitivity of inflation to output gap movements κ_y, and decreasing in the preference weight attached to output gap variability. In particular, notice that

$$\frac{\partial \Theta}{\partial \gamma} < 0; \quad \frac{\partial \Theta}{\partial \eta} < 0$$

This implies that the sensitivity of the output gap to inflation is decreasing in the degree of openness γ (for it lowers the sensitivity of the real marginal cost to the terms of trade) and decreasing in the elasticity of substitution between domestic and foreign goods η (for it lowers the adjustment in the terms of trade necessary to absorb any change in domestic output relative to world output). Hence in response to a rise in inflation the monetary authority of an open economy will have to contract the output gap *less* relative to its closed economy counterpart. For lowering the output gap implies also an appreciation of the terms of trade, which, via (18), implies also a fall in the real marginal cost and a dampening of inflation. This shows that, besides the aggregate demand channel, the monetary authority of an open economy can also handle the *relative price channel* to inflation. It stands obvious that such channel is reinforced when the nominal exchange rate is free to float, for the exchange rate tends to compensate for the excess smoothness in the terms of trade due to the stickiness in the adjustment of nominal prices.

By substituting (44) into (15) one obtains the following second order stochastic difference equation for the price level:

$$a\ p_{H,t} = \beta E_t\{p_{H,t+1}\} + \left(1 + \frac{\kappa_y^2}{b_w}\right) p_{H,t-1} + u_t \tag{45}$$

where $a \equiv 1 + \beta + \frac{\kappa_y^2}{b_w} > 1$. The characteristic polynomial associated with the above equation is $\mu^2 - \frac{a}{\beta}\mu + \frac{a-\beta}{\beta} = 0$, whose roots are given by $\mu_{1,2} = \frac{a}{\beta}\left(1 \pm \frac{a+2\beta}{a}\right)$. For both roots lie outside the unit circle we have that under the discretionary policy the domestic price level exhibits a non-stationary dynamic.

We can then build a relationship between the dynamic of the price level and the one of the nominal exchange rate. By using equation (23) and (29), and recalling that the terms of trade (under the assumed price stability policy in the rest of the world) are given by $s_t = e_t - p_{H,t}$ we can write

$$e_t = p_{H,t} + \xi_{d,t} \tag{46}$$

where $\xi_{d,t} \equiv -\left(\frac{\sigma\Theta\omega_s^{-1}}{\Theta\kappa_y+1-\beta\rho}\right) u_t + \left(\frac{\sigma(1+\varphi)}{\sigma+\varphi\omega_s}\right) z_t - \left(\frac{\sigma(\sigma+\varphi)}{\sigma+\varphi\omega_s}\right) y_t^*$. Hence, given that $\xi_{d,t}$ is composed only of exogenous stationary processes, we have the following result:

Result 1. *Under the time consistent (discretionary) policy the (producer) price level and the nominal exchange rate both exhibit a unit root.*

3.2 Optimal Plan under Commitment

In the case in which the monetary authority has the possibility of committing as of time zero, the optimal program consists in choosing a state contingent sequence $\{\pi_{H,t}, \widetilde{y}_t\}_{t=0}^{\infty}$ to maximize (41) subject to the sequence of constraints in (35) holding in every period $t + j$, $j \geq 0$.

The optimality conditions of this problem can be written:

$$\widetilde{y}_{t+j} - \widetilde{y}_{t+j-1} = -\Theta\pi_{H,t+j}, \quad j > 0 \tag{47}$$

$$\widetilde{y}_t = -\Theta\pi_{H,t}, \quad j = 0$$

As illustrated in Clarida, Gali and Gertler (1999) and Woodford (2002) it stands clear that the optimal program under commitment entails an inertial behavior. This strategy allows the policy authority to take full advantage of the forward-looking feature of both consumers' and firms' decisions. Consider a rise in inflation due to a positive cost-push shock. Unlike the case of discretion, the Central Bank under commitment will continue to reduce the output gap beyond the impact period of the shock. If this is credible, and given the forward-looking nature of the price setting process, anticipation of such a *future* path of the output gap will result in the *current* impact of the cost-push shock on inflation to be dampened.

By noticing that (47) can be interpreted as a price level targeting rule $\widetilde{y}_t = -\Theta p_{H,t}$ and by substituting into (15) one can obtain the following second order stochastic difference equation for the domestic price level

$$a\ p_{H,t} = \beta E_t\{p_{H,t+1}\} + p_{H,t-1} + u_t \tag{48}$$

Such equation has a unique bounded solution that takes the form

$$p_{H,t} = \mu_{1,c}\ p_{H,t-1} + \left(\frac{\mu_{1,c}}{1-\rho\beta\mu_{1,c}}\right) u_t \tag{49}$$

where $\mu_{1,c} \equiv \frac{a}{2}\left(1-\sqrt{\left(1-\frac{4\beta}{a^2}\right)}\right) < 1$ is the stable root associated with the characteristic polynomial, and $\mu_{2,c} = \beta^{-1}\mu_{1,c}^{-1}$. Hence we see that under commitment the domestic price level must be stationary. Similarly to above we can build a link between the nominal exchange rate and the price level as follows:

$$e_t = (1+\Theta)p_{H,t} + \xi_{c,t} \tag{50}$$

where $\xi_{d,t} \equiv \left(\frac{\sigma(1+\varphi)}{\sigma+\varphi\omega_s}\right) z_t - \left(\frac{\sigma(\sigma+\varphi)}{\sigma+\varphi\omega_s}\right) y_t^*$. Hence we have the following result:

Result 2. *Under the optimal commitment policy the (producer) price level and the nominal exchange rate are both stationary.*

3.3 Fixed Exchange Rates

When the small economy pegs its exchange rate vis a vis the world economy or, alternatively, relinquishes its monetary independence by joining a currency area, the nominal exchange rate will be irrevocably fixed. In this case the interest parity condition reduces to:

$$r_t = r_t^* \text{ for all t}$$

and the terms of trade will read

$$\begin{aligned} s_t &= p_t^* - p_{H,t} \\ &= -p_{H,t} \end{aligned} \tag{51}$$

where the second equality follows from our assumption that the monetary authority in the rest of the world pursues a price stability policy. By substituting into (18) and in turn into (15) one obtains

$$a_f \; p_{H,t} = \beta E_t\{p_{H,t+1}\} + p_{H,t-1} + u_t \tag{52}$$

where $a_f \equiv 1 + \beta + \kappa_y$. The above equation has a unique bounded representation of the form

$$p_{H,t} = \mu_{1,f} \; p_{H,t-1} + (\frac{\mu_{1,f}}{1 - \rho\beta\mu_{1,f}})u_t \tag{53}$$

where $\mu_1 \equiv \frac{a_f}{2}\left(1 - \sqrt{\left(1 - \frac{4\beta}{a_f^2}\right)}\right) < 1$ and $\mu_{2,f} = \beta^{-1}\mu_{1,f}^{-1}$. Hence we can state the following result:

Result 3. *In a regime of fixed exchange rates, like in the optimal commitment regime, the domestic price level must be stationary.*

4 Monetary Regimes and Equilibrium Dynamics

In this section we compare the dynamics implied by the three monetary regimes in response to a cost-push shock. Before doing that let us briefly describe our baseline parameterization. We set σ equal to 1, which corresponds to a log utility specification, and η equal to 1.5. We assume $\varphi = 3$ (which implies a labor supply elasticity of $\frac{1}{3}$), and a value for the steady-state markup $\mu = 1.2$ (which implies that ε, the elasticity of substitution between differentiated goods, is 6). The parameter θ is set to 0.75, a value consistent with an average period of one year between price adjustments. We assume $\beta = 0.99$, which implies a riskless annual return of about 4 percent in the steady state. We assume, for simplicity, that the cost-push shock follows a simple autoregressive process with persistence parameter $\rho_u = 0.7$ and unitary standard deviation of the shock. All the previous parameters are assumed to take identical values in the small open economy and the world economy. In addition, the small economy is characterized by an openness index γ for which we assume a value of 0.4. Finally we assume that $b_w = 0.05$ as a starting baseline value. Although in the low range this is consistent with the absolute size derived in Woodford (2002), where the Central Bank's loss function is derived by means of a second order approximation of the household's utility (so that b_w is a convolution of underlying structural parameters).[9] The sensitivity analysis on this parameter, though, will be of considerable importance below.

[9] The derivation, along the lines of Woodford (2002), of a tractable loss function from first principles has proved a much more difficult task in an open economy, as outlined in Benigno and Benigno (2002) and Gali and Monacelli (2002). In particular, in these models an accurate quadratic approximation of households' welfare can be obtained only under very specific assumptions on preferences and on the value of the international elasticity of substitution. The issue of how computing welfare maximizing polices in fully dynamic open economy models still remains a subject of research. See Faia and Monacelli (2003) for an alternative approach based on the direct solution of the Ramsey

4.1 Optimal Policy vs. Time Consistent

In *Figure 1* the equilibrium response of selected variables under the optimal commitment policy is contrasted to the one under the time consistent (TC henceforth) or discretionary policy.

Figure 1 near here

As expected the positive cost-push shock generates a rise in inflation and a fall in the output gap. However the implied behavior of inflation differs sharply across the two regimes. Under the TC policy inflation returns monotonically to its initial values while it displays some overshooting under the optimal policy. Under the TC policy the monetary authority cannot exploit its commitment to a certain future path for the output gap to improve the short run inflation performance, which explains the lack of persistence in the response of the output gap. The different behavior of inflation across the two regimes rationalizes the different behavior in the price level, which is stationary under the optimal program while it exhibits a unit root under the TC policy.

Under the optimal policy the response of the interest rate is much smoother than under TC. The rise in the interest rate is responsible for the initial appreciation of the nominal exchange rate, which is larger under the TC policy. However the exchange rate exhibits a sharply different dynamic under the two regimes afterwards. Namely it returns monotonically to the initial value under the optimal policy while it exhibits a unit root under the TC policy. Hence, and in response to the initial cost-push shock, the TC policy generates a permanently higher price level and depreciated nominal exchange rate.

The key factor that rationalizes this link between the price level and the nominal exchange rate is the stationarity of the terms of trade under the assumption of complete asset markets. Full risk sharing, as from equation (16), implies that permanent changes in relative consumption are not allowed in equilibrium in response to shocks. Hence the trade balance must always return to its steady state value of zero.[10]

problem and on the explicit consideration of all the distortions characterizing the equilibrium of the economy.

[10] This does not imply that movements in the trade balance are not allowed in the short-run. In this context, and unlike the framework of Corsetti and Pesenti (2000), the elasticity of substitution between domestic and foreign goods can be larger that unitary and this permits movements in the trade balance around its zero steady-state value even in the case of log preferences.

4.2 Optimal Policy vs. Fixed Exchange Rates

What distinguishes a regime of fixed exchange rates is its nature of commitment to a certain future course of action. This raises the issue of what features such regime actually shares with the one of fully optimal commitment.

In *Figure 2* the implied equilibrium responses of the same selected variables to a one percent cost-push innovation is compared to the one under fixed exchange rates.

Figure 2 near here

Notice that under fixed exchange rates once again inflation rises and the output gap falls. However the response of both variables relative to the optimal policy is much more amplified under fixed exchange rates than it was the case under the TC policy. This naturally suggests that under our benchmark calibration a regime of fixed exchange rates implies a greater overall loss for the monetary authority of the small economy.

The distinctive feature of the fixed exchange rate regime is that it implies a stationary response of the price level. This is again a natural consequence of the stationarity of the terms of trade. By construction the response of the price level must be the mirror image of the one of the terms of trade.

4.2.1 The Effect of Varying the Degree of Openness

Despite the fact that stationarity of the price level is a feature that a regime of fixed exchange rates shares with the fully optimal policy the latter regime still implies large fluctuations in inflation and in the price level. In this section we show how the results are affected by one key parameter that distinguishes our analysis, namely the degree of openness. *Figure 3* displays the effect of varying the import share γ on the volatility of the output gap, inflation and the terms of trade as well as on the total central bank's loss.

Figure 3 near here

Notice, first, that the model implies a negative relationship between the equilibrium volatility of the terms of trade and the degree of openness. This can be clearly seen from equation (23). The sensitivity ω_s of relative output to the terms of trade is in fact increasing in the degree of openness. The more open the economy the smaller is the equilibrium variation in the terms of trade necessary to absorb a required given variation in relative output. Under fixed exchange rates the volatility of the terms of trade is constantly below the one implied by the optimal policy and the TC policy.

The impossibility of the nominal exchange rate to compensate for the excess smoothness in prices is responsible for this result and it is reminiscent of the widely cited empirical evidence in Mussa (1986).[11]

For any degree of openness the volatility of the output gap is larger under the TC and optimal policy than it is under fixed exchange rates. This is due to the strong link between the terms of trade and the output gap implicit in the model. As fixed exchange rates tend to dampen the volatility of the terms of trade relative to the optimal regimes this is reflected in a less volatile output gap. However fixed exchange rates imply a much larger volatility in inflation relative to the optimal regimes. This is the factor that drives the loss ranking reported in the bottom-right picture. The relatively higher volatility of inflation under fixed rates is the result of a too low volatility in the terms of trade. Hence we have the following result:

Result 4. *Relative to the optimal policies (both under commitment and discretion), fixed exchange rates tend to excessively dampen the terms of trade (and therefore the output gap) volatility and to generate too volatile inflation. This results in fixed rates delivering higher loss under our baseline parameterization.*

However Figure 3 already shows that the total loss under fixed rates tend to converge quite closely to the one under TC when the degree of openness is very high, although the relative ranking is not altered. Recall that in this context the degree of openness measured by γ is also a measure of the degree of asymmetry between the domestic and the foreign consumption baskets. As $\gamma \longrightarrow 1$ the two consumption baskets tend to coincide. In that limit case no relative price variation is required in equilibrium, and hence the loss from excess smoothness in the terms of trade that characterizes fixed exchange rates is minimized. Not surprisingly, then, total loss is decreasing in openness under fixed exchange rates.

High weight on the output gap *Figure 4* displays the results of the same sensitivity analysis conducted above but with a change from the baseline calibration. Namely we increase the relative weight b_w assigned to output gap volatility in the loss criterion of the central bank (from 0.05 to 0.2). This already implies dramatic changes in the relative ranking between TC policy and fixed exchange rates, although the value of b_w remains still in the low range from the view point of the traditional literature assuming quadratic loss functions.[12]

[11] See Monacelli (2002) for a sticky price model that is able to rationalize quantitatively the evidence of Mussa (1986), according to which, in moving from fixed to floating exchange rate regimes, industrial countries experience dramatic rises in the variability of both nominal and real exchange rates.

[12] Some authors find a range $b_w \in [0, 2]$ as plausible, see for instance Dennis and Soderstrom (2002).

Figure 4 near here

A higher weight b_w implies more room under the optimal policy for smoothing the terms of trade (and therefore the output gap) in a way more similar to what is done under fixed exchange rates. However this tends to boost the volatility of inflation under TC. The volatility of inflation under fixed exchange rates now lies below the one under the TC policy regardless of the degree of openness. This generates a reversed ranking between TC and fixed rates, with the latter dominating the former for any degree of openness. This result can be recast in the following way:

Result 5. *When the policy weight on the output gap variability is high, fixing the exchange rate can be a good way to reduce inflation variability without trading off too much in terms of output gap volatility, a cost that must necessarily be paid under the TC policy.*

High elasticity of substitution between domestic and foreign goods In *Figure 5* we conduct a final sensitivity experiment. We are still interested in analyzing the sensitivity to the degree of openness of the relative ranking between fixed exchange rates and the TC policy.

Figure 5 near here

In this experiment we reduce the policy weight parameter b_w back to its original initial value ($b_w = 0.05$) and alter the baseline calibration along a different dimension, i.e., the elasticity of substitution between domestic and foreign goods (from $\eta = 1.5$ to $\eta = 3$). Relative to the baseline case illustrated in Figure 3 this result shows that, when the elasticity of substitution is high, there exists a degree of openness for which the equilibrium total loss under fixed is smaller than the one under the TC policy. Interestingly this happens for a relatively low value of the index of openness γ. Hence we have the following result:

Result 6. *For relatively high values of the elasticity of substitution between domestic and foreign goods (and already for a low degree of openness) a fixed exchange rate regime can dominate the optimal time consistent policy.*

This result is driven by the large reduction in inflation volatility that higher openness brings about under fixed rates (unlike the optimal policies, see upper-right panel). It was already clear from the baseline case analyzed in Figure 3 that under fixed exchange rates higher openness would dampen inflation volatility. This is a direct consequence of higher openness implying smoother terms of trade and therefore more stable prices (recall that under fixed exchange rates $s_t = -p_{H,t}$). While under the baseline calibration this effect is not strong enough to switch the relative ranking between TC and fixed rates, it does deliver this result when the elasticity of substitution is high. In this case the gain of reduced inflation volatility derived from higher openness is large and allows fixed exchange rates to dominate the TC policy already for low values of openness.

5 Conclusions

In this work we have presented a benchmark framework for the analysis of monetary policy in an open economy. We have spelled out a dynamic model with both consumers and firms acting in an optimizing manner. The fact that inflation maintains its feature of forward- looking variable makes it an ideal starting point for the analysis of alternative monetary policy and exchange rate arrangements. We have solved the equilibrium dynamics under three alternative policy regimes: optimal policy, time consistent policy and fixed exchange rates. We have shown that in a baseline calibration gains from commitment arise from the possibility of affecting the expectations on the future course of variables. When commitment is not feasible a discretionary (time-consistent) policy still outperforms a regime of fixed exchange rates. We have devoted particular attention to the performance of a fixed exchange rate regime. Such regime displays a fundamental pitfall, namely that it implies an excess smoothness in the adjustment of the terms of trade (the key channel that distinguishes the open economy dimension of monetary policy). This makes it undesirable relative to the other regimes under the baseline calibration. However a regime of fixed exchange rates displays a benefit of the optimal commitment regime that the TC policy lacks. Namely it entails stationary price level and exchange rate. We have indeed shown that there exist combinations of the parameter values that make such benefit outweigh the cost of excess smoothness in the terms of trade thereby rendering a regime of fixed exchange rates more desirable than the TC optimal policy. This happens for high values of the elasticity substitution between domestic and foreign goods and for a high relative weight assigned to the output gap variability in the Central bank's loss function. In such cases a regime of fixed exchange rates can be characterized as a feasible way to move the equilibrium closer to the one entailed by the optimal commitment program. This result also sheds light on a new type of tradeoff that a small economy may face when choosing to participate to a currency area. Namely a tradeoff between the cost of relinquishing exchange rate flexibility and the benefit of designing a monetary regime which allows to implement in practice some of the features of the optimal commitment policy.

References

[1] Bacchetta, Philippe, and Eric van Wincoop (2000): “Does Exchange Rate Stability Increase Trade and Welfare?”, *American Economic Review*, 90:5, 1093-1109

[2] Benigno, Gianluca and Pierpaolo Benigno (2002): “Price Stability in Open Economies”, forthcoming *Review of Economic Studies.*

[3] Betts, Caroline and Michael B. Devereux (1996): “The Exchange Rate in a Model of Pricing-to-Market,” *European Economic Review* 40, 1996.

[4] Betts, Caroline and Michael B. Devereux (2000): “Exchange Rate Dynamics in a Model of Pricing-to-Market”, *Journal of International Economics* 50,1,215-244.

[5] Calvo, Guillermo, 1983, “Staggered Prices in a Utility Maximizing Framework,” *Journal of Monetary Economics*, 12, 383-398.

[6] Chari, V.V, Patrick J.Kehoe and Ellen R. Mc Grattan (2003). ”Can Sticky Price Models Generate Volatile and Persistent Real Exchange Rates?”, forthcoming *Review of Economic Studies.*

[7] Christiano L., M. Eichenbaum and C. Evans (2001). ”Monetary Policy Shocks: What Have We Learned and to What End?”, in Taylor and Woodford, *Handbook of Macroeconomics.*

[8] Clarida, Richard, Jordi Galí, and Mark Gertler (1998): “Monetary Policy Rules in Practice: Some International Evidence” *European Economic Review*, vol. 42, 1033-1067.

[9] Clarida, Richard, Jordi Galí, and Mark Gertler (1999): “The Science of Monetary Policy: A New Keynesian Perspective,” *Journal of Economic Literature*, vol. 37, 1661-1707.

[10] Clarida, Richard, Jordi Galí, and Mark Gertler (2000): “Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory,” *Quarterly Journal of Economics*, vol. 105, issue 1, 147-180.

[11] Clarida, Richard, Jordi Galí, and Mark Gertler (2001): “Optimal Monetary Policy in Open vs. Closed Economies: An Integrated Approach,” *American Economic Review*, vol. 91, no. 2, 248-252.

[12] Corsetti, Giancarlo and Paolo Pesenti (2001a): “Welfare and Macroeconomic Interdependence,” *Quarterly Journal of Economics* vol. CXVI,issue 2, 421-446.

[13] Corsetti, Giancarlo and Paolo Pesenti (2001b): "International Dimensions of Optimal Monetary Policy", mimeo.

[14] Dennis R. and U. Soderstrom (2002). "How important is precommitment for monetary policy?" Federal Reserve Bank of San Francisco Working Paper No. 139.

[15] Devereux, Michael B. and Charles Engel (1998): "Fixed vs. Floating Exchange Rates: How Price Setting Affects the Optimal Choice of Exchange Rate Regime," mimeo.

[16] Devereux M. and Charles Engel (2002). "Exchange Rate Pass-Through, Exchange Rate Volatility, and Exchange Rate Disconnect". *Journal of Monetary Economics*, June, 913-940

[17] Erceg Christopher J., D.W. Henderson and A.T. Levine (2000): "Optimal Monetary Policy with Staggered Wage and Price Contracts", *Journal of Monetary Economics* 46 281-313.

[18] Faia E. and T. Monacelli (2003). "Ramsey Monetary Policy and International Relative Prices", IGIER Bocconi and Universitat Pompeu Fabra, Mimeo.

[19] Galí, Jordi and Mark Gertler (1999): "Inflation Dynamics: A Structural Econometric Analysis," *Journal of Monetary Economics*, vol. 44, no. 2, 195-222.

[20] Gali, Jordi and Tommaso Monacelli (2002). "Monetary Policy and Exchange Rate Volatility in a Small Open Economy". NBER W.P. # 8905.

[21] Goodfriend, Marvin and Robert G. King (2001): "The Case for Price Stability," in Garcia-Herrero et al. (eds.) *Why Price Stability?* European Central Bank.

[22] Hau, Harald (2000): "Real Exchange Rate Volatility and Economic Openness: Theory and Evidence", unpublished manuscript.

[23] King, Robert G., and Alexander L. Wolman (1996): "Inflation Targeting in a St. Louis Model of the 21st Century," *Federal Reserve Bank of St. Louis Review*, vol. 78, no. 3. (NBER WP #5507).

[24] Kollmann, Robert (2001): "The Exchange Rate in a Dynamic Optimizing Current Account Model with Nominal Rigidities: A Quantitative Investigation," *Journal of International Economics* vol.*55, 243-262.*

[25] Lane, Philip R. (1999): "The New Open Economy Macroeconomics: A Survey," *Journal of International Economics*, vol. 54, 235-266.

[26] McCallum Bennet and Edward Nelson (2000) "Monetary Policy for an Open Economy: An Alternative Framework with Optimizing Agents and Sticky Prices", *Oxford Review of Economic Policy* 16, 74-91.

[27] Monacelli, Tommaso (2002):"Into the Mussa Puzzle: Monetary Policy Regimes and the Real Exchange Rate in a Small Open Economy", forthcoming *Journal of International Economics.*

[28] Monacelli, Tommaso (2003): "Monetary Policy in a Low Pass-Through Environment", IGIER w.p # 228.

[29] Obstfeld, Maurice and Kenneth Rogoff (1995): "Exchange Rate Dynamics Redux," *Journal of Political Economy* 103, no. 3, 624-660.

[30] Obstfeld, Maurice and Kenneth Rogoff (1999): "New Directions for Stochastic Open Economy Models," *Journal of International Economics*, vol. 50, no. 1, 117-153.

[31] Rotemberg, Julio and Michael Woodford (1999): "Interest Rate Rules in an Estimated Sticky Price Model," in J.B. Taylor ed., *Monetary Policy Rules*, University of Chicago Press.

[32] Schmitt-Grohé Stephanie and Martín Uribe (1999): "Stabilization Policy and the Costs of Dollarization", mimeo.

[33] Svensson, Lars E.O. (2000): "Open-Economy Inflation Targeting," *Journal of International Economics*, vol. 50, no. 1.

[34] Taylor, John B. (1993): "Discretion versus Policy Rules in Practice," *Carnegie-Rochester Series on Public Policy* 39, 195-214.

[35] Taylor, John B. editor (1999): *Monetary Policy Rules*, University of Chicago Press.

[36] Vestin, D. (1999): "Price level Targeting versus Inflation Targeting in a Forward Looking Model," unpublished manuscript, IIES, Stockholm University.

[37] Woodford, Michael (2002), *Interest and Prices*, chapter 2, mimeo.

[38] Yun, Tack (1996), "Monetary Policy, Nominal Price Rigidity, and Business Cycles", *Journal of Monetary Economics*, 37:345-70.

Figure 1 Responses to a Cost Push Shock: Commitment vs. Discretion

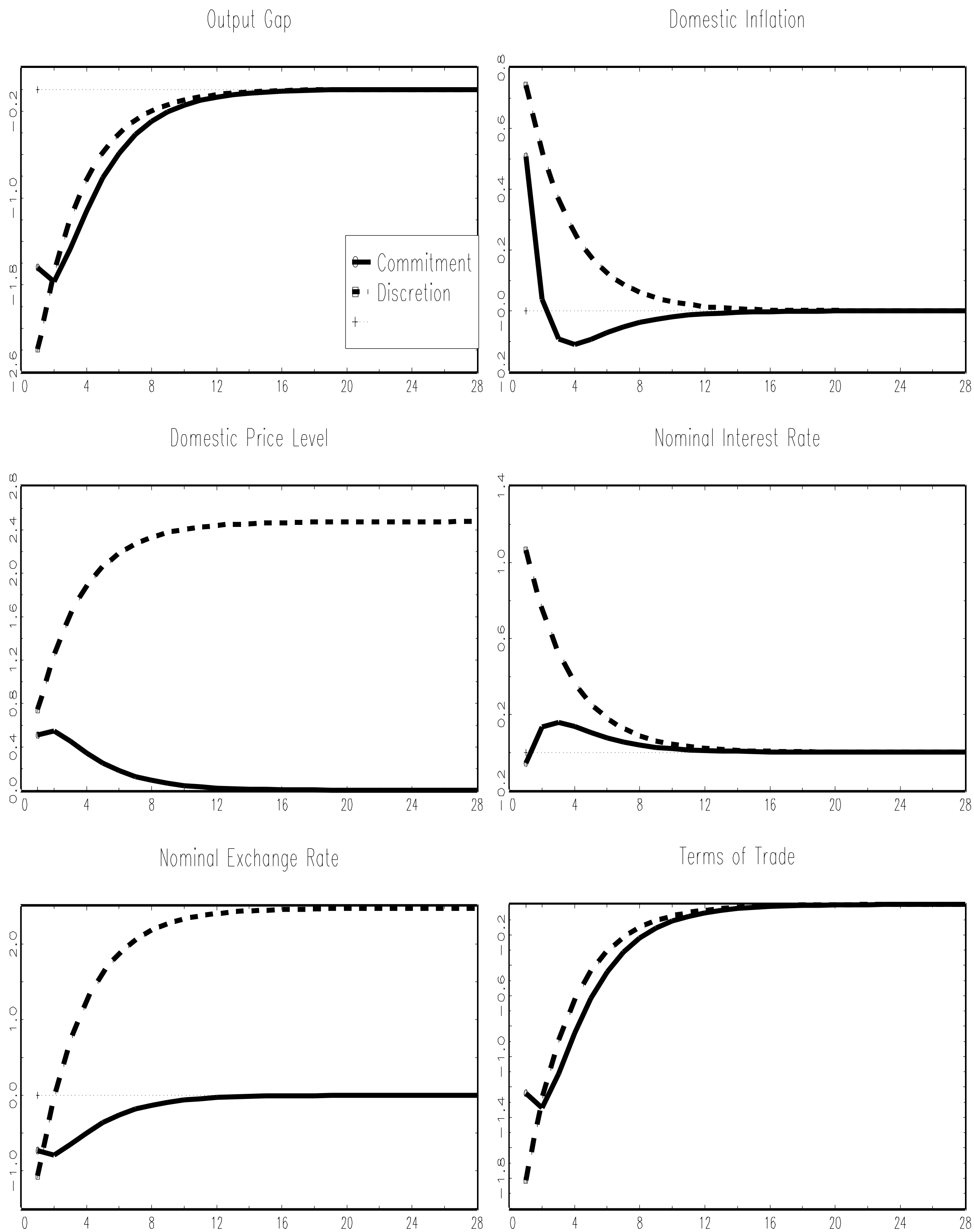

Figure 2 Responses to a Cost Push Shock: Commitment vs. Fixed

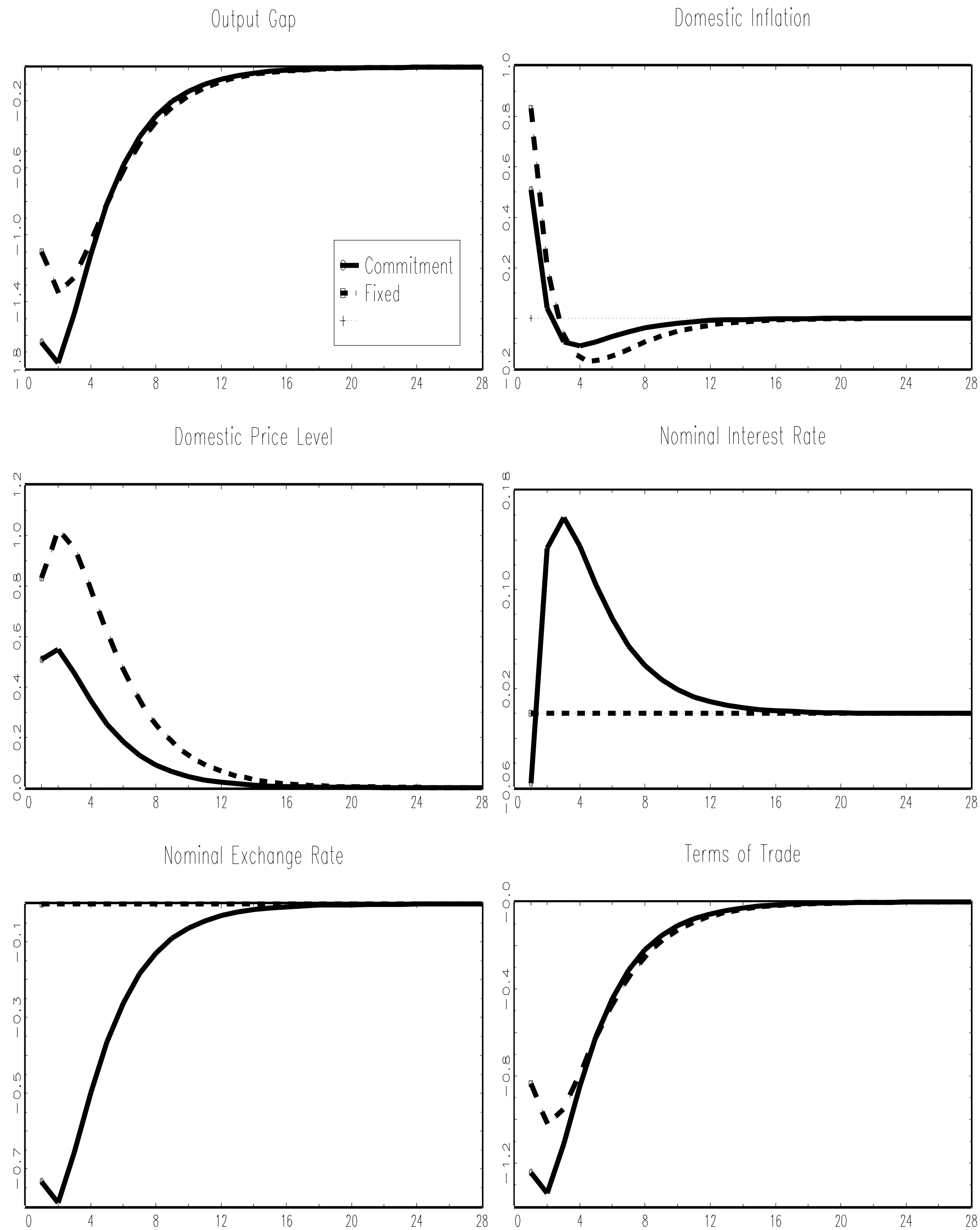

Figure 3 Effect of Varying Openness (baseline)

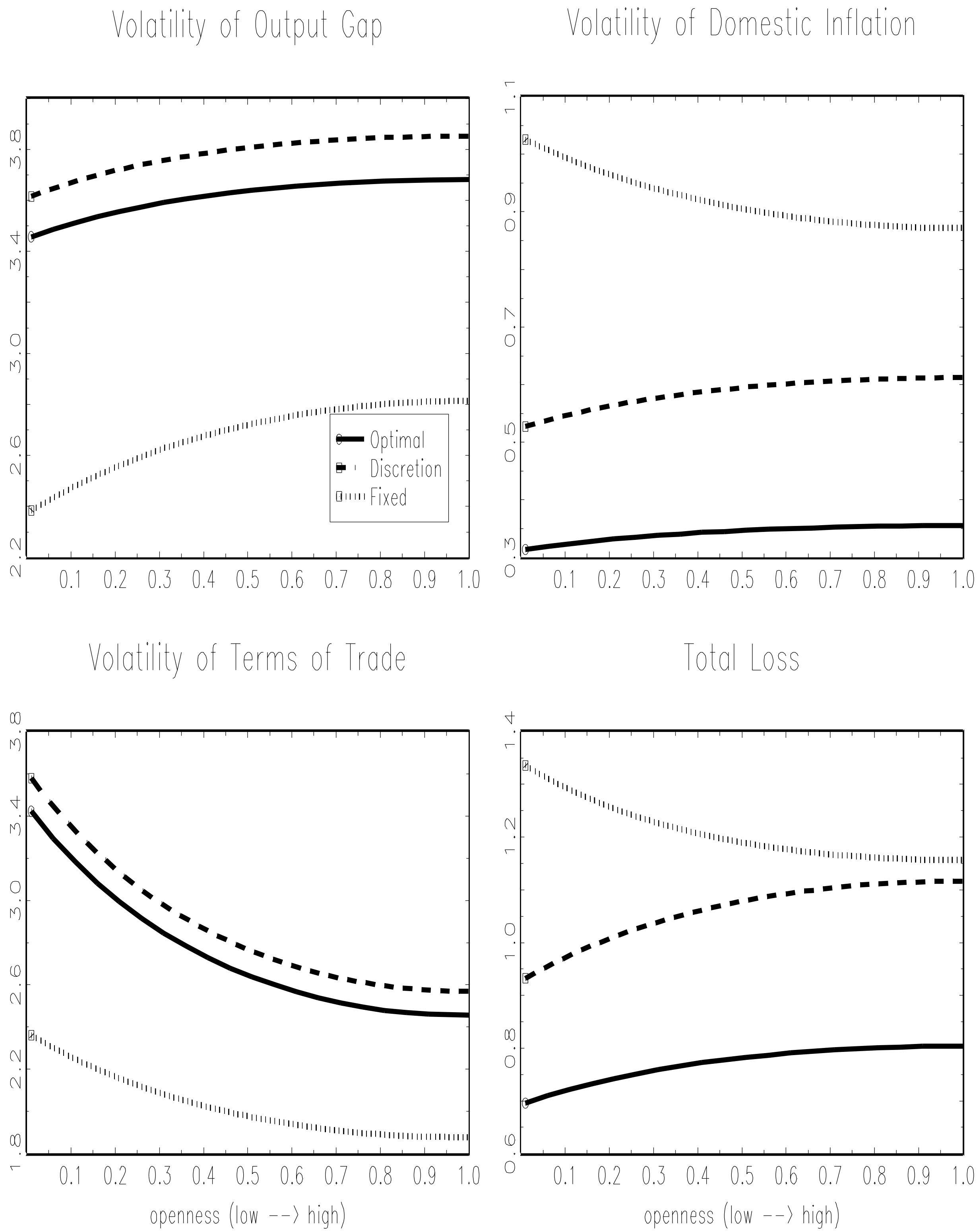

Figure 4 Effect of Varying Openness (high weight on output gap)

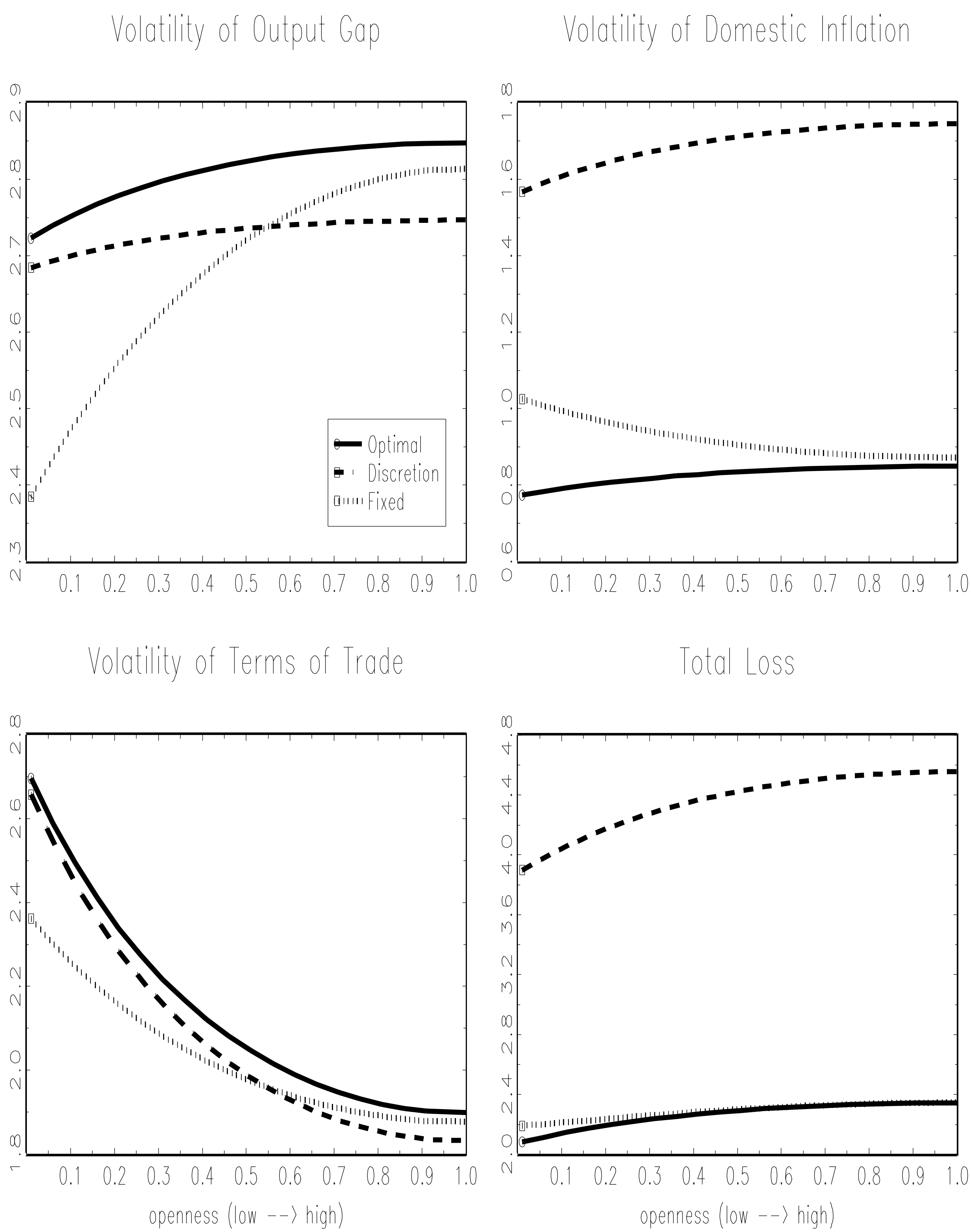

Figure 5 Effect of Varying Openness (high elasticity of substitution)