Optimal Monetary Policy in Open versus Closed Economies: An Integrated Approach

By RICHARD CLARIDA, JORDI GALÍ, AND MARK GERTLER*

In Clarida et al. (1999; hereafter CGG), we presented a normative analysis of monetary policy within a simple optimization-based closed-economy framework. We derived the optimal policy rule and, among other things, characterized the gains from commitment. Also, we made precise the implications for the kind of instrument feedback rule that a central bank should follow in practice. In this paper we show how our analysis extends to the case of a small open economy. Openness complicates the problem of monetary management to the extent the central bank must take into account the impact of the exchange rate on real activity and inflation. How to factor the exchange rate into the overall design of monetary policy accordingly becomes a central consideration.

Here we show that, under certain conditions, the monetary-policy design problem for the small open economy is isomorphic to the problem of the closed economy that we considered earlier. Hence, all our qualitative results for the closed economy carry over to this case. Openness does affect the parameters of the model, suggesting quantitative implications. Though the general form of the optimal interest-rate feedback rule remains the same as in the closed-economy case, for example, how aggressively a central bank should adjust the interest rate in response to inflationary pressures depends on the degree of openness. In addition, openness gives rise to an important distinction between domestic inflation and consumer price inflation (as defined by the CPI). To the extent that there is perfect exchange-rate pass-through, we find that the central bank should target domestic inflation and allow the exchange rate to float, despite the impact of the resulting exchange-rate variability on the CPI (Kosuki Aoki, 1999; Galí and Tommaso Monacelli, 2000).

I. A Small Open-Economy Framework

We consider a small open-economy model with money, imperfect competition, and nominal price rigidities, similar to that in Galí and Monacelli (2000), Maurice Obstfeld and Kenneth Rogoff (2000), Lars Svensson (2000), and others. One key difference is that, in addition to having nominal price rigidities in the form of staggered price-setting, we allow for a friction in the labor market in order to introduce a short-run trade-off between inflation and output.

Only consumption goods are produced and traded. Households consume a domestic and a foreign good that are imperfect substitutes. The domestic good is a composite of a continuum of differentiated goods, each produced by an associated monopolistically competitive firm at home. The home economy is small in the sense that it does not influence foreign output, the foreign price level, or the foreign interest rate; however, the equilibrium terms of trade will depend on both home and foreign disturbances. We abstract from wealth effects due to current-account imbalances by allowing households to share consumption risk internationally. To conserve space, we present only the log linearized version of the model. Accordingly, all variables are expressed as percentage deviations from their long-run equilibrium levels.

Household consumption, c_t, is a constant-elasticity-of-substitution (CES) composite of home and foreign goods, given in log-linear form by

$$c_t = (1 - \gamma)c_t^{\mathrm{h}} + \gamma c_t^{\mathrm{f}} \tag{1}$$

where the superscripts h and f denote home and foreign, respectively, and γ measures openness.

* Clarida: Department of Economics, Columbia University, 420 West 118th Street, New York, NY 10027; Galí: Department of Economics, New York University, 269 Mercer Street, New York, NY 10003, and Universitat Pompeu Fabra, Spain; Gertler: Department of Economics, New York University, 269 Mercer Street, New York, NY 10003. We thank Pierpaolo Benigno, Frank Smets, and Lars Svensson for helpful discussions.

In turn, domestic output, y_t, is divided between goods sold to domestic residents, c_t^{h} and goods sold to foreigners, $c_t^{\mathrm{h}*}$:

$$y_t = (1 - \gamma)c_t^{\mathrm{h}} + \gamma c_t^{\mathrm{h}*}. \tag{2}$$

The representative household chooses consumption, labor supply, saving, and moneyholding to maximize a discounted stream of utility that depends on the consumption index, leisure, and real money balances. The first-order conditions (in log-linear form) are given as follows:

$$c_t^{\mathrm{h}} - c_t^{\mathrm{f}} = \eta s_t \tag{3}$$

$$\omega_t - p_t - \gamma s_t = (\phi n_t + \sigma c_t) + \mu_t^{\mathrm{w}} \tag{4}$$

$$c_t = E_t c_{t+1} - \frac{1}{\sigma}[r_t - E_t(\pi_{t+1} + \gamma E_t \Delta s_{t+1})] \tag{5}$$

$$E_t \Delta s_{t+1} + r_t^* - E_t \pi_{t+1}^* = r_t - E_t \pi_{t+1}. \tag{6}$$

Equation (3) relates the household's demand for home versus foreign goods to the terms of trade s_t, where η is elasticity of substitution. We assume further that the law of one price holds, implying that $s_t = e_t + p_t^* - p_t$, where e_t the nominal exchange rate, p_t^* is the foreign price level, and p_t is the price of domestic output. Equation (4) is the first-order condition for labor supply. The left-hand side is the real wage: the nominal wage, ω_t, minus the consumer price level, $p_t + \gamma s_t$. The first term on the right-hand is the marginal rate of substitution between leisure and consumption, where n_t is employment, ϕ is the inverse of the labor-supply elasticity, and σ is the coefficient of relative risk aversion. The second term, μ_t^{w}, which we call the "wage markup," reflects frictions in the wage-setting that may distort the real wage from its competitive equilibrium value $(\phi n_t + \sigma c_t)$. In general, these frictions may stem from either real rigidities (e.g., efficiency wages) or nominal rigidities (e.g., long-term nominal contracts). For simplicity, we take μ_t^{w} as an exogenous stationary first-order stochastic process.

Among the complete set of state-contingent claims the household may hold are domestic and foreign one-period nominal bonds. Equation (5) is the first-order condition for consumption versus saving in domestic bonds, where the real return on domestic bonds is the difference between the nominal interest, r_t, and the expected rate of consumer price inflation, $E_t(\pi_{t+1} + \gamma\Delta s_{t+1})$, given that $\pi_{t+1} = p_{t+1} - p_t$ is domestic inflation and $\Delta s_{t+1} = s_{t+1} - s_t$ is the rate of depreciation of the terms of trade. In addition, the option to trade costlessly in foreign bonds implies that, up to linearization, uncovered interest parity will hold, as expressed by equation (6), where r_t^* is the foreign nominal interest rate and π_{t+1}^* is inflation in the foreign-currency price of foreign goods. Finally, as noted, households have access to a complete set of international securities markets to share consumption risk. This assumption, together with the assumption that all exogenous shocks are stationary, implies that over time the terms of trade will revert to the steady state, as follows:

$$\lim_{i \to \infty} E_t s_{t+i} = 0. \tag{7}$$

We assume that consumption by foreigners is also a CES index of home-produced and foreign goods. Following Galí and Monacelli (2000), we treat the foreign country as large by assuming that the weight in the foreign CES aggregator on home goods is negligible. Accordingly, for the foreign country, output is equal to domestic consumption, and consumer price inflation is equal to domestic inflation. It follows that foreign demand for domestic output depends on foreign output, y_t^*, and the terms of trade:

$$c_t^{\mathrm{h}*} = y_t^* + \eta s_t \tag{8}$$

where, for convenience, we assume that the elasticity of substitution, η, is the same across countries. In addition, we can express the consumption Euler equation for foreigners as

$$r_t^* - E_t \pi_{t+1}^* = \sigma E_t (y_{t+1}^* - y_t^*). \tag{9}$$

Equation (9) links the foreign real interest rate to the growth of foreign output, taken here to be an exogenous stationary process.

The domestic production sector of this small open economy is identical to the closed-economy counterpart of this model. In particular, the domestic consumption good is a CES composite of a continuum of goods produced at home. Each firm accordingly faces a demand curve with constant relative price elasticity that is homogeneous of degree 1 in total demand for home consumption. Production is linear in labor, the only input, as follows:

$$y_t = a_t + n_t \tag{10}$$

where a_t is an exogenous, stationary stochastic process for home productivity.

We assume that firms set nominal prices on a staggered basis, following Guillermo Calvo (1983). Firms changing price in the current period choose an optimal price based on the expected path of marginal cost. Firms not changing price simply adjust output to meet demand. Aggregating across firms leads to the following "new Phillips Curve" that, in its primitive form, relates domestic inflation to real marginal cost, mc_t, and expected future inflation as follows:

$$\pi_t = \beta E_t \pi_{t+1} + \delta \mathrm{mc}_t \tag{11}$$

where, from cost minimization, mc_t equals the product wage divided by the marginal product of labor,

$$\mathrm{mc}_t = \omega_t - p_t - a_t. \tag{12}$$

Equations (11) and (12) are identical to their counterparts for the closed economy, except that they pertain strictly to domestic inflation.

II. The Open-Economy Policy Problem

Let y_t^{o} be the natural level of output, defined as the level of output that arises with perfectly flexible prices and no cyclical distortions in the labor market (i.e., with $\mathrm{mc}_t = 0$ and $\mu_t^{\mathrm{w}} = 0$). Similarly, let $\mathrm{rr}_t^{\mathrm{o}}$ and s_t^{o} be the domestic real interest rate and the terms of trade, respectively, that arise in the frictionless equilibrium. Finally, let $x_t = y_t - y_t^{\mathrm{o}}$ be the output gap. It is then possible to collapse the model into a system of three equations that determine x_t, π_t, and s_t conditional on the path of the nominal interest rate:

$$x_t = E_t x_{t+1} - \frac{1+w}{\sigma}(r_t - E_t\pi_{t+1} - \mathrm{rr}_t^{\mathrm{o}}) \tag{13}$$

$$\pi_t = \beta E_t \pi_{t+1} + \lambda_w x_t + u_t \tag{14}$$

$$s_t = \frac{\sigma}{1+w} x_t + s_t^{\mathrm{o}} \tag{15}$$

with $w = \gamma(\sigma\eta - 1)(2 - \gamma)$, $\lambda_w = \delta[\sigma/(1 + w) + \phi]$, $u_t = \delta\mu_t^{\mathrm{w}}$, and with

$$\mathrm{rr}_t^{\mathrm{o}} = \frac{w}{1+w}\mathrm{rr}_t^{*} + \frac{\sigma}{1+w}E_t(y_{t+1}^{\mathrm{o}} - y_t^{\mathrm{o}})$$

$$y_t^{\mathrm{o}} = \frac{(1+\phi)a_t - \sigma\left(\frac{w}{1+w}\right)y_t^{*}}{[\sigma/(1+w) + \phi]}$$

$$s_t^{\mathrm{o}} = \frac{\sigma}{1+w}(y_t^{\mathrm{o}} - y_t^{*}).$$

Equation (13) is essentially an "*IS* curve" that relates the output gap inversely to the domestic real interest rate and positively to the expected future output gap. As in the closed economy, holding constant the frictionless equilibrium, a rise in the domestic real rate reduces aggregate demand and, hence, the current output gap, by inducing intertemporal substitution of consumption. For the open economy, since the rise in the domestic real rate induces an appreciation of the terms of trade, there is also an expenditure-switching effect on demand, captured by the influence of the parameter w on the interest sensitivity of x_t. The expenditure-switching effect causes net exports to move in a direction that magnifies the overall impact on demand, if the elasticity of substitution between home and foreign goods, η, is sufficiently large to satisfy $\sigma\eta > 1$ (implying $w > 0$), as seems reasonable empirically.

Equation (14) is a short-run aggregate supply (*AS*) curve that relates domestic inflation to the output gap and a "cost-push shock," u_t. As in CGG, the "cost-push shock" reflects determinants of marginal cost that do not move proportionately with the output gap. Here we relate u_t explicitly to the wage markup, μ_t^{w}. (To see this, note that marginal cost may be expressed $mc_t = [\sigma/(1 + w) + \phi]x_t + \mu_t^{w}$, and then compare equations (11) and (14).) As emphasized in CGG, the cost-push shock introduces a short-run trade-off between x_t and π_t. Finally, equation (15) relates the terms of trade, s_t, positively to the output gap. As domestic output rises relative to foreign output, the terms of trade must depreciate. To clear markets, domestic goods must become cheaper relative to foreign goods.

We next turn to the policy objective. The consideration of the terms of trade makes the objective differ from what is standard for a closed economy (Giancarlo Corsetti and Paolo Pesenti, 2001). However, it follows from equation (15) that the "terms-of-trade gap," $s_t - s_t^{o}$ is proportionate to the output gap, x_t. Accordingly, under certain conditions, based on a second-order approximation of the household's utility function, it is possible to collapse the policy objective to

$$(16) \quad \max\{-(1/2) \sum_{i=0}^{\infty} E_t[\alpha_w x_{t+1}^2 + \pi_{t+1}^2]\}$$

where we use equation (15) to fold $s_t - s_t^{o}$ into x_t. Equation (16) thus takes a standard form for a closed economy (see e.g., Michael Woodford, 1999): a quadratic loss function in the output gap and inflation, though we emphasize that the latter in this case corresponds to domestic inflation. To derive equation (16), we assume that taxes adjust to counteract the distortions in the economy in a way that eliminates any incentive to create either unanticipated inflation or unanticipated deflation (see Gianluca Benigno and Pierpaolo Benigno, 2000).

The monetary-policy problem for the small open economy thus simplifies to choosing a path for the nominal interest rate, r_t, to minimize the loss (16) subject to the *IS* and *AS* equations. As we have foreshadowed, both the *IS* and *AS* curves have the same general form as in the closed economy studied by CGG. Indeed, as the parameter which reflects openness, γ, goes to zero, $w = \gamma(\sigma\eta - 1)(2 - \gamma)$ converges to zero, implying that the coefficients in the *IS* and *AS* curves become identical to their closed-economy counterparts. Similarly, the objective is of the same general form as for the closed economy. Thus, we have the following result.

Result 1: The policy problem for the small open economy studied here is isomorphic to the policy problem for the closed economy in CGG.

It follows that the feedback rule for nominal interest rate (r_t) and the time paths for x_t and π_t under the optimal policy are qualitatively the same as in the closed-economy case. For the open economy, of course, the optimal policy also has implications for the terms of trade. From equation (15), however, conditional on the path of x_t under the desired monetary policy and on s_t^{o}, we obtain an expression for the optimal path of s_t.

III. Optimal Policy Under Discretion and Under Commitment

Under discretion, the central bank re-optimizes each period. Under commitment, the central bank chooses a binding state-contingent rule. With forward-looking price-setting and a short-run output–inflation trade-off, as we have here, there are gains from commitment to a rule, as emphasized in CGG, Woodford (1999), and elsewhere. We begin with discretion and then briefly discuss commitment.

Given Result 1, we follow CGG to derive the solution under discretion. In analogy to the closed-economy case, the optimum is characterized by a "lean against the wind" policy that has the central bank contract demand as domestic inflation rise above target, as follows:

$$(17) \qquad x_t = -(\lambda_w/\alpha_w)\pi_t.$$

The reduced forms for the output gap and domestic inflation, in turn, are given by

$$(18) \qquad x_t = -\lambda_w q_w u_t$$

$$(19) \qquad \pi_t = \alpha_w q_w u_t$$

with $q_w = 1/[\lambda_w^2 + \alpha_w(1 - \beta\rho)]$, where $\rho < 1$ is the autocorrelation in the cost-push shock. In general, a positive cost-push shock induces the central bank to contract demand to moderate the impact on domestic inflation. Overall, the policy aims for gradual convergence of domestic inflation to the target (note that the cost-push shock is stationary), except in the extreme case where the policy objective places zero weight on the output gap (i.e., $\alpha_w = 0$). An interest-rate feedback rule which implements the optimal policy is

$$r_t = \mathrm{rr}_t^{\mathrm{o}} + bE_t\pi_{t+1} \quad (20)$$

with $b = 1 + [\sigma/(1 + \omega)](\lambda_w/\alpha_w)(1 - \rho)/\rho > 1$. The central bank should respond to expected deviations of domestic inflation from the target by adjusting the nominal rate sufficiently to have the real rate move in a stabilizing manner. The rule is of the same form as for the closed economy. International factors are relevant to the extent that they affect domestic inflation or the equilibrium real rate, $\mathrm{rr}_t^{\mathrm{o}}$.

Under the optimal policy, CPI inflation is more volatile than domestic inflation. The monetary tightening that follows a positive cost-push shock also induces an appreciation in the terms of trade [see equations (15) and (18)], which moderates the initial impact on the CPI. Over time, however, the terms of trade depreciate, causing CPI inflation to rise above domestic inflation. In addition, the optimal policy has the central bank accommodate real shocks that move the equilibrium terms of trade, also causing the CPI to vary relative to the domestic price index.

With commitment possible, the optimal policy is history-dependent, as stressed by Woodford (1999), CGG, and others. Following CGG, in this case, the optimal policy has the change in the output gap adjust to deviations of inflation from the target:

$$x_t - x_{t-1} = -\frac{\lambda_w}{\alpha_w}\pi_t. \quad (21)$$

Roughly speaking, the "difference" rule exploits the dependence of current behavior on expectations of future policy. Equation (21) implies

$$x_t = -\frac{\lambda_w}{\alpha_w}p_t \quad (22)$$

which suggests that the policy is interpretable as domestic price-level targeting. It remains optimal, however, to accommodate movements in the terms of trade. Even with commitment, accordingly, pegging the nominal exchange rate does not produce the best policy.

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