

# NEW FRONTIERS FOR MONETARY POLICY IN CHILE

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Inflation targeting can be broadly defined as a framework for the conduct of monetary policy, in which the central bank guides its instruments in order to hold inflation near a preannounced target or to bring back to the target.<sup>1</sup> Although understanding the framework is straightforward, its practical implementation is not. In the real world, central bankers can practice only a rough version of the Tinbergen-Theil targets-and-instruments approach to economic policy. Knowledge of the monetary policy transmission mechanism (magnitudes and lags) is imperfect, achieving consensus on any moment of the probability distribution of exogenous variables is very difficult, and there is no single objective function in society or even at the central bank for authorities to optimize. However, autonomous central banks must make decisions based on this imperfect set of information and then convincingly explain the rationale for those measures to financial markets, the legislature, and the general public.

This paper focuses on some of the practicalities of implementing inflation targets, using empirical evidence for Chile. The goal is to find evidence on which type of monetary policy rule is likely to be efficient

We thank Rómulo Chumacero for insightful comments and Leonardo Luna for his outstanding assistance and dedication.

1. The framework usually includes other ingredients such as a strong commitment to the primary objective of controlling inflation, an increase in transparency and accountability, direct and abundant communication with the public, and reliance on a broad set of indicators.

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in Chile when used as a guideline for monetary policy. Several issues are relevant. Should monetary policy react to unemployment or the output gap in this framework? If so, how much should it react? Should it focus on current headline inflation, core inflation, or a forecast of either one? If a forecast, over what horizon? Should the Central Bank tighten monetary policy when faced with a hike in oil prices? Should it track changes in the international interest rate and the sovereign risk premium, or should it lean against them? What should be the role of the exchange rate in the monetary policy rule? All of these questions have arisen at one point or another in the implementation of inflation targeting in Chile, and none can be answered without a specific model that describes the mechanics of the economy.

To analyze these issues, we construct a small macroeconomic model of the Chilean economy, which allows us to calculate the performance of alternative monetary policy rules through stochastic simulation. We use these simulations to calculate the levels of volatility of both inflation and output that result from a series of alternative monetary policy rules, given a fixed distribution for exogenous shocks. On the basis of these volatilities, it is possible to assess, for instance, whether monetary policy gains in efficiency by reacting to the output gap even when inflation is the central bank's sole objective.

We use these same volatilities to calculate the envelope of efficiency frontiers for different families of policy rules and to evaluate whether it is possible to gain efficiency through simple changes in the monetary policy reaction function, regardless of preferences on the volatility and persistence of inflation and output levels or the degree of activism associated with the policy. In particular, we evaluate whether it is convenient to react to core instead of headline inflation, to react to inflation forecasts instead of actual inflation, or to include the cost of international finance (both the sovereign spread and the relevant interest rate).

This exercise parallels similar studies undertaken for other countries that target inflation.<sup>2</sup> All of these studies evaluate the efficiency of simple monetary policy rules in the context of specific models and check their robustness across different models (Levin, Wieland, and Williams, 1999). In some respects, our results parallel those found for industrial countries. However, verifying the robustness of simple monetary policy rules in Chile requires paying special attention to specific features of the Chilean economy, such as the degree of economic openness, the volatility of supply shocks, and the extent of price and wage indexation.

2. For example, see Rudebusch and Svensson (1999); Batini and Haldane (1999).

Some related research for the case of Chile can be found in Valdés and Medina (2000a, 2000b). Some important differences must be emphasized, however. First, the search for optimal, as opposed to efficient, rules hinges on the definition of the appropriate loss function to be maximized. This is a particularly difficult issue to settle within central banks. Second, focusing on the efficiency of different rules shifts the focus from preferences to outcomes. For example, including the output gap in the central bank's loss function goes against many preconceived notions of how an autonomous monetary policy should be conducted. Including the output gap in the policy rule is much less debatable, however, due to the impact of aggregate demand conditions on inflationary pressures.

The macroeconometric model we use in this paper is a simple open-economy, IS-LM-AS model with rational expectations. It is simple enough to allow us to track the key parameters that influence some of the results. The model comprises five main equations: an output equation; a forward-looking long-term interest rate; an exchange rate equation based on uncovered interest rate parity; a forward-looking accelerationist Phillips curve for core inflation; and a monetary policy rule. The model also includes some simple pricing rules for noncore items in the consumer price index (CPI), such as fuels and perishables. Uncertainty takes into account both equation innovations and innovations in exogenous variables such as world output, international interest rates, sovereign spreads, terms of trade, oil prices, and fiscal policy.

By construction, the model assumes perfect credibility in that it includes rational expectations and a known monetary policy rule. It therefore cannot address issues such as lack of confidence in macroeconomic management. In our opinion, however, this limitation is relevant only when inflation is converging toward a steady-state level, and not when it is at its steady-state level. Indeed, discussing whether monetary policy should react to core or headline inflation is essentially irrelevant when the inflation targeting framework is on a converging path. In that case, credibility issues take precedence. The contrary happens when inflation has already converged to its steady-state level. A second caveat is that the model used to carry this exercise grants us only partial immunity from the Lucas critique. It includes an explicit expectations component in the inflation, exchange rate, and interest rate equations. Some parameters, however, such as the degree of indexation, the backward-looking component in the price equation, and the dynamics of the exchange rate pass-through, may also depend on the monetary policy framework.

The paper is organized as follows. Section 1 describes the model we use. Section 2 discusses the comparative efficiency of some prototypical monetary policy rules. This section then generalizes the analysis to a fuller set of parameters for defining each monetary policy rule, and it evaluates whether focusing on headline, forecast, or core inflation yields better results and whether reactions to international interest rates improve monetary policy efficiency. The final section presents the main conclusions and directions for future work.

## **1. A SMALL MACROECONOMIC MODEL FOR THE CHILEAN ECONOMY**

This paper relies on a small macroeconometric model along the lines of an open-economy, IS-LM-AS model with rational expectations. As such, the model shares many of the strengths and pitfalls of short-term, aggregate-demand-driven models. It centers on empirically based equations that are not explicitly derived from first principles. Recent research on dynamic neo-Keynesian (DNK) models shows, however, that the version of the IS-LM-AS model that results from combining an intertemporal Euler equation for aggregate demand with the new Phillips curve effectively embeds Calvo-style price setting and rational expectations.<sup>3</sup>

The model abstracts from many of the transmission channels of monetary policy, but it emphasizes three areas: the effect of monetary policy on the level and structure of market interest rates and its subsequent impact on aggregate demand pressures and inflation; the role of exchange rate dynamics in imported inflation; and expectations with regard to asset prices and inflation. The model excludes other channels of monetary policy, most notably the impact on credit and money markets. Similarly, it does not consider the effect of monetary policy on asset prices other than the exchange rate and long-term bonds. This leaves an important area for future research. The role of the credit channel in an open economy, in particular, requires further analysis. The recent international financial crises highlight the importance of these transmission channels, including the balance sheet effect. Although the discipline has made theoretical progress on these issues, there is still a clear need for an adequate empirical counterpart for policy evaluation.

3. For example Clarida, Galí, and Gertler (1999).

### 1.1 Basic Structure<sup>4</sup>

The output equation (the IS curve) relates the difference between quarterly growth of gross domestic product (GDP) and its trend to the deviations from steady state of a set of domestic and external variables. The domestic variables include real interest rates (both short  $r$  and long  $R$ ), the real exchange rate,  $e$ , fiscal policy,  $f$ , and the lagged output gap. The external variables consist of international real interest rates adjusted for Chile’s sovereign spread,  $r^*$ , the growth of the terms of trade,  $tt$ , and GDP growth of Chile’s five main trading partners,  $y^*$ . In the following equation, all variables are in logs; overbars indicate trend or equilibrium values. The specific lag structure (not shown) was chosen according to statistical significance, using Newey-West standard errors.

$$\begin{aligned} \Delta y = \Delta \bar{y} &- 0.16(y - \bar{y})_{-1} - 0.50(r_{-1} - \bar{r}) - 0.54(R_{-2} - \bar{R}) - 0.49(r^* - \bar{r}^*)_{-2} \\ &\quad (-1.83) \quad (-4.00) \quad (-1.71) \quad (-3.52) \\ &+ 0.98(\Delta y - \Delta y^*)_{-2} + 0.22f_{-1} + 0.08(e - \bar{e})_{-3} - 0.38\Delta y_{-1} - 0.17\Delta y_{-2} \\ &\quad (3.61) \quad (2.22) \quad (2.29) \quad (-3.12) \quad (-1.37) \end{aligned}$$

OLS estimation

Newey-West t-stats in parenthesis 1990–98

Adjusted R<sup>2</sup> = 0.52

MSE = 1.16%

LM serial correlation test: F = 0.094 (p-value 0.984)

Estimation period: 1987:1–2001:2

Several modeling assumptions are noteworthy. First, the level of real interest rates (short, long, and foreign) affects the rate of change of output. At first glance, this is conceptually similar to the dynamic neo-Keynesian version of an IS curve, but we do not include the expected output level on the right-hand side (doing so would be theoretically consistent with a Euler equation).

Second, the real exchange rate misalignment (instead of its rate of change) has an impact on growth. This implies that the exchange rate has an expansionary impact on aggregate demand when it is above its equilibrium or fundamental value (that is, when it is overdepreciated).

4. The equations shown below are estimates of the corresponding equations. The specific parameters used for calibration are available upon request.

Third, the current cyclical position acts as either a brake or an accelerator: growth is higher when the economy is recovering from a downturn. This allows for mean reversion in growth rates toward full employment, assuming that output is not a unit root. Although the coefficient on this term in the equation is imprecisely estimated, we impose mean reversion. Otherwise, monetary policy would have permanent effects on the economy.<sup>5</sup>

Fourth, although capital flows are not modeled, the international interest rate has a very strong effect. This can be interpreted either as a proxy for capital inflows and outflows or as a reflection of a segmented market for investment finance, in which larger firms tap the dollar-denominated international bond markets while smaller firms are restricted to domestic financing.

Fifth, the equation shows negative autocorrelation, which implies that output overshoots policy shifts in the short term. The trend effects are around half the instantaneous impact. This is a feature of using first differences of output as the dependent variable. Indeed, annual rates of change tend to exhibit positive serial correlation, which obscures short-term dynamics.

As mentioned above, the model does not focus on money demand as an important transmission channel. Thus, instead of having an LM block, the model includes a relation between short- and long-term real rates that is determined by a variant of the rational expectations hypothesis, as in Herrera and Magendzo.<sup>6</sup> The exclusion of the LM curve is not a substantial deviation from traditional Keynesian modeling.<sup>7</sup> The relationship implies that current long-term rates provide information about the future path of short-term rates. There is widespread evidence, however, on the failure of the yield-curve hypothesis in its simplest form. This failure is reflected by the existence of a risk premium (or maturity premium) that affects the slope of the yield curve, which can also be autocorrelated.<sup>8</sup> The autocorrelation is probably due to the lack of liquidity in Chile's financial markets.

In practice, the model assumes an exogenously given maturity premium, relating short- and long-term rates in equilibrium:  $\bar{R} = \bar{r} + \zeta$ .

5. Chumacero (2000) shows strong evidence against a unit root in output for the case of Chile.

6. Herrera and Magendzo (1997).

7. Romer (2000) shows how one can have a model without the LM curve, but with a policy rule. This is precisely the kind of framework that we follow.

8. For evidence for the Chilean economy, see Fernández (2000).

The dynamics of long-term rates are given by the following equation, with parameters obtained through instrumental variables estimation:

$$R = \bar{R} + 0.28(R_{-1} - \bar{R}) + 0.60(R_{+1} - \bar{R}) + 0.03(r - \bar{r})$$

(5.50)                      (12.49)                      (2.24)

GMM estimation

Newey-West t-stats in parenthesis

Adjusted  $R^2 = 0.77$

MSE = 3.21%

Estimation period: 1986:2–2001:4

Hence, leads and lags of the long-term rate, as well as the monetary policy stance, determine long-term rates. On solving this equation forward, and assuming that  $R(-1) = R$ , we find that the current deviation of the long-term rate from its steady-state value reflects the discounted sum of expected future deviations of the policy stance from its neutral position. In the short run, the interest rate dynamics display some degree of inertia.

Even in the long run, exchange rates can deviate substantially from purchasing power parity. Moreover, uncovered interest rate parity fails miserably at tracking the dynamics of monetary policy and exchange rates in the short run. This poses a challenge for exchange rate modeling. We take a pragmatic approach, allowing convergence of the real exchange rate to its long-run equilibrium while at the same time incorporating overshooting dynamics and some inertia:

$$e = 0.23e_{-1} + 0.63e_{+1} + 0.14\bar{e} + (r^* - r)$$

(2.16)                      (5.80)

IV estimation

Adding-up restriction on lag, lead and equilibrium exchange rate coefficients

Uncovered interest parity imposed

Newey-West t-stats in parenthesis

Adjusted  $R^2 = 0.90$

MSE = 3.48%

LM serial correlation test (4 lags):  $F = 1.098$  (p-value 0.367)

Estimation period: 1986:2–2001:2

Assuming  $e = e(-1)$ , this equation demonstrates that the current deviation of the real exchange rate from its fundamental or long-run

value is equal to the discounted sum of expected real interest rate differentials. In the short run, however, a degree of inertia affects the dynamic adjustment.

The model determines core CPI inflation,  $\pi^x$ , through an accelerationist Phillips curve, which implies that

$$\begin{aligned} \Delta\pi^x = & -0.0001 + 0.43 \sum_{i=2}^4 \frac{\pi_{i-1}^x - \pi_{i-2}^x}{3} + 0.27 \sum_{i=1}^2 \frac{\pi_{i-1}^x - \pi_{i-2}^x}{2} + 0.06(\Delta\varepsilon + \pi^* - \pi_{-1}) + 0.54\Delta VAT \\ & (-0.43) \quad (3.35) \quad (2.30) \quad (1.61) \quad (2.70) \\ & + 0.08(\bar{y} - \bar{y}) + 0.04 \sum_{i=3}^5 \frac{\pi_{i-1}^x - \pi_{i-2}^x}{3} + 0.13 \sum_{i=4}^6 \frac{\pi_{i-1}^x - \pi_{i-2}^x}{3} + 0.24(\pi - \pi^*)_{-1} \\ & (2.03) \quad (0.30) \quad (1.24) \quad (1.40) \end{aligned}$$

#### IV estimation

Newey-West t-stats in parenthesis

Adjusted  $R^2 = 0.47$

MSE = 0.69%

LM serial correlation test:  $N R^2 = 5.705$  (p-value 0.222)

Estimation period: 1986:4–2001:2

Core inflation is thus related to its own lags and leads, and imported inflation is given by the sum of nominal exchange rate devaluation and foreign (dollar) inflation. The equation is homogeneous to the first degree in these determinants, reflecting long-term neutrality.

Two other factors influence core CPI inflation. One is the output gap. This is obviously a reduced form, whereas a more general framework would include wage setting and unemployment as determinants. A positive output gap tends to accelerate inflation, and the coefficient might very well depend on the level of inflation itself. The slope of the Phillips curve thus changes with disinflation. The coefficient shown in the equation is consistent with the current level of inflation in Chile. The output gap's impact on inflation could also be affected by the existence of speed limits, which implies a convex Phillips curve. That is, if the output gap rises above a certain threshold, inflation shoots up at a much faster rate. Conversely, it is hard to deflate below a certain negative output gap.

The second factor is the gap between headline and core inflation. Direct indexation of core inflation is already reflected through the inclusion of a lag. In Chile, however, prices such as wages and housing rents are commonly indexed to headline inflation. Noncore CPI shocks are likely to feed back into core inflation through this indexation process.

The model takes an ad hoc approach to markups, assuming that they are a constant fraction of total costs.

Noncore CPI items include products such as fuels, regulated services, and perishables, which follow simple price-setting rules. In the case of fuels, for example, these take the form of the law of one price for long-run prices. The short-term dynamics, on the other hand, are calibrated through an error correction model, based on exploratory regressions. A similar approach is used with regulated services and utilities, which depend on fuel prices as well as the exchange rate. For perishables, we assume a constant growth rate of 3 percent to allow for transitory deviations along the lines of an error correction mechanism, as in the case of fuels.

To close the model, we specify the conduct of the central bank in terms of a generic policy rule:

$$r - \bar{r} = \theta \left\{ (\gamma / \tau) \sum_{i=0}^{\tau} [\lambda \pi_{4,+i} + (1 - \lambda) \pi_{4,+i}^x - \bar{\pi}_4] + (1 - \gamma)(y - \bar{y}) \right\} + \eta(r^* - \bar{r}^*) + \rho(r_{-1} - \bar{r})$$

This rule is general enough to allow for a wide choice of parameters for determining monetary policy reactions. It accommodates different degrees of anti-inflationary zeal, for example, which is captured by the parameter  $0 < \gamma < 1$ , and varying levels of activism, given by  $\theta > 0$ . The latter indicates the size of the interest rate reaction to weighted deviations of output and inflation from their targets, while the former represents the relative weight of inflation in the monetary policy rule. This does not necessarily imply that output per se is an argument in the central bank's implicit loss function. However, it is consistent with the case in which the central bank either targets full employment or is concerned about the volatility of output around this long-run trend. A very different set of issues arises if the central bank targets a level of output that is inconsistent with full employment.

This rule also encompasses different horizons,  $\tau$ , for evaluating whether inflation is on target. Although the inflation target itself is defined in terms of headline inflation, this rule allows for the use of a weighted average of core and headline inflation (given by  $0 < \lambda < 1$ ) to determine the reaction of monetary policy.

Monetary policy is also allowed to respond to international interest rates (adjusted for risk premium), thereby possibly smoothing the inflationary or deflationary impact of this variable. Two forces are at play in a framework of floating exchange rates. On the one hand, movements in international interest rates tend to affect the exchange rate in the short run and also possibly in the long run. On

the other hand, international interest rates have a strong effect on domestic activity, which operates in the opposite direction in terms of inflationary consequences. It is not easy, therefore, to pinpoint the sign of  $\eta$  in advance.

Finally, the persistence of the policy stance is measured by  $0 < \rho < 1$ : if  $\rho = 0$ , then deviations of the policy interest rate from a neutral stance are completely transient in nature; if  $\rho = 1$ , then changes in the policy stance are fully persistent, and monetary policy does not revert to its neutral state.

## 1.2 Five Families of Policy Rules

The database and model are calibrated to yield a steady-state path for all the variables, which are broadly defined to conform with the current macroeconomic situation in Chile. We further define five families of policy rules to reflect whether monetary policy targets core or headline inflation, whether it focuses on current or forecast deviations from the target, and whether it shadows international interest rates. In terms of the notation of the model above, these cases are as follows: Current headline targeting (CH),

$$r - \bar{r} = \theta \left[ \gamma(\pi_4 - \bar{\pi}_4) + (1 - \gamma)(y - \bar{y}) \right] + \rho(r_{-1} - \bar{r});$$

Current core targeting (CC),

$$r - \bar{r} = \theta \left[ \gamma(\pi_4^x - \bar{\pi}_4) + (1 - \gamma)(y - \bar{y}) \right] + \rho(r_{-1} - \bar{r});$$

Forecast headline targeting (FH),

$$r - \bar{r} = \theta \left[ (\gamma/\tau) \sum_{i=0}^{\tau} (\pi_{4+i} - \bar{\pi}_4) + (1 - \gamma)(y - \bar{y}) \right] + \rho(r_{-1} - \bar{r});$$

Forecast headline targeting with positive shadowing of external financial shocks (FH+),

$$r - \bar{r} = \theta \left[ (\gamma/\tau) \sum_{i=0}^{\tau} (\pi_{4+i} - \bar{\pi}_4) + (1 - \gamma)(y - \bar{y}) \right] + \rho(r_{-1} - \bar{r}) + \eta(r^* - \bar{r}^*); \text{ and}$$

Forecast headline targeting with negative shadowing of external financial shocks (FH-),

$$r - \bar{r} = \theta \left[ (\gamma/\tau) \sum_{i=0}^{\tau} (\pi_{4+i} - \bar{\pi}_4) + (1 - \gamma)(y - \bar{y}) \right] + \rho(r_{-1} - \bar{r}) - \eta(r^* - \bar{r}^*).$$

Thus splitting the parameter space, which encompasses all the monetary policy rules, breaks the problem down into smaller bits. It then becomes possible to ask which of these five families leads to a more efficient monetary policy, independently of the degree of persistence, activism, or inflationary zeal that the policymaker might choose. We start by examining how specific examples of these monetary policy rules illustrate most of the more generic results found above.

## 2. THE EFFICIENCY OF DIFFERENT MONETARY POLICY RULES

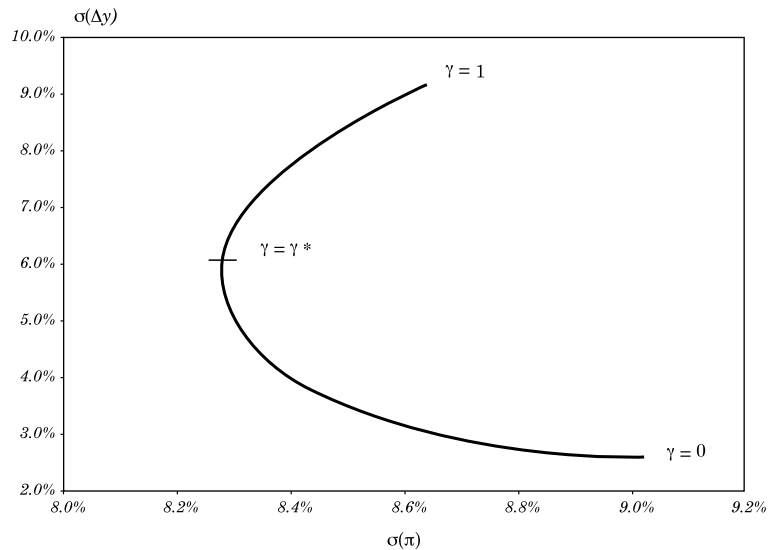
This section focuses on the trade-offs between output and inflation volatility. We proceed by fixing two of the three parameters ( $\theta$ ,  $\gamma$ , and  $\rho$ ) and varying the third, and we then compare the resulting trade-offs between rules. Because the results may be sensitive to the choice of persistence, activism, and inflationary bias in each simulation, we construct efficiency frontiers (that is, the envelope of the variance trade-offs) through extensive stochastic simulations of the macroeconomic model described above, incorporating a wider set of parameters than that used in the simulations in the previous section.<sup>9</sup> Most of the results of the paper, however, are apparent from the first, simpler exercise.

On the basis of this analysis, we derive three main results. First, biasing monetary policy responses toward output stabilization is efficient. Second, while it is inefficient to target core inflation, targeting forecast headline inflation does improve efficiency. Finally, leaning against movements in the cost of international finance can be efficient.

### 2.1 Output Stabilization

The different exercises consistently show that achieving an efficient trade-off between inflation and output volatility requires heavily weighting output stabilization. In terms of our policy rule, there is a threshold value for  $\gamma$ , the anti-inflationary zeal of monetary policy, above which the volatility of both output and inflation increases. The reason for this is straightforward and is widely documented in the literature on Taylor rules: given the importance of the output gap in accelerating inflation, stabilizing output directly stabilizes inflation. Figure 1 shows a typical backward-bending trade-off given current headline targeting, in which  $\rho = 0.4$  and  $\theta = 40$ .

9. In total, we conducted 2,325 stochastic simulations.

**Figure 1. The Trade-off under Contemporaneous Headline Targeting ( $\theta = 40$ ,  $\rho = 0.4$ )**

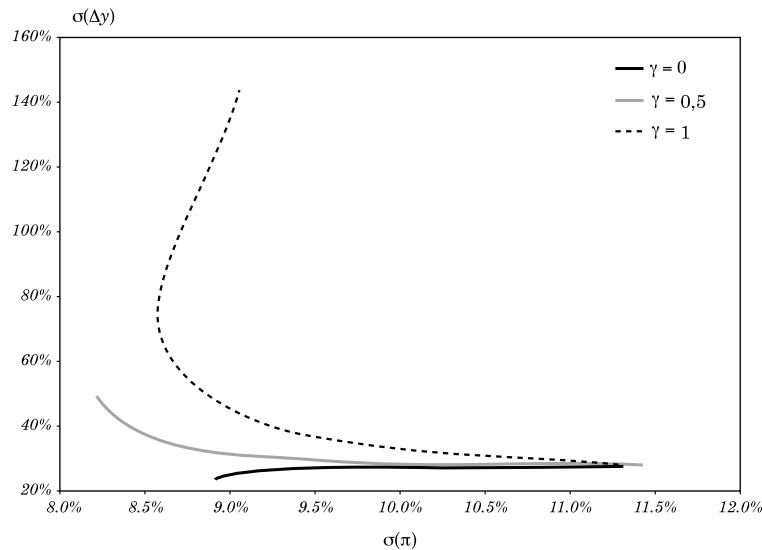
Source: Authors' calculations.

Thus the first feature of this particular monetary policy rule is that at some point, increasing the weight on inflation increases the volatility of both output and inflation. For some value of  $\gamma^*$ , lower weights on inflation increase the trade-off between output volatility and inflation volatility.

A second feature of this monetary policy rule is that the cost, in terms of output volatility, of putting some weight on inflation seems rather small, while the gain in reduced inflation volatility is large. This occurs because weighting inflation reduces the volatility of the nominal exchange rate.

The efficiency of a biased weight on output stabilization can be verified through an analysis of other relevant trade-offs. Most notably, monetary policy can be more or less aggressive, which in the model is captured by the size of  $\theta$ . A large  $\theta$  implies that monetary policy reacts strongly to the weighted deviations of output and inflation. Figure 2 shows the output-inflation trade-offs associated with different levels of activism, based on three different values of  $\gamma$ . If all weight is put on output stabilization, that is, if  $\gamma = 0$ , the threshold that output and

**Figure 2. Policy Rules under Contemporaneous Headline Targeting**

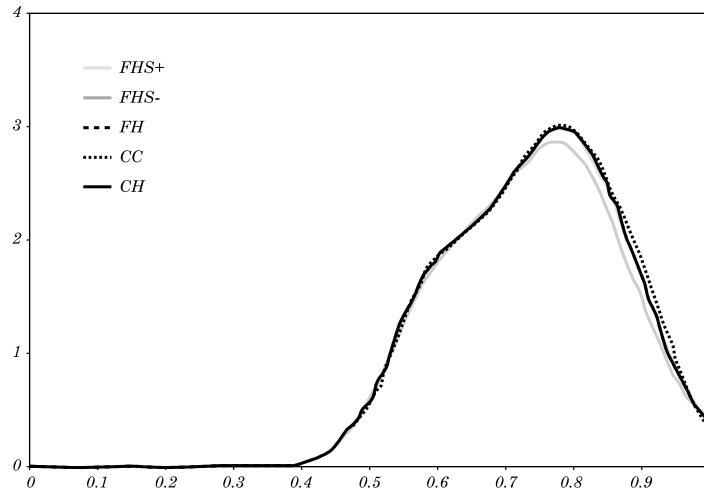


Source: Authors' calculations.

inflation volatility cannot breach falls. Thus, no matter how aggressive monetary policy is, it produces little gain in reduced inflation and output volatility if it only reacts to output. More can be achieved if some weight is put on inflation. Inflation volatility can be reduced by a more aggressive monetary policy, albeit at a cost in terms of output volatility; this case is plotted in the figure as  $\gamma = 0.5$ .

The case that highlights the efficiency of putting some weight on output stabilization is shown by the trade-off that exists when  $\gamma = 1$ . A soft stance on inflation is clearly the best approach under this monetary policy rule: reduced inflation and output volatility can be achieved if a positive weight is put on output stabilization. In addition, increased activism runs into the backward-bending part of the trade-off sooner than does a more neutral course. Thus, this hawkish monetary policy is not only dominated by a more dovish approach, but also restricts the degree of activism that monetary policy might pursue.

A more general way of looking at this issue involves examining the distribution of the threshold inflationary bias over which monetary policy becomes ineffective. This corresponds to  $\gamma^*$  in figure 1. Given a particular parameterization of the policy rule, if  $\gamma > \gamma^*$  the variance

**Figure 3. Kernel Approximations for the Distribution of  $\gamma^*$** 

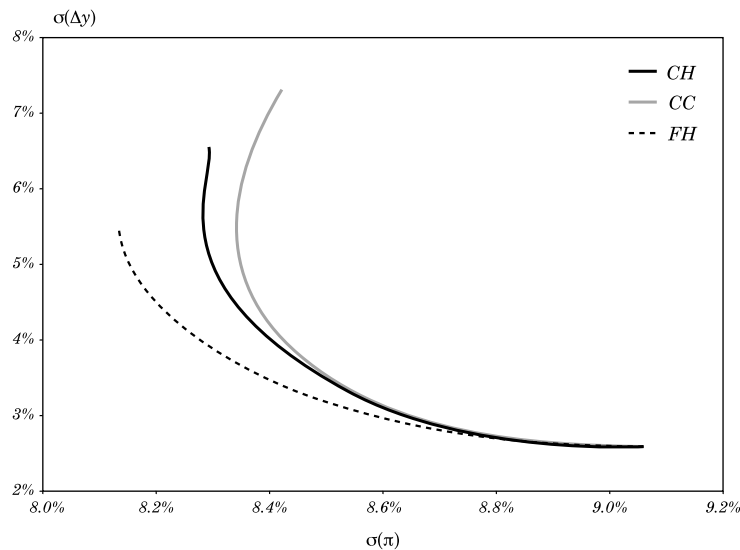
Source: Authors' calculations.

trade-off has a positive slope, and efficiency can be enhanced by putting less weight on inflation. Figure 3 shows numerical approximations of the distribution of  $\gamma^*$ . The approximate distribution is similar across families of policy rules, which shows that  $\gamma^*$  is sensitive mostly to the choice of persistence and activism in the rule. The mode of these distributions is close to 0.8, with a lower bound around 0.4. This shows that a robust policy rule—that is, a rule that is always efficient, regardless of the choice of its parameterization—implies no more than a 40 percent weight on inflation deviations and a corresponding 60 percent weight on stabilizing the output gap.

## 2.2 Targeting Forecast Headline Inflation

Chile's adoption of a formal inflation targeting scheme in September 1999 has not been without some degree of confusion regarding the specific target. Although the objective of price stability is defined in terms of headline inflation, the Central Bank has explicitly focused on the evolution of core inflation. Some observers have therefore concluded that the target was defined in terms of core inflation. This is not a far-fetched deduction: many central banks that target inflation explicitly

**Figure 4. Policy Rules under Contemporaneous Core Targeting and Forecast Headline Targeting ( $\theta = 40, \rho = 0.4$ )**



Source: Authors' calculations.

define their target in terms of core inflation. The rationale for such a decision lies in the convenience of not overreacting to price shocks that a priori have no bearing on the permanent inflationary path. Moreover, the contractionary effect of large supply shocks might require a more flexible monetary stance.

The key element in this respect is the likelihood that price shocks that are unrelated to the underlying supply and demand conditions in the economy might feed back into inflation expectations and wage and price indexation. Automatic indexation clauses are widespread in the Chilean economy because of the country's long history of high, variable inflation. Furthermore, backward-looking price setting behavior is prevalent among both firms and workers. Targeting core inflation would thus be a dangerous proposition in terms of efficiency, at least in the case of Chile. Our results confirm this finding. Figure 4 shows that targeting current headline inflation (CH) produces a better result than targeting current core inflation (CC) when  $\theta = 40$  and  $\rho = 0.4$ . Focusing on headline targeting is therefore the correct approach for stabilizing output and inflation. As expected, the differences between target-

ing headline versus core inflation and are small when the weight on the output gap is large.

Noncore inflation shocks do not necessarily imply acceleration in core inflation, however. The new inflation targeting scheme in place at the Central Bank of Chile addresses this fact by setting the monetary policy stance such that forecast inflation is within the 2 to 4 percent range. As figure 4 shows, targeting forecast headline inflation (FH) is preferable to targeting current headline inflation.

Our research does not tackle a number of interesting issues, such as the appropriate time horizon for the forecast.<sup>10</sup> We took a conservative approach in using five quarters ahead. This seems like a reasonable assumption since the typical lag between the monetary policy decisions and inflation is around four quarters. However, forecast deviations of output from trend can be included in the monetary policy rule. This probably enhances the policy's efficiency, given the three-quarter lag with which monetary policy affects output.

Some researchers stress a downside of using forecast inflation in setting policy rules, mainly arguing that this type of policy can generate inflation indeterminacy.<sup>11</sup> This is indeed the case if the argument in the policy rule is, for example, annual inflation two years from now. We avoid this problem by setting the argument in the rule as average annual inflation throughout the forecast horizon. The price level is then safely anchored in known information, thereby avoiding such indeterminacy.

Again, the differences between targeting current core versus current headline inflation are small when the weight on the output gap is large. These results are robust to different parameterizations. Figure 5 shows the efficiency frontiers for a broad set of activism, anti-inflationary zeal, and persistence of monetary policy. CC is always less efficient than CH, while FH is more efficient than both. The differences are small when monetary policy chooses a low degree of output volatility.

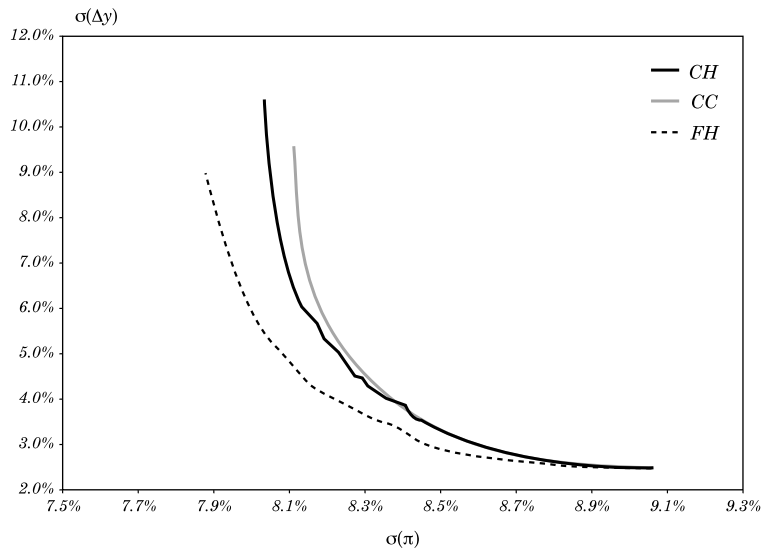
### **2.3 Leaning against Movements in International Rates**

Under fixed exchange rates, domestic interest rates must shadow the developments in international interest rates. This can be an automatic reaction, as in the case of a currency board, or a policy option, as in the case of a relatively loose peg. The implied loss of an autonomous

10. For example, see Cunningham and Haldane (2002).

11. See, for example, Wieland (2000).

**Figure 5. Efficiency Frontiers under Contemporaneous Headline Targeting, Contemporaneous Core Targeting, and Forecast Headline Targeting**

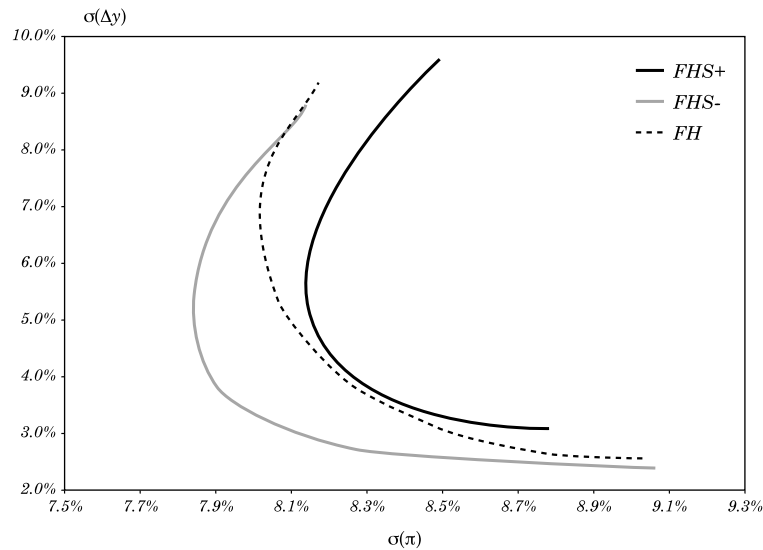


Source: Authors' calculations.

monetary policy is one of the arguments advanced for establishing a flexible arrangement. The Chilean peso currently floats freely. In terms of the model, the exchange rate is determined by a simple variant of uncovered interest rate parity. The relevant policy question is whether monetary policy should track changes in the cost of international finance or lean against them. What should be the role of the exchange rate in the monetary policy rule?

A simple way of tackling these issues is by examining how the output-inflation variance trade-off changes when monetary policy is allowed to respond to deviations of the international interest rate from its long-run level. We compare these trade-offs for particular cases of the monetary policy families FH, FH+, and FH-. The resulting curves are shown in figure 6.

In this particular case, leaning against the trend appears to be the efficient monetary policy response to international interest rates. This result stems from the particular assumptions in the model used for the simulations. The inflationary effect of international interest rate shocks

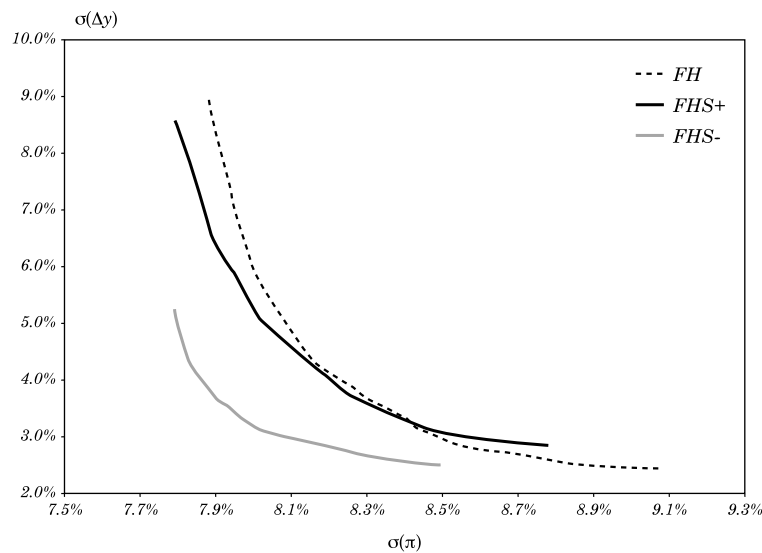
**Figure 6. Policy Rules under Forecast Headline Targeting with Shadowing ( $\theta = 50, \rho = 0.4$ )**

Source: Authors' calculations.

works through two channels. The direct effect on exchange rates is small, given that the equilibrium real exchange rate is independent of international interest rates. In contrast, the indirect effect on the output gap is large. Indeed, international real interest rates have a larger effect on growth than domestic real interest rates.

On balance, therefore, the impact of an increase in international interest rates is deflationary. The efficient response thus involves a reduction in domestic interest rates, which is captured by the FH– policy rule. This is robust to different parameterizations, as the efficiency frontiers in figure 7 show. The particular set of assumptions that feed the model drive this result. The key assumption here is the zero correlation between the equilibrium real exchange rate and international interest rates. Relaxing this assumption (for example, by defining the accumulation of net foreign assets as an endogenous variable) would imply that international interest rates have income and wealth effects, and it would generate movements in equilibrium real exchange rates. In this alternative environment, the direct inflationary impact of international interest rates would be magnified.

**Figure 7. Efficiency Frontiers under Forecast Headline Targeting with Shadowing**



Source: Authors' calculations.

The model assumes perfect credibility in that it includes rational expectations and a known monetary policy rule. It therefore cannot address issues such as lack of confidence, which can be a key factor in emerging economies that have weak links to international financial markets. The credibility problem may be exacerbated if monetary policy follows some type of exchange rate targeting. In that case, the credibility of the exchange rate commitment becomes the cornerstone of monetary policy. The framework used in this paper for analyzing monetary policy issues is of little value in such a setting.

These results stem from exogenous movements in the cost of international credit, such as those associated with higher sovereign spreads stemming from contagion effects. They would not apply in a more realistic environment in which international interest rates react to shifts in world GDP growth. If the latter effect more than compensates the movements in international interest rates, positive shadowing might be the efficient response to changes in the world environment.

### 3. CONCLUSIONS AND DIRECTIONS FOR FUTURE RESEARCH

The main results of this work shed some light on the efficient conduct of monetary policy. First, given that the output gap is a main determinant of inflationary pressures, output stabilization can prevent persistent and volatile deviations of inflation from its target. Moreover, putting too much weight on inflation can actually produce increases in the volatility of both output and inflation itself. A bias toward output stabilization thus offers a robust way to ensure efficiency. The actual weight on the output gap employed in the policy rule, over and above the degree that ensures efficiency, depends on the preferences and objectives of the central bank.

The second result relates to how the central bank should react to possibly permanent supply shocks. One option is to focus on core CPI, that is, on the price measure that excludes the components driving supply shocks in general, such as fuels or perishables. This response does not seem appropriate for the Chilean economy, given the structure of the model. Specifically, the existence of automatic indexation clauses that tie individual prices to headline CPI introduces a high degree of inflationary volatility and persistence if monetary policy simply does not respond to these supply shocks. The second, and better, alternative is to respond to deviations in forecast inflation from the target. This allows the central bank to focus on the actual persistence of headline inflation and thereby avoid overreacting to short-term fluctuations, which actually increases volatility.

Finally, the model indicates that given the high real effects of movements in the international cost of credit, monetary policy could improve efficiency by leaning against those movements.

A matter that remains unresolved, and that is not addressed in the body of the paper, is that in a steady state,  $\sigma_\pi$  is very large in all cases. This is not consistent with Chile's current inflation target of 2 to 4 percent, which the Central Bank established as its definition of price stability. What are the possible reasons for this apparent puzzle? First, the model assumes a historical degree of credibility, although it is more likely that the credibility of monetary policy is higher today than in the past, due to the successful disinflation of the 1990s and the absence of a political business cycle in 1998–99. This enhanced credibility allows a more active role for markups in absorbing temporary relative price shocks, as well as accommodating exchange rate movements. The latter results in a lower pass-through, which has been a surprising feature of the last few years in Chile. Increased credibility might also

encourage lower wage indexation, with a higher weight of the inflation target in the formation of inflation expectations.

Second, the model might be underestimating the effect of the output gap on inflation. Although the output gap parameter is estimated in the Phillips curve to account for trend disinflation in the 1990s, other factors, such as increased competition in goods markets, have increased the sensitivity of inflation to the output gap. A third possibility is that noncore CPI components will be less volatile in the future than in the past.

This puzzle poses several fundamental questions, which can serve as a guide for future research: Has the new inflation targeting framework in place in Chile caused a structural shift? If so, to what degree? What is the relation between the credibility of monetary policy and its efficient response to movements in the international cost of credit? What role do other transmission channels play? These issues set the agenda for extending the work on model development and the transmission mechanism at the Central Bank of Chile.

## APPENDIX

**Variables Used**

- $y$  : Seasonally adjusted log gross domestic product, excluding fisheries, mining and energy  
 $\bar{y}$  : Trend GDP, constructed with the HP filter  
 $r$  : Monetary policy rate: Interbank rate 1995–2001; yield on 90 day index bond 1986–1994.  
 $R$  : Long term interest rate: yield on indexed bond (8 year 1992 onwards, extrapolated with other long term bonds before that)  
 $f$  : Fiscal impulse (see Monetary Policy Report May 2000)  
 $r^*$  : Real foreign interest rate: 180 day libor, adjusted for sovereign spread (official series 1999 onwards, short term spread in Chapter XIV credits before), tax on capital inflows, US core inflation.  
 $y^*$  : Trade weighted GDP of US, Japan, Eurozone, Argentina and Japan  
 $e$  : Multilateral real exchange rate  
 $\varepsilon$  : Multilateral nominal exchange rate  
 $\pi$  : Headline CPI inflation  
 $\pi^x$  : Underlying CPI inflation: headline minus perishables, fuel prices and regulated services  
 $\pi^*$  : Dollar trade-weighted world inflation

Overbars in variables reflect steady state assumptions, which are not relevant for the stochastic simulation results presented in the paper.

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