OPTIMAL MONETARY POLICY RULES WHEN THE CURRENT ACCOUNT MATTERS

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Policymakers and the academic community have reached an increasing consensus during the last two decades: the primary objective of monetary policy should be to control inflation (see, for example, King, 1999). A less settled issue is the appropriate role of the central bank regarding other, secondary objectives. Some countries have explicitly included unemployment (or the output gap) among the central bank's objectives, whereas others make explicit reference to the output gap when explaining policy to the public. For example, the U.S. Federal Reserve has among its goals "to promote maximum employment," and the Reserve Bank of Australia has "the maintenance of full employment" as an explicit objective in addition to price stability. The Sveriges Riksbank, the Bank of England, and even the European Central Bank have identified output gap volatility as a reason to follow a gradualist approach to controlling inflation. For example, the Bank of England has stated that, in choosing among various alternative paths to achieving the inflation target, the monetary authority should be concerned about deviations of the level of output from capacity (see Svensson, 1999).

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But the output gap and inflation are not the only relevant objectives of monetary policy from a practical point of view. The law that establishes the Central Bank of Chile sets as a formal objective the stability and proper functioning of the country's external payments system. Operationally, this objective has been interpreted as maintaining a sustainable current account deficit. Specifically, there is an operational objective of keeping this deficit, measured at trend terms of trade, between 4 and 5 percent of GDP.[1] Behind this objective is the idea that an excessive current account deficit can easily jeopardize the normal functioning of the external payments system, including access to external financing.

Including a target for the current account deficit in the objective function of the central bank has potentially important consequences for the formulation of monetary policy, particularly regarding the optimal reaction to various shocks. Both the magnitude and the persistence of appropriate movements in interest rates following a specific shock can change when this objective is considered. This paper investigates this issue, deriving and comparing optimal policy rules using a simple macroeconomic model of the Chilean economy. It further analyzes what happens to optimal monetary policy when the current account objective is asymmetric, that is, when it is considered that positive deviations are relatively more undesirable than negative ones.[2]

The paper first studies the problem of a central bank that chooses interest rates so as to minimize the expected discounted loss of a quadratic loss function in an economy described by linear equations and in which there are some forward-looking variables. Although it makes use of standard dynamic programming, the paper departs from previous work by explicitly incorporating the current account in the objective function and by considering a macroeconomic model whose structure and lags are chosen to realistically represent the Chilean

1. See Massad (1998) for a description of the central bank's objectives and of the way monetary policy is conducted in Chile based on an inflation target. One important feature of the Chilean economy in this regard is the widespread practice of indexing for inflation, including indexing of financial assets. In addition, before September 1999 the central bank used a target zone framework as the basis of its exchange rate policy.

2. Of course, it is quite difficult to argue from first principles that the current account should be an objective in its own right. Ultimately, its inclusion is a short cut to avoid a very complex model in which inflation and output are severely affected by highly nonlinear events such as balance of payments crises.

economy.[3] The model structure is similar to that of a simple central bank macroeconomic projection model. It includes equations for the output gap, the absorption-output gap, a Phillips curve, uncovered interest rate parity, and a term structure. Using this model, we investigate how optimal policy reactions change when the current account matters, and the implications of incorporating the output gap among the central bank's objectives.

The paper then studies the consequences of having an asymmetric objective for the current account. This is done within a considerably simpler framework, as otherwise it would be difficult to solve the central bank's problem. The economy is described by a central bank loss function that depends on inflation and the absorption-output gap, with two linear equations describing their evolution. Again, the central bank has to choose interest rates so as to minimize the expected discounted loss, this time of a nonquadratic loss function. The solution method we use in this case is based on standard dynamic programming using a convenient discretization of the economy. We investigate how optimal policy reactions change both with the asymmetry in objectives and with uncertainty about future shocks.[4]

It is important to clarify at the outset that by an *optimal reaction* we mean the best possible policy rule in terms of maximizing the objective function in the context of the model under analysis. It is not necessarily the best policy for day-to-day policymaking, because, by definition, any model is an incomplete description of reality. Actual policymaking might take into account these rules—indeed, they are quite appealing as they give precise answers to a quite complex problem of combined lagged effects. However, policymakers should also evaluate the implications of developments that are not considered in the model. In other words, the optimality of the rules we study is model-specific.

The main results of the paper yield relevant policy conclusions. For example, we find that including the current account among the objectives of the central bank has important consequences for optimal policy reactions. Interest rates react vigorously (and without much persistence) to shocks that affect the current account deficit, but are

3. Svensson (2000), Ryan and Thompson (1999), and many others study optimal policy rules in inflation targeting frameworks for open economies. Among other issues, these papers analyze the usefulness of monetary conditions indexes and the merits of targeting inflation of nontraded goods.

4. Because with asymmetric objectives the problem is not linear-quadratic, there is no certainty equivalence.

less responsive to output gap and inflation shocks when the current account is among the objectives. If the current account does not matter, optimal policy rules change considerably when the central bank cares about the output gap. However, these changes are far less dramatic if the central bank already has the current account among its objectives. An asymmetric current account objective does not greatly change the optimal reactions to demand shocks, but it makes monetary policy clearly more aggressive toward positive inflation shocks. The change in this policy reaction is economically relevant. Finally, when there is an asymmetric current account objective, a higher volatility in current account shocks generates a more aggressive monetary policy.

The paper is organized as follows. Section 1 describes the structure of the economy as modeled, as well as monetary policy objectives in a standard linear-quadratic framework. Section 2 presents the method for solving the central bank's problem and compares optimal policy rules for alternative central bank preference parameters using a realistic model estimate. Section 3 studies policy rules in a simpler economy but one in which current account objectives are asymmetric. Finally, section 4 presents some concluding remarks.

1. The Economy

The economy is described by a series of state variables, some of which are exogenous, while others are endogenous, predetermined, and subject to stochastic shocks, and the rest are endogenous and forward-looking. These variables evolve according to a simple linear macroeconomic model in which monetary policy affects some variables instantaneously and others with a lag.[5] The exogenous variables represent the fundamentals for the economy and follow simple stochastic processes. The economy is endowed with a central bank, which has an explicit objective function. The frequency of the empirical counterpart of the model is quarterly, and we assume that variables are observed contemporaneously.[6]

5. The model we consider is not immune to the Lucas critique, although expectations are completely rational and the public knows the central bank's objectives. However, the Lucas critique is not that relevant when policy shocks are small (which is the case considered in this paper).

6. One way of interpreting this assumption is to consider that monetary policy chooses end-of-period interest rates. An alternative is to consider that actual (off-model observed) short-term projections are very good (within a quarter).

All variables in the model are measured as deviations from their (possibly stochastic) long-run trend and consequently are stationary. For example, r_t represents deviations of the interest rate with respect to its long-run trend.[7]

1.1 Monetary Policy Objectives

The central bank has three objectives: to keep inflation close to the target, to maintain the current account deficit close to a preannounced value, and to keep the output gap close to zero. In addition, the central bank dislikes large and sudden movements in interest rates.[8] These objectives are summarized in the following quadratic loss function of period t:

$$l_t = \mu_\pi \pi_t^2 + \mu_{cc} cc_t^2 + \mu_y y_t^2 + \mu_r \left(r_t - r_{t-1} \right)^2 , \tag{1}$$

where π_t is the gap between actual and target inflation, cc_t is the gap between the actual and the target current account (as a proportion of GDP), and y_t is the gap between actual and potential output.[9] The term $(r_t - r_{t-1})^2$ captures the costs for the central bank of frequent and sudden changes in monetary policy. Lastly, μ_π, μ_{cc}, μ_y, and μ_r are nonnegative constants that together characterize the central bank type.

The central bank is forward looking and in each period t chooses the level of the real (indexed) interest rate that minimizes the expected discounted sum of future losses:

$$L_t = \mathrm{E}\left(\sum_{\tau=0}^{\infty} \delta^\tau l_{t+\tau} \mid \Omega_t \right), \tag{2}$$

where Ω_t represents the information set available in period t. Moreover, because there are forward-looking variables, both the central

7. See note 13.

8. See Woodford (1999a) for a derivation from first principles of these preferences for smooth movements in the policy instrument. Massad (1998) makes the case for instrument stability in Chile. The concern of the central bank regarding the normal functioning of the domestic payments system gives another argument for such an objective.

9. In this framework the authority recognizes that monetary policy can have only temporary effects on output. Moreover, there are no intertemporal inconsistency problems of the Barro-Gordon type. See note 13.

bank and the public know that the former can reoptimize in each period. Hence, the only possible solution is a discretionary one.[10] Therefore, the optimal policy rule has the form $r_t = FX_t$, where X_t is the vector of predetermined variables and F is a vector of constants to be endogenously determined (see Backus and Driffill, 1986, and Söderlind, 1999a, for further details).

1.2 State Variables

There are three fundamental exogenous variables in this economy: the terms of trade (in logarithms) (*tot),* the country risk premium (φ), and the international real interest rate (r_t^*). We assume that these three variables are stationary (or that they are transformed so as to eliminate any trend). Their law of motion is given by the following equations:

$$tot_t = \rho_{tot}\, tot_{t-1} + \rho^r{}_{tot}\, r^*_{t-1} + \xi_t^{tot}\,, \tag{3}$$

$$r_t^* = \rho_r r^*_{t-1} + \xi_t^r\,, \quad \text{and} \tag{4}$$

$$\varphi_t = \rho_\varphi \varphi_{t-1} + \xi_t^\varphi\,, \tag{5}$$

respectively, where $0 < \rho_j < 1$ and ξ_t^j are i.i.d. shocks ($j = tot, r^*$, and φ).[11]

Domestic inflation moves according to inflation in traded goods and in nontraded goods. Traded goods inflation, in turn, depends on international prices and the exchange rate, and nontraded goods inflation depends (because of indexation) on previous inflation, on inflation expectations in previous periods, and on the output gap

10. A solution involving a commitment would attain a better outcome (see Woodford, 1999b). However, like Svensson (1999), we assume that a commitment technology is not available. Thus, the only realistic solution is discretionary.

11. A more realistic approach would be to model the risk premium as an endogenous variable that depends on domestic variables such as the current account. Then an increase in the current account deficit would cause a nominal devaluation following a rise in the risk premium. However, considering this possibility would only add an additional, indirect concern of the central bank regarding the current account, without substantially changing the main results.

(according to a standard accelerationist Phillips curve). In particular, the (annualized) inflation gap evolves according to

$$\pi_t = (1-\omega)\pi_t^T + \omega\pi_t^N - \overline{\pi}\,, \tag{6}$$

where π_t^T is tradables inflation, π_t^N is nontradables inflation, $\overline{\pi}$ is the inflation target, and ω is a constant parameter. Tradables inflation is determined as follows:

$$\pi_t^T = \alpha'_T(\mathrm{L})\left(\hat{e}_{t-1} + \pi_{t-1}^*\right) + \xi_t^T\,, \tag{7}$$

where $\alpha'(\mathrm{L})$ is a polynomial in the lag operator L, $\hat{e}_t$ is the nominal devaluation, π_t^* is international inflation, and ξ_t^T is an i.i.d. shock. This specification assumes that the weak version of purchasing power parity obtains for tradables (controlling for changes in value-added taxation and tariffs) and that there is no instantaneous pass-through. On the other hand, nontradables inflation evolves according to

$$\pi_t^N = \alpha'_{\pi\mathrm{L}}(\mathrm{L})\pi_{t-1} + \mathrm{E}\left[\alpha'_{\pi F}(\mathrm{F})\pi_{t+1} \mid \Omega_{t-1}\right] + \alpha'_y(\mathrm{L})y_t + \xi_t^N\,, \tag{8}$$

where $\alpha'_{\pi F}(\mathrm{F})$ is a polynomial in the forward (lead) operator. This means that $\mathrm{E}\left(\pi_{t+1} \mid \Omega_{t-1}\right)$ is a predetermined variable in period *t*.[12]

Let us define the real exchange rate (RER) as $q_t = e_t p_t^* / p_t$ and assume, without loss of generality, that $\overline{\pi} = 0$. Then the inflation gap equation can be written as

$$\begin{aligned}\pi_t = {} & \alpha_T(\mathrm{L})\hat{q}_{t-1} + \alpha_{\pi\mathrm{L}}(\mathrm{L})\pi_{t-1} + \mathrm{E}\left[\alpha_{\pi F}(\mathrm{F})\pi_{t+1} \mid \Omega_{t-1}\right] \\ & + \alpha_y(\mathrm{L})y_t + \xi_t^\pi\,,\end{aligned} \tag{9}$$

where $\alpha_T(\mathrm{L}) = (1-\omega)\alpha'_T(\mathrm{L})$, $\alpha_{\pi\mathrm{L}}(\mathrm{L}) = \omega\alpha'_{\pi\mathrm{L}}(\mathrm{L}) + (1-\omega)\alpha'_T(\mathrm{L})$, $\alpha_{\pi F}(\mathrm{F}) = \omega\alpha'_{\pi F}(\mathrm{F})$, $\alpha_y(\mathrm{L}) = \omega\alpha'_y(\mathrm{L})$ and $\xi_t^\pi = \omega\xi_t^N + (1-\omega)\xi_t^T$. Furthermore,

12. This structure is based on one of the projection models used at the Central Bank of Chile and is similar to the price equation derived from first principles in Svensson (2000).

in order to preserve homogeneity in prices we assume that $\omega\left[\alpha'_{\pi L}(1)+\alpha'_{\pi F}(1)\right]+(1-\omega)\alpha'_{T}(1)=1$. Notice that in this framework monetary policy affects inflation through three different channels: the output gap, the exchange rate, and lagged expectations of future monetary policy (and hence future inflation).

The RER is a forward-looking variable that is determined by the uncovered interest parity condition:

$$q_t = \mathrm{E}\left(q_{t+1} \mid \Omega_t\right) + 0.25\left(r_t^* - r_t + \varphi_t\right). \tag{10}$$

Besides the short-term real interest rate controlled by the central bank, there is a long-term interest rate determined as a forward-looking variable in the bond market. According to the expectation hypothesis of the term structure, the behavior of the long-term interest rate R_t can be approximated by

$$R_t = \lambda r_t + (1-\lambda)\mathrm{E}\left(R_{t+1} \mid \Omega_t\right), \tag{11}$$

where λ is a constant that negatively depends on the bond duration.

The output gap has some persistence and reacts with lags to the interest rates, the terms of trade, and the RER:

$$\begin{aligned} y_t = {} & \beta_y(\mathrm{L})y_{t-1} + \beta_R(\mathrm{L})R_{t-1} + \beta_r(\mathrm{L})r_{t-1} + \beta_{tot}(\mathrm{L})tot_{t-1} \\ & + \beta_q(\mathrm{L})q_{t-1} + \xi_t^y, \end{aligned} \tag{12}$$

where ξ_t^y is an i.i.d. shock. This equation represents a standard dynamic IS curve.

To construct the ratio of the current account (proxied by the trade balance) to GDP, we consider a linear approximation that depends on the gap between absorption and output (denoted by y_t^d), the terms of trade, the output gap, and the RER. A first-order (log) Taylor expansion of the trade balance yields the following approximation:

$$cc_t = -y_t^d - k_0 q_t + k_0 y_t + k_1 tot_t, \tag{13}$$

where k_0 is the ratio of the trade balance to GDP during the expansion year (2 percent in 1997), and k_1 is the ratio of exports to GDP during that year (30 percent in 1997). The current account deficit during the expansion year was 4.8 percent of GDP.

Finally, we assume that the absorption-output gap has some persistence and depends on interest rates, the terms of trade, and the RER. In particular, this gap is determined by the following equation:

$$\begin{aligned} y_t^d = \gamma_d(\mathrm{L})y_{t-1}^d + \gamma_R(\mathrm{L})R_{t-1} + \gamma_r(\mathrm{L})r_{t-1} + \gamma_{tot}(\mathrm{L})tot_{t-1} \\ + \gamma_q(\mathrm{L})q_{t-1} + \xi_t^d, \end{aligned} \tag{14}$$

where ξ_t^d is an i.i.d. shock. In order to be consistent with our prior definition of y_t, we consider y_t^d as the gap between, on one hand, the difference between actual and trend absorption and, on the other, the output gap.[13] Of course, because both equations include output in the left-hand side, and both represent cyclical movements of the economy, equations (14) and (12) are closely related. Thus the shocks ξ_t^y and ξ_t^d need not be orthogonal. In the exercises below we consider both independent and common shocks to both equations.

In sum, the economy is described by equations (3) to (5) and (9) to (14). Appendix A presents the estimation and calibration results of these equations using Chilean quarterly data. We choose a lag structure in each equation so as to maximize the realism and fit of the model, even though this strategy generates several state variables.

2. Solution

The solution of the model requires us to rewrite the model so as to represent it in the state-space form. Once it is represented in this way, one can apply directly the algorithms described in Backus and Drifill (1986), Svensson (1994), and Söderlind (1999b). As mentioned before, we consider a discretionary solution.

2.1 State-Space Representation

Following the same notation as Svensson (2000), let X_t be the (column) vector of predetermined variables, Y_t the (column) vector of

13. In this framework, therefore, we study the effects of monetary policy on the current account without considering secular trends in the expenditure-output gap. This is consistent with the idea that the central bank is only capable of choosing (temporary) deviations of the real interest rate with respect to its long-run trend. The latter is actually endogenous and responds to the aforementioned secular trend.

variables that enter as arguments in the central bank's loss function, x_t the (column) vector of forward-looking variables, and ξ_t the (column) vector of shocks. Considering the lag structure embedded in the model estimation presented in appendix A, one has

$$\mathrm{X}_t = \begin{pmatrix} tot_t, tot_{t-1}, tot_{t-2}, r_t^*, \varphi_t, q_{t-1}, q_{t-2}, q_{t-3}, \pi_t, \pi_{t-1}, \pi_{t-2}, \pi_{t-3}, y_t, y_{t-1}, \\ r_{t-1}, R_{t-1}, y_t^d \end{pmatrix}',$$

$$\mathrm{Y}_t = \left(\pi_t, cc_t, y_t, r_t - r_{t-1}\right)',$$

$$\mathrm{x}_t = \left[R_t, q_t, \mathrm{E}\left(\pi_{t+1} \mid \Omega_{t-1}\right), \mathrm{E}\left(\pi_{t+2} \mid \Omega_{t-1}\right)\right]', \text{ and}$$

$$?_t = \left(\xi_t^{tot}, 0, 0, \xi_t^r, \xi_t^\varphi, 0, 0, 0, \xi_t^\pi, 0, 0, 0, \xi_t^y, 0, 0, 0, \xi_t^d\right)'.$$

Let n_1, n_2, n_3, and $n = n_1 + n_2$ be the dimensions of X_t, x_t, Y_t, and Z_t, respectively. In the particular model we consider, $n_1 = 17$, $n_2 = 4$, and $n_3 = 4$. Let $\mathrm{Z}_t = (\mathrm{X}'_t, \mathrm{x}'_t)$ be the vector that describes the state of the economy. Using these definitions, the model can be written in the following way (in the state-space):

$$\begin{bmatrix} \mathrm{X}_{t+1} \\ \mathrm{E}\left(\mathrm{x}_{t+1} \mid \mathrm{O}_t\right) \end{bmatrix} = \mathrm{AZ}_t + \mathrm{Br}_t + \begin{bmatrix} ?_{t+1} \\ 0 \end{bmatrix}, \tag{15}$$

$$\mathrm{Y}_t = \mathrm{C}_z \mathrm{Z}_t + \mathrm{C}_r \mathrm{r}_t, \tag{16}$$

$$\mathrm{l}_t = \mathrm{Y}_t' \mathrm{K} \mathrm{Y}_t, \tag{17}$$

where A is a $n \times n$ matrix, B is a $n \times 1$ column vector, C_z is a $n_3 \times n$ matrix, C_r is a $n_3 \times 1$ column vector, and K is a $n_3 \times n_3$ diagonal matrix with $(\mu_\pi, \mu_{cc}, \mu_y, \mu_r)$ in the diagonal. Appendix B describes the construction of these matrices in detail.

The solution to the central bank's problem is characterized by a policy function of the following form:

$$r_t = FX_t \ , \tag{18}$$

where F is a $1 \times n_1$ row vector to be endogenously determined.

The solution also characterizes the evolution of the forward-looking variables according to the following linear function:

$$x_t = HX_t \ , \tag{19}$$

where H is a $n_2 \times n_1$ matrix to be endogenously determined.

Hence the dynamics of the economy are given by equations (18) and (19) and the following pair of equations:

$$X_{t+1} = M_{11}X_t + ?_{t+1} \ , \quad \text{and} \tag{20}$$

$$Y_t = \left(C_{z1} + C_{z2}H + C_rF\right)X_t \ , \tag{21}$$

where M_{11}, C_{z1}, C_{z2} are $n_1 \times n_1$, $n_3 \times n_1$ and $n_3 \times n_2$ matrices, respectively, corresponding to the partitions of

$$M \equiv A + B\begin{bmatrix} F \\ 0 \end{bmatrix} = \begin{bmatrix} M_{11} & M_{12} \\ M_{21} & M_{22} \end{bmatrix}, \quad \text{and}$$

$$C_z = \begin{bmatrix} C_{z1} & C_{z2} \end{bmatrix},$$

according to X_t and x_t.

In order to find the matrices F and H we use the algorithm mentioned above.

2.2 Optimal Reaction Functions

The optimal policy rule depends both on the structure of the economy and on the preferences of the central bank. These preferences, in turn, are described by a discount rate and by a set of relative weights for the loss function in equation (1). We consider a discount factor of 0.99 and four sets of weights for equation (1) and thus define four types of central banks. The "hawk" type (H) has inflation as its almost unique objective; the "dove" type (D) has as its objectives both inflation and the output gap; the objectives of the "strict condor" type (SC) are inflation and the current account deficit; and those of the "flexible condor" type (FC) include inflation, the current account deficit, and the output gap. We assume that all four central bank types dislike large changes in interest rates and therefore have $\mu_r > 0$. Table 1 presents the weights (μs) of the loss function for each of these central bank types.[14]

Table 2 presents the optimal reaction functions for each of the four types. Each column corresponds to the vector F', which, multiplied by the vector X_t, yields the optimal interest rate deviation for period (quarter) *t*. For example, if the central bank is of the hawk type, it will increase the (indexed) interest rate by 0.45 percentage point after a 1-percentage-point upward shock to inflation.[15]

Examining the dynamic reaction of the interest rate to alternative shocks is another way of analyzing optimal policy rules. These reactions show the path of interest rates that would prevail if the rule is followed and no other shocks occur, and thereby include reactions to expected future movements in other endogenous variables.

Figure 1 presents the path of interest rates between quarter 0 (on impact) and quarter 7 following different exogenous shocks. Besides the six basic (structural) shocks of the model, we consider a combined shock to output and the absorption-output gap, which can be thought of as the case of an overheated economy. The figure presents the reactions of the four central bank types to such a shock. The panels on the left show the reactions of central bank types H and P, whereas those on the right ones show the reactions of types SC and FC.

Table 1. Preference Parameters for the Four Central Bank Types

Type of central bank	μ_π	μ_{cc}	μ_y	μ_r
Hawk	0.95	0.00	0.05	0.10
Dove	0.50	0.00	0.50	0.10
Strict condor	0.65	0.30	0.05	0.10
Flexible condor	0.35	0.30	0.35	0.10

Source: Authors' definitions.

14. The central bank preferences are "deep" parameters unaffected by the structure of the economy (for example, the degree of indexation). The structure of the economy modifies the optimal reaction functions, not preferences.

15. Notice that the interest rate persistence depends on both the parameter for r_{t-1} and that for R_{t-1}.

Table 2. Optimal Policy Functions by Central Bank Type

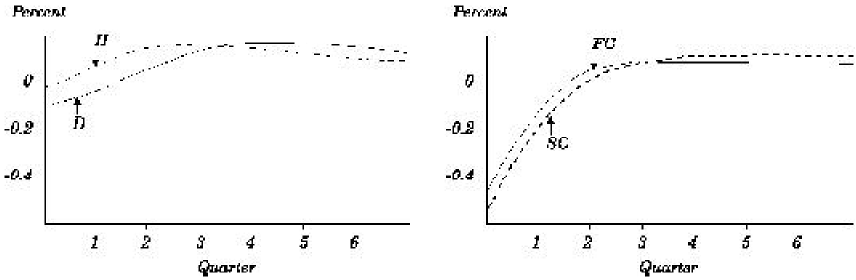
Variable	*Central bank type* Hawk	Dove	Strict condor	Flexible condor
tot_t	−0.02	−0.01	−0.11	−0.10
tot_{t-1}	0.02	0.03	0.05	0.05
tot_{t-2}	0.01	0.02	0.01	0.01
r_t^*	0.87	0.43	0.52	0.34
φ_t	0.72	0.32	0.43	0.27
q_{t-1}	−0.13	−0.06	−0.09	−0.06
q_{t-2}	−0.09	−0.04	−0.07	−0.04
q_{t-3}	−0.11	−0.05	−0.06	−0.04
π_t	0.45	0.28	0.24	0.17
π_{t-1}	0.32	0.19	0.17	0.11
π_{t-2}	0.19	0.11	0.10	0.07
π_{t-3}	0.09	0.05	0.04	0.03
y_t	0.57	0.60	0.31	0.33
y_{t-1}	0.12	0.07	0.06	0.04
r_{t-1}	0.28	0.12	−0.04	−0.07
R_{t-1}	−0.27	−0.37	−0.15	−0.20
y_t^d	0.00	0.00	0.13	0.12

Source: Authors' calculations.

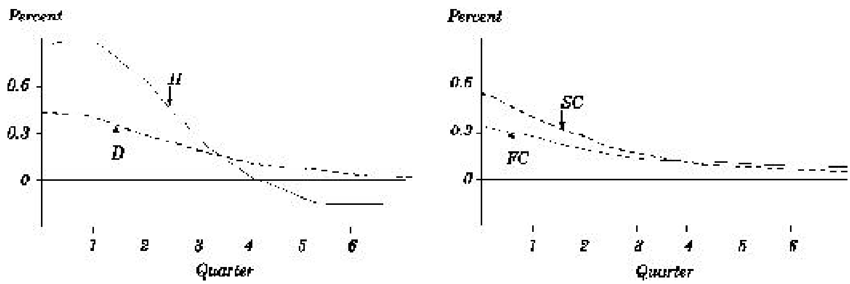
The results of table 2 and figure 1 have implications in at least three dimensions (besides the numerical results, which may be useful as a benchmark for policymaking). First, once the current account is part of the central bank's objectives, optimal policy reactions change in many respects, sometimes substantially. As expected, the SC and FC types respond to shocks to the absorption-output gap and to the terms of trade in a very different way than do types H and D. These two shocks have direct effects on the current account, for which the latter two central banks do not care. Interestingly, types SC and FC are less responsive to shocks to the international interest rate and the risk premium than types H and D, respectively. More important, when there is a target for the current account, monetary policy is clearly less aggressive in responding to shocks to inflation (compare type H with type SC) and to the output gap. All these differences are economically relevant.

Figure 1. Reaction Functions of Four Central Bank Types

5 percent schock to the terms of trade



1 percent schock to the real interest rate



1 percent schock to the country-risk premium

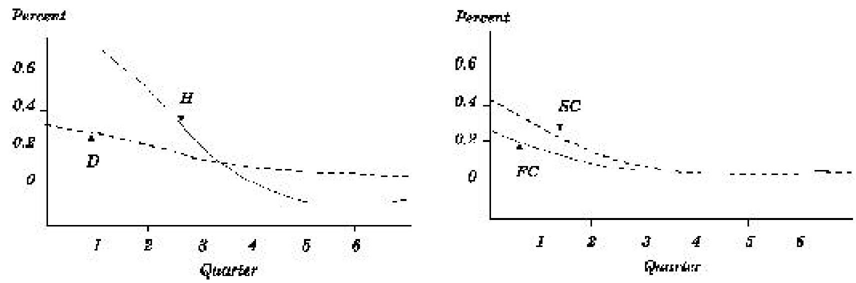
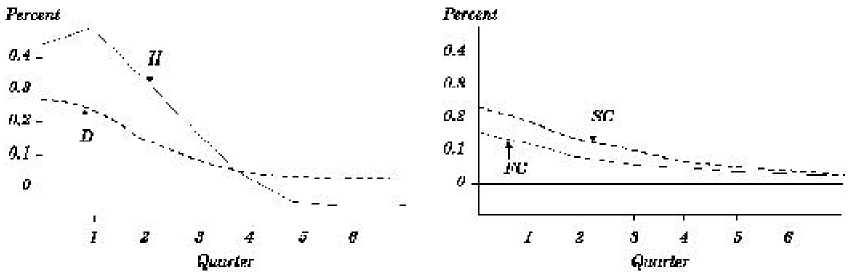
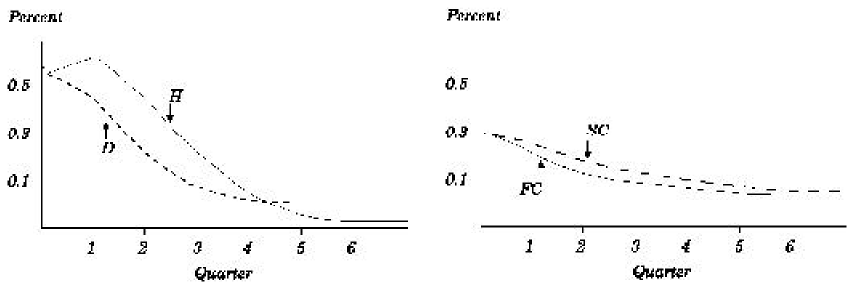


Figure 1. (Continued)

1 percent schock to the inflation gap



1 percent schock to the output gap



1 percent schock to the absorption-output gap

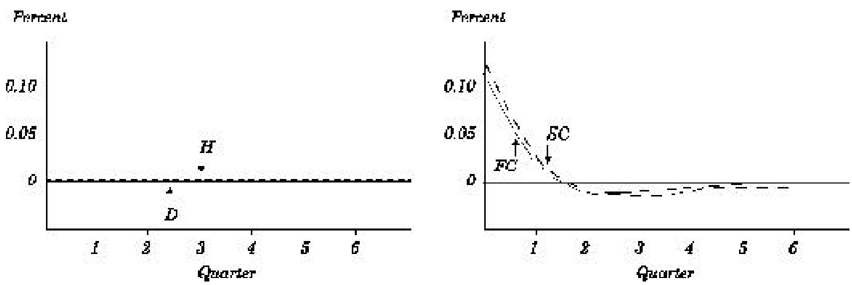
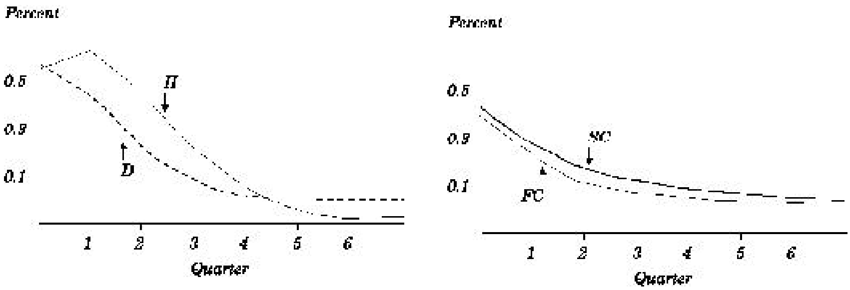


Figure 1. (Continued)

Simultaneous 1 percent schock to the output gap and the absorption-output gap



Source: Authors' calculations.

Second, the results show that, in general, reactions are less persistent for shocks that directly and indirectly affect the current account when the current account matters. This is probably due to the relatively lower persistence in the absorption-output gap in comparison to other variables. However, the reaction to inflation and output shocks is more persistent in types SC and FC than in types H and D.

Finally, the differences in optimal rules that arise when the central bank incorporates the output gap among its objectives are far less dramatic when the current account is already one of its objectives. Indeed, the differences between the reactions of types H and D are considerably more important than the differences between those of types SC and FC. One case in which this difference appears most clearly is in the dynamic central bank reaction to an inflation shock—probably the key issue in monetary policymaking. In this case type SC is only marginally more hawkish than type FC. Thus one can conclude that incorporating the output gap into the central bank's objectives does not appear to be crucial when the current account already matters. The intuition for this result is simple: the current account also presents a trade-off for monetary policy, because a more aggressive response to an inflation shock generates a larger current account deviation. However, for this result to hold, it is necessary to have a symmetric current account objective. The next section analyzes optimal policy reactions when this objective is asymmetric.

3. Optimal Monetary Policy with an Asymmetric Current Account Objective

Ultimately, behind the objective of keeping the current account under control is the notion that an "excessive" deficit usually brings about a serious balance of payments crisis, in which voluntary financing disappears and the economy enters a deep recession. The converse, however, is not true: too small a deficit is not considered to be a threat to external stability. But the loss function described by equation (1) is symmetric, treating positive and negative deviations as equally undesirable. Therefore the rules we have derived are, by construction, symmetric. This section investigates the implications for monetary policy of having an asymmetric loss function for the current account.

We analyze two issues that arise with asymmetric objectives. First, we investigate how much optimal reactions change, in response to both price and demand (current account) shocks. Second, we analyze whether optimal monetary policy changes when the volatility of shocks increases. We evaluate both how policy changes and the economic relevance of these changes.

Departing from the linear-quadratic framework (that is, from a symmetric current account objective) has the benefit of allowing for a more realistic loss function, but at the same time, it seriously complicates the problem. In the linear-quadratic problem we were able to find closed-form solutions of the form $r_t = FX_t$, whereas in this case we have to resort to numerical simulations. To be able to solve the central bank's problem, we have to simplify the model of the economy substantially. In particular, we calibrate a simple stochastic, two-equation, backward-looking economy with two state variables, namely, inflation and the absorption-output gap, and directly associate the latter with the current account deficit. For simplicity, we assume that a positive absorption-output gap has inflationary consequences.[16] Moreover, we do not consider any preferences over interest rate variability, nor do we consider bounds for possible interest rate values. Thus the rules we derive will in general prescribe a more aggressive

16. It should be stressed that this is a simplification. There is no reason for this gap to have direct inflationary consequences. What happens is that this gap is usually highly correlated with the output gap, which does affect inflation.

monetary policy than what a central bank would normally follow. Accordingly, rather than taking the quantitative results we derive at face value, they should be analyzed relative to the baseline scenario of rules for a symmetric current account objective (derived from a standard quadratic loss function).

3.1 A Simpler Economy

The economy is described by the following two equations:

$$\pi_t = \pi_{t-1} + \alpha_y y_{t-1}^d + \varepsilon_t^\pi \,, \quad \text{and} \tag{22}$$

$$y_t^d = \beta_y y_{t-1}^d + \beta_r r_{t-1} + \varepsilon_t^y \,, \tag{23}$$

where, as before, π_t is the inflation gap in period t, y_t^d is the absorption-output gap, r_t is the real (or indexed) interest rate (again measured as a deviation from its long-run trend), and ε_t^π and ε_t^y are serially uncorrelated mean-zero stochastic shocks. The quantities α_y, β_r, and β_y are constant parameters.

As before, the central bank's problem at time t is to choose a sequence of interest rates $\{r_{t+\tau}\}_{\tau=0}^{\infty}$ so as to minimize the intertemporal loss function in equation (2). Let x_t be the vector with the state variables, $x_t = (\pi_t, y_t^d)'$. We seek to characterize the interest rate sequence through a time-invariant (and probably nonlinear) policy function for a loss function of the following type:

$$l(x_t) = \begin{cases} a\pi_t^2 + b_L \left(y_t^d\right)^2 & \text{for } y_t^d \in (-\infty, 0) \\ a\pi_t^2 + b_H \left(y_t^d\right)^2 & \text{for } y_t^d \in (0, \infty), \end{cases} \tag{24}$$

where a, b_L, and b_H are positive constants. The asymmetric current account objective is described by $b_L < b_H$.

Therefore the central bank's problem is to set interest rates in order to minimize equation (2) with equation (24) subject to equations (22) and (23). We consider three alternative central bank types: quadratic, asymmetric, and one-sided. Table 3 presents the preference parameters of each. The quadratic central bank has the standard symmetric loss

Table 3. Loss Functions of Alternative Central Bank Types

	Central bank type		
Variable	*Quadratic*	*Asymmetric*	*One-sided*
a	1.00	1.00	1.00
b_L	0.50	0.20	0.00
b_H	0.50	0.80	1.00
δ	0.95	0.95	0.95

Source: Authors' definitions.

function, the asymmetric central bank cares considerably more about positive deviations of the current account from its target than about negative ones, and the one-sided central bank dislikes positive current account deviations (and inflation) only. In all cases, on average, there is a 2:1 weight relation between inflation and current account gap deviations.

We calibrate the model using the following parameter values: $\alpha_y = 0.5$, $\beta_y = 0.6$, $\beta_r = -0.5$, S.D.(ε_t^{π}) = 0.8 percent, S.D.(ε_t^{y}) = 0.8 percent, and zero covariance between shocks (where S.D. represents the standard deviation). These parameters are approximately in line with the estimation of equations (22) and (23) with Chilean data, with the caveat that we use the output gap in the former equation (see note 16).[17] The frequency of the real-world counterpart of the model can be thought of as being either quarterly or semiannual.

3.2 Solution

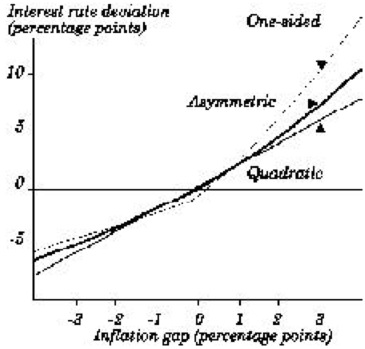
To solve the problem we discretize the economy along the lines followed by Medina and Valdés (2002) and apply standard dynamic programming techniques. It should be mentioned that this approximation yields quite accurate solutions for the linear-quadratic case.

Figure 2 shows the optimal policy functions for the central bank's problem under alternative combinations of inflation and the absorption-output gap. In each panel the x-axis shows a gap deviation, and the y-axis shows the optimal policy reaction (given by the interest rate deviation) of each of the central bank types.

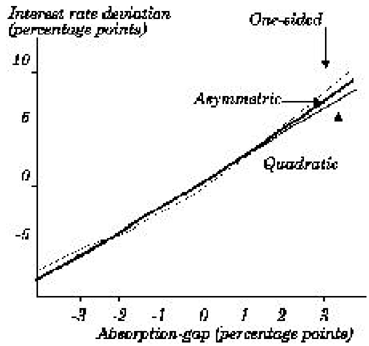
17. The estimation of equation (22) yields a considerably higher inflation volatility. However, as shown by Magendzo (1998), in Chile there is close relation between the level and the volatility of inflation. The estimation of the same equation using the difference between actual and long-run trend inflation yields a standard deviation of 0.2 percent.

Figure 2. Optimal Policy Functions with an Asymmetric Current Account Objective

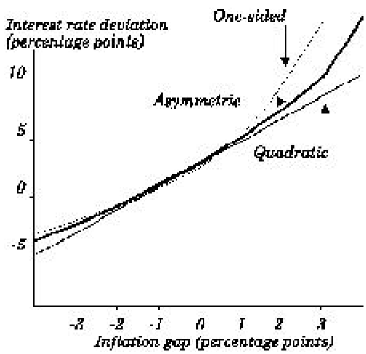
Reaction to inflation
Absorption-output gap = 0



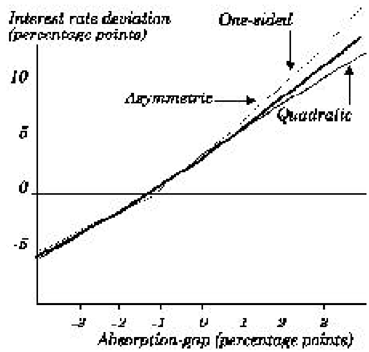
Reaction to absorption-output gap
inflation gap = 0



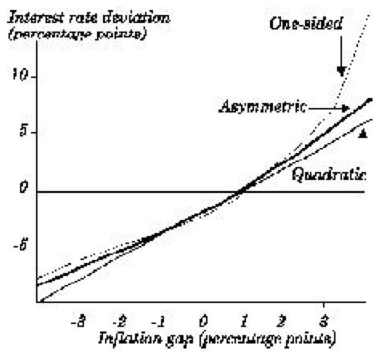
Reaction to inflation gap
absorption-output gap = 1



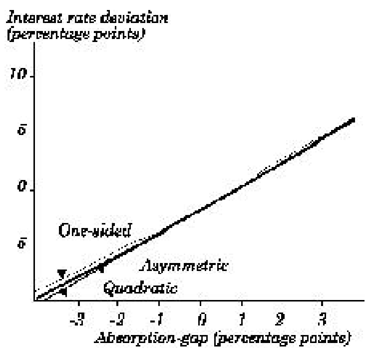
Reaction to absorption-output gap
inflation gap = 1



Reaction to inflation
absorption-output gap = −1



Reaction to absorption-output gap
inflation gap = −1



Source: Authors' calculations.

The results show two interesting features. First, and more important, the asymmetric current account objective generates a more aggressive response to positive inflation shocks. The intuition for this is straightforward: there is no trade-off involved. The differences are quite large. For example, if the current account gap is zero while the inflation gap is 3 percent, a one-sided central bank will increase interest rates by almost twice as much as the symmetric one, and an asymmetric central bank will increase them by one-third more than the symmetric one. In the case of negative inflation shocks, the asymmetry generates a less aggressive monetary policy (higher interest rates). Hence the two effects together imply that a central bank with an asymmetric current account objective can end up having inflation, on average, below its target.[18]

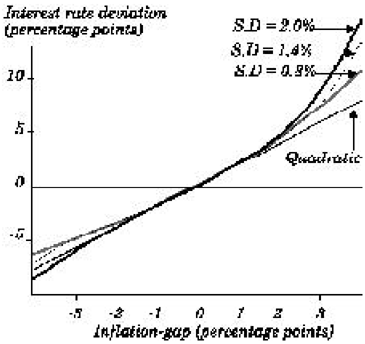
Second, at least for the case in which there is a negative or a zero inflation gap, the asymmetric current account objective does not greatly affect the optimal policy response to demand (current account) shocks. The reason for this result is that even if an expenditure gap does not matter directly, it can matter indirectly through its future impact on inflation, especially when inflation has a unit root. This is not the case if there is a positive absorption-output gap and a positive inflation gap. In this case monetary policy is more aggressive because the no-trade-off argument applies.

Figure 3 illustrates what happens to optimal policy reactions when the standard deviation of current account shocks increases. As one might expect, when the standard deviation rises from 0.8 percent (the baseline case) to 1.4 percent, the reactions of the central bank are more aggressive against inflation. However, these changes are not of great economic relevance. Only when the standard deviation rises to 2 percent do the differences start to become important, although they still are less important than the differences created by the asymmetry itself. In the case of negative inflation shocks, we find that a higher volatility of shocks also makes monetary policy more aggressive. One possible explanation is that when the inflation gap is very negative, a higher demand volatility risks a movement toward an even more negative gap (through a Phillips curve effect). Acting preemptively, when volatility is higher, monetary policy tries to return inflation to its target faster. Again, however, the differences are not that relevant from an economic perspective.

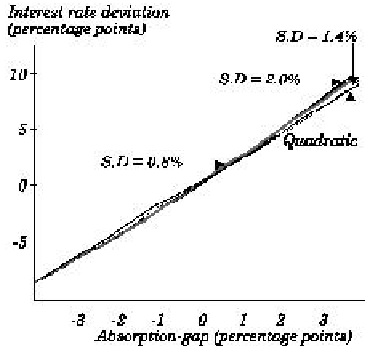
18. Of course, one can argue that the bias is for (not against) inflation if the counterfactual is a central bank with no current account objective at all.

Figure 3. Effects of Volatility on Optimal Policy Functions with an Asymmetric Current Account Objective

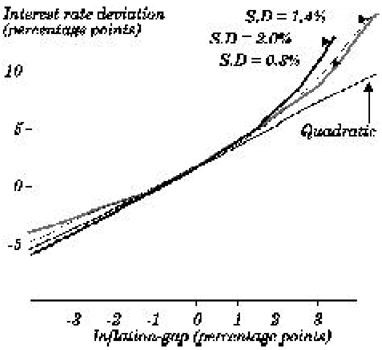
Reaction to inflation
absorption-output gap = 0



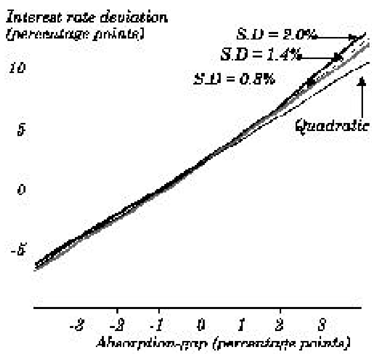
Reaction to absorption-output gap
inflation gap = 0



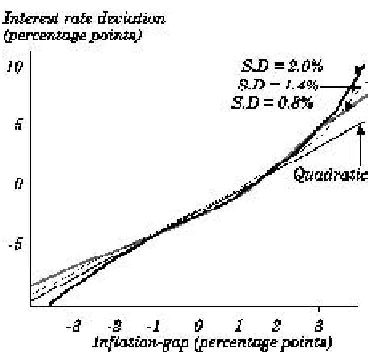
Reaction to inflation gap
absorption-output gap = 1



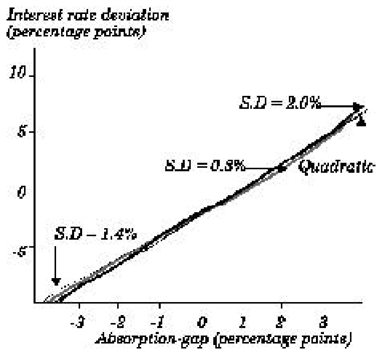
Reaction to absorption-output gap
inflation gap = 1



Reaction to inflation
absorption-output gap = −1



Reaction to absorption-output gap
inflation gap = −1



Source: Authors' calculations.

4. Concluding Remarks

This paper has presented two different models in order to analyze the implications for monetary policy of having a target for the current account deficit among the central bank's objectives. The first model is a simple linear-quadratic model estimated (or calibrated) for the Chilean economy with several state variables, some of which are forward-looking. The second model is a simple two-equation model in which the monetary authority has an asymmetric objective for the current account.

The analysis of this realistic linear-quadratic economy indicates that including the current account in the central bank's objectives has important consequences for optimal policy reactions. Interest rates become less reactive to shocks to inflation and the output gap and, as expected, more reactive to shocks that directly affect the current account. For example, the optimal reaction to a terms-of-trade shock is completely different once the central bank cares about the current account.

Furthermore, the results show that optimal monetary rules change much less when the central bank incorporates the output gap among its objectives if it already has a target for the current account among those objectives. Therefore, although the discussion of incorporating unemployment in the central bank's objectives is highly relevant in Chile, it is considerably less so than in a country in which the central bank has no current account objectives. Of course, this result hinges on having a symmetric objective for something that offers a trade-off to rapid inflation control.

The asymmetric nature of the current account objective has important consequences for optimal policy reactions against inflation shocks. Compared with the case of a symmetric current account objective, monetary policy is considerably tighter when the objective is asymmetric. When the volatility of current account shocks increases and the central bank has an asymmetric current account objective, monetary policy becomes more aggressive (that is, more reactive). This last change, however, is quantitatively less important from an economic perspective.

APPENDIX A

Model Estimation and Calibration

This appendix describes the estimation results and calibration for the Chilean economy of the model presented in the text. The data are of quarterly frequency, and the sample size varies according to data availability.

For the risk premium equation, we assume an AR(1) parameter of 0.90, equal to that estimated for the international interest rate. We calibrate the current account gap equation with a log Taylor expansion in 1997 (see text for details). We estimate the inflation equation using a specification in terms of levels, with international inflation (which includes nominal depreciation, foreign inflation, and changes in value added taxes and tariffs) among the explanatory variables, and we impose homogeneity in prices. We then modify the equation incorporating the inflation target and the RER. In the output equation we assume elasticities with respect to the RER and estimate the rest of the parameters. Here and in appendix B we denote the conditional expectation $\mathrm{E}\left(x_{t+\tau} \mid \Omega_t\right)$ as $x_{t+\tau|t}$.

A.1 Terms of Trade

The estimated equation for the terms of trade is

$$tot_t = \underset{(21.4)}{\underset{0.86}{\rho_{tot}}} \, tot_{t-1} + \underset{(-3.7)}{\underset{-0.53}{\rho^r_{tot}}} \, r^*_{t-1} + \xi^{tot}_t .$$

The method of estimation is ordinary least squares (OLS), the sample period is 1977 Q2 to 1998 Q2, and robust Newey-West t tests are used. The $\overline{R}^2$ of the equation = 0.85, the F statistic = 237.4, and the Durbin-h statistic = 1.19.

A.2 International Real Interest Rate

The estimated equation for the international real interest rate is

$$r^*_t = \underset{(18.8)}{\underset{0.90}{\rho_r}} \, r^*_{t-1} + \xi^r_t .$$

The estimation method is OLS, the sample period is 1977 Q2 to 1998 Q2, and robust Newey-West *t* tests are used. The $\overline{R}^2$ of the equation = 0.84, the *F* statistic = 443.0, and the Durbin-*h* statistic = 2.30.

A.3 Country Risk Premium Calibration

The country risk premium is calibrated as follows:

$$\varphi_t = \underset{0.90}{\rho_\varphi} \varphi_{t-1} + \xi_t^\varphi .$$

A.4 Inflation (Levels)

The estimated equation is

$$\begin{aligned}
\pi_t - \pi_{t-1} &= \underset{\substack{0.41 \\ (3.4)}}{\psi_0} \left[\left(\pi_{t-2} + \pi_{t-3} + \pi_{t-4} \right) / 3 - \pi_{t-1} \right] \\
&+ \underset{\substack{0.29 \\ (2.0)}}{\psi_1} \left[\left(\pi_{t+1 | t-1} + \pi_{t+2 | t-1} \right) / 2 - \pi_{t-1} \right] \\
&+ \underset{\substack{0.15 \\ (2.3)}}{\psi_2} \left[\left(p^*_{t-1} + e_{t-1} - p^*_{t-4} - e_{t-4} \right) / 3 - \pi_{t-1} \right] \\
&+ \underset{\substack{0.39 \\ (2.1)}}{\psi_3} \left(y_{t-1} + y_{t-2} \right) / 2 + \underset{\substack{0.08 \\ (6.2)}}{\psi_4} D912 + \underset{\substack{1.97 \\ (2.1)}}{\psi_5} DTax + \xi_t^\pi .
\end{aligned}$$

The method of estimation is two-stage least squares (TSLS), the sample period is 1988 Q3 to 1998 Q4, and robust Newey-West *t* tests are used. The $\overline{R}^2$ of the equation = 0.59, and the *F* statistic = 11.52. The inflation target, wages, R_{t-1} , and lags are used as instruments.

A.5 Inflation Gap (Transformation)

The equation is as follows:

$$\pi_t = \underset{0.20}{\alpha^0_{\pi L}} \pi_{t-1} + \underset{0.37}{\alpha^1_{\pi L}} \left(\pi_{t-2} + \pi_{t-3} \right)/2 + \underset{0.14}{\alpha^2_{\pi L}} \pi_{t-4} + \underset{0.29}{\alpha_{\pi F}} \left(\pi_{t+1 \mid t-1} + \pi_{t+2 \mid t-1} \right)/2$$

$$+ \underset{0.60}{\alpha_q} \left(q_{t-1} - q_{t-4} \right)/3 + \underset{0.39}{\alpha_y} \left(y_{t-1} + y_{t-2} \right)/2 + \xi^{\pi}_t .$$

A.6 Long-Term Real Interest Rate

The estimated equation is as follows:

$$R_t = \underset{\substack{0.13 \\ (2.1)}}{\lambda} r_t + \underset{\substack{0.87 \\ (18.8)}}{\left(1 - \lambda \right)} R_{t+1 \mid t} .$$

The estimation method is TSLS, the sample period is 1987 Q3 to 1998 Q4, and robust Newey-West t tests are used. The $\overline{R}^2$ of the equation = 0.74, the F statistic = 110.1, and the Durbin-Watson statistic = 1.64. Instruments used are π_t, y^d_t, tot_t, and lags.

A.7 Output Gap

The estimated equation is as follows:

$$y_t = \underset{\substack{0.61 \\ (11.1)}}{\beta_y} y_{t-1} + \underset{\substack{-0.97 \\ (-3.3)}}{\beta_R} \left(R_{t-1} + R_{t-2} \right)/2 + \underset{\substack{-0.28 \\ (-1.7)}}{\beta_r} r_{t-2} + \underset{\substack{0.04 \\ (4.2)}}{\beta_{tot}} \left(tot_{t-2} + tot_{t-3} \right)/2$$

$$+ 0.005 q_{t-1} + 0.010 q_{t-2} + 0.015 q_{t-3}$$

$$+ 0.020 q_{t-4} + \xi^y_t .$$

The method of estimation is OLS, the sample period is 1987 Q3 to 1998 Q4, and robust Newey-West t tests are used. The $\overline{R}^2$ of the equation = 0.57, the F statistic = 16.1, and the Durbin-h = -0.72.

A.8 Absorption-Output Gap

The estimated equation is as follows:

$$y_t^d = \underset{(2.4)}{\underset{0.29}{\gamma_d}} y_{t-1}^d + \underset{(-3.3)}{\underset{-0.91}{\gamma_r}} \left(r_{t-1} + r_{t-2}\right)/2 + \underset{(-0.05)}{\underset{-0.02}{\gamma_{q1}}} q_{t-1} + \underset{(-0.08)}{\underset{-0.02}{\gamma_{q2}}} q_{t-2} + \underset{(-2.0)}{\underset{-0.03}{\gamma_{q3}}} q_{t-3} + \underset{(-0.3)}{\underset{-0.02}{\gamma_{q4}}} q_{t-4}$$

$$+ \underset{(4.2)}{\underset{0.08}{\gamma_{tot}}} tot_{t-2} + \xi_t^d .$$

The method of estimation is OLS-PDL for q, the sample period is 1986 Q2 to 1998 Q4, and robust Newey-West t tests are used. The $\overline{R}^2$ of the equation = 0.49, the F statistic = 11.1, and the Durbin-h = 0.85.

A.9 Current Account Gap Calibration

The calibration of the current account gap is as follows:

$$cc_t = -y_t^d + \underset{0.02}{k_0} q_t - \underset{0.02}{k_0} y_t + \underset{0.30}{k_1} tot_t .$$

The calibration is based on a log Taylor expansion with 1997 as the base year.

A.10 Uncovered Interest Rate Parity

The equation is as follows:

$$q_t = q_{t+1|t} + 0.25\left(r_t^* + \varphi_t - r_t\right).$$

Appendix B

State-Space Representation

This appendix shows how to write the model in the state-space form. As noted by Svensson (2000), given rational expectations, the inflation gap has the following behavior:

$$\pi_{t+1} = \pi_{t+1|t} + \xi^{\pi}_{t+1} .$$

Moreover, shifting the inflation equation one period forward and taking expectations based on information up to time *t*, one arrives at an equation that can be solved for $\pi_{t+3|t}$ as a function of known variables and of $\pi_{t+2|t}$ and $\pi_{t+1|t}$. With these considerations one can write the matrix A of equation (15) in the following way:

$$A = \begin{bmatrix} \rho_{tot}E_1 + \rho^r_{tot}E_4 \\ E_1 \\ E_2 \\ \rho_r E_4 \\ \rho_\varphi E_5 \\ E_{19} \\ E_6 \\ E_7 \\ E_{20} \\ E_9 \\ E_{10} \\ E_{11} \\ A_{13} \\ E_{13} \\ 0 \\ E_{18} \\ A_{17.} \\ [1/(1-\lambda)]E_{18} \\ E_{19} - 0.25E_4 - 0.25E_5 \\ E_{21} \\ A_{21.} \end{bmatrix},$$

where E_j represents a $1 \times n$ row vector with 1 in position j and zeros otherwise, and $A_{j\cdot}$ is row j of matrix A. Furthermore,

$$A_{13\cdot} = \beta_y E_{13} + \beta_R \left(E_{16} + E_{18} \right)/2 + \beta_r E_{15} + \beta_{tot} \left(E_2 + E_3 \right)/2 + \beta_{q1} E_{19} + \beta_{q2} E_6 + \beta_{q3} E_7 + \beta_{q4} E_8 \ ,$$

$$A_{17\cdot} = \gamma_d E_{17} + \gamma_r E_{15}/2 + \gamma_q \left(E_6 + E_{19} \right)/2 + \gamma_{tot} E_2 + \gamma_{q1} E_{19} + \gamma_{q2} E_6 + \gamma_{q3} E_7 + \gamma_{q4} E_8 \ ,$$

and

$$A_{21\cdot} = \frac{2}{\alpha_{\pi F}} \begin{bmatrix} E_{20} - \alpha_{\pi L}^0 E_9 - \alpha_{\pi L}^1 \left(E_{10} + E_{11} \right)/2 - \alpha_{\pi L}^2 E_{12} - \alpha_{\pi F} E_{21}/2 \\ - \alpha_q \left(E_{19} - E_8 \right)/3 - \alpha_y \left(E_{13} + E_{14} \right)/2 \end{bmatrix}.$$

The B vector, in turn, is given by

$$\left[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, \gamma_r/2, -\lambda\left(1-\lambda\right), 0.25, 0, 0 \right]'.$$

The $\mathbf{C}_Z$ matrix and the $\mathbf{C}_r$ vector of equation (16) are given by

$$C_Z = \begin{bmatrix} E_9 \\ -E_{17} - k_0 E_{19} + k_0 E_{13} + k_1 E_1 \\ E_{13} \\ -E_{15} \end{bmatrix} \quad \text{y} \quad C_r = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}.$$

Finally, the K matrix of equation (17) is given by

$$K = \begin{bmatrix} \mu_\pi & 0 & 0 & 0 \\ 0 & \mu_{cc} & 0 & 0 \\ 0 & 0 & \mu_y & 0 \\ 0 & 0 & 0 & \mu_r \end{bmatrix}.$$

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