

# **On Discretion versus Commitment and the Role of the Direct Exchange Rate Channel in a Forward-Looking Open Economy Model.**

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## **ABSTRACT**

Irrespective of whether discretion or commitment to a binding rule guides the conduct of monetary policy, the existence of a direct exchange rate channel in the Phillips Curve causes the behavior of key economic variables to differ dramatically in an open economy compared to a closed economy. In an open economy, the policymaker can no longer perfectly stabilize real output and the rate of inflation in the face of IS and UIP shocks as well as shocks to foreign inflation. If the exchange rate channel in the Phillips Curve is operative, then in an open economy the policymaker faces an output-inflation tradeoff that differs substantially from its counterpart in a closed economy.

Our analysis of the conduct of monetary policy reveals that the stabilization bias under discretion is weaker in an open economy relative to a closed economy. In an open economy, a “less conservative central banker”, one that attaches a smaller weight to the variance of inflation in the loss function, can be appointed to replicate the behavior of real output that eventuates under optimal policy.

Evaluating the social loss function under discretion and commitment, we find that the existence of a direct exchange rate channel in the Phillips Curve mitigates the pronounced differences between the two strategies in case of high persistence in the stochastic shocks.

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## Introduction.

In an open economy the exchange rate is an important factor in the design of monetary policy. The nominal exchange rate may serve as the underlying objective of monetary policy in the short-to-medium term in its capacity as an intermediate target. The real exchange rate is of concern to policymakers not least because of its importance in determining the competitiveness of domestic goods in global markets. Clarida, Gali, and Gertler (2001) emphasize the role of the real exchange rate as the driving force behind the expenditure switching effect in their open economy model. Their model is by-and-large an extension of the closed-economy New Keynesian framework to the open economy, albeit one that allows only a circumscribed role for the real exchange rate in the transmission of monetary policy effects.<sup>1</sup> That the real exchange rate can play a much more pervasive role has recently been documented by Ball (1999), Froyen and Guender (2000), McCallum and Nelson (1999), Svensson (2000), and Walsh (1999).<sup>2,3</sup> All of these contributions share the common characteristic that the real exchange rate directly affects behavior on the production side of the economy.<sup>4</sup>

This paper underscores the importance of the direct exchange rate channel in the transmission of monetary policy effects in an open-economy forward-looking model. We show that the stabilizing properties of optimal policy under discretion and commitment in the face of demand-side disturbances diminish dramatically if this direct exchange rate channel is present in the Phillips Curve. In addition, we illustrate that the optimal relationship that characterizes real output and the rate of inflation in an open economy

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1 For a detailed exposition of the closed economy New Keynesian framework, see their survey article (1999).

2 This list is by no means exhaustive. Early contributions that highlight the real exchange rate effects on aggregate supply are by Marston (1985) and Turnovsky (1983).

3 While writing this paper, I became aware of the existence of an unpublished paper by Walsh (1999). He examines the conduct of monetary policy in the open economy from a similar perspective after extending Calvo's (1983) staggered price setting model to the open economy.

4 Employing a backward-looking framework, Ball (1999) motivates the direct real exchange rate effect on the rate of inflation by assuming that foreign producers care only about goods prices expressed in *their* home currency. McCallum and Nelson (1999) and Froyen and Guender (2000) assume that a foreign resource input enters as an intermediate input in production. Walsh (1999) introduces a real exchange rate channel by assuming that real wage demands are based on the CPI.

depends on all structural parameters of the model and the policymaker's preferences. Persistence in the stochastic disturbances figures also in the determination of the optimality condition under commitment. Our analysis also reveals that the output-inflation tradeoff is more favorable under commitment than under discretion in part because of the existence of the direct exchange rate channel. Moreover, the stabilization bias inherent in discretionary policymaking is found to be lower in our open economy framework relative to the standard closed economy framework. As a consequence, a less "conservative central banker" can be entrusted with the task of running the central bank. Towards the end of the paper, we investigate the effects of varying the degree of persistence in the stochastic disturbances and the size of the direct exchange rate effect in the Phillips Curve on the attractiveness of discretionary policymaking versus commitment. High persistence in the stochastic shocks combined with a weak or non-existent direct exchange rate channel in the Phillips Curve detract from the appeal of conducting monetary policy with discretion.

The organization of the paper is as follows. In Section II.A we lay out the building blocks of the model while in Section II.B we present a brief description of the policymaker's preferences. Section III and Section IV analyze the conduct of monetary policy under discretion and commitment. The issue of appointing a conservative central banker is taken up in Section V. In Section VI we parameterize the model to evaluate the performance of policymaking under discretion and commitment. This exercise relies on a numerical evaluation of loss functions. Concluding remarks appear in Section VII.

## II.A. The Model.

This section presents a model of a small open economy. Three equations make up the model. All variables with the exception of the nominal interest rate are expressed in logarithms. All parameters are positive.

$$\pi_t = E_t \pi_{t+1} + a y_t + b q_t + u_t \quad (1)$$

$$y_t = E_t y_{t+1} - a_1 (R_t - E_t \pi_{t+1}) + a_2 q_t + v_t \quad (2)$$

$$R_t - E_t \pi_{t+1} = R_t^f - E_t \pi_{t+1}^f + E_t q_{t+1} - q_t + \varepsilon_t \quad (3)$$

where:

$y_t$  = the real output gap.

$\pi_t$  = domestic rate of inflation at time  $t$  measured as  $p_t - p_{t-1}$ .

$E_t \pi_{t+1}$  = the expectation of  $\pi_{t+1}$  formed at time  $t$ .

$E_t \pi_{t+1}^f$  = the expectation formed at time  $t$  of the foreign rate of inflation for period  $t+1$

$R_t$  = the domestic nominal interest rate at time  $t$ .

$R_t^f$  = the foreign nominal interest rate at time  $t$ .

$q_t$  = the real exchange rate defined as  $s_t + p_t^f - p_t$  where  $s_t$  is the nominal exchange rate (domestic currency per unit of foreign currency),  $p_t^f$  is the foreign price level, and  $p_t$  is the domestic price level.

$E_t q_{t+1}$  = the expectation dated  $t$  of the real exchange rate for period  $t+1$ .

$u_t, v_t$ , and  $\varepsilon_t$  are stochastic disturbances.

The first two relations incorporate the forward-looking behavior typical of the New Keynesian framework. Equation (1) represents the forward-looking Phillips curve relation for an open economy. In this economy real output is produced by monopolistically competitive firms. These firms set the price of output in order to minimize a cost function that takes into account the existence of menu costs and the cost of charging a price different from the optimal price. Apart from the standard excess demand effect, the open-economy Phillips Curve also features a direct real exchange rate effect on domestic inflation. The rationale for the existence of this effect is that a depreciation causes the domestic currency price of the foreign good,  $(p_t^f + s_t)$ , to increase. The increase in the exchange rate in turn forces up the optimal price, which, *ceteris paribus*, induces firms to raise the price of their output so as to minimize the deviation between the optimal price and the actual price charged. At the aggregate level the increase in the domestic price level causes the rate of inflation to rise. Thus we observe the positive link between the exchange rate and the rate of inflation. The derivation of the open economy Phillips Curve is explained fully in the appendix.

Equation (2) defines an open economy IS relation - output demanded depends on the expected real interest rate and the real exchange rate.<sup>5</sup> Equation (3) is the uncovered interest rate parity condition (UIP), expressed in real terms, where  $\varepsilon_t$  can be thought of as a time-varying risk premium.

## II.B. The Preferences of the Policymaker.

The policymaker's preferences extend over the variability of the real output gap and the domestic rate of inflation, respectively. The explicit objective function that he attempts to minimize is given by

$$\frac{1}{2} E_t \left[ \sum_{i=0}^{\infty} \beta^i [y_{t+i}^2 + \mu \pi_{t+i}^2] \right] \quad (4)$$

The target for the real output gap is zero, which implies that the policymaker attempts to ensure that the level of output is at its potential level. The level of potential output is assumed to be constant. The target for the rate of inflation is assumed to be zero. Fluctuations in the real exchange rate do not enter explicitly the loss function. The reason for the omission is that changes in the real exchange rate are reflected in changes in the output gap.<sup>6,7</sup>

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5 This is a simplified version of the IS relation for the open economy in McCallum and Nelson (1997), Svensson (2000) or Guender (2003) that is derived from first principles. The IS relation presented in Guender (2003) differs from the one above in that the expectation of the real exchange rate for period  $t+1$ , the current foreign output gap as well as the expectation of the foreign output gap for period  $t+1$  enter. The simplified IS relation suffices for the purpose of the current paper as, for instance, it yields the same optimizing condition under discretion as the more elaborate IS specification. There is no LM relation as the policymaker uses the nominal interest rate as the policy instrument.

6 This is evident once the UIP condition is solved for  $R_t$  and the resulting expression is inserted into the IS curve. For a similar view on why the loss function contains only real output and the domestic rate of inflation, see Clarida, Gali, and Gertler (2001). Adopting equation (4) as the welfare criterion ignores the effects on welfare of changes in the real exchange rate in the open economy framework. Ignoring these potential effects is rather inconsequential in the current context as there is no *imported* intermediate input in production.

7 Woodford (1999a) derives an endogenous loss function based on the utility-maximizing framework. According to this analysis, the policymaker ought to be concerned with the variability of the output gap (and not the level of output) and the stability in the general price level.

### III. Policy Making under Discretion.

Period-by-period optimization and the treatment of expectations as being fixed characterize discretionary policymaking in the forward-looking framework.<sup>8</sup> The first characteristic implies that the policymaker sets policy anew every period. The other characteristic suggests that the policymaker treats the expectations of agents as constants when re-optimizing every period.

To set the stage for illustrating how discretionary policymaking in the open economy is carried out, it is helpful at the outset to reduce the dimension of the optimization problem to one involving only one constraint. A few simple steps need to be taken. First, we solve the UIP condition for the real exchange rate and substitute it into both the IS equation and the Phillips curve relation. Next, we solve the IS relation for the expected real rate of interest ( $R_t - E_t \pi_{t+1}$ ). Following this, we insert the expression for expected real rate of interest into the Phillips curve relation. The following expression results:

$$\pi_t = \left(a + \frac{b}{a_1 + a_2}\right)y_t + E_t \pi_{t+1} + \left[\frac{ba_1}{a_1 + a_2}(R_t^f - E_t \pi_{t+1}^f + E_t q_{t+1} + \varepsilon_t)\right] - \frac{b}{a_1 + a_2}(E_t y_{t+1} + v_t) + u_t \quad (5)$$

When setting policy with discretion, the policymaker takes the expectations of the endogenous variables  $y_t, \pi_t, q_t$  and the remaining terms as given.<sup>9</sup> Hence we can rewrite the above as

$$\pi_t = \left(a + \frac{b}{a_1 + a_2}\right)y_t + f_t \quad (6)$$

where

$$f_t = E_t \pi_{t+1} + \left[\frac{ba_1}{a_1 + a_2}(R_t^f - E_t \pi_{t+1}^f + E_t q_{t+1} + \varepsilon_t)\right] - \frac{b}{a_1 + a_2}(E_t y_{t+1} + v_t) + u_t \quad (7)$$

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<sup>8</sup> There is a third characteristic of discretionary policymaking that applies to the Barro-Gordon framework but not to the forward-looking framework: the target for the *level* of real output exceeds the potential level of real output. This feature gives rise to the inflationary bias in the model of Barro-Gordon (1982).

<sup>9</sup> Here we adopt the convention of describing the conduct of discretionary policy along the lines of Clarida, Gali, and Gertler (1999).

Notice further that the objective function can be neatly broken up into two separate components as future values of the endogenous variables are independent of today's policy action:<sup>10</sup>

$$\frac{1}{2}[y_t^2 + \mu\pi_t^2] + F_t \quad (8)$$

$$\text{where } F_t = \frac{1}{2} E_t \left[ \sum_{i=1}^{\infty} \beta^i (y_{t+i}^2 + \mu\pi_{t+i}^2) \right]$$

The problem of setting policy under discretion thus reduces to the following simple one-period optimization problem:

$$\text{Min}_{y_t, \pi_t} \quad \frac{1}{2}[y_t^2 + \mu\pi_t^2] + F_t$$

subject to

$$\pi_t = \left( a + \frac{b}{a_1 + a_2} \right) y_t + f_t$$

Combining the first-order conditions produces a systematic negative relationship between real output and the rate of inflation:

$$y_t = -\mu \left( a + \frac{b}{a_1 + a_2} \right) \pi_t \quad (9)$$

The coefficient on the rate of inflation indicates the loss of output that the policymaker is prepared to sustain if the rate of inflation exceeds its zero target level.

There are several noteworthy facts about the systematic relationship between real output and the rate of inflation under discretion:

- a. If the direct exchange rate channel is absent from the Phillips Curve, i.e. if  $b=0$ , then the optimal relationship between real output and the rate of inflation is the same for both an open- and a closed-economy framework. In this case, the coefficient on

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<sup>10</sup> Future values of  $y_t$  and  $\pi_t$  are not affected by policy today as the effect of policy is contemporaneous and

$\pi_t$  reduces to  $-\mu a$ . If  $b > 0$ , then the optimality condition depends on *all* parameters of the model, and not only on the parameter on excess demand in the Phillips curve.

- b. As long as  $b > 0$  the coefficient on the rate of inflation is greater in an open economy than in a closed economy since  $\mu(a + \frac{b}{a_1 + a_2}) > \mu a$ .
- c. The greater the size of the two Phillips curve parameters,  $a$  and  $b$ , the greater the sacrifice in terms of real output that must be made when the rate of inflation exceeds its target. Conversely, the more sensitive real output responds to the exchange rate and the real rate of interest (i.e. the greater  $a_1$  and  $a_2$ ), the less real output must decrease in case inflation exceeds its target level. Clearly, greater aversion to deviations of the rate of inflation from target (increasing  $\mu$ ) also increases the coefficient on  $\pi_t$ .
- d. In a closed economy, the inverse relationship between real output and inflation in the optimizing condition depends critically on the existence of cost-push shocks. In the present open economy framework, this inverse relationship also exists if the excess demand channel is shut off (i.e. in case  $a = 0$ ). Moreover, real output and inflation are inversely related under discretionary policy even in the wake of a demand shock. Suppose  $v_t > 0$ . Real output increases along with the real rate of interest. The increase in the real rate of interest causes the exchange rate to appreciate which in turn causes the rate of inflation to decrease. Thus real output and the rate of inflation move in opposite directions.

To obtain the reduced form equations for the endogenous variables, we combine the optimality condition, Equation (9), with Equation (5). As expectations are formed rationally, we pose putative solutions of the endogenous variables in line with the minimum state variable approach that produces solutions that excludes sunspots and bubbles.<sup>11</sup> We can show that the two endogenous variables of interest, the rate of inflation

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the absence of persistence in the endogenous variables.

<sup>11</sup> This method simply states that a trial solution for the endogenous variables should include all stochastic disturbances. If the model features any predetermined variables or constants, then they should appear in the

and the output gap, reduce to the expressions that appear in Table 1. The results presented underscore a critical difference between an open and a closed-economy framework.<sup>12</sup> While in a closed economy framework the rate of inflation and the output gap respond only to the cost-push disturbance, the two endogenous variables respond to all disturbances of the model in an open economy. Demand-side disturbances – foreign or domestic - can no longer be perfectly stabilized because of the existence of the direct exchange rate channel in the Phillips Curve. Any change in the real rate of interest in the wake of a demand disturbance prompts a change in the real exchange rate that directly affects the rate of inflation. The importance of the direct exchange rate channel depends on the size of the structural parameter  $b$ . Setting  $b$  to zero restores the perfect stabilization property of monetary policy in the face of demand-side disturbances.

#### IV. Policymaking under Commitment.

Commitment implies that the policymaker follows a rule systematically. In view of the fact that the policymaker cares about deviations of inflation from target and deviations of the real output gap from its target level, the policy rule focuses on the two target variables.<sup>13</sup> The policy rule takes a simple linear form:

$$\theta y_t + \pi_t = 0 \tag{10}$$

One critical difference that sets policy under commitment apart from policy under discretion pertains to the role of expectations in the model. Under discretion, the policymaker acts on the basis of fixed or given expectations as he is unable to manipulate them systematically. In contrast, under commitment, expectations about future values of the rate of inflation, real output, and the real exchange rate are endemic to the system. Indeed, the temporal properties of the stochastic disturbances that impinge upon the

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trial solution as well. For further details on how this method is applied, see McCallum (1983) or McCallum and Nelson (2004).

12 Throughout the analysis the coefficient on  $R_t^f$  is identical to that on  $\varepsilon_t$ . For the sake of brevity, we report only the latter.

economy are very important in determining these expectations. All shocks are assumed to follow an AR(1) process:<sup>14</sup>

$$\begin{aligned}
v_t &= \phi v_{t-1} + \hat{v}_t & \hat{v}_t &\sim (0, \sigma_v^2) \\
u_t &= \phi u_{t-1} + \hat{u}_t & \hat{u}_t &\sim (0, \sigma_u^2) \\
\pi_t^f &= \phi \pi_{t-1}^f + \hat{\pi}_t^f & \hat{\pi}_t^f &\sim (0, \sigma_{\pi^f}^2) \\
\varepsilon_t &= \phi \varepsilon_{t-1} + \hat{\varepsilon}_t & \hat{\varepsilon}_t &\sim (0, \sigma_\varepsilon^2)
\end{aligned} \tag{11}$$

To proceed, we combine Equation (10) with the IS relation, the Phillips Curve, and the UIP condition. To solve out the expectations of the future rate of inflation, real output, and the real exchange rate, we again posit putative solutions for the three endogenous variables in line with the minimum state variable approach referred to earlier. The solution for  $y_t$  appears in Table 2. It is apparent that the coefficients on the stochastic disturbances depend on the parameters of the model, the policy parameter  $\theta$ , and the autoregressive parameter  $\phi$ .

Prior to stating the policy objective of the policymaker, we rewrite the objective function in a slightly different form.<sup>15</sup>

$$\frac{1}{2} E_t \left[ \sum_{i=0}^{\infty} \beta^i [y_{t+i}^2 + \mu \pi_{t+i}^2] \right] = (1 + \mu \theta^2) y_t^2 E_t \sum_{i=0}^{\infty} \frac{\beta^i y_{t+i}^2}{y_t^2}$$

The next step consists of substituting the reduced form equation for  $y_t$  into the objective function. Under commitment the policymaker chooses the policy parameter  $\theta$  so as to minimize the objective function. The objective of the policymaker under commitment can be restated as:

$$Min_{\theta} \frac{(1 + \mu \theta^2) [b v_t - (a_1(1 - \phi) + a_2) u_t + a_1 b \phi \pi_t^f - a_1 b (\varepsilon_t + R_t^f)]^2}{[(a_1(1 - \phi) + a_2)(\theta(1 - \phi) + a) + b(1 - \phi)]^2} L_t$$

13 Here we will abstract from the notion of conducting monetary policy from a timeless perspective as discussed by Woodford (1999b) and McCallum and Nelson (2004).

14 To simplify things, we assume that the autoregressive parameter is the same for each disturbance. Imposing this condition has the advantage of allowing us to derive an analytical solution to the problem of determining optimal policy under commitment.

15 Here we follow Clarida, Gertler, and Gali (1999). Also recall that  $\theta y_t = -\pi_t$ .

(12)

where  $L_t = E_t \sum_{i=0}^{\infty} \frac{\beta^i y_{t+i}^2}{y_t^2}$ , an expression that does not contain the policy parameter  $\theta$ .

The solution to the minimization problem is given by:

$$\theta^c = \frac{1 - \phi}{\mu \left[ a + \frac{b(1 - \phi)}{a_1(1 - \phi) + a_2} \right]} \quad (13)$$

Substituting Equation (13) back into Equation (10) and rearranging it slightly yields:

$$y_t = -\frac{\mu}{1 - \phi} \left[ a + \frac{b(1 - \phi)}{a_1(1 - \phi) + a_2} \right] \pi_t \quad (14)$$

Equation (14) describes the optimal relationship between real output and the rate of inflation in an open economy under commitment.<sup>16</sup> In addition, Table 3 shows how the rate of inflation and real output, respectively, responds to the stochastic disturbances of the model under commitment. In the paragraphs to follow, we shall attempt to highlight the essential differences between policymaking under discretion as opposed to commitment.

Inspection of the optimizing conditions under discretion (Equation (9)) and commitment (Equation (14)) reveals that they differ only if  $\phi \neq 0$ . Thus for the behavior of real output and the rate of inflation to be different under commitment relative to discretion it is necessary for the disturbances to be autocorrelated. More importantly, the coefficient on the rate of inflation in the optimizing condition is greater under commitment than discretion for  $\phi > 0$ .<sup>17</sup> To see how the improved tradeoff between

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16 The points made earlier about the properties of the optimality condition under discretion in an open as opposed to a closed economy also apply with minor modifications under commitment. For instance, if the exchange rate channel is absent from the Phillips Curve then the optimality condition is the same for both open and closed economies and given by  $\frac{\mu a}{1 - \phi}$ .

17 This assumes that the disturbances are positively correlated.

inflation and real output comes about, we have to reconsider the Phillips Curve for the open economy. Iterating Equation (1) forward yields:

$$\pi_t = E_t \sum_{i=0}^{\infty} a y_{t+i} + b q_{t+i} + u_{t+i} \quad (1a)$$

Next, we insert the putative solutions for  $y_{t+i}$  and  $q_{t+i}$  that underlie the minimum state variables approach:

$$\pi_t = E_t \sum_{i=0}^{\infty} a(\gamma_{10} v_{t+i} + \gamma_{11} u_{t+i} + \gamma_{12} \varepsilon_{t+i} + \gamma_{13} \pi_{t+i}^f) + b(\gamma_{30} v_{t+i} + \gamma_{31} u_{t+i} + \gamma_{32} \varepsilon_{t+i} + \gamma_{33} \pi_{t+i}^f) + u_{t+i} \quad (1b)$$

$$\begin{aligned} \pi_t = & (a\gamma_{10} + b\gamma_{30})(v_t + \phi v_t + \phi^2 v_t + \dots) + (a\gamma_{11} + b\gamma_{31} + 1)(u_t + \phi u_t + \phi^2 u_t + \dots) \\ & + (a\gamma_{12} + b\gamma_{32})(\varepsilon_t + \phi \varepsilon_t + \phi^2 \varepsilon_t + \dots) + (a\gamma_{13} + b\gamma_{33})(\pi_t^f + \phi \pi_t^f + \phi^2 \pi_t^f + \dots) \end{aligned} \quad (1c)$$

The above reduces to:

$$\pi_t = \frac{(a\gamma_{10} + b\gamma_{30})}{1-\phi} v_t + \frac{(a\gamma_{11} + b\gamma_{31} + 1)}{1-\phi} u_t + \frac{(a\gamma_{12} + b\gamma_{32})}{1-\phi} \varepsilon_t + \frac{(a\gamma_{13} + b\gamma_{33})}{1-\phi} \pi_t^f \quad (1d)$$

Equation (1d) in turn can be rewritten as:

$$\pi_t = \frac{a}{1-\phi} y_t + \frac{b}{1-\phi} q_t + \frac{1}{1-\phi} u_t \quad (1e)$$

Equation (1e) illustrates the relationship between the rate of inflation, real output, and the real exchange rate under commitment. According to this equation, a decrease in the output gap and a decrease of the real exchange rate (real appreciation of domestic currency) are accompanied by a decrease in the rate of inflation. It is instructive to

compare the coefficients on the right-hand side of Equation (1e) to their counterparts under discretion.<sup>18</sup>

$$\pi_t = ay_t + bq_t + E_t \bar{\pi}_{t+1} + u_t \quad (1g)$$

It becomes immediately apparent that the size of the coefficients on real output and the real exchange rate are greater under commitment than under discretion:

$$\frac{a}{1-\phi} > a \quad \text{and} \quad \frac{b}{1-\phi} > b \quad (15)$$

The more sensitive response of the rate of inflation under commitment is a direct consequence of the effect of the policy rule on the expectations of the future evolution of *both* real output *and* the real exchange rate.

The second critical difference between policymaking under commitment as opposed to discretion follows directly from the improved output-inflation tradeoff and pertains to the size of the coefficients on the disturbances in the equations for  $\pi_t$  and  $y_t$ . Inspection of the coefficients in Tables 1 and 3 reveals that the rate of inflation is less responsive to shocks under commitment than under discretion. While the numerator of each coefficient is the same for both strategies, the denominator is clearly greater in size under commitment, i.e.  $C > D$ . In contrast, real output is more sensitive to shocks under commitment than under discretion.<sup>19</sup> Thus inflation is closer to target under commitment while the output gap is smaller under discretion. Hence there is a bias towards stabilizing real output under discretion. But how serious is the stabilization bias in an open as opposed to a closed economy?

To provide a partial answer to this question, let us compare the response of real output to a cost-push shock in both frameworks. The comparison focuses on the cost-push disturbance, as it is the only disturbance that affects real output in a closed economy. Figure 1 underscores the importance of the real exchange rate channel in

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<sup>18</sup> The bar over the expectation of inflation next period implies that the policymaker treats the expectation as given, i.e. as a constant.

reducing the size of the stabilization bias in an open economy. In the case where  $b = 0$ , which also corresponds to a closed economy framework, the stabilization bias is not only much greater in size but is also more sensitive to the degree of persistence in the stochastic disturbances than in an open economy. As  $b$  increases in steps of 0.25 the stabilization bias becomes ever smaller. Irrespective of the size of  $b$ , the stabilization bias first rises and then drops off as the degree of persistence in the stochastic disturbances increases.

Taken altogether, the results reported in this section can be summarized as follows. First, the optimal policy parameter in an open economy differs substantially from its counterpart in a closed economy due to the existence of a direct exchange rate channel. Second, the findings suggest that in an open economy the responses of real output and inflation to stochastic disturbances – though more complex and different in size - follow the same pattern under commitment and discretion as in a closed economy.<sup>20</sup> Third, the stabilization bias is smaller in an open compared to a closed economy framework.

## V. On the Issue of the Conservative Central Banker.

The closed-economy analysis by Clarida, Gali, and Gertler (1999) contains an intriguing result. They argue that the rationale for appointing a conservative central banker of the Rogoff (1985) type also holds in a closed economy framework that fits the New Keynesian mold. Indeed, the appointment of a banker who attaches a greater weight to inflation variability than society in the objective function and carries out policy with discretion results in outcomes for inflation and real output that are identical to those under commitment.<sup>21</sup>

Consider the case of a closed economy first. In the IS equation,  $a_2 = 0$  while in the Phillips Curve  $b = 0$ . It follows that the coefficient on the rate of inflation in the

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19 A separate appendix, which is available upon request, provides a detailed explanation of this result.

20 It should be borne in mind, however, that the autoregressive parameter  $\phi$  has a far more important role to play in an open economy than in a closed economy. This is made evident by  $1-\phi$  being attached not only to the preference parameter of the policymaker but also to structural parameters such as  $b$  and  $a_1$ .

21 Intuitively, a conservative central banker responds more vigorously to deviations of inflation from its target than society would if it conducted monetary policy.

optimizing condition under discretion (Equation (9)) and commitment (Equation (14)), respectively, is given by:

$$\begin{array}{cc} \text{Discretion} & \text{Commitment} \\ \mu a & \text{and } \frac{\mu a}{1-\phi} \end{array} \quad (16)$$

Thus if  $\mu$  in the objective function is replaced with  $\mu^* = \frac{\mu}{1-\phi} > \mu$ , and the policymaker carries out policy with discretion, he will deliver the same solutions for real output and the rate of inflation as under commitment.

This result does not, however, carry over to an open-economy framework where the direct exchange rate channel in the Phillips Curve is operative. This can easily be seen by comparing the optimality conditions under commitment and discretion:

$$\begin{array}{cc} \text{Discretion} & \text{Commitment} \\ \mu \left[ a + \frac{b}{a_1 + a_2} \right] & \frac{\mu}{1-\phi} \left[ a + \frac{b(1-\phi)}{a_1(1-\phi) + a_2} \right] \end{array} \quad (17)$$

Appointing a conservative central banker, one who has a greater aversion to inflation variability (replacing  $\mu$  with  $\mu^*$  and vesting him with discretion, will not suffice to deliver the same output-inflation tradeoff (or induce the same behavior for real output and inflation) as prevails under commitment.

Nevertheless it is possible to induce real output and the rate of inflation to mimic their behavior under commitment if a conservative banker with the appropriate dislike for inflation variability is chosen. This weight is given by:<sup>22</sup>

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22 To obtain this result, simply equate the optimizing conditions under discretion and commitment and solve for  $\mu^{CB}$  (which is the  $\mu$  that appears in the optimizing condition under discretion). Alternatively, set the denominators of the coefficients of the rate of inflation (or output) on a given shock under both policy regimes equal to each other and solve for  $\mu^{CB}$ .

$$\mu^{CB} = \frac{\mu}{1-\phi} \left[ \frac{a + \frac{b}{a_1 + \frac{a_2}{1-\phi}}}{a + \frac{b}{a_1 + a_2}} \right] \quad (18)$$

As the numerator of the expression within brackets is smaller than the denominator in Equation (18) it follows further that:

$$\mu < \mu^{CB} < \mu^* . \quad (19)$$

Thus, compared to a closed economy, in an open economy, a “less conservative” central banker vested with discretion would do to replicate the behavior of real output and the rate of inflation that prevails under commitment. The existence of the direct exchange rate effect on the rate of inflation in the forward-looking Phillips Curve accounts for the smaller weight on inflation in the loss function. Consider the following scenario. Suppose that there is upward pressure on inflation as a result of a cost-push shock or demand-side disturbance. The monetary tightening in response to the inflationary pressure causes the real exchange rate to decrease. This in turn has an immediate mitigating effect on the rate of inflation that complements the indirect effect that the output gap exerts on inflation through the combined interest rate and exchange rate channels. With monetary policy being able to influence the rate of inflation through the exchange rate, the policymaker can afford to accord a smaller relative weight to inflation in the loss function.

## **VI. The Monetary Policy Strategies in Perspective.**

In this section we intend to compare and contrast policy making under discretion and commitment from a somewhat different angle. The role of a “conservative central

banker will also be briefly touched on. Throughout this section we assume that the policymaker minimizes the expected (social) loss function:<sup>23</sup>

$$E(L_t) = V(y_t) + \mu V(\pi_t) \quad (20)$$

Our primary objective is to examine the merits of discretion vis-à-vis commitment on the basis of a numerical evaluation of the social loss function. Two parameters,  $\phi$  and  $b$ , play a key role in this comparison. The degree of autocorrelation in the disturbances features because it affects the optimality condition under commitment but not under discretion. The sensitivity of inflation to the real exchange rate in the Phillips Curve is accorded a prominent role because it is instrumental in shaping the optimizing behavior of the policymaker in an open economy. In addition, we also investigate the behavior of the constituent parts of the loss function, i.e. we take a close look at the behavior of the variance of the rate of inflation and the variance of real output in isolation under either strategy of monetary policy.

Table 4 provides summary information about the numerical values of the loss functions and the respective variances under discretion (Dis), commitment (Com), and the case of a “conservative central banker” (CB). Inspection of the contents of Table 4 yields several noteworthy observations. First, as pointed out above, autocorrelation in the disturbances is necessary to generate differences in social welfare. In case of white noise disturbances the three loss functions are equal. Second, commitment is welfare-improving vis-à-vis discretion for  $0 < \phi < 0.99$  as indicated by the lower score of the loss function under commitment. Third, losses under discretion and commitment are increasing in the degree of persistence in the stochastic disturbances. Fourth, in the absence of firm commitment to optimal policy, the appointment of a “conservative central banker”, who acts with discretion, can successfully replicate the outcome under commitment as shown by the entries of columns two. The weight  $\mu^{CB}$  that the “conservative central banker” must attach to the variance of inflation in his loss function is an increasing function of the degree of persistence of the stochastic disturbances. The weights corresponding to the different values of  $\phi$  appear in the last column of the table.

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23 Numerical evaluations are typically based on loss functions that consist of unconditional variances. It can be shown that  $\lim_{\beta \rightarrow 1} (1 - \beta) E_t \sum_{i=0}^{\infty} \beta^i (y_{t+i}^2 + \mu \pi_{t+i}^2)$  equals the weighted sum of the unconditional

Finally, turning attention to the size of fluctuations of the rate of inflation and real output, we find that under discretion the ratio of the variance of the rate of inflation to that of real output is not only greater than its counterpart under commitment (for  $\phi > 0$ ) but also immune to the degree of autocorrelation in the disturbances.<sup>24</sup> Dividing column five by column four, we find this value to be constant at 2.98. In marked contrast, we find the ratio of the variance of the rate of inflation to the variance of real output to be extremely sensitive to the degree of autocorrelation under commitment. The difference in the two ratios is evident in Figure 2. Under commitment the ratio in question declines from a maximum value of 2.98 to a minimum value that is close to zero while the horizontal line marks the constant value of the ratio under discretion.<sup>25</sup>

Figure 3 shows how the ratio of loss functions,  $LossDis/LossCom$ , changes as the degree of persistence in the disturbances changes. Each of the five relative loss functions is based on a different value for  $b$ . All relative loss functions are rather flat and tightly bunched around one for low values of  $\phi$ , but they increase steadily and drift apart for  $\phi > 0.5$ . This result implies that marked differences between policymaking under commitment as opposed to discretion arise only if there is a rather high degree of autocorrelation in the disturbances and no pronounced response of the rate of inflation to the real exchange rate in the Phillips Curve. It is apparent that relative losses are most pronounced if  $b=0$  and  $\phi$  tends towards maximum persistence ( $0.99$ ). For rather high values of  $\phi$ , relative losses are much smaller if a potent exchange rate channel is operative in the Phillips Curve ( $b=1$ ). Closer inspection of Figure 3 also reveals that for medium-size values of  $\phi$  the magnitude of relative losses does not necessarily move in lock-step

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variances of the variables in question. On this point see Svensson (2000).

24 Recall that under discretion the autoregressive parameter appears only in the denominator of the coefficients in the reduced form equation. But the denominators cancel in the process of calculating the ratio of the variances, thus accounting for the absence of a relationship between the variances of real output and inflation under discretion and the size of  $\phi$ .

25 Here a slight anomaly ought to be pointed out. Closer inspection of column 7 in Table 4 reveals that for extremely high values of  $\phi$  like 0.99 the variance of inflation is actually less than for smaller values of  $\phi$ . This is clearly attributable to the particular parameter values chosen for the purpose of the comparisons. If the current parameter values are replaced with those chosen by Leitimo et al. (2002), the variance of inflation under commitment increases throughout as  $\phi$  increases. Nevertheless, the essential characteristic of Figure 2, the downward sloping curve, also materializes in this alternative scenario.

with the size of  $b$ . For instance, for  $\phi < 0.6$  relative losses based on  $b=0.25$  and indicated by the dotted curve exceed those associated with  $b=0$ , represented by the solid curve.<sup>26</sup>

Taken altogether, in an open economy that features a direct exchange rate channel in the Phillips Curve, the difference between policymaking under discretion and commitment – as measured by the relative social loss function is rather stark. Social losses are greater under discretion especially if there is a large degree of persistence in the stochastic disturbances. The losses mount under discretion because the policymaker ignores the persistence property of the stochastic disturbances, which conveys important information about the future behavior of the endogenous variables, when carrying out the optimization exercise every period.

## VII. Conclusion.

The main conclusion that the present paper offers is that the conduct of stabilization policy in an open economy can - but need not - differ markedly from that in a closed economy. Likewise, the optimizing condition in an open economy that gives rise to an inverse relationship between real output and the rate of inflation can - but need not – take a different shape from the one that prevails in a closed economy. The difference lies in the existence of a direct exchange rate channel in the Phillips Curve.

Irrespective of whether discretion or commitment to a binding rule guides the conduct of monetary policy, the existence of a direct exchange rate channel in the Phillips Curve causes the behavior of the key economic variables in an open economy to be dramatically different from that in a closed economy. In an open economy, the policymaker can no longer perfectly stabilize real output and the rate of inflation in the face of IS and UIP shocks as well as shocks to foreign inflation. If the exchange rate channel in the Phillips Curve is operative, then in an open economy the policymaker faces an output-inflation tradeoff that differs substantially from its counterpart in a closed economy. These findings stand in sharp contrast with the claim that monetary policy in an open economy is isomorphic to the case of monetary policy in a closed economy as recently stated by Clarida, Gali, and Gertler (2001).

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<sup>26</sup> Precise calculations of the relative loss functions appear in Table 5A in the separate appendix.

Our analysis of the conduct of monetary policy reveals that the stabilization bias under discretion is weaker in an open economy relative to a closed economy. In an open economy, a “less conservative central banker”, one that attaches a smaller weight to the variance of inflation in the loss function, can be appointed to replicate the behavior of real output that eventuates under optimal policy.

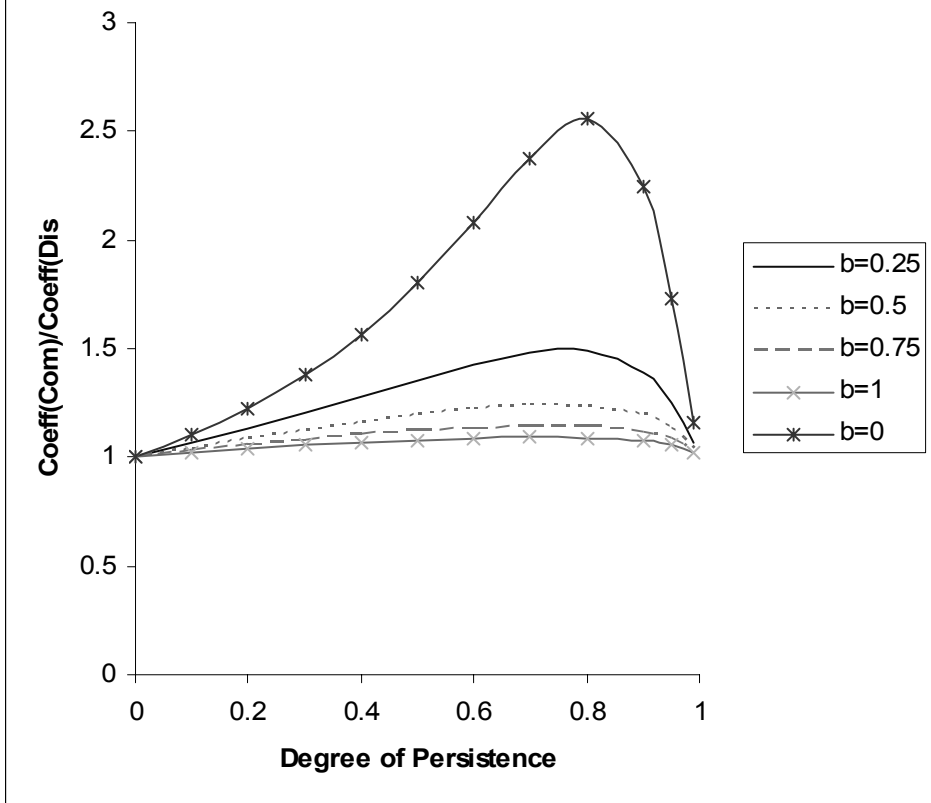
Evaluating the social loss functions under discretion and commitment, we find that pronounced differences between the two strategies exist in case of high persistence in the stochastic shocks coupled with a weak or non-existent direct exchange rate channel in the Phillips Curve.

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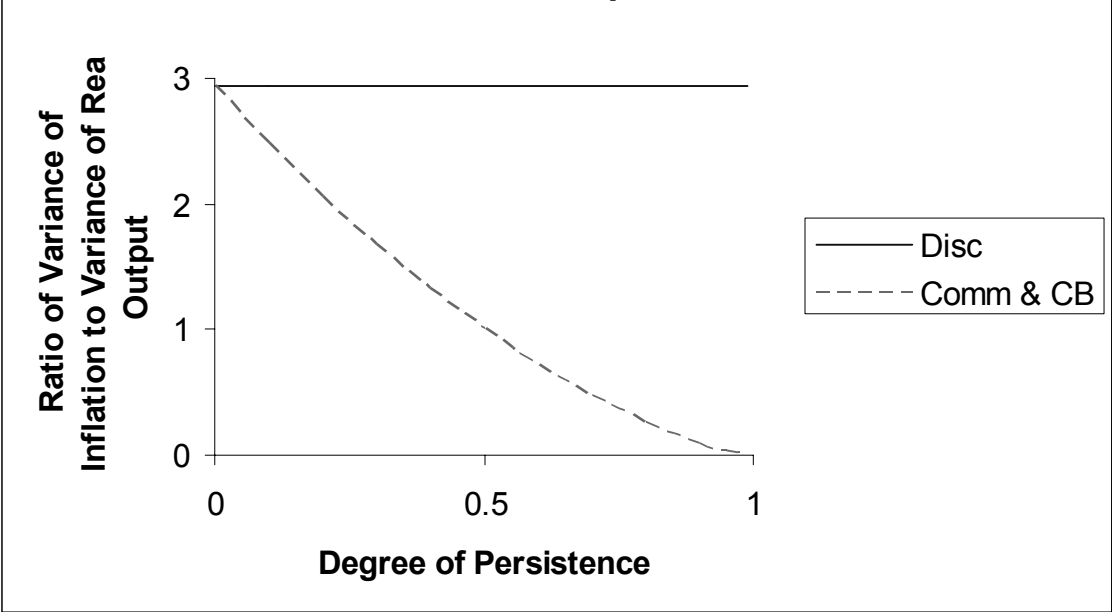
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**Figure 1: The Stabilization Bias: Cost-Push Shock**



**Figure 2: The Behavior of Inflation Relative to Real Output**



**Figure 3: The Relative Loss Function**

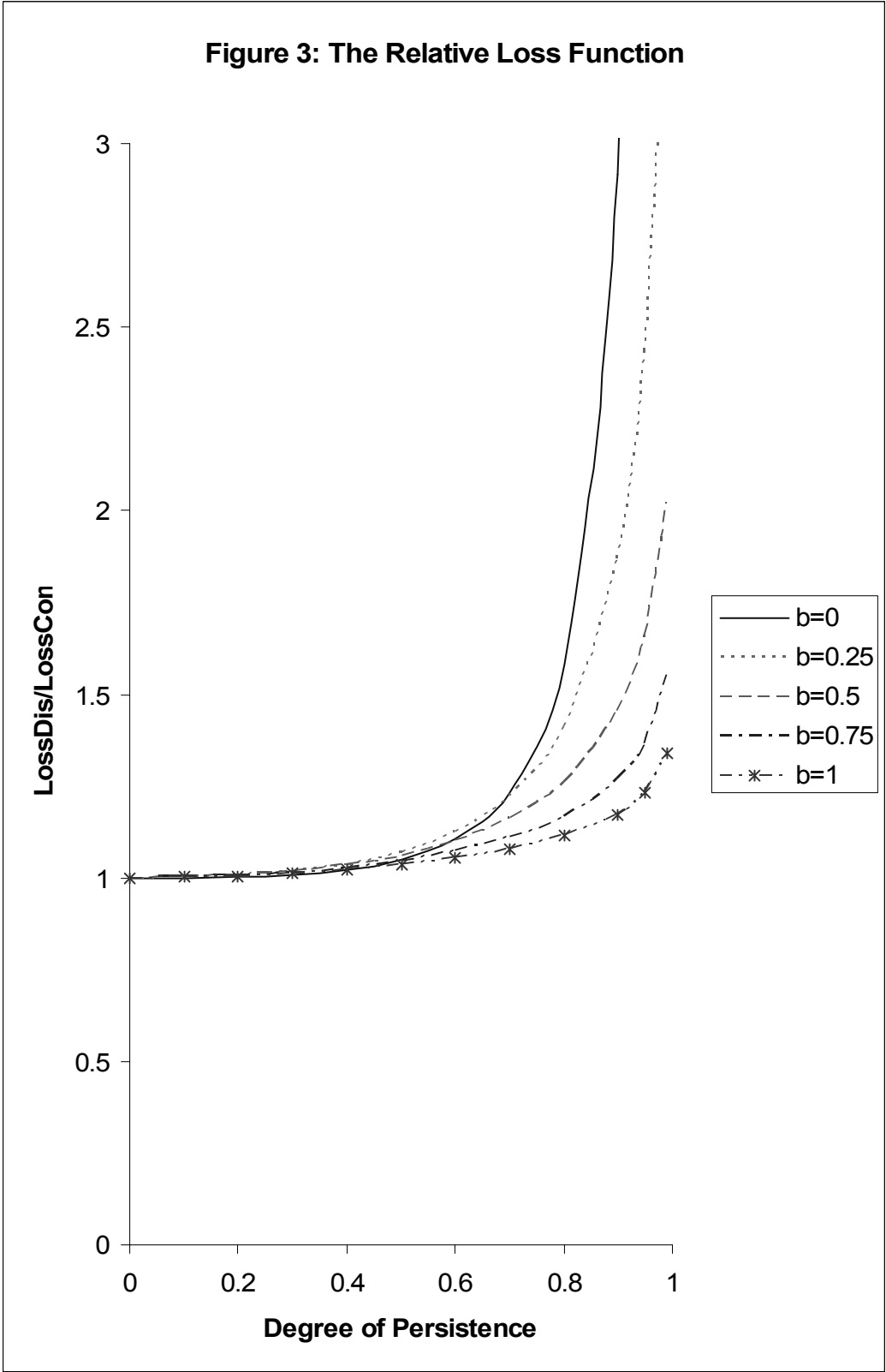


TABLE 1:  
*The Responses of the Rate of Inflation and the Output Gap to the Disturbances of the Model: The Case of Discretion.*

<b>Disturbance</b>	<b>Rate of Inflation (<math>\pi_t</math>)</b>	<b>Output Gap (<math>y_t</math>)</b>
<b>IS (<math>v_t</math>)</b>	$-\frac{b}{D}$	$\frac{b\mu(a + \frac{b}{a_1 + a_2})}{D}$
<b>Cost-Push (<math>u_t</math>)</b>	$\frac{a_1(1 - \phi) + a_2}{D}$	$-\frac{(a_1(1 - \phi) + a_2)\mu(a + \frac{b}{a_1 + a_2})}{D}$
<b>UIP (<math>\varepsilon_t</math>)</b>	$\frac{a_1 b}{D}$	$-\frac{a_1 b \mu(a + \frac{b}{a_1 + a_2})}{D}$
<b>Foreign Inflation (<math>\pi_t^f</math>)</b>	$-\frac{a_1 b \phi}{D}$	$\frac{a_1 b \phi \mu(a + \frac{b}{a_1 + a_2})}{D}$

where  $D = b\mu[(a + \frac{b}{a_1 + a_2})(1 - \phi) + \frac{a}{a_1 + a_2}((1 - \phi)a_1 + a_2)] + (a_1(1 - \phi) + a_2)(1 - \phi + a^2\mu)$

TABLE 2:  
The Reduced Form Equation for Real Output.

<b>Disturbance</b>	<b>Output Gap (<math>y_t</math>)</b>
<b>IS (<math>v_t</math>)</b>	$\frac{b}{(a_1(1-\phi)+a_2)(\theta(1-\phi)+a)+b(1-\phi)}$
<b>Cost-Push (<math>u_t</math>)</b>	$\frac{-(a_1(1-\phi)+a_2)}{(a_1(1-\phi)+a_2)(\theta(1-\phi)+a)+b(1-\phi)}$
<b>UIP (<math>\varepsilon_t</math>)</b>	$\frac{-a_1b}{(a_1(1-\phi)+a_2)(\theta(1-\phi)+a)+b(1-\phi)}$
<b>Foreign Inflation (<math>\pi_t^f</math>)</b>	$\frac{\phi a_1 b}{(a_1(1-\phi)+a_2)(\theta(1-\phi)+a)+b(1-\phi)}$

Note: Substituting the equation for  $y_t$  into the policy rule yields the reduced form equation for the rate of inflation:  $\pi_t = -\theta y_t$ .

TABLE 3:  
*Responses of the Rate of Inflation and the Output Gap to the Disturbances of the Model: The Case of Commitment.*

<b>Disturbance</b>	<b>Rate of Inflation (<math>\pi_t</math>)</b>	<b>Output Gap (<math>y_t</math>)</b>
<b>IS (<math>v_t</math>)</b>	$-\frac{b}{C}$	$\frac{b(\frac{\mu}{1-\phi})(a+\frac{b(1-\phi)}{a_1(1-\phi)+a_2})}{C}$
<b>Cost-Push (<math>u_t</math>)</b>	$\frac{a_1(1-\phi)+a_2}{C}$	$-\frac{(a_1(1-\phi)+a_2)(\frac{\mu}{1-\phi})(a+\frac{b(1-\phi)}{a_1(1-\phi)+a_2})}{C}$
<b>UIP (<math>\varepsilon_t</math>)</b>	$\frac{a_1b}{C}$	$-\frac{a_1b(\frac{\mu}{1-\phi})(a+\frac{b(1-\phi)}{a_1(1-\phi)+a_2})}{C}$
<b>Foreign Inflation (<math>\pi_t^f</math>)</b>	$-\frac{a_1b\phi}{C}$	$\frac{a_1b\phi(\frac{\mu}{1-\phi})(a+\frac{b(1-\phi)}{a_1(1-\phi)+a_2})}{C}$

where  $C = b\mu(a + \frac{b(1-\phi)}{a_1(1-\phi)+a_2} + a) + ((1-\phi)a_1 + a_2)((1-\phi) + \frac{a^2\mu}{1-\phi})$

TABLE 4: The Loss Functions and the Variances of the Rate of Inflation and Real Output.

$LossDis$	$LossCom$ $=LossCB$	$\phi$	$V(y)Dis$	$V(\pi)Dis$	$V(y)Com$ $=V(y)CB$	$V(\pi)Com$ $=V(\pi)CB$	$\mu^{CB}$
0,212435	0,212435	0	0,053934	0,158501	0,053934	0,158501	1
0,258051	0,257686	0,1	0,065516	0,192536	0,074034	0,183652	1,088
0,326993	0,324868	0,2	0,083019	0,243974	0,106244	0,218623	1,195
0,435529	0,428155	0,3	0,110575	0,324954	0,160354	0,267801	1,327
0,616945	0,595258	0,4	0,156634	0,460311	0,256853	0,338405	1,494
0,946734	0,885417	0,5	0,240362	0,706371	0,442708	0,442708	1,714
1,62208	1,441746	0,6	0,411823	1,210256	0,83944	0,602306	2,024
3,274021	2,675869	0,7	0,831228	2,442793	1,820066	0,855803	2,500
8,688688	6,144074	0,8	2,205936	6,482751	4,87945	1,264624	3,367
40,85878	21,82294	0,9	10,37347	30,48531	20,02105	1,801894	5,714
1572,193	452,9007	0,99	399,1579	1173,035	452,2307	0,669991	44,538

Notes:

- a. It is conventional practice to assume that the discount factor in the loss function approaches unity. Following this convention allows us to replace the standard intertemporal loss function with the unconditional variances of real output and the rate of inflation. Hence the policymaker minimizes

$$E(L_t) = V(y_t) + \mu V(\pi_t).$$

In calculating  $LossDis$ ,  $LossCom$ , and  $LossCB$ , we let  $\mu = 1$ .

- b. The parameter values and the variances of the disturbances upon which the calculations are based are:

$$a_1 = 0.5; a_2 = a = b = 0.25; \sigma_v^2 = \sigma_u^2 = \sigma_\varepsilon^2 = \sigma_{\pi}^2 = 0.25$$

Other constellations of parameter values were tried as well. However, they do not affect the results in any meaningful way. For instance, taking the values of the parameters from the study by Leitimo, Roisland and Torvik (2002) produces merely greater numerical values for the loss functions (even though they consider essentially a backward-looking framework, some characteristics of which are incongruent with those of the forward-looking framework).

See footnote 23 of the text for a minor difference concerning the behavior of the rate of inflation under commitment.

Appendix:

Monopolistically competitive firms aim to minimize menu costs weighed against the cost of being away from the optimal price they would charge in the absence of those menu costs. This optimal price is denoted  $p^*$ . The objective function faced by the typical firm is:

$$\min_p \Omega_t = E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left[ (p_{\tau} - p_{\tau}^*)^2 + c(p_{\tau} - p_{\tau-1})^2 \right] \quad (\text{A1})$$

where:<sup>27</sup>

$\Omega_t$  = the total cost at time t

$p_t$  = the price of the domestic good at time t

$p_t^*$  = the optimal price a firm charges.

$\beta$  = the constant discount factor

$c$  = the parameter that measures the ratio of the costs of changing prices to the costs of deviating from the optimal price

$E_t$  = the expectations operator conditional on information available at time t.

After taking and rearranging the first-order condition for the above cost-minimization problem (where we have assumed  $\beta$  to equal one for simplicity), we can characterize the relationship between past, current, and future price levels as:

$$p_t - p_{t-1} = E_t(p_{t+1} - p_t) - \frac{1}{c}(p_t - p_t^*) \quad (\text{A2})$$

The optimal price  $p^*$  is:

$$p_t^* = \hat{p}_t + \kappa y_t + \zeta_t \quad \kappa > 0 \quad (\text{A3})$$

where all variables are as previously defined. In addition:

$\hat{p}_t$  = the price charged by foreign firms at time t

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<sup>27</sup> Lower case letters denote the logarithms of variables.

$\zeta_t$  = a stochastic disturbance.

The optimal price responds to changes in marginal cost. But marginal cost and real output are positively related.<sup>28</sup> Hence it is innocuous to replace marginal cost with the output gap in (A3).

So far our analysis of price-setting behavior has been very much in the spirit of the closed economy "New Keynesian Framework". In a small open economy, however, the price-setting behavior of domestic firms also takes into consideration developments abroad. Being a small player in world markets, the typical firm is guided in its pricing decision by the prevailing conditions in world markets.<sup>29</sup> More specifically, there exists a benchmark price  $\hat{p}_t$  that the firm faces in world markets. This benchmark price affects the optimal price charged by the firm. Indeed, the firm adjusts its optimal price in line with the domestic currency price of the *final* goods charged by its foreign competitors. Thus  $\hat{p}_t$  becomes:

$$\hat{p}_t = p_t^f + s_t \quad (\text{A4})$$

where

$p_t^f$  = the natural logarithm of the price of the foreign good in foreign currency at time  $t$ .

Using this specification for  $p_t^*$ , we can rewrite equation (A3) as:

$$p_t - p_{t-1} - E_t(p_{t+1} - p_t) = -\frac{1}{c}(p_t - p_t^f - s_t - \zeta_t) + \frac{\kappa}{c}y_t \quad (\text{A5})$$

If aggregated over all firms, equation (A5) represents a Phillips Curve relation for an open economy. The same equation can also be expressed as:

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28 Within a general equilibrium framework where labor is the only variable labor input, the comovement between marginal cost and economic activity can be established by combining the labor supply and demand relations with the market clearing condition in the goods market. On this point see Clarida, Gali, and Gertler (2001). Gali and Monacelli (1999) derive a similar relation that stresses the positive relation between real marginal cost and domestic consumption. The positive link between output and marginal cost is also characteristic of earlier models of monopolistic competition such as Blanchard and Kiyotaki (1987).

29 In a general equilibrium setting, for the pricing decision of domestic firms to be sensitive to the prevailing price charged by foreign competitors, it is necessary to drop the assumption of constant elasticity of substitution in the utility function. Bergin and Feenstra (2000) and Taylor (2000) show how a *translog* specification for preferences or a *linear* demand relation yields an optimal pricing rule that responds to competitors' prices *in addition* to marginal cost. Equation (A3) embodies this idea.

$$\pi_t = E_t \pi_{t+1} + ay_t + bq_t + u_t \quad (\text{A6})$$

where

$$\pi_t = p_t - p_{t-1}$$

$$E_t \pi_{t+1} = E_t p_{t+1} - p_t$$

$$q_t = p_t^f + s_t - p_t$$

$$a = \frac{\kappa}{c}$$

$$b = \frac{1}{c}$$

$$u_t = \frac{1}{c} \zeta_t.$$

Equation (A6) differs from the standard forward-looking Phillips Curve by allowing the real exchange rate to affect domestic inflation directly.<sup>30</sup> In the wake of a depreciation of the domestic currency, domestically produced goods become cheaper. Hence domestic production is stepped up. In addition, the domestic currency price of the imported foreign consumption good rises. Both the rise of domestic production and the higher price of the import-competing good cause the optimal price to increase. Facing an increase in the optimal price, firms raise the price of their output so as to minimize the deviation between the actual price charged and the optimal price. At the aggregate level, the increase in the domestic price level causes the rate of domestic inflation to rise. Thus we observe the positive link between the real exchange rate and the rate of domestic inflation.

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<sup>30</sup> It can be shown that the Calvo (1983) framework, where price adjustment occurs randomly, can be extended to an open economy too. The extension produces a Phillips curve for the open economy that also includes the real exchange rate.