On Optimal Monetary Policy Rules and the Construction of MCIs in the Open Economy

By

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Abstract:

This paper presents a simple open-economy forward-looking model to underscore the important role of the real exchange rate channel in the conduct of optimal monetary policy. As opposed to the closed economy, optimal monetary policy in the open economy depends on both demand-side and supply-side parameters.

The paper also highlights the importance of the exchange rate channel for the design and implementation of a Monetary Conditions Index in the conduct of monetary policy. The model gives rise to an alternative MCI where the weight on the real exchange rate depends on all parameters of the model and the policymaker's preferences.

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Introduction

Are there any significant differences in the conduct of monetary policy in a small open economy as opposed to a closed economy? What is the proper role of the exchange rate in monetary policy rules? A number of recent contributions have addressed these important issues with which policymakers have to grapple in practice. Using a variant of the optimization-based New Keynesian framework, Clarida, Gali, and Gertler (2001) find that the case of optimal monetary policy in a small open economy is isomorphic to the case of optimal policy in the closed economy. In their view, the only characteristic of the open economy framework that figures in determining the optimal feedback response is the degree of openness. There is no special role for the real exchange rate. Taylor (2001) sees no direct role for the real exchange rate in monetary policy rules either. According to him, monetary policy rules that respond directly to the real exchange rate are prone to generating instability in real output and inflation. A somewhat different stance is taken by Ball (1999). In a simple backward-looking framework optimal monetary policy ought to be based on a monetary conditions index (MCI), a weighted average of the real rate of interest and the real exchange rate.[1] Using a simple rational expectations framework, Gerlach and Smets (2000) explain the rationale behind conducting monetary policy with the help of a MCI. They do, however, recognize some of the limitations of following simple MCIs as do Ericsson et al. (1997). Ericsson et al., in particular, show in convincing fashion that the econometric estimates of the relevant parameters have excessively wide confidence intervals and are therefore only of limited use in guiding monetary policy.

This paper has two focal points: the role of the real exchange rate in a stylized macro model and the specification of MCIs in the conduct of monetary policy in a small open economy. The paper begins with laying out a simple forward-looking open economy model to underscore the important link between the real exchange rate and the rate of inflation in the Phillips curve. The existence of the direct exchange rate effect on inflation has material consequences for the conduct of optimal monetary policy in the forward-looking open economy framework.[2] Indeed, the crucial result established in this paper shows that optimal monetary policy in the open economy model depends on both demand-side and supply-side parameters alongside the policymaker's preferences. This result is in stark contrast to the case for the standard forward-looking closed economy model (Clarida, Gali, and Gertler (1999)) where optimal monetary policy depends only on one supply-side parameter and the policymaker's preferences. In addition, it is shown that in the open economy version of the forward-looking model the temporal properties of the stochastic disturbances affect the setting of the optimal policy parameter in the monetary policy rule in a more complex way than in the closed economy model.

Second, this paper points out the importance of the direct exchange rate channel in the Phillips Curve for the specification of MCIs that serve as indicator variables or operating targets in the conduct of monetary policy. Conventional MCIs ignore the effect of the direct exchange rate channel in the Phillips Curve in assessing the relative importance of the various channels of the monetary transmission mechanism. The conventional MCIs that are used by some central banks, international organizations, and consulting companies feature a weight on the real exchange rate that is composed of two demand-side elasticities. The model employed in this paper gives rise to an alternative MCI where the weight on the real exchange rate depends on all parameters of the model and the policymaker's preference parameter.

1 The Model

In this section we present our forward-looking model of a small open economy. The model consists of three equations. All variables with the exception of the nominal interest rate are expressed in logarithms. All parameters are positive.

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

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

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

where:

y_t = the real output gap.

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

$E_t \pi_{t+1}$ = the expectation of π_{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 ε_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 the open economy. In this economy real output is produced by monopolistically competitive firms.[3] 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. Unlike in previous incarnations of supply-side behavior such as the standard Lucas-type curve where inflation *surprises* induce a positive co-movement of real output, the existence of price stickiness introduces the difference between the current rate of inflation and the current expectation of future inflation into the Phillips curve. There is also a direct real exchange rate effect on domestic inflation. The rationale behind this is that a depreciation causes the domestic currency price of the foreign good, ($p_t^f + s_t$), to increase. As explained in the appendix, the increase in the exchange rate 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. Equation (2) defines an open economy IS relation - output demanded depends on the expected real interest rate and the real exchange rate.[4] Equation (3) is the uncovered interest rate parity condition (UIP), expressed in real terms. This equation embodies the assumption of perfect capital mobility, reflecting the high level of integration of a small open economy's financial sector with the rest of the world. The disturbance term ε_t can be interpreted as a time-varying risk premium.

2 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

$$L = \left[V(y_t) + \mu V(\pi_t)\right] \tag{4}$$

Equation (4) implies that the real exchange rate does 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.[5,6] Consequently, there is no need for the real exchange rate to appear as a separate argument in the loss function. The policymaker is not worried about the volatility of the policy instrument either.

3 Solving the Model.

The policymaker sets policy on the basis of the two variables that he cares about: the output gap y_t and the rate of domestic inflation π_t:

$$(\theta y_t + \pi_t) = 0 \tag{5}$$

To solve the model, we first solve equation (3) for q_t and substitute the resulting expression into equations (1) and (2). These two expressions are substituted in turn into equation (5). Solving this equation for R_t yields the policymaker's reaction function:

$$R_t = \Delta\left[(\theta + a)(E_t y_{t+1} + v_t) + ((\theta + a)(a_1 + a_2) + b + 1)E_t\pi_{t+1} + ((\theta + a)a_2 + b)\Omega + u_t\right] \tag{6}$$

where $\Delta = \dfrac{1}{(\theta + a)(a_1 + a_2) + b}$ $\qquad \Omega = (R_t^f - E_t\pi_{t+1}^f + E_t q_{t+1} + \varepsilon_t)$

Successful stabilization of the economy requires that the policymaker raise the setting of the policy instrument by more than the increase in the level of expected inflation – as is evidenced by the coefficient on the latter being strictly greater than one. It is also evident that the policy parameter θ plays an important role in the way the policymaker responds to current observable variables, expectations of variables, and observed disturbances. A larger weight on the real output gap in the policy rule causes the policy instrument to react more forcefully to IS disturbances and the current expectation of the output gap next period. At the same time, putting more emphasis on the output gap in the policy rule reduces the response of the policy instrument to cost-push disturbances, expected inflation next period, and the factors subsumed in Ω. Notice that the size of the change in the nominal interest rate in response to a change in the level of the expected output gap or expected inflation next period depends inversely on the size of the coefficient of the real exchange rate in the Phillips curve (for a given θ). A similar, inverse response pattern of the interest rate is evoked by shocks in the goods market *(v_t)* and shocks to the Phillips curve relation (u_t) as the size of *b* changes. In stark contrast, the response of the policy instrument becomes more pronounced in the wake of changes in the expected foreign real interest rate, changes in the risk premium, and the expected real exchange rate next period, i.e. variables governing the UIP relation, as the size of *b* increases.

To obtain a reduced form solution for y_t, we substitute the reaction function into the IS function (after replacing the real exchange rate with the remaining variables of the UIP condition). This equation takes the following form:

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

The three endogenous expectations $E_t y_{t+1}$, $E_t\pi_{t+1}$, and $E_t q_{t+1}$ are determined with the help of putative solutions while the fourth, the expected foreign rate of inflation, is considered to be determined outside the model. Applying the Minimum State Variable (MSV) approach suggested by McCallum (1983), we pose the following solutions for the three endogenous variables.[7]

$$y_t = \gamma_{10}v_t + \gamma_{11}u_t + \gamma_{12}\varepsilon_t + \gamma_{13}R_t^f + \gamma_{14}\pi_t^f \quad (8)$$

$$\pi_t = \gamma_{20}v_t + \gamma_{21}u_t + \gamma_{22}\varepsilon_t + \gamma_{23}R_t^f + \gamma_{24}\pi_t^f$$

$$q_t = \gamma_{30}v_t + \gamma_{31}u_t + \gamma_{32}\varepsilon_t + \gamma_{33}R_t^f + \gamma_{34}\pi_t^f$$

It is apparent that the solutions for all the endogenous variables depend on the behavior of the stochastic disturbances that impinge upon the economy. To underscore the importance of the time series properties of the shocks in the conduct of optimal monetary policy, we shall distinguish between two cases. The first case treats all stochastic disturbances as independent, white noise processes, while the second case treats all disturbances as serially correlated processes.

4 Optimal Monetary Policy under Simple Commitment.[8]

Case I: All Shocks are Independent, White Noise Processes.

Under the assumption of white noise disturbances, the conditional expectations of the endogenous variables are straightforward:

$$E_t y_{t+1} = 0 \tag{9}$$

$$E_t \pi_{t+1} = 0$$

$$E_t q_{t+1} = 0$$

The expectation of the foreign rate of inflation, $E_t\ \pi^f_{t+1}$ is likewise zero.

Substituting these expectations into equation (6) yields the following final form equation for real output:

$$y_t = \frac{1}{(a_1 + a_2)(\theta + a) + b}\left[bv_t - a_1 b(R^f_t + \varepsilon_t) - (a_1 + a_2)u_t\right] \tag{10}$$

The solution for the domestic rate of inflation is given by

$$\pi_t = \frac{\theta}{(a_1 + a_2)(\theta + a) + b}\left[-bv_t + a_1 b(R^f_t + \varepsilon_t) + (a_1 + a_2)u_t\right] \tag{11}$$

After inserting equations (10) and (11) into equation (4), we can express the objective of the policymaker in the following way:

$$\underset{\theta}{Min}\left[\frac{1}{(a_1 + a_2)(\theta + a) + b}\right]^2 \begin{Bmatrix} \left[b^2\sigma^2_v + (a_1 b)^2(\sigma^2_{Rf} + \sigma^2_\varepsilon) + (a_1 + a_2)^2\sigma^2_u\right] + \\ \mu\theta^2\left[b^2\sigma^2_v + (a_1 b)^2(\sigma^2_{Rf} + \sigma^2_\varepsilon) + (a_1 + a_2)^2\sigma^2_u\right] \end{Bmatrix} \tag{12}$$

The policymaker chooses θ, the weight on the output gap in the policy rule, so as to minimize fluctuations in the output gap and the domestic rate of inflation. The resulting optimal value for the policy parameter is:

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

Equation (13) shows that in the forward-looking open economy model the weight on the output gap in the policy rule is a function of the parameters of *both* the IS relation and the Phillips curve.[9] This is a consequence of the fact that a change in the policy setting has an immediate impact on the nominal exchange rate that in turn has a direct effect on the rate of inflation through the real exchange rate in the Phillips curve. This effect complements the indirect effect on the rate of inflation brought about by a change in the output gap through changes in the expected real rate of interest and the real exchange rate.

The appearance of a_1, a demand-side parameter, in the optimal setting for the policy parameter in the forward-looking open economy model stands in marked contrast to its closed economy version. For the closed economy $a_2=b=0$. Hence for the closed economy forward-looking model, the optimal policy parameter reduces to

$$\theta^* = \frac{1}{\mu a}. \quad (14)$$

The interest sensitivity of the output gap to the expected real rate of interest does not figure in the optimal setting of θ in the closed economy framework because in the absence of an exchange rate channel in the IS relation the policymaker can perfectly control the size of the output gap by simply varying the interest rate.

As $\theta>0$ optimal monetary policy is characterized by a trade-off between the output gap and the rate of inflation in both the closed and the open economy. Notice though that the optimal setting for θ is always *smaller* in the open economy than in the closed economy. This implies that for a given change in the rate of inflation, output responds more aggressively in the open economy than in the closed economy.[10]

It is instructive to see how the size of the structural parameters affects the optimal weight on the output gap in the policy rule. The size of θ varies inversely with the size of the two supply-side parameters a and b but positively with the size of the demand-side elasticities a_1 and a_2. If a and b are large relative to a_1 and a_2, the rate of inflation reacts quite sensitively to output and exchange rate changes while the output gap's response to interest rate and exchange rate changes is rather muted. Hence the policymaker shows a greater concern for the rate of inflation in setting policy. Conversely, the policymaker shifts more weight onto the output gap if a_1 and a_2 are large relative to a and b as in this case output stabilization can be achieved with only minor adverse effects on the rate of inflation.

The limiting cases of the policymaker's preferences regarding the variability of the output gap and the rate of inflation illustrate that the trade-off between output and inflation stability exists not only for cost-push shocks but also for demand-side shocks (including those that originate abroad). Again the existence of the real exchange rate effect in the Phillips curve is responsible for this result. With $b=0$ neither goods market disturbances nor foreign disturbances would affect the inflation-output trade-off. The importance of the exchange rate effect in the Phillips curve is brought out by Table 1 where the variances of the real output gap and the rate of inflation are calculated for $\mu \to \infty$ and $\mu \to 0$. The top panel considers the case for $b>0$ while the bottom panel considers the case where $b=0$.

Case II: Introducing Serially Correlated Disturbances.

The purpose of introducing serially correlated disturbances to the model is to show that the conduct of optimal monetary policy is different in the face of serially correlated disturbances compared to white-noise disturbances. In order to underscore the sensitivity of the coefficient in the optimal policy rule to the temporal nature of the disturbances, we shall make the following assumptions about the behavior of the disturbances that impinge upon the economy. First, in line with CGG (1999) we assume that both demand-side and cost-push shocks follow a first-order autoregressive process. In addition, we shall assume that the foreign rate of inflation and the risk premium in the UIP condition are serially correlated. In short, the disturbances are modelled as follows:[11]

$$
\begin{aligned}
v_t &= \phi v_{t-1} + \hat{v}_t \qquad && \hat{v}_t \sim (0, \sigma^2_{\hat{v}}) \\
u_t &= \rho u_{t-1} + \hat{u}_t \qquad && \hat{u}_t \sim (0, \sigma^2_{\hat{u}}) \\
\pi^f_t &= \kappa \pi^f_{t-1} + \hat{\pi}^f_t \qquad && \hat{\pi}^f_t \sim (0, \sigma^2_{\hat{\pi}^f})
\end{aligned}
\tag{15}
$$

$$\varepsilon_t = \delta\varepsilon_{t-1} + \hat{\varepsilon}_t \qquad \hat{\varepsilon}_t \sim (0, \sigma^2_{\hat{\varepsilon}})$$

Allowing for the autoregressive behavior of the stochastic disturbances results in reduced form equations for the real output gap and the rate of inflation that differ in a number of respects from their counterparts derived under the assumption of white-noise disturbances. The coefficients on each disturbance that appear in the two equations appear in Table 2. In the absence of knowing what the optimal θ is it is virtually impossible to say anything definite about how changes in the degree of persistence of the disturbances affect the response pattern of the output gap and the rate of inflation.

For autocorrelated shocks to the IS relation, the Phillips curve, the UIP condition, and shocks to the rate of foreign inflation, the policymaker's objective function becomes:

$$\underset{\theta}{Min}\, L = (1+\mu\theta^2)\left\{ \frac{b^2\sigma_v^2}{[[a_1(1-\phi)+a_2][\theta(1-\phi)+a]+b(1-\phi)]^2} + \frac{[a_1(1-\rho)+a_2]^2\sigma_u^2}{[[a_1(1-\rho)+a_2][\theta(1-\rho)+a]+b(1-\rho)]^2} \right.$$

$$\left. + \frac{(a_1 b)^2\sigma_\varepsilon^2}{[[a_1(1-\delta)+a_2][\theta(1-\delta)+a]+b(1-\delta)]^2} + \frac{(a_1 b\kappa)^2\sigma_{\pi f}^2}{[[a_1(1-\kappa)+a_2][\theta(1-\kappa)+a]+b(1-\kappa)]^2} \right\} \quad (16)$$

Unfortunately, the solution to the minimization problem turns out to be cumbersome. Indeed there is no closed-form solution for the optimal choice of θ in case the IS shock, the cost-push shock, the UIP shock, and the shock to the foreign rate of inflation follow distinct autoregressive processes, each characterized by a different degree of persistence. There exists, however, an analytic solution if a simplifying assumption regarding the degree of serial correlation of each of the aforementioned disturbances is made. Suppose that the degree of persistence is the same for these disturbances. Let $\phi=\rho=\kappa=\delta$.

Imposing this structure on the model and carrying out the minimization problem faced by the policymaker yields the following optimal value for θ:

$$\theta^* = \frac{1-\phi}{\mu\left[a + \dfrac{b(1-\phi)}{a_1(1-\phi)+a_2}\right]} \quad (17)$$

The autoregressive parameter ϕ bears an inverse relationship to the policy parameter θ. As the degree of persistence in the disturbances increases, the policymaker ought to decrease the weight on the output gap in the policy rule.

Our examination of what constitutes optimal monetary policy in open economy has uncovered two noteworthy results. First, it appears that the weight attached to the output gap in the optimal policy rule is a function of the policymaker's preferences and *all* parameters of the open economy forward-looking model – not just parameter(s) that appear in the Phillips curve as is the case in the closed economy framework.[12] Second, the degree of persistence in the autocorrelated disturbances affects the size of the optimal policy parameter. The optimal policy parameter θ^* is greater in case the disturbances follow white noise processes compared to the case where the disturbances follow an autoregressive process. The existence of autoregressive disturbances implies that the expectations of the endogenous variables, the rate of inflation, the output gap, and the real exchange rate, are affected by these disturbances and by the response of the monetary authorities. Thus an aggressive response to a given disturbance that moves the rate of inflation and real output away from target also affects the rate of inflation and real output expected in the future. In a sense, the output-inflation tradeoff improves which in turn allows the monetary authorities to pursue a more aggressive response.[13]

The findings reported above also need to be reconciled with those reported by Clarida, Gali, and Gertler (CGG) (2001). On one important point there exists agreement: the optimal policy *setting* in the open economy, i.e. the trade-off between real output and the rate of inflation, differs from that in the closed economy. However, on another important point, the relationship between the real exchange rate and the rate of inflation and the associated implications for optimal policy, this paper reaches a different conclusion. The open economy model presented in this paper provides for a *direct* effect on the rate of inflation via the real exchange rate in the Phillips curve. This direct effect figures in the determination of optimal policy. There is no such direct effect in the CGG model. Their approach focuses solely on the role of openness in determining optimal policy.[14,15] In the CGG model openness matters to the extent that it affects the size of the expenditure switching effect in the IS relation and affects the response of domestic inflation to the output gap in the Phillips curve. Given the difference in approach, it is not surprising that their conclusions regarding optimal monetary policy in the open economy are somewhat different from those presented here.

It bears repeating that the existence of the direct exchange rate channel in the Phillips curve complicates the policy problem as the variability of the output gap and the variability of inflation are susceptible to the variance of IS disturbances and the variance of UIP disturbances (See Table 1A). There are no IS disturbances or UIP disturbances in CGG's model. Even if both were to be introduced into their model, it is unlikely that they would appear in the final form equations for real output and the rate of inflation because of the absence of the direct exchange rate channel in their version of the Phillips curve.

5 Monetary Conditions Indices and Monetary Policy

In this section we question the usefulness of conventional monetary conditions indices (MCIs) in the conduct of monetary policy. In our view conventional monetary conditions indices are based on an overly simplistic transmission process of monetary policy, one that rules out direct exchange rate effects on inflation. Using the model laid out in section II, we construct an alternative monetary conditions index that differs dramatically from the conventional monetary conditions index used in practice. We show that the direct exchange rate channel in the Phillips Curve plays a critical role in determining the composition of the weight on the real exchange rate in the alternative MCI. Barring complete output stabilization, the weight on the real exchange rate in the alternative model-consistent MCI depends on the policymaker's preferences and *all* parameters of the model. Before deriving and elaborating on the model-consistent MCI, we give a brief account of the way conventional MCIs are constructed and interpreted.[16]

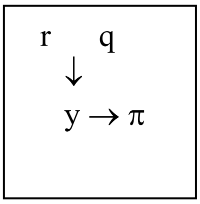
During the 1990s a number of central banks adopted a monetary conditions index as an operating target or as an indicator variable in the conduct of monetary policy. The Bank of Canada was the first central bank to use a MCI as a means to gauge the combined effect of the interest rate and the exchange rate on the state of the economy. The Reserve Bank of New Zealand adopted the MCI in the mid-1990s. The MCI also figured in discussions of monetary policy strategies in the Nordic countries at around the same time. While the Bank of Canada and the Reserve Bank of New Zealand used the

MCI as an operating target, other central banks such as the central bank of Norway and Sweden used it merely as an indicator variable. By the turn of the millennium the MCI had more or less disappeared from the scene in most countries with the exception of Canada.

The demise of the MCI is partly attributable to the fact that there is no agreement on the proper interpretation of a MCI.[17] Some economists view it as merely a device that captures the relative importance of the interest rate vis-à-vis the exchange rate in affecting aggregate demand, while others think of it as an operating target for the central bank. The current paper adheres to the latter interpretation.

The central idea underlying the use of a MCI is that there exist two primary channels through which monetary policy affects the output gap in an open economy. Changes in the real rate of interest *(r)* and the real exchange rate *(q)* are viewed to be the most important determinants of changes in aggregate demand relative to the trend level of real output *(y)*. Changes in the output gap in turn affect the level of domestic inflation *(π)*. This view of the transmission process of monetary policy is depicted schematically in Figure 1:

Figure 1:



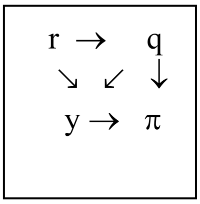
The monetary conditions index that accords with the above description of the simple transmission process of monetary policy is usually specified in the following way:

$$MCI_t^{CON} = (r_t - r_0) - \frac{a_2}{a_1}(q_t - q_0) \qquad (18)$$

r_0 and q_0 are the base values of the real interest rate and the real exchange rate. The weight attached to the real exchange rate is the ratio of the elasticity of real output demand with respect to the real exchange rate (a_2) to the (semi-) elasticity of real output demand with respect to the real rate of interest (a_1). An increase in the MCI reflects a tightening while a decrease reflects an easing of monetary conditions.[18]

Leaving aside technical problems of constructing a MCI such as the choice of the interest rate and exchange rate or estimation of the relevant parameters, we believe that the conventional MCI as described above does not capture the important role that the real exchange rate plays on the supply-side of the economy. In our model, the real exchange rate has a direct effect on domestic inflation. This direct channel complements the indirect effect that changes in the real exchange rate have on the rate of inflation through changes in the output gap. The arrow linking q with π in Figure 2 conveys the significance of the direct effect of the real exchange rate on domestic inflation in the Phillips Curve.

Figure 2:



In order to show that the existence of a direct exchange rate channel in the Phillips Curve calls for extensive alterations in the design of the MCI, we proceed as follows. First, we substitute equations (1) and (2) into the policy rule (equation (5)). Next, we isolate the two variables that make up the MCI on the left-hand side of the equation. Finally, we divide by the coefficient on the expected real rate of interest. Proceeding in this way results in the following expression:

$$(R_t - E_t\pi_{t+1}) - \left[\frac{(\theta + a)a_2 + b}{(\theta + a)a_1}\right]q_t = MCI_t^{ALT} = \frac{1}{a_1}(E_t y_{t+1} + v_t) + \frac{E_t\pi_{t+1} + u_t}{(\theta + a)a_1} \qquad (19)$$

The left-hand side of equation (19) consists of a weighted combination of the expected real rate of interest and the real exchange rate.[19] This is our alternative, model-consistent MCI. What is striking about the alternative MCI is that the weight on the real exchange rate on the left-hand side of the equation is no longer a simple ratio of the elasticities that appear in the IS relation. Instead the weight on q_t now depends on both a and b as well as on the optimal policy parameter θ. Indeed the existence of the exchange rate channel in the Phillips Curve *(b>0)* makes all the difference. Given its existence, the weight on the real exchange rate in the model-consistent MCI is clearly greater than the weight in the conventional MCI as long as the policymaker attaches some positive but finite weight on the output gap in the policy rule.

The variables to which the model-consistent MCI responds appear on the right-hand side of equation (19). Given the forward-looking nature of the model, the MCI responds to the expectations of the output gap, inflation as well as IS and cost-push shocks. The way the MCI operates depends on the size of the monetary policy parameter θ. Consider the two polar cases of monetary policy. If the policymaker pursues a strict inflation target then $\theta = 0$. Hence equation (19) takes the following form:

$$(R_t - E_t\pi_{t+1}) - \left[\frac{aa_2 + b}{(aa_1)}\right]q_t = \frac{1}{a_1}(E_t y_{t+1} + v_t) + \frac{E_t\pi_{t+1} + u_t}{aa_1} \tag{20}$$

Under strict inflation-targeting, the relative weight on the real exchange rate in the model-based MCI clearly exceeds $\frac{a_2}{a_1}$, the weight placed on the real exchange rate in the conventional MCI. Moreover, the MCI responds to both demand and supply-side conditions.[20] The MCI responds more to supply than to demand-side conditions if $a<1$ which is generally assumed to be the case.[21]

Under a strict output target, equation (19) becomes:

$$(R_t - E_t\pi_{t+1}) - \frac{a_2}{a_1}q_t = \frac{1}{a_1}(E_t y_{t+1} + v_t) \tag{21}$$

Here we see that the weight on the real exchange rate in the MCI reduces to the ratio of the two demand-side elasticities in the special case where the policy-maker targets the real output gap. Thus, the weight on the real exchange rate in the model-based MCI coincides with the weight in the conventional MCI only in the rather *unlikely* event of monetary policy focusing solely on the output gap. Notice that under output targeting the MCI responds only to developments on the demand-side of the economy. Both Phillips curve parameters, *a* and *b*, are absent from equation (21).

6 Conclusion

This paper has addressed two topical issues that are relevant in the debate on policy-making in open economies. The first issue concerns the conduct of optimal monetary policy in an open economy. Using a forward-looking model of a small open economy, the paper shows that optimal monetary policy in an open economy takes account of structural parameters that appear in both the IS relation and the Phillips curve. The fact that demand-side elasticities figure in the determination of optimal policy is due to the existence of a direct real exchange rate channel in the Phillips curve. It is further shown that the degree of autocorrelation of the disturbances affects the setting of the optimal policy parameter under simple commitment.

The second issue concerns the use of a monetary conditions index (MCI) in policy-making. MCIs were introduced in the early 1990s with a view towards making the conduct of monetary policy more transparent to the public in countries like Canada and New Zealand. The paper shows that the existence of the exchange rate channel in the Phillips Curve complicates the construction and operation of a MCI. The weight on the real exchange rate in the alternative MCI is shown to depend not only on all parameters of the model but also ultimately on the policymaker's preferences regarding the variability of inflation and real output. Due to the prominence of the real exchange rate channel in this open-economy model, the relative weight in the alternative MCI is always greater than the relative weight on the real exchange rate in the conventional MCI except under strict real output targeting.

Given the complexities surrounding the construction and operation of MCIs in practice, it is not surprising they have lost their erstwhile appeal. For instance, the conventional MCI index that served as the operating target in New Zealand during the 1997-1999 period is no longer reported on a daily basis by the financial press in New Zealand.

Future research could address one additional relevant issue. For the purpose of commenting on earlier contributions to the literature, this paper assumes that the policymaker cares about domestic inflation only and not about imported inflation. However, most central banks define the target rate of inflation in terms of CPI inflation. Thus, future research could explore the implications for the setting of the optimal policy parameter if the policymaker cares about CPI inflation.

Appendix:

The New Keynesian approach emphasizes the price setting behavior of firms with market power. The key feature is that price changes are assumed to be costly for these firms. Thus prices set by these firms have a tendency to be sticky.[22]

Firms wish 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^*. Their objective function is thus:

$$\min_P Z_t = E_t \sum_{\tau=t}^{\infty} \delta^{\tau-t} \left[\left(p_\tau - p_\tau^*\right)^2 + c\left(p_\tau - p_{\tau-1}\right)^2 \right] \tag{1}$$

where:

Z_t is the total cost at time *t*

p_t is the natural logarithm of the price at time *t*

p^* is the natural logarithm of the optimal price a firm charges.

δ is the constant discount factor

c is the parameter that measures the ratio of the costs of changing prices to the costs of being away from the optimal price

E_t is the expectations operator conditional on information available at time *t*.

The first-order condition for the above cost-minimization problem is:

$$E_t \left\{ 2\left(p_t - p_t^*\right) + 2c\left(p_t - p_{t-1}\right) - 2c\left(p_{t+1} - p_t\right) \right\} = 0 \tag{2}$$

where we have assumed δ to equal one for simplicity.

Rearranging equation (2), we get:

$$p_t - p_{t-1} = E_t\left(p_{t+1} - p_t\right) - \frac{1}{c}\left(p_t - p_t^*\right) \tag{3}$$

Notice that expectations of the *future* change in the price level are present in the first order condition. It is in this sense that firms are forward-looking. Next we specify the optimal price p^* as

$$p_t^* = \hat{p}_t + \beta y_t + \varsigma_t \tag{4}$$

where:

$\beta > 0$

$\hat{p}_t$ is the natural logarithm of the price charged by *foreign* firms at time *t*

y_t is the output gap at time *t*, defined as the percentage deviation of aggregate output at time *t* from its trend.

$\varsigma_t \sim N(0, \sigma_\varsigma^2)$ is a stochastic disturbance.

Equation (4) posits quite reasonably that a firm raises its price if demand (or aggregate income) is high. Under monopolistic competition, prices are set as a mark-up over marginal cost. And marginal cost rises as real output expands. The latter positive link is a feature of fully specified general equilibrium models (Gali and Monacelli, (2002), Clarida, Gertler, and Gali (2002)).

In a small open economy, the optimal price also responds to developments abroad. The typical firm adjusts its optimal price in line with the domestic currency price of the final goods charged by its foreign competitors. This behavior of on the part of firms implies that developments abroad have implications for the way firms go about setting prices in the domestic economy.[23] Thus $\hat{p}_t$ becomes:

$$\hat{p}_t = p_t^f + s_t \tag{5}$$

where:

p_t^f is the natural logarithm of the foreign price level at time *t*

s_t is the natural logarithm of the spot exchange rate at time *t*, defined as the units of domestic currency required to buy one unit of foreign currency.

Using this specification for p_t^*, we can rewrite equation (3) as:

$$p_t - p_{t-1} - E_t(p_{t+1} - p_t) = -\frac{1}{c}(p_t - p_t^f - s_t - \varsigma_t) + \frac{\beta}{c} y_t \tag{6}$$

If aggregated over all firms, equation (6) represents a Phillips Curve relation for an open economy. The same equation can also be expressed as:

$$\pi_t = E_t \pi_{t+1} + a y_t + b q_t + u_t \tag{7}$$

where:

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

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

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

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

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

$$u_t = \frac{1}{c} \varsigma_t$$

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ENDNOTES:

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[1] Even in Ball's model, which provides a special role for the real exchange rate, allowing the policy instrument to react to the exchange rate directly leads to only minor improvements in the volatility of inflation (holding the volatility of real output constant). In Svensson (2000) a similar rule would lower the volatility of inflation at the expense of increasing the volatility of the output gap. Gali and Monacelli (2002) compare optimal monetary policy in a sticky price model to two alternatives: a Taylor Rule and an Exchange Rate Peg. Optimal policy leads to less volatility in nominal and real variables in their model than is implied by real world data. A Taylor Rule leads to excess smoothness in real variables at the expense of excess volatility in nominal variables. They also find an exchange rate peg to have better stabilizing features than a Taylor Rule.

[2] That a direct exchange rate channel on the supply-side of the economy materially affects the stabilizing properties of monetary policy rules in open economies is demonstrated by Froyen and Guender (2000).

[3] The reader is referred to the appendix where a detailed derivation of the New Keynesian Phillips Curve is presented. For a derivation of the closed-economy counterpart, see Roberts (1995).

[4] This is a simplified version of McCallum and Nelson's (1999) IS relation for the open economy. There is no LM relation as the policymaker uses the nominal interest rate as the policy instrument.

[5] 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).

[6] The target level for real output is the trend level of output. The target rate for the rate of inflation is assumed to be zero. Equation (4) is the limiting case of a standard loss function where the discount factor approaches unity. The standard loss function consists of squared deviations of current and discounted future deviations of real output and the rate of inflation.

[7] Just as the foreign rate of inflation (π^f_t) is considered to be exogenous to the model, so is the foreign interest rate (R^f_t).

[8] The timeless perspective of monetary policy is stronger form of commitment that introduces inertia into the behaviour of real output and inflation. McCallum and Nelson (2004) and Woodford (2003) discuss the timeless perspective in greater detail.

[9] The expression in equation (13) is also the solution to the case of monetary policy being carried out under discretion. Under discretion, the policymaker minimizes the loss function, treating all expectations as fixed. As seen above, under commitment, all expectations of the endogenous variables are fixed at zero due to the assumption of all shocks following white noise processes. Hence the optimal weight on real output is the same for both discretion and commitment.

[10] This is easily seen by rewriting the optimal policy rule as $y_t = -\mu\left[a + \frac{b}{a_1 + a_2}\right]\pi_t$.

[11] Both ε_t and R_t^f have the same coefficient in the final form equation for output and inflation . Hence in the following discussion we set R_t^f arbitrarily to zero.

[12] In closed-economy models where persistence and policy lags matter, the optimal policy parameter typically depends on all parameters of the model, too. See Svensson (1999).

[13] To see that for a given deviation of inflation from target real output adjusts by more, rewrite the optimal policy rule as:

$y_t = -\mu\left[\frac{a}{1-\phi} + \frac{b}{a_1(1-\phi)+a_2}\right]\pi_t$. Clearly $\frac{a}{1-\phi} > a$ and $\frac{b}{a_1(1-\phi)+a_2} > \frac{b}{a_1 + a_2}$.

Hence, the adjustment of real output is greater for a given deviation of inflation from target when the disturbances follow autoregressive processes relative to the case when they follow white noise processes.

[14] Openness is defined as the share of the imported consumption good in total consumption. Thus openness has a role to play in the determination of aggregate demand.

[15] On page 251 CGG (2001) go as far as arguing that “As we have foreshadowed, both the IS and AS have the same general form as in the closed economy studied by CGG (1999)”.

[16] Gerlach and Smets (2000), Ball (1999), Mayes and Viren (2000), and Peeters (1999) discuss various aspects of MCI-based monetary policy. For a critical assessment of the reliability of MCIs in the conduct of monetary policy, see Ericsson et al (1997).

[17] The construction, too, is somewhat problematic. For instance, should the UIP condition be looked upon as a third relation – next to the IS and the Phillips Curve equations, that underlies the construction of the MCI? An earlier version of the paper treated the MCI answered this question in the affirmative and found that the sign of the coefficient on the real exchange rate in the MCI was indeterminate.

[18] Some variants of the MCI are based on a *nominal* rate of interest and a *nominal* exchange rate.

[19] There are no constants in this model. Hence the base values for the real rate of interest and the real exchange rate have been set to zero.

[20] There are two differences between equation (6) and equation (19). While the former features the nominal interest rate on the left-hand side and is therefore called a reaction function, the latter features the expected real interest rate and the real exchange rate on the left-hand side. The second difference pertains to the role of the elasticities with respect to the real exchange rate (a_2 and b). They appear only in the weight on the real exchange rate on the left-hand side of the MCI but not on the right-hand side. In the reaction function, of course, they appear on the right-hand side of the equation. In a nutshell, there is a direct role for the real exchange rate in the MCI but only an indirect role for the exchange rate in the reaction function.

[21] See, for instance, Roberts (1995) or McCallum and Nelson (2004).

[22] Roberts (1995) derives a forward-looking Phillips curve in the closed-economy context.

[23] That such behavior applies to firms that are based in a small open economy but trade in world markets is borne out by the following excerpt from a newspaper article that appeared in the Christchurch Press on February 17, 2001: "About 95 per cent of New Zealand's milk is used for exports, and the world price for dairy products has recently climbed, making it more costly for local

dairy manufacturers to compete for milk. Milk that is used for export products sets the *benchmark for the price we pay for milk processed for the local market.*" (page 2) (italics added for emphasis).

Table 1:

A. Case where *b>0*.

μ	θ*	$V(\pi_t)$	$V(y_t)$
$\mu \to 0$	$\propto$	$\frac{1}{(a_1+a_2)^2}\left[b^2\sigma_v^2+(a_1b)^2(\sigma_{Rf}^2+\sigma_\varepsilon^2)+(a_1+a_2)^2\sigma_u^2\right]$	*0*
$\mu \to \propto$	*0*	*0*	$\frac{1}{[(a_1+a_2)a+b]^2}\left[b^2\sigma_v^2+(a_1b)^2(\sigma_{Rf}^2+\sigma_\varepsilon^2)+(a_1+a_2)^2\sigma_u^2\right]$

B. Case where *b=0*.

μ	θ*	$V(\pi_t)$	$V(y_t)$
$\mu \to 0$	$\propto$	σ_u^2	*0*
$\mu \to \propto$	*0*	*0*	$\left[\frac{\sigma_u^2}{a^2}\right]$

Table 2:

Shock	**Real Output Gap (y_t)**	**Inflation (π_t)**
$v_t = \phi v_{t-1} + \hat{v}_t$ (IS)	$\frac{b}{(a_1(1-\phi)+a_2)(\theta(1-\phi)+a)+b(1-\phi)}$	$\frac{-\theta b}{(a_1(1-\phi)+a_2)(\theta(1-\phi)+a)+b(1-\phi)}$
$u_t = \rho u_{t-1} + \hat{u}_t$ (Cost-push)	$\frac{-(a_1(1-\rho)+a_2)}{(a_1(1-\rho)+a_2)(\theta(1-\rho)+a)+b(1-\rho)}$	$\frac{\theta(a_1(1-\rho)+a_2)}{(a_1(1-\rho)+a_2)(\theta(1-\rho)+a)+b(1-\rho)}$
$\pi_t^f = \kappa\pi_{t-1}^f + \hat{\pi}_t^f$ (Foreign inflation)	$\frac{a_1 b\kappa}{(a_1(1-\kappa)+a_2)(\theta(1-\kappa)+a)+b(1-\kappa)}$	$\frac{-\theta a_1 b\kappa}{(a_1(1-\kappa)+a_2)(\theta(1-\kappa)+a)+b(1-\kappa)}$
$\varepsilon_t = \delta\varepsilon_{t-1} + \hat{\varepsilon}_t$ (Risk premium)	$\frac{-a_1 b}{(a_1(1-\delta)+a_2)(\theta(1-\delta)+a)+b(1-\delta)}$	$\frac{\theta a_1 b}{(a_1(1-\delta)+a_2)(\theta(1-\delta)+a)+b(1-\delta)}$