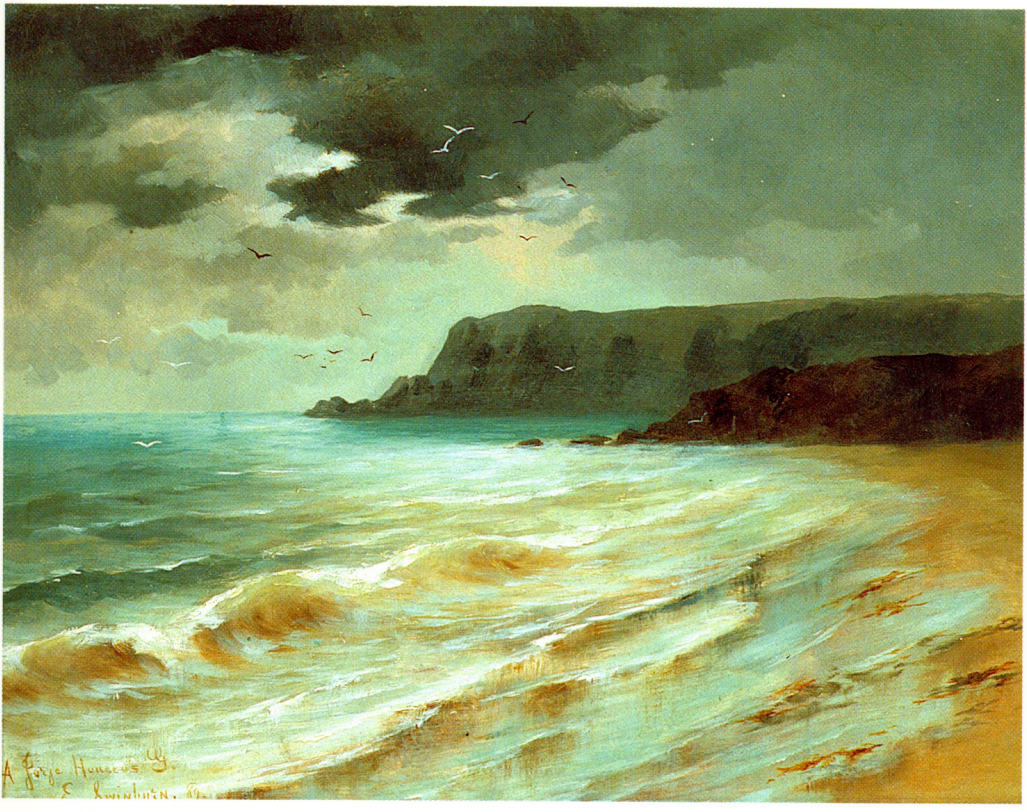
# Inflation Targeting: Design, Performance, Challenges

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# Inflation Targeting: An Overview

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After the emergence of a consensus in the 1980s on the harmful effects of inflation, the last decade of the twentieth century witnessed a marked reduction in inflation rates across the world. By the end of the 1980s, empirical evidence collected from large cross-country analyses and numerous case studies indicated that the negative effects of high and variable inflation on macroeconomic stability, economic growth, and income distribution largely outweigh the potential benefits derived from financing fiscal deficits through monetization. Similarly, short-term monetary policies aimed at higher output or lower employment were found to result in high inflation without, in the end, systematically achieving their explicit goals.

In the 1990s, the need to achieve price stability finally moved from the pages of research papers to the agendas of monetary authorities and politicians. After experiencing moderate but persistent inflation rates for more than two decades, industrialized economies have controlled and maintained inflation at historically low levels in recent years. Latin America, once the epitome of chronically high inflation, has also managed to achieve single digit inflation levels, a feat once thought to be undesirable and, more realistically, almost impossible.

The abatement of inflation is the result of a profound change in the conduct of monetary policy. Even if one concedes that the absence of significant supply shocks in the 1990s helped to control inflation in

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some countries, the driving force in this phenomenon is clearly the strong anti-inflationary stance adopted by the central banks of developed and developing countries. This change in central banks' attitude toward inflation is largely based on their recently obtained ability to conduct monetary policy with independence, transparency, and credibility. One monetary scheme that couples these virtues with a pragmatic use of policy instruments is inflation targeting. Following the pioneering example of New Zealand and Chile, several countries—as diverse as Brazil, England, and Sweden—have formally adopted inflation targeting as the defining feature of their monetary policies.

Although the term inflation targeting is now commonly used by bankers and scholars, several features of this monetary regime and its effects on economic performance remain elusive. The papers in this volume should contribute to bridging this knowledge gap in several key areas of interest. Most studies included here are substantially revised versions of papers presented at the Fourth Annual Conference of the Central Bank of Chile, on "10 Years of Inflation Targeting: Design, Performance, Challenges," held in Santiago in November 2000. These articles provide an original contribution from a variety of methodological approaches. While some authors treat the issues theoretically, others adopt an empirical perspective, whether based on a single country or an international sample. To varying extent, all the papers in the volume have three central objectives: to understand the distinctive features of inflation targeting and appreciate the variety within this class of monetary regimes; to evaluate the performance of inflation targeting in reaching the goal of price and output growth stability, particularly in comparison with alternative monetary frameworks; and to analyze the optimal way to design policy objectives, instruments, and responses under inflation targeting, especially in the case of economies in transition to low inflation.

This overview paper selectively surveys the articles included in the volume. The purpose here is not to provide an exhaustive summary, but to highlight how the works address the three objectives posed above. The following sections group and discuss the papers in the order in which they are included in the volume. Section 1 deals with the definition and empirical evaluation of inflation targeting as a framework for monetary policy. Section 2 presents the theoretical analysis on, first, the merits and weaknesses of inflation targeting and, second, the best ways to implement it. Section 3 reviews the case studies on four inflation-targeting countries, namely, Chile, New Zealand, Australia, and Brazil. Section 4 offers some concluding remarks.

## 1. Inflation Targeting: Definition and Empirical Evaluation

Inflation targeting started a decade ago in New Zealand and Chile as a means of achieving low and stable inflation levels. It is thus a novel approach to monetary policy. Given the successful experience of these countries, the popularity of inflation targeting has risen steadily, as has the number of countries that have adopted it. According to Vittorio Corbo, Óscar Landerretche, and Klaus Schmidt-Hebbel, in their paper in this volume, by 2000 there were eighteen full-fledged inflation-targeting countries, and another five, mostly emerging economies, were considering implementing it. Except for two countries that became part of the European Monetary Union (Finland and Spain), no inflation-targeting country has ever abandoned the regime.

What exactly is inflation targeting? Although definitions differ in detail, there is some consensus on the main characteristics of this monetary regime: the existence of an explicit quantitative goal that engages the central bank in the primary objective of price stability; the lack of fiscal dominance and the absence of competing nominal objectives; and a monetary institution that enjoys instrument independence and operates transparently and openly to the public. The papers by Gabriel Sterne and Richard Agénor in this volume discuss how each of these characteristics is incorporated into a definition of an inflation-targeting regime.

Sterne and Agénor both emphasize that inflation targeting involves a framework for monetary policy and not a single policy rule (Bernanke and others, 1999, share this view). In a sense, inflation-targeting proposes a solution to the long-standing debate in economics of rules versus discretion. The monetary authority enjoys what Svensson (1999) calls constrained discretion: the inflation-targeting framework sets out very clear goals for monetary policy, defines responsibilities, and establishes measures of accountability and transparency. However, it leaves to the central bank the decision of which instruments to use and how to use them to hit the target. Inflation targeting also forces the central bank to forecast the future behavior of prices, giving it the opportunity to tighten policies before sustained inflationary pressures develop.

Sterne goes beyond the general characterization given above and provides an in-depth study of the different monetary regimes in ninety-four countries, looking for a more operational definition of inflation targeting. This is certainly a difficult task and has decisive implications

for evaluating the effects of this monetary regime.[1] Adopting a narrow definition may cause one to understate inflation targeting's contribution to the design of monetary policy in a wide range of countries. Conversely, a loose definition may lead to overstating its contribution, since many of the characteristics of inflation targeting have previously been used in other regimes of monetary policy.

Sterne's paper uses a survey of monetary framework design to quantify ten characteristics, including central banks' objectives, targets, independence, accountability, transparency, and analytical capacities.[2] An interesting result of this paper is the finding that targets are increasingly being used in monetary policy worldwide. By 2000, more than half of the countries in the sample used explicit targets, and although inflation targets were a minority, their number expanded quite rapidly in the 1990s. According to Sterne, an important explanation behind the increased use of inflation targets relative to money targets is the capacity of inflation targets to provide a visible vehicle for guiding private sector expectations and communicating with the government. The use of targets, in general, appears to produce an incentive for the central bank to explain its policies to the public; the use of inflation targets, in particular, seems to facilitate the communication between central banks, fiscal authorities, and the private sector. Another potential advantage of inflation targets is that they can be more precisely obtained. Sterne shows that the number of inflation target misses was less than half that of money target misses. The median inflation target miss (in absolute terms) for countries that announce both inflation and money targets was 1.5 percentage points, compared with 3.2 percentage points for broad money growth. These results are consistent with the view that over a broad range of countries, the mix of shocks leads the economy to greater deviations from money targets than inflation targets.

Regarding institutional aspects of monetary policy, Sterne shows that almost all central banks in his sample consider instrument independence to be an important aspect of their ability to conduct autonomous policy. By contrast, goal independence tends to be important to central banks only in particular circumstances that are closely related

1. As mentioned by Sterne, it is difficult to distinguish between money-targeting and inflation-targeting frameworks by observing which countries publish inflation targets, because virtually all countries that classify themselves as money targeters also publish inflation targets, guidelines, or reference values.

2. See Fry and others (2000).

to the target-setting capacity. Countries that target money or the exchange rate are more likely to define independence according to statutory objectives, while central banks that focus their framework on inflation targets define independence less in reference to official mandate than to the practical ability to achieve their objectives.

The paper by Agénor provides a thorough survey of the analytical literature on the mechanics and effects of inflation targeting, particularly in developing countries. Following Svensson (1997, 1999), Agénor presents an analytical model for inflation targeting in both closed and open economies. The closed economy model shows how the inflation target drives the basic reaction rule of the central bank. The analysis is then extended to an open economy setting to highlight the role of the exchange rate in the transmission process of monetary policy. Based on these models, Agénor provides a comparison between inflation-targeting regimes and those based on money supply and exchange rate targeting. The most innovative section of the paper focuses on some unresolved analytical issues in the design of inflation-targeting regimes, namely, the role of nonlinearities and asymmetric effects in the Phillips curve, the uncertainty regarding behavioral parameters and the transmission process of monetary policy, and the treatment of credibility and reputation in empirical macroeconomic models of inflation. These subjects are particularly relevant for monetary policy in developing countries. Agénor's efforts thus contribute to bridging the gap between the rigorous analytical study of inflation targeting in developed countries and the practical problems of its application in developing economies. Agénor's paper builds on the assumption that inflation targeting is applicable to developing countries. This has been the subject of an interesting debate, with authors like Masson, Savastano, and Sharma (1997) taking a rather cautious view while Mishkin (2000) and Morandé and Schmidt-Hebbel (1999) adopt a more favorable position. The latter group holds that inflation targeting is possible at least in the case of high- and middle-income developing countries, where the financial system is sufficiently developed to permit the use of indirect instruments of monetary policy.

The papers by Sterne and Agénor provide a significant number of hypotheses and insights on the strengths and weaknesses of inflation targeting, but they do not assess them empirically. This is undertaken in the study by Frederic Mishkin and Klaus Schmidt-Hebbel in this volume, study which compares the experience of eighteen inflation-targeting countries with a group of ten developed economies. Using annual data for the 1990–99 period, these authors find that the likelihood

of having inflation targeting in place is positively associated with both formal and instrument independence of the central bank. Their results indicate, however, that inflation targeting is negatively associated with the central bank's goal independence. This suggests that when central banks determine their target levels, they are more likely to choose exchange rate or monetary growth anchors than inflation –targets. This result highlights the difference between the formal and operative independence of the monetary authority.[3] Mishkin and Schmidt-Hebbel also find that the adoption of an inflation-targeting regime is more likely when the initial level of inflation is relatively high. Coupled with their result that inflation is reduced more rapidly under inflation targeting, this implies that central bankers perceive and use this regime as a tool for stabilizing prices. Mishkin and Schmidt-Hebbel further establish that the implementation of inflation targeting is associated with lower fiscal deficits, confirming the absence of fiscal dominance under this regime.

The most direct study in this volume to empirically analyze inflation targeting in relation to other regimes is the paper by Corbo, Landerretche, and Schmidt-Hebbel. They compare a sample of fifteen countries that adopted inflation targeting with a group of ten countries that follow a variety of other monetary frameworks. Their objective is to conduct a broad empirical search on the rationale and consequences of adopting inflation targeting. Thus the paper addresses a variety of issues that jointly give an overall evaluation of this regime. Some of these questions are the following. First, how effective have inflation-targeting countries been in reducing inflation, and at what cost? Second, how has the adoption of inflation targeting changed the behavior of the central bank, including its aversion to inflation? Third, what effect has inflation targeting had on the macroeconomy, particularly the predictability and variability of inflation and output growth?

Based on a number of econometric models, Corbo, Landerretche, and Schmidt-Hebbel conclude that inflation-targeting countries perform consistently better than the control group in terms of controlling inflation and, most importantly, without inducing additional volatility in output. They also find that output sacrifice ratios, as measured by industrial production, were lower in inflation-targeting countries than in potential inflation targeters and nontargeters during the 1990s. The volatility of industrial output fell to levels similar to those found among nontargeting countries. To some extent, this evidence contradicts

3. Walsh (1995) sparked an extensive literature that stresses the difference between goal and instrument independence.

Bernanke and others (1999, p. 298), who suggest that disinflation is costlier in the short run under inflation targeting. Although Corbo, Landerretche, and Schmidt-Hebbel's positive assessment applies to mature inflation-targeting regimes, in which credibility, transparency, and accountability in the conduction of monetary policy are well established, the authors find evidence that inflation targeting can facilitate the process of achieving these institutional virtues. In particular, inflation targeting can help bring down and guide inflation expectations so as to achieve a faster and less costly reduction in inflation. The paper uses country vector autoregressive (VAR) models to demonstrate that inflation forecast errors fall consistently with the adoption of inflation targeting. This reflects both a learning process on the part of economic agents with regard to the monetary framework and the increased credibility of the monetary authorities. Finally, Corbo, Landerretche, and Schmidt-Hebbel find that inflation-targeting countries have gradually gained a measure of credibility that allows them to achieve their targets with smaller changes in their policy instrument than previously. As the authors recognize, their results are more favorable to inflation targeting than are previous findings, such as those of Almeida and Goodhart (1998) and Bernanke and others (1999).

## 2. The Effectiveness of Inflation Targeting: Theoretical Perspectives

Given the broad definition of inflation targeting, it appears reasonable to look for optimal inflation-targeting policies. Such policies would necessarily depend on the specifics of each economy. The paper by Jordi Galí in this volume obtains and compares optimal and near-optimal policies within the context of a monetary business cycle model in which agents optimize subject to staggered price restrictions. Following Calvo (1983), Galí's model incorporates price rigidities based on the assumption that only a fraction of producers are able to change their prices at any point in time. Inflation and its evolution over time are thus an immediate consequence of periodic price revisions by profit-maximizing firms. These price rigidities and periodic jumps give a stabilizing role to monetary policy.[4] This simple setup allows the author to derive an optimal forward-looking interest rate rule that implements an inflation-targeting regime. Such a rule generally depends on the structure

4. This specification is consistent with a forward-looking Phillips curve, such as that derived by Clarida, Galí, and Gertler (1999).

of the model, the settings for the parameters describing the economic environment, and the properties of the underlying sources of fluctuations. Galí shows that the stabilization of the output and inflation gaps requires a credible threat by the central bank to vary the interest rate sufficiently in response to any deviations of inflation or output from the target, yet the very existence of that threat makes its effective application unnecessary.

As with most models, the nature of the optimal inflation-targeting rule in Galí's paper suggests that its actual implementation would face major difficulties. First, the authorities would have to have complete knowledge of the structure of the economy and the value of the parameters. Second, they would need unbiased forecasts of the future path of all underlying exogenous disturbances. These considerations lead the author to propose an alternative rule that may both approximate the outcome of the optimal one and be easier to implement in practice. This rule is a simplified version of the so-called Taylor rule, under which the monetary authority adjusts the interest rate in response to deviations of inflation from target.[5] The analysis shows that in the absence of significant measurement error in the inflation data, a simple Taylor rule can approximate the outcome of the optimal inflation-targeting policy arbitrarily well, as long as the interest rate response to movements in inflation is sufficiently strong. If the inflation data are ridden with error, however, the alternative rule carries a risk of raising the volatility of inflation.

The paper by Eric Parrado and Andrés Velasco in this volume develops a general equilibrium, open economy model with monopolistic competition and short-term price rigidities. The model enriches the discussion initiated by Galí by explicitly considering the existence of both domestic and foreign goods, which in turn gives a role to different exchange rate regimes (fixed versus flexible), and by allowing the existence of both nominal and real shocks. The authors use this framework to compare the welfare impact of various specifications of Taylor rules in the presence of different shocks; they find that when the economy suffers a real shock, a regime with flexible exchange rates and inflation targeting is superior in terms of welfare to one based on fixed exchange rates. The opposite conclusion obtains when a nominal shock hits the economy.

5. Taylor rules are monetary reaction functions in which the policy instrument, such as a short-term interest rate, changes in response to current or expected output and inflation gaps.

The Parrado and Velasco model allows the authors to systematically explore two recurrent issues in the literature. The first deals with the best inflation measure to be targeted. Since consumers in this model demand both domestic and foreign goods, it is possible to evaluate under what conditions targeting an index of domestic prices is superior to targeting headline consumer price index (CPI) inflation. In Parrado and Velasco's model, domestic inflation targeting is welfare superior to CPI inflation targeting. Because the CPI is affected by exchange rate variations that escape the control of the central bank, responding to all CPI fluctuations may be an overreaction that destabilizes output. Conversely, the paper by Pablo García, Luis Óscar Herrera, and Rodrigo Valdés in this volume (which is reviewed below) finds that in the presence of widespread backward price and wage indexation to CPI inflation, only targeting its domestic component may result in higher volatility of output and headline (CPI) inflation. The second issue addressed by Parrado and Velasco involves a comparison of strict rules (that is, interest rate rules that only react to inflation gaps) with flexible rules (those that also react to output gaps). Given that output volatility also enters into their welfare function, it is not surprising that they conclude in favor of flexible rules.

The interpretation of empirical studies on inflation targeting is difficult because the adoption of this regime has taken place in a period when supply shocks were largely absent (until the recent oil shock). Moreover, most countries have adopted inflation targeting under rather favorable macroeconomic conditions, including low fiscal deficits and foreign exchange availability. Both conditions can bias the evaluation of inflation targeting's efficiency in comparison with other monetary regimes. The paper by Michael Kumhof in this volume takes the perspective that inflation targeting is not intrinsically superior to other monetary frameworks and in fact is as vulnerable to external shocks as exchange rate targeting in the presence of fiscal dominance and disequilibria. Kumhof's model shows that given a high degree of pass-through from exchange rates to domestic prices, an inflation target can lead to greater instability than exchange rate or money targets. Following this logic, however, Kumhof's results have a rather limited application to countries that have achieved a high degree of fiscal discipline and a low pass-through, as is the case in most current inflation-targeting countries. Kumhof's analysis reinforces two lessons presented above. First, countries that are considering adopting inflation-targeting policies should be aware of the need to achieve and ensure fiscal discipline and avoid exchange rate misalignment. This lesson is consistent with the empirical evidence presented by

Mishkin and Schmidt-Hebbel. Second, countries that have already implemented inflation targeting should avoid fiscal imbalances, or they will run the risk of increased output instability.

The paper by Bennett McCallum in this volume analyzes a rather recent criticism of inflation targeting, namely, that in countries that experience deflation, the nominal interest rate may approach a zero bound. If, in addition, the economy is in a recession and thus requires expansionary monetary policy, the central bank faces a liquidity trap, since it is not able to place open market bonds at below-zero nominal rates. The case of Japan in the 1990s appears to support this claim. From a theoretical perspective, it has been suggested that the dangers of an expectations trap and indeterminacy are created by variants of inflation targeting, the latter when forecasts of future inflation enter the policy rule. McCallum's paper shows that these alleged dangers are not an exclusive characteristic of inflation targeting and, more importantly, are probably not of practical importance. He develops an open economy model to evaluate the likelihood of encountering a liquidity trap for several policy rules. Following the work of Evans and Honkapohja (1999, 2001) on expectational stability and least squares learning, McCallum shows that the risk of falling into this liquidity trap is mostly a theoretical curiosity, given that the deflationary solution is not stable. Furthermore, through calibration and simulation of a structural model, he finds that a liquidity trap can be avoided by having an inflation target and a long-run average real interest rate whose sum does not fall below a certain lower bound; according to McCallum's calibrations, this bound is 5 percent per year. Also, if the usual interest rate instrument is immobilized by a liquidity trap, monetary policy can still exert stabilizing effects by means of an exchange rate channel. The relevant target variable can still be the inflation rate.

The implementation of inflation targeting does not only raise interesting analytical questions but has also prompted a reassessment on the part of the International Monetary Fund (IMF) of its conditionality policies. It would appear that the inflation-targeting framework, by the very nature of its operating procedures, is not compatible with the traditional IMF monetary conditionality framework. As discussed by most authors in this volume, inflation targeting is based on the premise that an independent central bank can use its various instruments in the proportions considered appropriate in each particular circumstance to ensure the attainment of its inflation goal. This seems to clash with IMF conditionality schemes that set explicit and somewhat rigorous quantitative objectives for key monetary variables.

The paper by Mario Blejer, Alfredo Leone, Pau Rabanal, and Gerd Schwartz in this volume describe how IMF conditionality has traditionally relied on two performance criteria: a ceiling on the central bank's net domestic assets and a floor on its net international reserves. Since inflation targeting is usually implemented alongside a floating exchange rate regime, floors on reserves would appear to be irrelevant. However, while an inflation-targeting central bank would not be expected to use its foreign reserves to stabilize the exchange rate per se, it may react to movements of the exchange rate to the extent that they threaten the inflation target. Trade-offs between domestic objectives (that is, inflation) and external objectives (that is, external viability) may be unavoidable, at least conceptually. Even when the exchange rate is flexible, retaining a floor on net international reserves may simply reflect the fact that one important aspect of an IMF program is to safeguard external viability. In contrast, retaining a ceiling on net domestic assets in the context of inflation targeting is more problematic. In the first place, inflation, in most cases, is not primarily a function of net domestic financial assets or its components, and it is therefore unlikely to respond predictably or immediately to changes in base money. Second, transparency and consistency problems can arise, as there would generally be little correspondence between the monetary objectives underlying IMF programs and the relevant instruments chosen by the central bank to achieve the inflation target. There is also an apparent tension between the forward-looking nature of inflation targeting and the backward-looking mechanics of setting limits on the growth rates of net domestic assets employed in IMF programs. The authors evaluate the recent experience of Brazil—the only inflation targeting country with an IMF-supported adjustment program—to make suggestions for modifying the standard conditionality framework of the IMF. Among other measures, they propose using the central bank's inflation target as an indicator of monetary stance and considering simple monetary policy rules (such as Taylor rules or McCallum rules) as potential trigger mechanisms for policy consultations. These rules should be simple but forward looking, in the sense of reacting to inflationary expectations.

## 3. Comparing Different Ways of Implementing Inflation Targeting

Sterne's extensive survey of monetary regimes around the world suggests that inflation targeting is a multifaceted creature and that idiosyncratic factors are important for understanding the strengths and limitations of this monetary framework. The final part of this vol-

ume is devoted to the experience of four countries. The decade-long experience of the pioneers of inflation targeting, namely, Chile and New Zealand, allows us to draw interesting conclusions on the implementation, effectiveness, and long-run performance of inflation-targeting economies. This vision is complemented by the study of two successful, though quite different, experiences: Australia, which exemplifies the ability of inflation targeting to deal efficiently with external shocks, and Brazil, which has achieved a record-fast convergence of inflation to international levels without inducing internal disequilibria.

All country studies benefit from detailed insights and observations on the operational aspects of inflation targeting, as perceived by the officials in charge of implementing and running daily operations.

## 3.1 Chile

After a decade of central bank independence and explicit inflation targets, the results of this monetary framework appear to be satisfactory in Chile. Endemic inflation has finally been defeated, and its current level is both comparable to that of industrial countries and consistent with the central bank's current medium-term annual inflation target of 3 percent, within a 2–4 percent range.[6] The inflation-targeting framework was adapted somewhat to the more steady-state goal of keeping inflation low (as compared to reducing inflation year after year) in September 1999, when the crawling exchange rate band operating since 1985 was abandoned to eliminate a possible source of policy inconsistencies between two (eventually) conflicting objectives.

In reviewing the Chilean experience, the paper by Felipe Morandé in this volume derives interesting lessons regarding the rules-versus-discretion dilemma. When implementing inflation targeting, the authorities face a classic but difficult trade-off: the more they emphasize commitment and reputation building through strict application of the inflation-targeting framework, the less flexibility they have to accommodate shocks that eventually lead to lower output or higher inflation in the short run. Chile's case suggests that in a transition from moderately high to steady-state low inflation rates, emphasizing the nominal anchoring provided by inflation targeting might be justified. Tough

6. Inflation in Chile was high and very volatile. Annual inflation averaged 31 percent between 1890 and 1999, with a standard deviation of 79 percent. In the 1930–99 period, when the state's intervention and relevance within the economy began to grow, average annual inflation reached 45 percent, with a standard deviation of 96 percent.

monetary policy buys credibility at a cheaper long-run price.

However, the application of a strict monetary policy does not automatically imply that low inflation targets should be set immediately. Morandé argues that in the transition from moderately high to low inflation, gradualism in target setting is crucial. In Chile, price stabilization in the 1990s evolved very gradually, taking nine years to reach what was originally considered the long-run objective: an annual inflation rate of 3 percent. Gradualism reflects the fact that in the policy reaction function of the central bank (and perhaps in its objective function as well), both inflation and output stabilization matter.

Faced with a credibility-flexibility trade-off, the policymaker should favor the credibility side when initial conditions are marked by high inflation, a record of poor inflationary performance, and backward-looking indexation. It takes time for people to get used to the notion that stable prices could be the norm rather than the exception. Once inflation reaches a figure close to its expected long-run level, the central bank's improved reputation will allow for more flexibility and the inflation-targeting parameters can be eased up. Two additional challenges appear as the inflation-targeting regime matures. First, the targeting horizon becomes more stringent: the authorities now face the need to control any inflationary pressure within an explicitly defined and rather short period. In the case of Chile, for example, stabilization is now expected to be achieved within two years instead of nine as was the case in the early 1990s. Second, maintaining credibility must be achieved through transparency in the conduct of monetary policy, rather than solely from hitting headline inflation target accurately at the end of the year.

Chile's disinflation program did not cause, on average, significant costs in terms of real variables. On the contrary, the economy showed an impressive record of sustained growth, declining inflation and unemployment, and a healthy external balance. All along, the monetary authorities remained concerned with determining the best way to implement the inflation-targeting regime. As discussed in the paper by García, Herrera, and Valdés, the Chilean monetary authorities confronted a variety of questions, in many cases without the advantage of previous experience. Should the central bank react to unemployment or the output gap (and by how much)? Should it focus on current headline inflation, core inflation, or a forecast of one of them? If a forecast, over what horizon? Should the central bank conduct restrictive monetary policy when faced with negative external shocks (such as oil price shocks, changes in international interest rates, or sovereign risk premiums)? What should be the role of the exchange rate in the monetary policy rule?

To formally assess these questions, García, Herrera, and Valdés present a macroeconometric model that describes the mechanics of the Chilean economy and allows them to calculate the performance of alternative monetary policy rules through stochastic simulation. An interesting contribution of this paper is the development of a methodology for calculating the envelope of efficiency frontiers for different families of policy rules. These frontiers track the trade-off between inflation and output volatility arising from alternative policy rules, given a fixed distribution of exogenous shocks. While similar comparative studies focus on the efficiency of various monetary policy rules (see Levin, Wieland, and Williams, 1999), García, Herrera, and Valdés search for optimal rules from a welfare perspective, highlighting the importance of choosing appropriate loss functions for the central bank.

Following Romer (2000), the authors build and calibrate what might be called an IS-MP model of the Chilean economy, in which the standard LM curve is replaced by a monetary policy rule (MP). The model is simulated stochastically for the following inflation-targeting rules: contemporaneous headline inflation targeting, contemporaneous core inflation targeting, forecast headline inflation targeting, forecast headline inflation targeting with leaning against external financial shocks, and forecast headline inflation targeting without leaning against international financial shocks. The paper shows that it is efficient for monetary policy to take output stabilization into account even if its ultimate goal is inflation control. This is so because the output gap is an important determinant of the acceleration of inflation. A more controversial result is that it may not be efficient to target core inflation, as many countries do, whereas targeting the forecast of headline inflation may be more effective. The reason behind this result is that in economies in which indexation with respect to CPI (headline) inflation is widespread, not responding to CPI inflation (but rather to a subset of those prices) will allow the inflation shock to be propagated to all prices and perpetuated over time through indexation.

### 3.2 New Zealand

Inflation in New Zealand fell to 2 percent a year in 1991 and remained low and stable within a 0 to 2 percent band throughout the decade, despite significant domestic and external shocks. The stability of inflation in New Zealand is remarkable considering that the country's economic activity, exchange rates, and interest rates fluctuated markedly in the 1990s. The paper by Aaron Drew in this volume reviews the

main questions for monetary policy that arose during this period and the corresponding responses by the Reserve Bank of New Zealand. To provide a quantitative evaluation of these issues, Drew uses the Reserve Bank's economic forecasting and policy system (FPS) model.

Among the most interesting lessons that emerge from the analysis of this experience is the importance of preempting inflationary pressures arising from wealth effects. A feature of the expansion that occurred in New Zealand in the mid-1990s was that consumption growth outstripped income flows, leading to substantial increases in household debt. This was also observed at a national level: net foreign assets to gross domestic product (GDP) deteriorated considerably following a sequence of substantial current account deficits. This behavior can be explained as the response to an expected permanent increase in wealth. The Reserve Bank's inflation projections in the early 1990s did not adequately incorporate this wealth effect on current consumption. Drew's simulation results suggest that had wealth effects been better understood, the duration of the upward pressures on interest and exchange rates might have been noticeably shorter.

Drew's paper also explores the rationale behind the evolution of monetary policy at the Reserve Bank of New Zealand. As the structure of the economy changes, it is likely that the lags in monetary policy transmission will also change, and policy design should take this into account. Starting in the early 1990s, the pass-through from nominal exchange rate fluctuations to local prices became more muted in New Zealand, thereby lengthening the lags of monetary policy transmission. This occurred as the slower transmission mechanism that works through aggregate demand gained importance relative to the quicker exchange rate mechanism. In response, the Reserve Bank tended to extend the forecast horizon that it uses to guide its policy decisions. Coupled with the reduction of both inflation and inflation expectations over the 1990s, the extended policy horizon eventually led to a more flexible inflation-targeting approach in New Zealand. This means that the Reserve Bank now more freely exercises the option of centering its reaction on the more persistent sources of inflationary pressures when deciding on the stance of monetary policy.

### 3.3 Australia

As the paper by Guy Debelle and Jenny Wilkinson in this volume shows, Australia's recent experience in dealing with the adverse effects of the Asian crisis has provided substantial empirical support to the

claim that inflation targeting can efficiently accommodate inflationary shocks from external sources. An important issue that confronts an inflation-targeting central bank in an open economy is that exchange rate fluctuations can have a significant effect on inflation, mainly through traded goods prices. If the central bank is pursuing a strict inflation target, the policy responses required to offset the effects of exchange rate fluctuations may hurt the nontraded sector of the economy and generate a large degree of output volatility. The conventional advise in this case is to focus the policy reaction on controlling the prices of nontraded goods (Svensson, 1999). Debelle and Wilkinson challenge this point of view. They hold that the monetary reaction to external price shocks should depend on the sources of the shocks, the extent to which aggregate and nontraded inflation are affected by movements in the exchange rate, and whether inflation expectations are forward looking. Debelle and Wilkinson derive an econometric model to evaluate different policy rules in the face of external shocks.

Debelle and Wilkinson find that for the Australian economy, the choice of inflation target does not make much difference on the outcomes of inflation or output variability. This may be explained by the observation that the pass-through from the exchange rate to aggregate inflation is not immediate but delayed in this country. As Debelle and Wilkinson point out, a protracted pass-through has not always been a feature of the process of inflation formation in Australia. Over the last two decades, the response of domestic prices to external price shocks has become more diffused, and inflation formation has grown less vulnerable to specific changes. The main conclusion of Debelle and Wilkinson's paper is that the Australian economy has become more resilient to temporary price-level shocks.

### 3.4 Brazil

The recent history of inflation in Brazil is perhaps one of the most remarkable cases of the 1990s. In 1994, inflation reached 994 percent a year; by 1998, it had dropped to less than 2 percent. The stabilization program known as the Real Plan was successful in putting an end to Brazil's history of chronic high inflation. However, it did not provide the basis for long-term sound macroeconomic policy, as it led to significant exchange rate misalignments. The initial decision to float the new currency, the real, was later reversed, and the country initiated a fixed exchange rate regime. By early 1999, substantial fiscal imbalances and a lack of policy credibility—compounded by foreign shocks such as the Asian

crisis—put in evidence the gross overvaluation of the Brazilian currency and led to a massive exchange rate attack. The fixed exchange rate regime had to be abandoned, and the Central Bank adopted an inflation-targeting regime, while the government implemented severe fiscal measures.

The paper by Joel Bogdanski, Paulo Springer de Freitas, Ilan Goldfajn, and Alexandre Tombini in this volume examines the recent evolution of monetary policy since the adoption of formal inflation targeting in Brazil. An interesting feature of the new monetary policy regime is its gradual implementation. It was not feasible to adopt formal inflation targets right after the floating, given the uncertainties regarding the post-devaluation inflationary process. At the same time, the adoption of the new monetary framework required institutional changes to ensure operational independence for the Central Bank, as well as sufficient time for consolidating the fiscal policy measures. Consequently, the intention to adopt an inflation-targeting framework was announced immediately, but its formal implementation (including the announcement of the target) was delayed for half a year. The authors provide an interesting discussion of backward price indexation and its effect on the efficiency of monetary policy. Backward price adjustment is widespread in Brazil, and it is particularly important in some administered tariffs for public utilities. These tariffs have a prominent weight in the consumer price index. Using simulations of a small macroeconomic model, the authors show that when the adjustment of these prices is based on past inflation, the degree of inertia increases, which forces the Central Bank to be more restrictive in order to disinflate the economy. This effect, however, diminishes in importance as inflation gets closer to steady-state values.

Another interesting issue that arises in the case of Brazil is how to monitor inflation targeting under agreements with the IMF. In a simple structural model, the authors show that the behavior of relevant macroeconomic variables does not change significantly when the frequency at which monetary policy is evaluated is increased from yearly to quarterly. This does not mean, however, that a central bank should be indifferent between year-end accountability and quarterly accountability. The reason is simple: there can be circumstances in which the probability of meeting the target by year-end is high, but the probability of breaching the tolerance bands in the intermediate quarters is also high. This is a very likely phenomenon when the variables are initially out of equilibrium. Under such circumstances, monitoring quarterly figures can send unnecessary false alarms, introducing unwarranted noise in the conduct of monetary policy by affecting expectations.

Although the Brazilian inflation-targeting regime is quite young, it has already been subjected to large external shocks (high oil prices and increased international financial volatility) and domestic challenges (fiscal fragility, indexation, and financial sector weakness) that have tested its robustness. Bogdanski, Freitas, Goldfajn, and Tombini make a good case that inflation targeting in Brazil is here to stay.

## 4. Conclusions

The main conclusion that can be drawn from the studies in this volume is that there is substantial evidence in favor of inflation targeting as the guiding framework for monetary policy. Along with the theoretical considerations that support inflation targeting, its success in controlling inflation without incurring large costs of output volatility is evident from both cross-national and country-case studies. However, this does not imply that inflation targeting is a sufficient condition for success: as with any other monetary policy regime, its success depends on the consistency and credibility with which it is applied. Erroneous or irresponsible fiscal, exchange rate, and monetary policies will condemn to failure any monetary regime, and inflation targeting is no exception.

Given the basic role of policy credibility and inflation expectations in achieving the goal, an important merit of inflation targeting is that it forces the Central Bank to communicate its decisions effectively and transparently to the public and to be accountable for its actions. By diminishing the asymmetries of information between the Central Bank and other economic agents, good communication and transparency of monetary policy warn the public about inconsistent policies and diminish the uncertainty about future actions. Inflation targeting has achieved price stability, which is now deemed to be the central concern of monetary policy, while also providing for output stabilization and helping countries deal with the turbulence of international markets.

This volume highlights the fact that many questions do not yet have a satisfactory answer. This is partly due to the broadness in the definition of inflation targeting. There is agreement on its basic features but not on the details of its actual implementation. These details can make the difference in the success of the monetary regime. The implementation of inflation targeting will remain a complex issue, given that its operational aspects must be chosen on a country-by-country basis, with only basic guidelines to be applied cross-nationally. Thus the selection of the actual price inflation to be targeted,

the policy time horizon, and the weight given to output gaps and other variables in the Central Bank's reaction function depend to a large extent on the specific characteristics of each economy, including the types of shocks that it faces.

Although inflation targeting is far from a magical solution, it is a reliable monetary alternative for countries that have the political willingness and technical capacity to adopt and communicate responsible macroeconomic policies. More countries can be expected to adopt inflation targeting in the coming years, most likely in connection with a policy of flexible exchange rates. The specific implementation of this monetary regime will continue to be a source of future research.

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# Inflation Targets in a Global Context

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Inflation targeting has become a global framework. There is an inflation-targeting country on every continent, and many other countries have introduced particular characteristics of inflation targeting into their monetary framework. Inflation targets have thus far proved to be durable: no country has dropped its inflation target, other than to join a monetary union.

Assessing the global contribution of inflation targeting in pioneering new options for framework designers is, however, complicated. Drawing lessons from a narrowly defined group of countries commonly labeled as inflation targeters may understate the mechanism's contribution in influencing the frameworks of a very wide range of countries. Conversely, it is also possible to overstate its contribution, since many of the characteristics of inflation targeting have been previously used in other contexts. The Bundesbank, for example, has clearly stated its numerical inflation and money objectives for a number of years, and according to Posen (2000), the transparency with which the Bundesbank explained expected deviations from these objectives is a model for emerging economies.

An accurate assessment of the wider contribution of inflation targeting must therefore look at global developments in monetary framework design. This paper focuses on the relations among the jigsaw pieces of characteristics that together form a monetary policy framework. It not only assesses the experience of those countries recognized as operating inflation-targeting frameworks, but examines the monetary frameworks of a total of ninety-four economies using the results of a survey contained

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in Fry and others (2000). That survey of monetary framework design is the broadest ever conducted, and it contains questions relating to central bank objectives, targets, independence, accountability, transparency, and the analytical capacities of central banks.

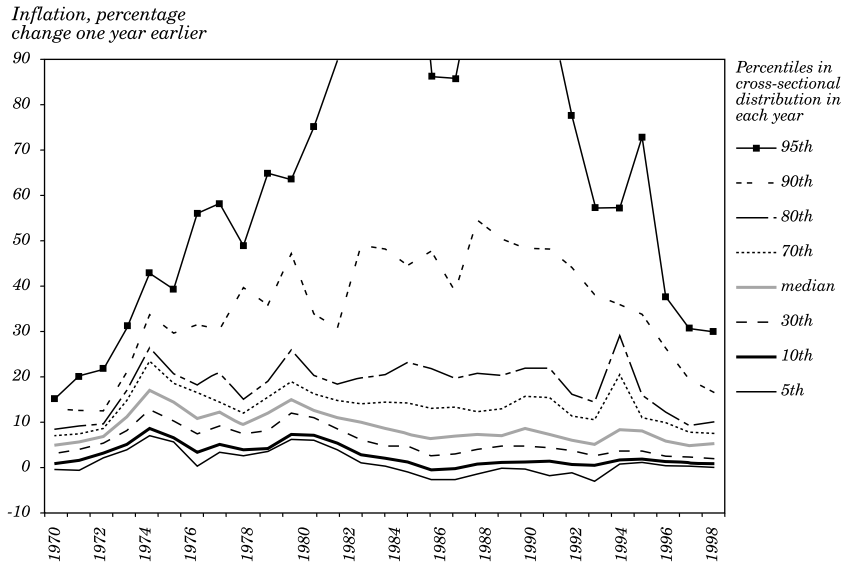
The following section sets the scene by reviewing international performance in using various alternative nominal anchors to achieve stable inflation since 1970. Sections 2 and 3 address the roles of inflation targeting as seen by practitioners, compare these views with more formal definitions of inflation targeting provided in the literature, and then outline how a broadly based survey of monetary framework characteristics can be used to place the contribution of inflation targeting in a global context. Sections 4 through 6 present some results of the survey, focusing on how targets have been used and relating their use to other framework characteristics of independence, transparency and analysis. Section 7 concludes.

## 1. The Search for Inflation Stability over Three Decades

Judging by inflation outcomes, the search for a nominal anchor was quite successful in the 1990s. Many different types of economies registered declines in inflation: inflation fell across the spectrum of low-, medium-, and high-inflation economies. Figure 1 illustrates the cross-sectional distribution of inflation rates across ninety-one economies for which continuous inflation data exist between 1970 and 1998. The lowest line in the figure represents the fifth percentile of the global inflation distribution. The lowest point on this fifth percentile line shows that in 1993, 5 percent of countries in the sample had inflation below –3 percent (that is, deflation of over 3 percent). In contrast, the upper line, which represents the ninety-fifth percentile, goes off the scale in some years. Inflation fell sharply across a very wide distribution of economies after 1994. These reductions mirror the rapid increases in inflation following the oil price shocks of the 1970s, but there is no causation in the 1970s and 1990s. The chart shows that global inflation (across the entire distribution) is lower now than it has been since the start of the 1970s.

The data are also useful for establishing the circumstances in which inflation stability has occurred. I define a stable period of inflation as occurring when inflation remains within a particular range for a minimum of five years. The ranges are specified by splitting the sample according to percentiles in the entire distribution of inflation, using

**Figure 1. Cross-Sectional Distribution of Inflation Rates in Ninety-One Economies, 1970–98a**




Source: World Bank, World Development Indicators; IMF, International Financial Statistics.
a. Data taken from ninety-one developing and industrialized economies for which data are available in each year from 1970 to 1998. Data for 1997 and 1998 includes estimates.

data for 96 economies between 1970 and 1996.[1] Of the 2,520 annual observations, 20 percent are of inflation that is less than 3.8 percent; 40 percent are less than 7.4 percent; 60 percent are less than 11.5 percent; 80 percent are less than 19.7 percent; and 20 percent are higher than 19.7 percent. This generates the following ranges:

—Very low inflation: under 3.8 percent;

—Low inflation: 3.8 to 7.4 percent;

—Medium inflation: 7.4 to 11.5 percent;

—High inflation: 11.5 to 19.7 percent; and

—Very high inflation: over 19.7 percent

The results establish that very low inflation (below 3.8 percent) is strongly associated with periods of stable inflation. In other words, once inflation is low, it is more likely to stick there than is the case at higher rates. Of the seventy occasions in the study in which inflation remained

1. The sample includes full data on the framework used in each year for the ninety-six economies, but five of these countries lack full inflation data. The analysis does not include transitional economies, as their time series are not long enough.

in a particular range for at least five years, 39 percent (twenty-seven cases) were episodes of very low, stable inflation (less than 3.8 percent).

The data suggest that exchange rate targeting has been the most successful nominal anchor in terms of achieving periods of stable inflation.[2] Thirty-nine of the seventy stable-inflation episodes occurred when the country was targeting the exchange rate for all or most of the period. Industrialized countries have been far more successful than developing countries in achieving episodes of stable inflation within ranges of very low, low, or medium inflation.[3] Over the past three decades, low, stable inflation has occurred predominantly in Germany, Japan, and the United States, as well as in countries that successfully fixed their exchange rates to these large economies. More recently, it has also been achieved by inflation-targeting countries and by Switzerland, which historically has used money targeting.

The analysis highlights the poor historical performance of domestic anchors in emerging economies, together with the consequent gap that might be filled by the recent developments in monetary frameworks. Currency crisis have pushed a number of emerging economies toward a floating exchange rate regime.[4] At the same time, there is no example of a developing economy achieving very low or low stable inflation while relying on a domestic policy anchor.[5] The fourteen episodes of very low or low stable inflation in developing economies were all achieved through exchange rate targeting, that is, through borrowing monetary credibility from abroad. The data contain no precedents of developing and transitional economies successfully using a domestic nominal anchor to achieve periods of inflation stability.

The poor historical record of developing countries in using domestic nominal anchors to achieve stable inflation is not necessarily suggestive of a similar future performance. Advances in the technology of monetary frameworks, ranging from reduced provision for fiscal deficit finance to greater independence, accountability, and transparency of policy, have increased the likelihood of improving inflation performance within individual countries.

2. Data for monetary frameworks are from Cottarelli and Giannini (1997), supplemented by International Monetary Fund (IMF) annual publications and the Bank of England survey.

3. This could be attributable both to policy and to a greater prevalence of exogenous shocks such as commodity prices.

4. Fischer and Sahay (2000), for example, note that only four transitional economies had fixed exchange rate regimes in early 2000.

5. India achieved stable inflation in the medium range in the 1990s using a discretionary policy that was based on managing—as opposed to pegging—its exchange rate.

## 2. The Essence of Inflation Targeting: Practitioners' Views

Inflation targeting has received positive mid-term reports in some of the countries in which it has been implemented, where it is widely regarded as having contributed to achieving monetary stability.[6] The reflections of framework practitioners are thus a good place to identify the most important themes and questions concerning inflation targeting. Over fifty central bank governors and deputy governors addressed the issue of monetary policy frameworks at the Bank of England in June 1999. Josef Tosovsky of the Czech National Bank framed the key issue in the choice of framework design in nautical terms: As "navigators aboard the good ship *Monetary Policy*", he argued that we search not just for an explicit target to provide a nominal anchor, but for institutional arrangements that constitute a harbor for safe anchorage (in Mahadeva and Sterne, 2000, pp. 191–92). The discussion provides an overview of the nature and the importance of inflation targeting from the point of view of practitioners.[7] The governors represented four countries that have several years of experience with inflation targeting (namely, Canada, the Czech Republic, New Zealand, and the United Kingdom), as well as many others that have more recently implemented an inflation targeting regime or whose frameworks have been influenced by the mechanism.

### 2.1 Does Inflation Targeting Represent a Sea Change in Framework Design?

The discussion indicates that practitioners generally perceive inflation targeting to be important in the evolving framework options, rather than viewing it in terms of a radical shift from previous frameworks. According to Mervyn King (Bank of England), when the Bank of England was deciding on its monetary framework following the country's exit from the ERM (the European exchange rate mechanism), its choice of framework was not influenced exclusively by central banks that had pioneered inflation targeting, such as the Reserve Bank of New Zealand. King reports that "[We] looked at what we thought were broadly successful central banks around the world, and let me take the examples

6. Haldane (1995) contains an early assessment of its use, while Bernanke and others (1999) compare inflation targeting frameworks with those used in Germany, Switzerland, and the United States. In the context of emerging economies, Blejer and others (2000) conclude that the strategy should be considered further.

7. The discussion is published in Mahadeva and Sterne (2000, pp. 182–205).

of the Bundesbank and the Federal Reserve. Neither had an inflation target: one had a monetary target and the other had no quantified specific target at all, though it had general commitment to price stability and high employment. But, we asked ourselves, what sort of discussion took place in the Bundesbank Council and the FOMC [the U.S. Federal Open Market Committee]? And it seemed to us that a good description of what they actually did was that they looked ahead to where inflation was likely to go in the absence of a policy change. And then they decided whether or not the likely inflation outcome was acceptable" (Mahadeva and Sterne, 2000, p. 184).

All frameworks aim to keep inflation low in the long run but to respond to shocks, an observation that prompted King to state that "An inflation target is not a new view of monetary economics or the monetary transmission mechanism" (Mahadeva and Sterne, 2000, p. 182). Christian Stals (Reserve Bank of South Africa) reinforces the view and expresses reservations about classifying countries into different frameworks: "[A] monetary policy framework is very much about presentation, transparency, explanation, and so on.... I think there is only one particularly defined monetary policy framework: it can begin with an inflation target, and if you have an inflation target you have to control the growth in the money supply, and if you have to control the growth in the money supply you have some kind of restriction on bank credit extension, and if you have to control bank credit extension then you have a liquidity policy, and if you have a liquidity policy you have an interest-rate policy.... So deciding in the end which one of those elements of the framework you use as a reference point or as an intermediate target or as a final target, you cannot ignore the other elements of that framework" (Mahadeva and Sterne (2000, p. 195).

## 2.2 The Benefits of Inflation Targets

The aspects of inflation targeting that practitioners mention as being particularly important are its contribution to improving coordination between the fiscal and monetary authorities, to influencing expectations of the private sector, and to providing focus within the central bank itself. These contributions however, are cited primarily by practitioners in low-inflation countries. Gordon Thiessen (Bank of Canada) comments that "It changes the way you make decisions and the way you describe decisions and I must say from my own personal point of view it has changed enormously my relationship with the House of Commons standing committee. Having an agreed target just changes the whole nature

of these discussions and I think makes monetary policy more credible, more understandable, and less an issue of controversy than it was before" (Mahadeva and Sterne, 2000, p. 194). Similarly, Don Brash (Reserve Bank of New Zealand) holds that specifying the inflation target in conjunction with the government is "hugely beneficial." He argues that "Having the target agreed with the government and known to the public greatly reduces the risk of government criticism of the central bank as long as the inflation rate is, and seems likely to remain, above the floor of the inflation target." Brash further states that "If the government stipulates an inflation target that it wants the central bank to deliver, it implicitly states that if fiscal policy is eased in a way that is inconsistent with that inflation target, the central bank will of necessity tighten monetary policy" (Mahadeva and Sterne, 2000, p. 187).

The target may also be useful in influencing the behavior of the private sector. With reference to wage setting, Brash reports that "When our inflation target was introduced, the trade union movement basically denounced it, and called the central bank Governor all kinds of unflattering names. But at the same time, they told their members that as long as this undesirable policy was in place, the unions would have to restrain their wage demands; otherwise unemployment was going to go up. And I think inflation targeting really meant that unions recognized that they were no longer influencing the inflation rate; they were influencing the unemployment rate, and I think that was a very important learning point."

Similarly, King argues that the inflation target can serve as a useful benchmark for explaining objectives and as a reference point to explain interest rate decisions. He argues that "It seems to be fundamental to get across to the public that the objective of monetary policy is solely to do with price stability in the long run." In terms of explaining particular policy decisions, he states that "it is more difficult to explain to the population at large that a particular interest rate decision was made in order to control the growth of a monetary aggregate. It is easier, I think, to explain if you can relate the decisions to something that is visible and comprehensible, and an inflation target has that great advantage" (Mahadeva and Sterne, 2000, p. 184).

Finally, several governors from a variety of economies spoke of the benefits of the inflation target for the internal workings of the central bank. Mervyn King explains that "It does give everyone in the central bank a very clear view as to what the domestic anchor for policy is. It is a common-sense approach to say that what we are trying to achieve is price stability, so let's be very clear and judge our

success or failure by what happens to inflation" (Mahadeva and Sterne, 2000, pp. 182–83). Josef Tosovsky (Czech National Bank**)** went even further by suggesting that **"**Inflation targeting changes the central bank completely. In our case, there were changes in organizational structure, in procedures, and in responsibilities and accountability of individual people in the central bank, including the board. So one breaks down the barriers and communicates very effectively with the general public. The 'kitchen' of monetary policy has to be open, showing what ingredients were used when the staff was preparing the forecast and what was behind a particular decision" (Mahadeva and Sterne, 2000, p. 194).

Inflation targeting thus has the potential to bring about improved credibility by affecting the incentives of policymakers, even when a sound track record has not yet been established. This is explained by Tosovsky: "Perhaps the most important issue in the framework of inflation targeting [is] expectations. Inflation targeting helps to reach a certain consensus on the inflation outlook between trade unions, on the one hand, and the Government and, of course, the central bank on the other. Gaining such agreement on the mix of policies—income policy, fiscal policy, and monetary policy—should be beneficial because it should reduce the cost of disinflation."

## 2.3 Under What Circumstances Should Inflation Targeting Be Implemented?

The governors' indicate two approaches to this question. The first is voiced by Arminio Fraga (Brazil), who argues that "It is very hard not to move toward inflation targeting once you have chosen to float" (see Mahadeva and Sterne, 2000, p. 202). An extension of this argument would suggest that even if it were not possible to implement all the ingredients for an effective domestic nominal anchor based on inflation targeting, implementing some of them is better than the alternative of doing nothing.

The second approach is to focus on the prerequisites and constraints to effective inflation targeting. Daudi Ballali (Bank of Tanzania) used the experience of Tanzania to illustrate the limitations of inflation targeting: "[W]hen the Treasury asks what is the size of reduction in the inflation rate that is achievable in the coming year, I just say, 'If you can give me the size of the deficit, then I can say what is achievable" (see Mahadeva and Sterne, 2000, p. 199). Similarly, Dr. Matthews Chikaonda (Bank of Malawi) extends the nautical analogy in stating, "What we need to do is to cross over to the other side of the harbor, the

fiscal side, and bring those guys on board." In the United Kingdom, too, Eddie George (Bank of England) feels that the success of the framework depends on government support for it. He argues that "Once [that] has been accepted at the political level and embodied in statute, or in the government endorsing or imposing a monetary or inflation target on the central bank, then… you can expect to have greater coordination on the fiscal side. And that is why the explicit endorsement by the political authorities in the country is absolutely crucial, in our experience, in implementing this regime" (see Mahadeva and Sterne, 2000, p. 203). All of these prerequisites are similar to those for operating an effective money-targeting or discretionary regime.

## 3. Using Definitions of Monetary Frameworks and Inflation Targeting

It is considerably easier to provide a general definition of a monetary framework than it is to identify precisely those components that distinguish different types of monetary frameworks such as money targeting and inflation targeting. McNees (1987, p. 3) defines a monetary framework as "the institutional arrangements under which monetary policy decisions are made and executed." Therefore, the analysis of any monetary policy framework necessarily extends considerably beyond a particular target and beyond the confines of the central bank. Monetary policy frameworks are normally politically determined. They may depend, for example, on the country's financial institutions, the degree of expertise in monetary policy matters that exists both inside and outside the central bank, and other institutional and structural economic features. With so many variables, one size does not fit all.

Inflation targeting is a particular type of monetary framework. Its emergence suggests that a more robust nominal anchor may be available across a wide variety of economies. Bernanke and others (1999) are among those who point out that it involves "a framework not a rule." To draw lessons, it is helpful to define the key characteristics of inflation targeting in those countries that have practiced it, which a number of authors do. Table 1 illustrates some of the core features of inflation- and money-targeting frameworks in industrialized economies as defined by various authors. Analogies such as "constrained discretion" capture the essence of inflation targeters.[8] It is difficult, however, to establish a consensus on a precise definition that distinguishes

8. See Bernanke and others (1999, pp. 293).

inflation-targeting, money-targeting, and discretionary frameworks. Definitions must, in practice, identify specific framework characteristics, yet defining essential characteristics of inflation targeting does not fit comfortably with the view that no single program is applicable to all monetary policy frameworks. Some definitions, for example, may be interpreted as overstating the relative importance of analytical methods or institutional characteristics to a particular framework.

**Table 1. Different Definitions of Money and Inflation Targets**

| *Study* | *Main distinction made between money and inflation targeting* |
|---|---|
| Leiderman and Svensson (1995) | With reference to Canada, Finland, New Zealand, Sweden and the United Kingdom, the authors write, "These inflation targeting regimes have two characteristics: an explicit quantitative inflation target (specifying the index, the target level, the tolerance interval, the time frame, and possibly situations under which the inflation target will be modified or disregarded… [and] the absence of an explicit intermediate target for monetary aggregates or exchange rates." |
| Masson, Savastano, and Sharma (1997) | The authors mention four essential ingredients of inflation targeting: "explicit quantitative targets for the rate of inflation some period(s) ahead;… clear and unambiguous indications that the attainment of the inflation target constitutes the overriding objective of monetary policy in the sense that it takes precedence over all other objectives;… a methodology ('model') for producing inflation forecasts that uses a number of variables and indicators containing information on future inflation; and a forward-looking operations procedure in which the setting of policy instruments depends upon the assessment of inflation pressures and where the inflation forecasts are used as the main intermediate target." |
| Cottarelli and Giannini (1997) | "Inflation targeting is not purely the announcement of some short-run inflation target by the government—something that to different degrees occurs in most countries—but the announcement of a targeted inflation path extending up to a few years ahead, coupled with the setting up of procedures for public monitoring of how the monetary authorities pursue their objective." In contrast, monetary targeting is "characterized by the announcement of a short-term intermediate target, either in the form of a monetary aggregate or of a (typically crawling) peg." |
| Mishkin (2000) | "Inflation targeting is a monetary-policy strategy that encompasses five main elements: (i) the public announcement of medium-term numerical targets for inflation; (ii) an institutional commitment to price stability as the primary goal of monetary policy, to which other goals are subordinated; (iii) an information-inclusive strategy in which many variables, and not just monetary aggregates or the exchange rate, are used for deciding the setting of policy instruments; (iv) increased transparency of the monetary-policy strategy through communication with the public and the markets about the plans, objectives, and decisions of the monetary authorities; and (v) increased accountability of the central bank for attaining its inflation objectives." |

## 3.1 Against a Prerequisite Approach to Introducing Inflation Targets

In labeling frameworks, a number of papers stress both the importance of macroeconometric models in inflation-targeting economies and the problems in building and using such models in developing and transitional economies.[9] Yet the survey results indicate that even in frameworks described by central banks as inflation targeting, judgmental forecasts are used just as frequently as model-based forecasts. Similarly, inflation targeting emphasizes the role of forward-looking policy and transparency, but these may be equally important in money-targeting frameworks and even more important in discretionary frameworks. In addition, definitions that focus on the explicitly targeted variable may not fully capture policy preferences. Very few money targeters, for example, would choose to adhere to the target if there was clear evidence of a velocity shock.

In a global context, attempts to define who is and is not targeting inflation can be an arbitrary exercise. Moreover, any attempt to establish prerequisites or preconditions to being classified as an inflation targeter is counterproductive.[10] Practitioners may interpret such discussions of prerequisites as implying that they should not employ an inflation target as an important part of their framework unless they already have in place transparency, central bank independence, and sound forecasting capacity. This would be a mistake.

There is no firm evidence, to my knowledge, that introducing certain characteristics associated with inflation targeting must be sequenced in a particular order. Emphasizing the importance of an inflation target could, in fact, be beneficial even when the other characteristics are not in place. Like other framework inputs, an inflation target may have positive marginal productivity toward the output of monetary stability, irrespective of the state of the other framework inputs. For example, a carefully negotiated inflation target could conceivably contribute to improved coordination of fiscal and monetary policy, even if forecasting capacity is limited, central bank independence is restricted, and little effort is being made to explain policy to the public. There are indeed many examples of both industrialized and emerging economies that adopted an inflation target be-

9. For example, Masson, Savastano, and Sharma (1997); Debelle and Hoon Lim (1998) for the Philippines; Christoffersen and Wescott (1999) for Poland; and Hoffmaister (1999) for Korea.

10. The discussion of prerequisites is a flaw in an otherwise excellent paper by Masson, Savastano, and Sharma (1997).

fore improving the coordination of fiscal and monetary policy, their forecasting performance, and central bank independence.[11]

The evidence on building credibility through the flexible use of targets presented below further undermines the view that strict prerequisites need to be in place before targets are adopted. Countries with unstable velocity have found intermediate money targets to be useful, just as countries with supply shocks, no detailed macroeconometric model, and limited independence have found inflation targets to be useful. In short, framework choices may evolve in a number of ways to meet particular circumstances, and focusing on prerequisites to any particular framework carries the risk of distracting policymakers from pursuing an optimal choice.

## 3.2 A Survey-Based Approach to Assessing the Contribution of Inflation Targeting

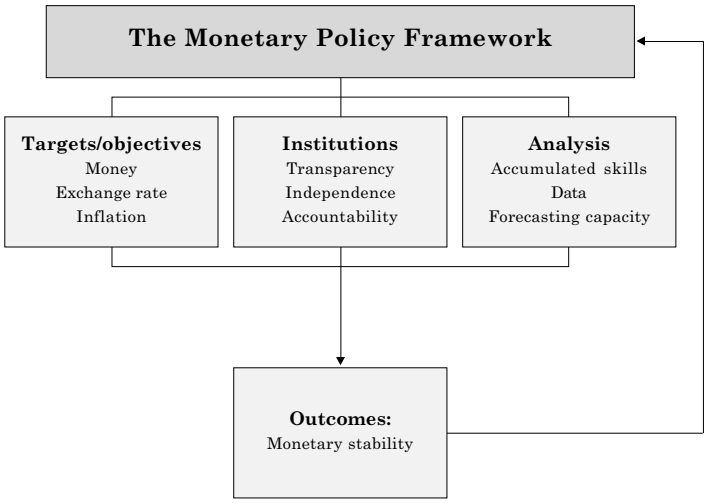
Macroeconomic policymakers have evolved their frameworks by fusing successful strategies from different types of regimes. The key advantage of a broadly based survey is that it considers the potential for a marginal contribution of any particular framework characteristic irrespective of the state of others. The paper investigates, for example, the extent to which inflation targets may be useful irrespective of the degree of transparency, accountability, independence, or other elements of an inflation-targeting framework. Similarly, it is possible to assess the contribution of transparency to delivering price stability irrespective of whether an inflation target is used.

A clearer perspective on the contribution of inflation targeting emerges when the experiences of inflation-targeting countries are compared with those from other economies that have developed nominal anchors over recent decades.[12] Figure 2 summarizes the characteristics from which a prototype monetary framework might be chosen. This paper analyzes each of these characteristics on the basis of data for a very broad group of ninety-four monetary frameworks that were surveyed in late 1988. The data are taken from a survey contained in Fry and others (2000); the countries included in the survey are listed in the appendix (table A1). Figure 2, which forms the basis of the framework characteristics measured by the

11. The Bank of England, for example, did not become independent until four years after it implemented inflation targeting, and its forecasting capacity was given impetus by the switch to inflation targeting.

12. None of the central banks from the largest three economies in the world, for example, describe their framework as inflation targeting.

**Figure 2. Monetary Framework Characteristics**




survey, is based on the presumption that there exist prerequisites to monetary stability, rather than to any particular monetary framework. The figure illustrates the distinct characteristics that may contribute to price stability. It would be difficult, however, to circle a group of these characteristics and identify them only with inflation targeting or money targeting. There would be many exceptions. Even the most carefully constructed definition of inflation targeting, such as Mishkin's, cannot exactly distinguish inflation targeting from money targeting frameworks, since effective money targeting might imply very similar ingredients.[13]

To improve understanding of the interactions between objectives, constraints, and the choice of policy framework instruments, the survey sought to measure as fully as possible the characteristics of frameworks. These include the following: the extent to which each country focuses on (1) exchange rate objectives, (2) money objectives, and (3) inflation objectives; institutional factors, namely, (4) the degree of independence of the central bank, (5) the accountability of the central bank to government and parliament, and (6) policy explanations (the extent to which the central bank provides the public with sufficient information to understand more fully the goals and reactions of policy); and analytical factors, namely, (7) the extent to which the central bank uses various indi-

13. See Posen's (2000) assessment of the post-war performance of the Bundesbank.

cators of inflation expectations, (8) the extent to which the central bank uses models and forecasts, and (9) the importance of analysis of money and the banking system to the choice of the monetary framework.

The authors use the survey results to compile a score between zero and a hundred percent for each of the categories, based on the weighted sum of responses to individual questions according to the criteria shown in the appendix (tables A2 to A7). The survey responses provide a store of facts, and many of these statistics can be drawn from the numbers in the right-hand side of each table. These columns illustrate the distribution of answers in all economies, together with a breakdown by industrialized, transitional, and developing economies.

## 4. The Use of Explicit Targets: Practical Experiences in the 1990s

The key characteristic of the framework is often an explicit target for monetary policy. This section assesses the use of such targets in a range of economies in the 1990s. The analysis is based on data provided by the ninety-three central banks that responded to the Bank of England questionnaire.[14]

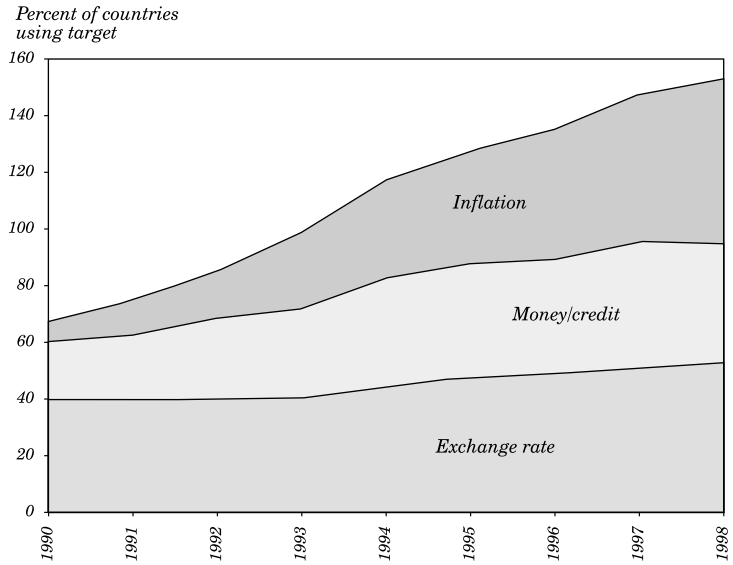
Explicit monetary policy targets became more widely used in the 1990s than at any time since the Bretton Woods era. In the survey of ninety-three central banks, 95 percent (all but four economies) used some form of explicit target or monitoring range in 1998.[15] The past three decades saw a marked increase in choices of explicit targets and monitoring ranges (see figure 3).[16] Table A8 in the appendix provides detailed information on the periods in which exchange rate, money, and inflation targets were adopted, used, and dropped in all ninety-three economies in the sample and for every year in the 1990s. The data indicate three particular trends.

14. The survey's ninety-four respondents include the European Central Bank (ECB), which completed the survey in 1999—later than other central banks. The information used here relates to the period before 1999, however, so the ECB data were excluded. The survey aimed to include variety of countries. Even so, some sample selection bias remains. For example, small open developing economies that target the exchange rate are under represented.

15. The exceptions are Botswana, Japan, Sri Lanka, and Thailand, but not the United States. In 1998 the Federal Reserve still published a monitoring range for broad money growth.

16. In the remainder of the section, I refer to targets rather than targets and monitoring ranges, although I acknowledge that some countries, including the United States, have stated that monitoring ranges have limited importance in terms of guiding monetary policy.

**Figure 3. Explicit Targets Used in the 1990s**




Source: Bank of England Survey of Monetary Frameworks.

First, many countries in the sample use more than one explicit target. In 1998, nearly half the economies in the sample announced an explicit target for more than one of the variables (namely, the exchange rate, growth in money or credit, and inflation), compared with only 8 percent in 1980. In 1998, each country published an average of 1.5 targets for these variables.

Second, the use of explicit targets—for the exchange rate, money, or inflation—became much more widespread in the 1990s than in the previous two decades. Between 1990 and 1998, the percentage of economies with explicit exchange rate targets increased from 37 to 54 percent; the percentage of countries with an explicit money target increased from 17 to 43 percent; and the number of countries with inflation targets increased over tenfold, from 5 to 58 percent of the sample.[17] Of the fifty-four countries that had inflation targets in 1998, eleven (12 percent of all countries) had an inflation target only, while of the six coun-

17. Some governments publish forecasts for inflation in their annual budget that may or may not represent an explicit target for monetary policy. These are considered explicit targets of monetary policy only if a central bank responded that there was an explicit inflation target.

tries that had explicit inflation targets in 1990, only one (New Zealand) described it as the centerpiece of its monetary framework.

Finally, in the 1990s (up to 1998), there were 114 examples of an economy announcing a new explicit target for the exchange rate, money, or inflation, while only nineteen economies dropped an explicit target. In other words, more new targets were adopted than there are economies in the sample. No country dropped its explicit inflation target in the 1990s, with the exception of countries joining the European single currency.[18]

## 5. Targets and Policy Reactions: Rules and Discretion in the Use of Explicit Targets

The debate about rules versus discretion in monetary policy can be traced back several decades.[19] The arguments are well summarized by Guitian (1994). He describes how, under a successful rules-based policy, "the predictability of policy should help offset the unpredictability of the environment." In contrast, a successful discretionary approach involves using "policy adaptability as a means of keeping an uncertain environment under control." The following section uses evidence from international experience in the use of money and inflation targets to determine the extent to which targets are followed rigidly.

### 5.1 Inflation and Money Target Misses

Policymakers may sometimes regard missing their target as acceptable. Such a choice could occur either because of shifts in preferences or because of shocks.[20] In the analysis that follows, a larger miss is associated with a relatively flexible approach to policy targeting. An important caveat, however, is that even when policy attempts to adhere rigidly to targets, transmission lags may imply that policy is unable to restore a variable to its targeted path within a given period. The data used here cannot distinguish between these two possibilities.

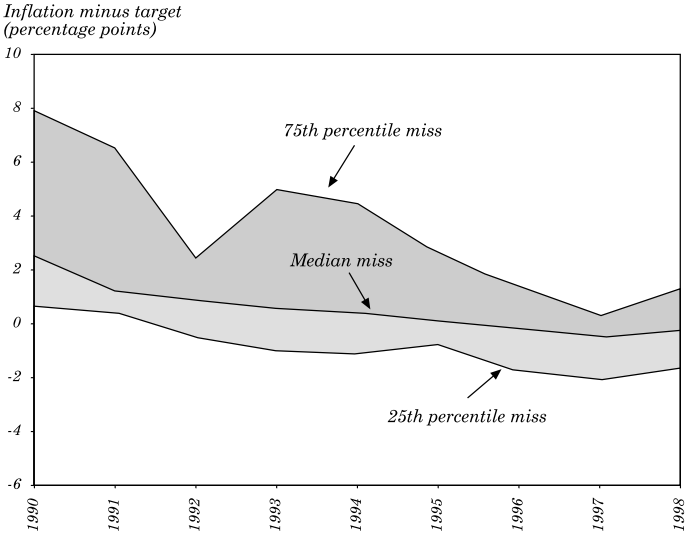
Figures 4 and 5 show the average performance relative to target and the distribution of misses for broad money growth and inflation

18. Some countries that joined the European single currency may have dropped formal targets for domestic inflation in 1999.

19. Simons (1936) stresses the policy benefits of stable money rules, which are also promoted by Friedman (1960).

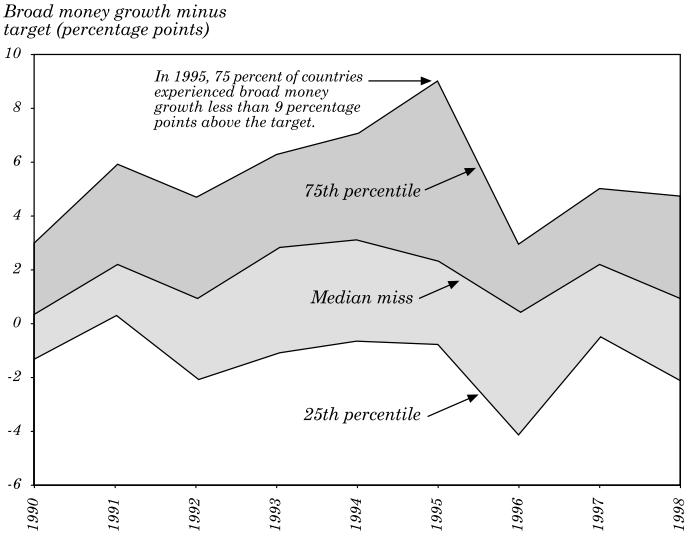
20. Debelle (1999) argues that the flexibility built into the design of inflation targets shields inflation targeting from criticism that they ignore output and employment.

## Figure 4. Distribution of Inflation Target Misses in the 1990s[a]




Source: Bank of England Survey of Monetary Frameworks; Cottarelli and Giannini (1997); IMF, International Financial Statistics (various issues).
a. Money targets include all targets for different definitions of money and credit period.

## Figure 5. Distribution of Broad Money Target Misses in the 1990s[a]




Source: Bank of England Survey of Monetary Frameworks.
a. See table 2 for the number of observations in each year.

**Table 2. Number of Observations of Inflation Misses**

| | *Inflation target* | | *Money target* | |
|---|---|---|---|---|
| *Year* | *Number of observations*[a] | *Median target* | *Number of observations*[ab] | *Median target* |
| 1990 | 7 | 3.5 | 14 | 9.2 |
| 1991 | 11 | 5.0 | 16 | 10.8 |
| 1992 | 14 | 9.0 | 19 | 10.5 |
| 1993 | 23 | 10.0 | 23 | 12.0 |
| 1994 | 30 | 8.0 | 27 | 12.5 |
| 1995 | 37 | 8.0 | 29 | 13.2 |
| 1996 | 44 | 7.0 | 30 | 14.8 |
| 1997 | 50 | 7.3 | 33 | 15.0 |
| 1998 | 53 | 6.5 | 26 | 11.6 |

Source: Bank of England Survey of Monetary Frameworks; International Monetary Fund (IMF).
a. Some outcomes for 1998 were not available from central banks. Where possible, these outcomes have been estimated using IMF data.
b. These are predominantly targets for broad money. Narrower measures were included only when no broad money target was used.

targets.[21] The number of observations varies from year to year, as do the median target levels (see table 2). For both money and inflation targets, the number of observations is particularly small in 1990–92. I therefore focus on the results for 1993–98, when there are between twenty-three and fifty-three observations in each year. The figures show the median miss for each year of the 1990s, plus the value of the miss for the country at the twenty-fifth and seventy-fifth percentile of the distribution. The shaded area thus encloses the outcomes for the half of the sample with the smallest misses above and below the target (that is, accurate observations). The analysis centers on the median rather than the mean because the distribution is skewed by a very small number of wide target misses.

The data raise several questions. First, to what extent does the increased use of explicit targets indicate a more rigid approach to monetary policy? For inflation targets between 1993 and 1998, the average width of the range of target misses between the twenty-fifth and seventy-fifth percentile is 3.9 percentage points (see figure 4). Figure 5

21. Data are responses to the Bank of England questionnaire. We tried to make data consistent by asking for information about when the target was set in the year prior to which the target referred. Target revisions during the course of the year were excluded, even when such data were provided. Where there is a target range, we use the average as the reference point. Where the target is specified as a ceiling, we treat the ceiling as the reference point.

illustrates country experience with broad money growth targets. Between 1993 and 1998, the average width of the range enclosed by the twenty-fifth percentile miss and the seventy-fifth percentile miss is 7.3 percentage points. These data suggest that broad money targets have not been treated as rigid rules.

The cross-sectional evidence presented here is complementary to the time-series evidence that assesses the likelihood of adhering to particular inflation outcomes. The time-series evidence from the 1980s and earlier suggests a humbling degree of inaccuracy in central banks' capacity to meet targets. Haldane and Salmon (1995) estimate a model for inflation in the United Kingdom and observe errors based on historical experience (1960–94).[22] In some of their simulations, they find that there is "only a 50 percent probability of adhering to a target range of 6 percentage points." This leads Haldane to suggest that the central bank faces a trade-off between "credibility and humility" (Haldane, 1995, p. 203). In practice, the relatively strong forecasting performance implies that the model-based results overstate such a trade-off. The cross-sectional evidence from the survey suggests that in the 1990s, outcomes were considerably better in meeting both inflation and money targets than model-based analysis of earlier experience suggested.[23] Nevertheless, the results from Table 3 show that the median absolute miss in the 1990s was 1.5 percentage point. In other words, the success rate for adhering to an inflation-target range of ±1.5 percentage points was approximately 50 percent in the 1990s.[24] Countries setting an inflation target of less than 3.5 percent had around a 50 percent probability of adhering to a much narrower range of ±0.7 percentage points.

One possible explanation for why the time-series and cross-country evidence differ is that combining judgement with models markedly improves the accuracy of policy. Another is that the time series results are based on estimates over several decades, whereas the results from the Bank of England survey refer only to the 1990s, when there may have been fewer exogenous shocks (that is, shocks that were not induced by policy) that triggered inflation volatility. This explanation is consistent with the view that the 1990s provided a relatively shock-free

22. Haldane and Salmon use a small macro model, add to it a policy rule, and then solve the system by feeding in a set of shocks calibrated from the historically estimated residuals. They control for policy-induced volatility. Their results are in line with time-series results for other countries estimated at the same time.

23. Though the cross-sectional analysis used here has the disadvantage of being unable to explain such good performance.

24. This is the median absolute miss for the entire sample—shown in the first column of Table 3.

**Table 3. Misses of Inflation and Broad Money Targets in Countries that Announced Explicit Targets in the 1990s**

| *Type of target and indicator* | *All observations* | *Percentile* | | | |
|---|---|---|---|---|---|
| | | *Low target observation* | | *High target observation* | |
| | | 0 – 25 | 25 – 50 | 50 – 75 | 75 – 100 |
| *Misses of inflation targets*[a] | | | | | |
| Range of targets (percentage points) | | Less than 3.5 | 3.5 – 7.2 | 7.2 – 13.5 | Above 13.5 |
| Median miss | 0 | – 0.4 | 0 | 0.3 | 1.3 |
| Median absolute miss | 1.5 | 0.7 | 1.0 | 2.2 | 6.7 |
| *Misses of money targets*[b] | | | | | |
| Range of Targets (percentage points) | | Less than 6.5 | 6.5 – 12.3 | 12.3 – 17.0 | Above 17.0 |
| Median miss | 1.8 | 0.3 | 1.8 | 2.7 | 3.5 |
| Median absolute miss | 3.1 | 1.8 | 3.0 | 3.0 | 6.5 |
| *Comparison of misses of inflation and money targets in economies that announced both in the same year*[c] | | | | | |
| Median absolute miss | | | | | |
| Inflation targets | 1.5 | 0.8 | — | 4.4 | — |
| Money targets | 3.2 | 2.3 | — | 6.2 | — |

Source: Bank of England Survey of Monetary Framework.
a. Total number of annual observations is 269; total number of countries is 56.
b. Total number of annual observations is 217; total number of countries is 37.
c. Total number of annual observations is 143; total number of countries is 31. The high and low groups were divided according to the magnitude of the sum of the inflation and money target in that year.

environment conducive to building credibility through the use of explicit targets.[25] Finally, sustained low inflation may have reduced the likelihood that shrinks will recur.

The second question raised by the data is whether the results are suggestive of bias—that is, do outcomes tend to overshoot or undershoot the target on average? To the extent that unexpected shocks even out over the sample period, the results suggest that policymakers have, on average, been realistic in setting inflation targets. In the sample as a whole, the median miss was close to zero. In contrast, money growth tended to overshoot the target. Part of the explanation may be that central banks consistently underestimated falls in velocity. Figure 5 provides evidence that money targets have been overshot more often than undershot. The table shows that the median money target miss for the entire sample was +1.8 percentage points.

25. It is less clear how the proliferation of explicit targets has helped to create such a shock-free environment.

Third, to what extent do the results depend on the inflation rate prevailing when the targets are set? Each section of table 3 shows that misses are higher when the targets are higher, both for inflation and for money growth. Overall, misses remain roughly in proportion to the level of the target. There are more than sixty-seven observations spread over the entire sample length for annual inflation targets of less than 3.5 percent. They illustrate that the median miss is –0.4 percentage points (the minus sign indicates that low-inflation countries have undershot the target more often than overshooting it).[26] Low-inflation countries have established a track record of accuracy in hitting targets, with little evidence of systematic over- or undershooting. For countries with higher targets, the table confirms that misses have been larger and outcomes more likely to be above target than for countries with low targets.

Money-growth targets exhibit a similar pattern of misses, increasing in magnitude for higher-target observations. The size of the absolute miss is not as clearly related to the size of the target as is the case for inflation. This is because several economies, such as Taiwan, have had considerable success in anticipating shifts in velocity and meeting money targets, even when the targets are set at relatively high growth rates.

The results show that inflation misses were less than half of those for money targets. The median inflation target miss (in absolute terms) for countries that announce both inflation and money targets is 1.5 percentage points, compared with 3.2 percentage points for broad money growth. The results are consistent with the view that over a broad range of countries, the mix of shocks leads to greater deviations from money targets than inflation targets. In particular, velocity shocks may have led to relatively larger deviations from money targets. The results may also reflect the priority that policymakers give to inflation targets over money targets, in the event of a conflict between them.

The results also illustrate that, in practice, it is difficult to assert that inflation targets imply any more or less discretion than do money targets, although inflation targets might be thought to be more discretionary in the short term. Cottarelli and Giannini (1997) note that money targeting is "characterized by the announcement of a short-term intermediate target, either in the form of a monetary aggregate or of a (typically crawling) peg."[27] Policy instruments typically affect

26. Some of these targets are ceilings, so a marginal undershoot may not be indicative of systematic target undershooting.

27. This argument about the nature of the implementation of intermediate money targets does not necessarily conflict with the view that inflation is purely a monetary phenomenon in the long term.

money aggregates sooner than inflation, such that policymakers wishing to adhere to money targets may have to act sooner and with less discretion.[28] Yet money target outcomes have deviated from target by more than inflation outcomes, indicating that money targets are either harder to hit or are interpreted more flexibly. This would support the view that policy may be set pragmatically, irrespective of the published target.

## 5.2 Inflation Targets and Policy Reaction Functions: A Survey-Based Approach

The survey responses provide new evidence with which to assess how central banks around the world direct policy toward their objectives. In particular, the survey sheds light on the capacity of monetary frameworks such as money and inflation targeting to distinguish adequately among frameworks, and it examines the extent to which exchange rate strategies are being pushed toward more extreme choices of freely floating or rigidly fixed arrangements.

### Policy focus and framework labels

It is convenient to attach labels to frameworks, such as inflation targeting, money targeting, and exchange rate targeting. In practice, only a small minority of economies treat their targets as rigid rules—and nearly all of these are targeting the exchange rate—so a label cannot predict how policy will react to a given shock. In the short run, almost all central banks may treat domestic targets flexibly in response to certain shocks. In the long run, by contrast, almost all central banks are likely to aim for monetary stability, as defined by their legal objectives.

Rather than categorize economies into lists of labeled frameworks, this study attempts to capture the degree to which policy focuses on a particular variable by assessing (i) whether a target is announced; (ii) whether the central bank defines its framework in terms of targeting a particular variable; (iii) how the central bank ranks policy priorities in practice; and (iv) which variables prevail in policy conflicts. Each

28. Although if inflation targeting implies rigid adherence to an inflation forecast, it may limit the scope for discretion even when policy does not attempt to hit the current inflation rate. Goodhart (2000) assesses how targeting future inflation may still leave scope for discretion in policy decision.

economy is given a single score—between zero and a hundred—for each variable. (See the appendix for a description of the scoring system and a list of scores.) The scores give an indication of the degree to which policy focuses on its principal objective and how far policy may be diverted toward other objectives.

The tables in the appendix help explain what governs the short- and medium-term policy focus. (The legal mandate of central banks to achieve price stability is often interpreted as a long-term objective.) For the great majority of countries, the indexes show that policy is sometimes diverted from its prime focus. The measures of policy focus suggest that only 10 percent of frameworks in the sample have a policy that focuses exclusively on either the exchange rate, money, or inflation. In the other 90 percent, the responses show evidence of discretion. For example, money targeters may rank inflation as important in setting the target, while inflation targeters may pay close attention to the exchange rate. Prospects for domestic inflation may affect decisions about exchange rate pegs.

A labels approach carries potential pitfalls, as demonstrated by a comparison of the categorization of regimes according to the variable for which a numerical target is published and self-classification by policymakers. In terms of how central banks in the sample classify their frameworks, just under a third of respondents do not classify their framework as targeting one variable in particular. Of those that do classify their regimes as targeting one particular variable, exchange rate targeting is the most popular self-classification (28 percent of the sample), followed by money-targeting (24 percent) and inflation-targeting (16 percent). There is by no means a one-to-one correspondence between such self-classifications and the variables for which policy targets are announced. The pitfalls of a labeling approach thus include the following:

—Not all targets are announced. About 7 percent of economies do not publish targets or reference values for the variable they classify themselves as targeting.

—Fourteen percent of countries publish a target for only one variable, but do not classify themselves as targeting that variable.

—Central banks that publish both inflation and money targets, but not exchange rate targets, do not classify their frameworks uniformly. Of these twenty-five economies, fourteen classify themselves as money targeting and three as inflation targeting, while eight choose not to classify themselves according to a single label.

—It is not possible to distinguish between money- and inflation-

targeting frameworks by observing which countries publish inflation targets, because virtually all countries that classify themselves as money targeters also publish inflation targets, guidelines, or reference values. These include the central banks of Germany (up to 1998) and Switzerland, which clearly state their medium-term inflation preferences, even though they do not describe themselves as inflation targeters. It is not surprising that so many money-targeting central banks announce inflation targets. To establish a money target, countries need to work back from an inflation and growth target or forecast. If the inflation projections are being missed while money targets are on track—for example, because of a velocity shock—there is no intrinsic reason why the intermediate target should take precedence over such inflation and output projections.

—Differences between money and inflation targeting do not necessarily reflect differences in a central bank's reaction function. Although 24 percent of respondents classified their regime as money targeting, only 1 percent reported that money always prevailed over inflation and exchange rate objectives in the event of policy conflicts. The survey results indicate that in the event of velocity shocks, both money and inflation targeters are likely to focus on inflation objectives.

—There are around four times as many central banks with explicit inflation targets as there are central banks that categorize themselves as inflation targeting. About 60 percent of economies announce inflation targets and 33 percent rank the variable as the main objective of policy, yet only 13 percent classify themselves as inflation targeting.

In practice, then, there is a continuum of overlapping possibilities, from inflation and money targets to exchange rate targets. Many frameworks have some of the characteristics of each. Analysts should therefore take a broad approach to assessing the extent to which the various objectives of monetary policy are, in the short and medium term, better described as complementary or as alternatives.

The increasing tendency of policymakers in money-targeting economies to announce such inflation projections as targets or reference values may have contributed to making policy preferences more transparent in these economies. In the 1990s a growing number of countries receiving support from the International Monetary Fund (IMF) have announced inflation objectives, reflecting their increasing importance in Fund-supported programs. This represents a change in emphasis from practices in the 1980s, when the IMF gave relatively more prominence to the role of money and credit targets in adjustment programs (see Cottarelli and Giannini, 1998).

The analysis supports the views of several authors who, when assessing the international context of monetary frameworks, reinforce the message of compromise between explicit targets and flexibility. In summarizing the debate between rules and discretion, Guitian reminds us that "there is an exception to every rule." Similarly Bernanke and others (1999) describe inflation targets as "a framework, not a rule" and as "constrained discretion".[29]

## 6. Inflation Targets, Independence, Accountability, and Transparency

Whichever variable they target, central banks appear to use their targets flexibly. How does this flexibility affect the debate surrounding the choice between money and inflation targets, and how does it affect other framework characteristics? The cross-country cross-correlation matrix of monetary policy framework characteristics shown in table 4 summarizes the broad relations among the categories measured in the survey (see the appendix for a description of the scoring methods). The table covers the ninety-three economies in the sample.[30] The following sections discuss the results from this table in more detail.

The simultaneous use of money and inflation targets appears to indicate that many countries have adapted or rejected the literature that regards targets as alternatives. The literature frames the choice of the explicit target for monetary policy in terms of the controllability of a particular variable and the stability of the relationship between that variable and the final objective.[31] While the premise on which such literature is based appears well grounded, it is hard to explain some countries' choice of targets using such a framework. Why do so many liberalizing countries with unstable velocity use money targets? Why do other countries that have poor data and are vulnerable to supply shocks use explicit inflation targets?[32] Are explicit targets in some cases better described as benchmarks, whose contribution lies in assisting the planning of fiscal and monetary policy, measuring outcomes, and assessing deviations? These questions are addressed below.

29. See Guitian (1994, p. 36); Bernanke and others (1999, pp. 293 and 299).

30. The ECB response, which was received later than the others, is excluded to avoid double-counting.

31. See, for example, Cukierman (1995).

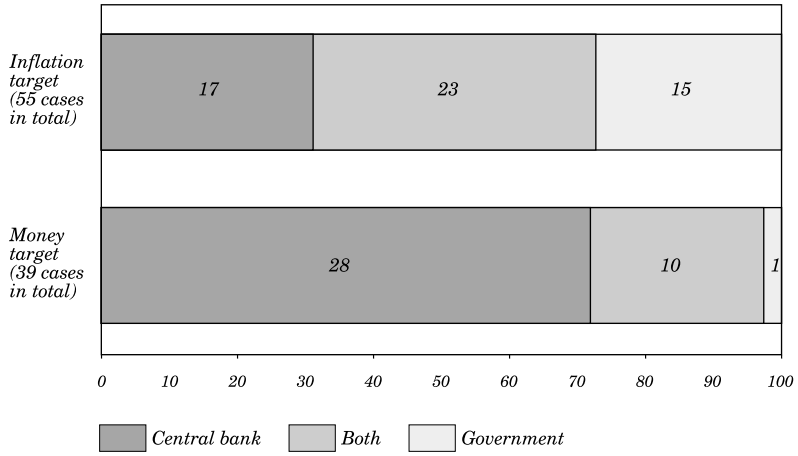
32. See Gerlach (1999).

**Table 4. Correlations between Measures of Framework Characteristics in Ninety-three Monetary Frameworks**

| | *Exchange rate* | *Money* | *Inflation* | *Discretion* | *Independence* | *Accountability* | *Explanations* | *Inflation expectations* | *Models and forecasts* |
|---|---|---|---|---|---|---|---|---|---|
| Exchange-rate focus | 1.00 | –0.54 | –0.68 | –0.46 | –0.09 | 0.03 | –0.26 | –0.29 | –0.07 |
| Money focus | –0.54 | 1.00 | 0.07 | 0.41 | –0.05 | –0.08 | –0.12 | –0.06 | –0.14 |
| Inflation focus | –0.68 | 0.07 | 1.00 | 0.18 | 0.15 | 0.09 | 0.30 | 0.43 | 0.15 |
| Discretion[a] | –0.46 | 0.41 | 0.18 | 1.00 | –0.09 | –0.25 | –0.10 | 0.06 | –0.18 |
| Independence | –0.09 | –0.05 | 0.15 | –0.09 | 1.00 | 0.06 | 0.42 | 0.32 | 0.47 |
| Parliamentary accountability | 0.03 | –0.08 | 0.09 | –0.25 | 0.06 | 1.00 | 0.14 | 0.21 | 0.11 |
| Policy explanations | –0.26 | –0.12 | 0.30 | –0.10 | 0.42 | 0.14 | 1.00 | 0.47 | 0.50 |
| Analysis of inflation expectations | –0.29 | –0.06 | 0.43 | 0.06 | 0.32 | 0.21 | 0.47 | 1.00 | 0.49 |
| Analysis using models and forecasts | –0.07 | –0.14 | 0.15 | –0.18 | 0.47 | 0.11 | 0.50 | 0.49 | 1.00 |
| Inflation[b] | 0.04 | 0.00 | –0.01 | 0.00 | –0.16 | 0.09 | –0.17 | –0.02 | –0.08 |
| Inflation rank[c] | –0.30 | 0.31 | 0.23 | 0.18 | –0.09 | 0.04 | –0.23 | –0.12 | –0.19 |

Source: Bank of England Survey of Monetary Frameworks.
a. A high score implies greater discretion.
b. Average of 1997 and 1998; includes estimates.
c. The lowest inflation rate in the sample is ranked as 1.

**Figure 6. Who Sets Explicit Targets and Monitoring Ranges for the Exchange Rate, Money, and Inflation?[a]**



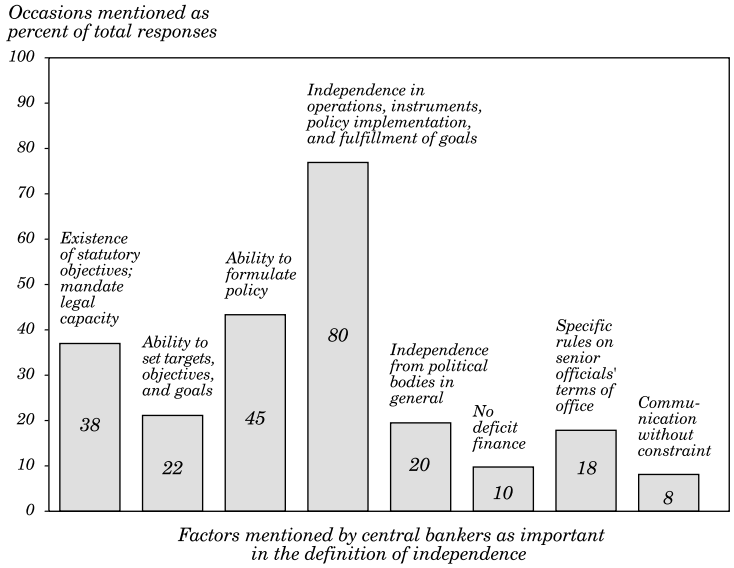

Source: Bank of England Survey of Monetary Frameworks.
a. From a sample of ninety-three central banks describing their practices in late 1998 (with some revisions for changes made in 1999, but not including changes in EMU countries). The figures in the bars indicate the number of economies with this arrangement; the length of the bars indicate the percentage set under different arrangements.

## 6.1 The Role of Targets in Defining a Relationship with Government

One of the most important contributions of inflation targets may be in terms of providing both government and the central bank with a clearly defined stake in the monetary strategy (see the discussion in section 2 above). This section verifies this assertion by examining global trends in money and inflation targets and how they relate to the nature of perceived central bank independence.

The global experience offers a variety of approaches to setting targets, ranging from demarcation of responsibilities to drawing together institutions to formulate targets. Figure 6 represents the responses of ninety-three central banks when asked whether they or the government set the explicit target in 1998, or whether the target was set jointly. The target-setting arrangements for money and inflation targets are strikingly different. Central banks have a comparative advantage in researching monetary and banking developments that may cause changes in velocity. They, after all, play a pivotal role in the banking system and

**Figure 7. How Central Bankers Define Independence[a]**




a. The responses are the author's categorisation of answers to the question "How would you define central bank independence?" There were sixty usable responses (twenty-three from industrialized economies and thirty-seven from developing and transitional economies). Respondents cited an average of 2.9 categories in industrialized economies and 2.2 in developing and transitional economies.

produce monetary data. It is natural, therefore, that central banks use money targets to monitor performance. Yet a central bank's comparative advantage in understanding monetary developments may be detrimental to the capacity of money to provide a vehicle for engaging government in setting policy strategy and in influencing public expectations. As argued by King, "It is easier, I think, to explain if you can relate the decisions to something that is visible and comprehensible, and an inflation target has that great advantage" (Mahadeva and Sterne, 2000, p. 183). Figure 6 confirms that central banks are more likely to have a dominant role in setting money targets than inflation targets.

The survey responses indicate that central banks regard independence as the most important aspect of their monetary framework. Figure 7 summarizes responses to the direct question, "How would you define central bank independence?" The general responses were translated into the categories shown in the chart, which is ordered with categories representing goal independence on the left, instrument independence in the center, and other aspects that may affect policy setting

on the right. The chart incorporates sixty responses with each country represented in at least one and, as it turned out, at most seven categories.[33] Most of the responses reflect the country's own experience, and it is under this premise that the responses are interpreted here.

The literature on independence centers on goal independence, which is represented by the clarity with which statutory objectives focus on price stability (see, for example, Cukierman, 1992). Extensive recent academic literature, prompted in part by Walsh (1995), stresses the difference between goal and instrument independence. Almost all central banks consider instrument independence to be an important aspect of independence. In practice, the effectiveness of formal arrangements providing central banks with instrument independence may, however, be undermined by a number of factors, which are represented by the bars on the right-hand side of the graph.

In contrast, goal independence tends to be important to central banks only in particular circumstances that are closely related to the target-setting capacity discussed above. Only 22 percent of respondents defined independence as the ability to set targets, objectives, or goals, while 38 percent mentioned the importance of legal objectives. The relative importance of these two measures of goal independence depends, as usual, on circumstances.

The 38 percent of respondents who defined independence by relating it to the central bank's statutory objectives generally fall into two categories.[34] The first group encompasses central banks whose mandate and statutory objectives have been revised in recent years, suggesting that governments and central banks are more likely to focus on legal objectives when these objectives are fresh and pertinent. The second group is made up of countries with money and exchange rate targets. Clear statutory objectives, coupled with instrument independence and numerical money targets set by the central bank, have helped a number of countries progress toward price stability, including Germany, Slovenia, and Switzerland.

Central banks that base their framework on inflation targets rarely define independence with reference to statutory objectives. For these

33. Only sixty responses are included because some central banks in the questionnaire did not complete this question and some answers were excluded because they explicitly referred only to the independence of their own central bank.

34. Typical responses included the extent to which the central bank can act effectively to fulfil its statutory objectives without political interference and the ability of the central bank to pursue statutory objectives without undue influence from other government officials or private parties.

countries, the target-setting arrangements are apparently much more important than in the case of money targets. In a contractual approach to monetary policy, the government may set a target and provide the central bank with operational independence to pursue the target. Perspectives on important ingredients of independence split the inflation target users into two groups, whose views on independence differ according to whether they are close to stable inflation.

Of the countries that describe themselves as inflation-targeting, only Israel and the United Kingdom have adopted a framework in which the government alone sets the target. Government sets the inflation target in thirteen other cases, but none of these arrangements were described by the central bank as inflation targeting frameworks. The responses from inflation-targeting central banks reflect how the relationship between government and central bank is strongly influenced by whether or not inflation is already acceptably low. Central banks in inflation-targeting countries with low inflation did not generally regard the ability to set the target as important in assessing their own independence. This suggests that when inflation is low, there is little scope for disagreement about what the target should be. Indeed, three inflation-targeting central banks in low-inflation economies explicitly stated that independence could be defined in terms of the central bank's capacity to meet a mutually agreed target. Such arrangements may allow government to control the long-run direction of policy, but they can also help to remove any incentive for the government to create surprise inflation (Goodhart, 2000). If government attempts to boost output in the short run by increasing the inflation target, the blatant opportunism of such an act is likely to remove the surprise from surprise inflation. This, in turn, may reduce any output effects and make such a policy ineffective.

This degree of comfort with target-setting arrangements in Canada, New Zealand, and the United Kingdom contrasts starkly with that expressed by countries using inflation targets on a disinflation path. Over 80 percent of countries using explicit inflation targets in 2000 were doing so as part of a disinflation process. Mahadeva and Sterne (2002) develop a theoretical model that shows that annual revisions to short-run targets are endogenous to outcomes during disinflation, since the chosen target depends on the last period's miss from each of the short- and long-run target. This result is confirmed using cross-country panel estimates of inflation target misses in sixty countries in the 1990s.

Short-term targets on a disinflation path are therefore inherently more akin to conditional forecasts than policy rules. Their publication

can increase transparency and hence credibility but in the context of Walsh-type models, (see Walsh, 1995), multi-year contracts may be difficult to define. A high degree of shocks may give rise to the temptation to revise the contract ex post, thus negating the contract's benefits. What should happen, for example, if inflation falls below the annual target, but remains above the long-run target for inflation (as happened in 1998 in the Czech Republic, Israel, Poland, and, to a lesser extent, Chile)? Hrncír and Smídková (2000) (for the Czech Republic), Landerretche, Morandé, and Schmidt-Hebbel (2000) (for Chile), and Bufman and Leiderman (2000) (for Israel) show how each of these economies have approached this issue. The optimal response to inflation falling between a short and long-run target may depend on the source of the shock that caused the inflation target to be missed, and in some circumstances an option might be to permit inflation to fall below its short-run target so that it can reach its long-run target more quickly.[35]

In the light of this discussion, it is not surprising that a number of respondents in disinflating countries defined independence according to the capacity to set their own targets or objectives. This is illustrated vividly by one such respondent who posed the rhetorical question, What good is instrument independence if the Parliament or Cabinet sets politically motivated goals that are binding?

An alternative to a contracting approach to target-setting may be for the government and the central bank to agree on an explicit target, in order to emphasize joint ownership of the monetary strategy. In twenty-three out of fifty-five cases (42 percent of central banks with explicit inflation targets), the government and the central bank jointly set the inflation target. These include seven central banks that describe their framework as inflation targeting (Armenia, Australia, Canada, Jamaica, Mexico, Mongolia, and New Zealand). Joint responsibility for the monetary strategy has been important in improving monetary and fiscal coordination in New Zealand and Canada, for example.

## 6.2 Inflation Targets and Policy Explanation

Targets have the potential to communicate both long-term preferences and the desired adjustment path in the face of economic shocks. Targets do not usually fulfil both roles in practice, however. Globally, the most common occurrence in setting either money or inflation targets is for the central bank or ministry of finance to announce, once a year, a

35. This is often called opportunistic disinflation, a term used by Blinder (1994).

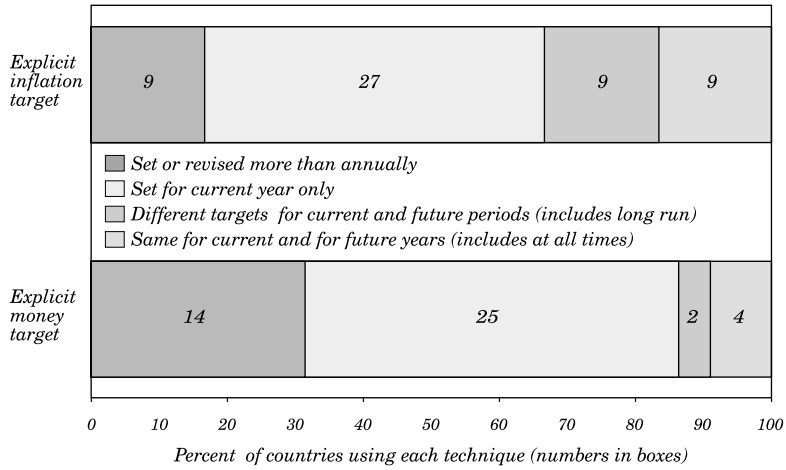
single number for the forthcoming year (see figure 8). This does not always square with the desire to use targets both to anchor long-term expectations and to steer expectations through what may be a bumpy ride toward price stability. Nor is an annual process necessarily consistent with the transmission lags of monetary policy, which appear to vary greatly from country to country (figure 9). The use of targets alone may therefore open a transparency gap, which can be filled using other instruments of communication. This section assesses the extent of such transparency gaps in different countries, the degree to which central banks have used published forecasts to close such gaps, and the effect of increased provision of information on inflation performance.

When inflation is low and relatively stable, governments or central banks may enjoy the luxury of setting targets that do not change much over time. In these countries, a constant target of, say, 2 percent inflation represents an attempt to anchor long-run expectations even when a shock to the economy temporarily diverts a variable from its long-term path. Only 17 percent of inflation targets (including those of Australia, Canada, Finland, Sweden and the United Kingdom) and 9 percent of money growth targets (including those of France and Switzerland) set the same target number year after year. Such targets may provide information about long-term preferences, rather than a planned adjustment path. In the event that shocks move inflation or money away from the target, the long transmission lags imply that the target by itself is insufficient to provide an indication of how quickly policy will restore inflation or money to the target. Additional instruments of communication, such as forecasts, are frequently used to fill this transparency gap.[36]

Two-thirds of inflation targets and 87 percent of money targets are set or revised at least annually and are not specified for more than one year ahead (see figure 8). In determining the nature of any potential transparency gap left open by targets in these economies, it helps to consider roughly how long it takes for policy instruments to have an impact on the target variable. Perceived transmission lags demonstrate enormous diversity across the different economies. Figure 9 represents the relation between changes in the operating instrument (for example, interest rates), the operating target (for example, base money), and the final objective (for example, inflation). Specifically, the figure indicates respondents' estimates of the full impact on inflation and the time taken for that impact to be felt.

36. Goodhart (2000) provides a vivid description of remaining sources of ambiguity, including the relative benefits of targeting the mean, median, or mode of inflation forecasts.

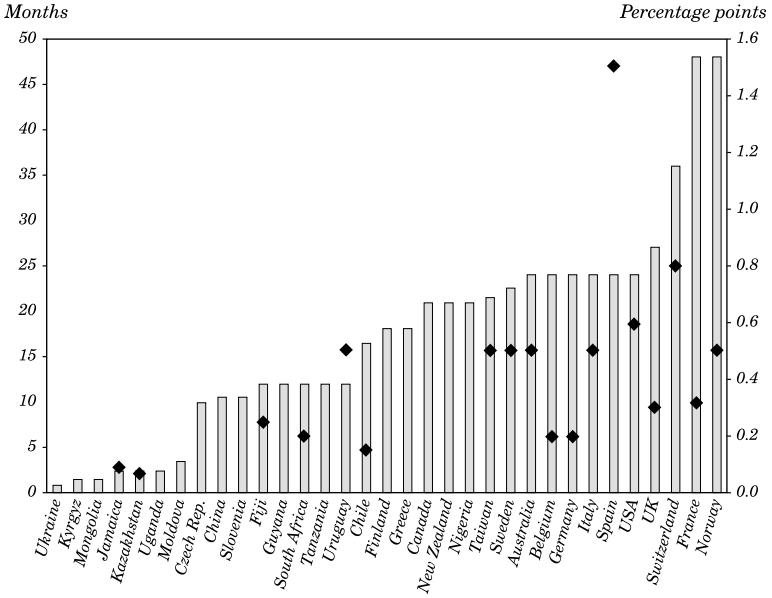
## Figure 8. Time Horizon of Inflation and Money Targets[a]




Source: Bank of England Survey of Monetary Frameworks.

a. Shorter-term arrangments are represented by boxes on the left. Numbers of frameworks in the boxes, percentage of each target set according to a particular time horizon measured on the axis.

## Figure 9. Estimated Average Length and Strength of Transmission




Source: Bank of England Survey of Monetary Frameworks.

a. Bars (left-hand scale) represent estimated average time for full impact of change in policy instrument to affect inflation; points (right-hand scale) represent estimated average strength of full impact of change in interest rates on inflation.

The bars in figure 9 represent the average transmission length; the points illustrate the average strength of the relation. The results provide a loose but illuminating means of cross-country comparison. A strong caveat is that although the results represent central bank views about the transmission mechanism in their economies, no attempts are made to ensure consistency across countries, either in terms of the model used or the approach to the experiment.[37] Differences may reflect several factors, including (i) structural differences between economies, (ii) differences in framework,[38] and (iii) differences in estimation and simulation procedures. Furthermore, not all respondents reported the strength of the effect on inflation of changes in instruments. To allow comparability across countries, results are reported only for those that specified the strength in terms of a relation between a short-term interest rate and inflation. The figure illustrates that the perceived average length of time taken for instruments to affect inflation ranges from one to fifty months in different economies.

The wide dispersion of lags in transmission mechanisms contrasts sharply with the relative homogeneity of the frequencies and time horizons over which targets are set. This indicates that targets communicate different aspects of short-run and long-run policy intentions in the various economies. It is not possible, however, to specify targets in such a way that they provide precise guidance on how policy should react to shocks and the time horizon over which price stability should be restored.

Target specification thus leaves open different forms of transparency gaps. When transmission lags are longer than the target-horizon, targets may need to be accompanied by a forecast that can indicate expected progress in bringing inflation back to target. When transmission lags are much shorter than the target horizon, the target may not necessarily bind policy in either the very short or long run. Once again, published forecasts may help to provide information on both central bank preferences and reactions to shocks.

Several recent papers highlight the importance of forward-looking policy in minimizing instabilities arising from any mismatch between the transmission mechanism length and the time horizon of targets. Batini and Haldane (1999), for example, explore this issue for the United Kingdom, while Mahadeva and Smídková (2000) use a similar approach for the Czech Republic. These papers address how far forward policy

37. For example, the policy simulation did not specify for how long instruments were to be changed.

38. The exchange rate channel is fast in many economies. If the exchange rate is fixed, the transmission mechanism may be longer.

should look, together with the costs of looking either too far forward or not far enough. They use small macroeconometric models to observe what happens to output and inflation volatility in response to shocks, when policy tries to bring inflation back to target relatively quickly or relatively slowly. Mahadeva and Smídková's results for the Czech Republic illustrate that to minimize the volatility in output and inflation, it is optimal for policy to react to forecasts for inflation between three and five quarters ahead in the Czech Republic.[39] The reaction time is longer in the United Kingdom.

The literature on transparency has grown rapidly in recent years.[40] It examines the effect of a central bank revealing its objectives and its knowledge of shocks, thereby reducing informational asymmetries between the central bank and the public. The motivation for providing such information to the public, which is similar in spirit in many central banks, is to fast-track the process of acquiring credibility.

Faust and Svensson (2000) develop a model in which increased transparency makes the intentions of the central bank observable, so the central bank sacrifices more credibility should it choose to pursue its undeclared employment objectives rather than its explicitly stated inflation objectives. Increased transparency generally reduces average inflation in their model. Jensen (2000) obtains a similar result. He focuses on the effect of a central bank revealing its preferences, which disciplines central bank actions, increases its credibility, and reduces inflation. Jensen points out an important proviso to this conclusion, however. When central bank preferences are already fully known, transparency neither increases credibility nor reduces inflation, but it does have a cost in terms of handicapping the central bank's capacity to influence the economy and pursue output stabilization.

The theoretical literature thus suggests that where reputation is important, increased transparency should lead to lower inflation by making credibility more sensitive to its actions, but that the effect is reduced or eliminated when the credibility is already high. In practice, the great majority of central banks are unlikely to have reached the stage at which they perceive their credibility to be so strong that the costs of transparency in terms of reduced capacity to stabilize output

39. The differences may reflect differing strengths of particular shocks, different forms of nominal and real rigidities, and the relative importance of the various transmission channels. In the Czech Republic, the exchange rate channel is particularly important.

40. Chortareas, Stasavage, and Sterne (2001) provide a review of the recent theoretical literature on transparency.

outweigh the benefits in terms of improved credibility. In the ninety-one economies analyzed in section 1, for example, median inflation was above 8.5 percent as recently as 1990. Most countries remain on a disinflationary path or have only recently achieved low, stable inflation. Any reluctance to pursue transparency likely stems from nervousness about exposing the central bank to external scrutiny, particularly if forecasting capacity is weak and if relationships with the government are less than fully clear.

Chortareas, Stasavage, and Sterne (2001) use data from the survey described in Fry and others to provide the first cross-sectional empirical evidence that transparency in terms of publishing central bank forecasts is associated with low inflation.[41] In the case of a country with a floating exchange rate, the central bank's decision to begin publishing a regular inflation forecast is associated with a significant reduction in inflation, particularly when the forecast is reinforced by a discussion of risks and past forecast errors. The effect of transparency on inflation is similar, irrespective of whether policy is based more upon a money or inflation target. Furthermore, for a small group of countries, Chortareas, Stasavage and Sterne (2002) also find that transparency is associated with lower costs of disinflation. Nevertheless, the results tend to support the view of Posen (2000), whose analysis suggests that the Bundesbank's success in maintaining low inflation stems partly from its thorough explanations of its policy decisions. Posen concludes that "when it comes to transparency, more is more."

## 6.3 The Relation between Measures of Analysis Conducted and Inflation Targets

The success of a monetary framework that retains any degree of exchange-rate flexibility depends on the analysis that supports it. The questionnaire therefore asked about the analysis of three separate issues. The first is the extent to which central banks monitor and use various measures of inflation expectations (such as financial markets, surveys, and outside forecasts). The second relates to the different methods used to forecast economic variables (for example, off-model forecasts, vector autoregressions, structural models, and theoretical models). The third area involves the importance of money-demand equa-

41. The authors define transparency in forecasting using data on the frequency of the forecast, its format, whether past forecast errors are discussed in bulletins, and whether risks to the forecasts are discussed.

tions and other means of analyzing the role of the financial sector in the transmission mechanism.

A summary of the results are shown in the appendix (tables A2 to A7), and the extent to which some of these characteristics are correlated with other aspects of monetary frameworks is shown in table 4. Some of the correlations in the table are as expected: the more important inflation objectives are, the greater the score for analysis of inflation expectations. The use of models and forecasts, however, is not significantly related to the choice of monetary framework. Knowledge of how policy actions affect the economy is always useful, irrespective of the policy target. Model-based forecasts tend to indicate much greater uncertainty in inflation and money outcomes than is actually the case, such that the purpose of modeling must be merely to forecast. The table provides a strong indication that such a purpose is related to transparency. The correlation between analysis using models and policy explanations is very strong, which is consistent with the view that models are used more to help understand the transmission mechanism than to provide a sharp increase in forecast accuracy. It is easier for central banks to explain why outcomes are deviating from target when they have access to analysis that makes them confident in their explanations.

The survey sought to measure the extent to which central banks focus on particular areas of analysis by asking about their research on particular subjects. The questionnaire set out a list of subjects and asked each respondent if their central bank had (i) published research in that area; (ii) considered it in detail; (iii) considered it; or (iv) not considered it to any great degree. The results, which are summarized in table 5, illustrate some marked differences between industrialized economies and developing and transitional economies.[42] Two of the main difference are as follows. First, in the past five years, central banks in industrialized-economy have, on average, published work in 59 percent of the categories identified in the table, compared to 26 percent in developing and transitional economies.[43] The difference is probably attributable both to a higher concentration of research resources in industrialized economies and to the availability of significantly more and better data. While industrialized economies have researched a broad

42. Central banks show much greater variation in research focus when categorized by economy type than by type of framework. This in part reflects the breadth of the research categories. Several central banks have published in almost all of these areas, irrespective of their framework.

43. Published works here include central bank working papers and bulletins, as well as external publications by central bank staff.

range of subjects, analysis in developing and transitional economies has focused on some core areas of the economy, including money, banking, the balance of payments, the exchange rate, and fiscal policy.[44] A third to a half of respondents in developing and transitional economies report having published research in these areas.

There appear to be large gaps in the analysis of the real sector in developing and transitional economies. Only 8 percent of respondent banks have published research on labor markets, and similarly little analysis has been conducted on consumption and investment. This largely reflects lack of data. For example, the September 1999 edition of the IMF's *International Financial Statistics* includes no recent quarterly data[45] at all for any item in the national accounts for 80 percent of the developing and transitional economies included in the survey, compared with only 15 percent of the industrialized economies.

These results may help to explain why so many developing economies describe themselves as money targeting rather than inflation targeting. Inflation-targeting central banks generally forecast inflation by assessing the impact of real disequilibria in domestic goods markets (through the output gap) and labor markets (through the nonaccelerating inflation rate of unemployment, or NAIRU).[46] These assessments are often supported by a variety of theoretical and econometric models. For example, all the industrialized economies that classify themselves as inflation targeting have published research on the Phillips curve and the output gap, whereas only 6 percent of developing and transitional economies report having published such research. Finally, the inflation reports of central banks from economies such as the Czech Republic, Hungary, Israel, Poland, Sweden, and the United Kingdom all give prominence to assessing the relative strength of demand and supply.[47]

Thus the weight placed on analyzing the various aspects of the transmission mechanism differs sharply across economies. In a developing country with limited data on the real economy and much more frequent and reliable data on the exchange rate and money supply, these latter variables are more likely to remain permanently close to the top of the hierarchy of indicators, even if neither is targeted directly. It makes sense for these countries to use annual data for real

44. The balance of payments is the only category in which greater proportions of developing and transitional economies have published research relative to industrialized economies.

45. For any of the previous four quarters.

46. See, for example, Bank of England (1999, p. 32).

47. Other central banks publish very similar documents that are not entitled inflation reports.

## Table 5. Focus of Research in Central Banks

Percent, except where indicated

| To what extent have researchers in each central bank considered the following issues in the last five years? | Level of research activity | | | Banks that have published | | | Overall ranking of priorities[a] | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Published* | *Considered in detail* | *Considered* | *Not considered* | *Industrialized* | *Developing and transitional* | *All countries* | *Industrialized* | *Developing and transitional* |
| Monetary policy framework | 59 | 24 | 10 | 7 | 93 | 44 | 1 | 1 | 2 |
| Behaviour of banks | 43 | 30 | 24 | 2 | 59 | 37 | 2 | 7 | 3 |
| Balance of payments (incl. Capital flows) | 46 | 28 | 20 | 7 | 41 | 48 | 3 | 14 | 1 |
| Analysis of financial instruments | 44 | 29 | 18 | 9 | 67 | 35 | 4 | 2 | 6 |
| Money-demand equation | 49 | 17 | 24 | 10 | 74 | 38 | 5 | 4 | 7 |
| Exchange rate and regime | 40 | 29 | 24 | 7 | 52 | 35 | 6 | 10 | 4 |
| Financial fragility issues | 39 | 28 | 29 | 4 | 52 | 33 | 7 | 11 | 4 |
| Fiscal sector | 32 | 28 | 28 | 12 | 41 | 29 | 8 | 13 | 8 |
| Transmission mechanism | 39 | 17 | 30 | 14 | 63 | 29 | 9 | 6 | 9 |
| Modelling and econometrics | 37 | 22 | 23 | 18 | 70 | 22 | 10 | 2 | 10 |
| Price specification | 30 | 17 | 34 | 19 | 59 | 17 | 11 | 8 | 11 |
| Commodity prices and terms of trade | 24 | 19 | 33 | 23 | 48 | 14 | 12 | 16 | 12 |
| Investment and corporate sector | 23 | 19 | 30 | 28 | 48 | 13 | 13 | 14 | 13 |
| Consumption and personal sector | 23 | 16 | 30 | 31 | 56 | 10 | 14 | 12 | 14 |
| Philips curve and output gap | 24 | 18 | 16 | 42 | 67 | 6 | 15 | 4 | 16 |
| Labor market | 24 | 9 | 31 | 36 | 63 | 8 | 16 | 9 | 15 |
| Total for all issues | 36 | 22 | 25 | 17 | 59 | 26 | | | |

Source: Bank of England Survey of Monetary Frameworks.

a. The rankings are based on a weighted sum average score of the three columns given by the following equation:
Priority of research topic = (number of countries in column 1) * 3 + (column 2) * 2 + (column 3) * 1.
The overall rankings are strongly influenced by the results for developing and transitional economies because there was considerably more variance across categories in their analytical focus. In industrialized economies, for example, no category had been at least considered in detail by more than 70 percent of economies.

and nominal output to derive quarterly or monthly forecasts and targets for variables such as money. This approach may be appropriate regardless of whether the central bank (or IMF) takes a monetarist view of the economy.

## 7. Interpretation and Conclusions

The 1990s saw some convergence in global monetary strategies. An increasing number of central banks use precisely defined medium-term objectives that are consistent with their statutory objectives of price and monetary stability. More generally, strategies have evolved by fusing successful practices from different types of frameworks. The Bundesbank pioneered the strategy of anchoring expectations though targets and communication, and more recently inflation-targeting countries have taken on the mantle. Similarly, the U.S. Federal Reserve was a pioneer of forward-looking policy, yet forecasts have become increasingly important in inflation-targeting countries and elsewhere. Inflation targets are now used far more widely than in the small group of industrialized economies that first made them the centerpiece of their monetary frameworks: of the ninety-four central banks included in the survey used in this study, well over half used inflation targets in 1998.

The adoption of explicit domestic targets has provided the momentum for a heightened role for explanation in monetary strategy. In the long run, credibility is built primarily through actions and achievements, but policymakers throughout the world have recently accelerated the process by defining objectives more narrowly and more clearly explaining the outcome of targeted variables. Whichever target is adopted, it is highly unlikely that the optimal strategy will always be to maintain policy exactly on target. A target miss coupled with a convincing explanation for the miss is unlikely to significantly undermine credibility.

An important explanation behind the increased use of inflation targets relative to money targets is the capacity of inflation targets to provide the most visible vehicle available for guiding private sector expectations and for communicating with the government. The value of inflation targets relative to money targets may lie in providing a medium-term focal point for macroeconomic policymakers.

As long as the commitment to a target carries some weight in affecting fiscal and monetary policy decisions, inflation targets may improve long-run macroeconomic outcomes even when subsequent shocks

cause them to be missed in the short term. An early reservation regarding the use of inflation targets stemmed from the relatively benign conditions in which they were used in industrialized economies up to the mid-1990s. Practitioners now have much more experience with their use: of the 269 annual inflation targets assessed here, there is no example of a country dropping its inflation target because it deemed the miss to be excessive or because meeting the target led to an unsatisfactory macroeconomic outcome.

Differences have emerged between the theory and practice of monetary policy, partly as a result of strategy fusion. Much of the literature identifies the circumstances under which policymakers might achieve alternative economic outcomes from the choice of either inflation or money targets, yet in practice policy regimes have converged toward a flexible use of targets. One of the most popular target combinations is to declare numerical targets for both money and inflation. The increasingly widespread use of explicit targets over the past decade reflects the progress of the debate between rules and discretion. Explicit domestic targets can be used to demonstrate that a particular variable ranks high on the hierarchy of indicators, even if it is acceptable to miss the target.

Central banks continue to exhibit important differences in the institutional arrangements and practice of monetary policy. One such difference lies in the trend of bipolar convergence, whereby countries with similar structures have moved toward either rigidly fixed or floating exchange rates. Even within the group of countries sharing the same explicit target, however, policy practices differ considerably. Some of this variability may reflect the fact that central banks in emerging economy may yet have some catching up to do as regards transparency and the analysis that is needed to support transparency. Developing and transitional economies, for example, demonstrate large gaps in the analysis of the real sector, and they do not generally publish research in this area. Other differences may reflect divergence in institutional preferences: for example, who should set the money or inflation target?

Thus, while the labels of inflation targeting, money targeting, and exchange rate targeting are a convenient means by which to distinguish broad differences among framework types, monetary policy frameworks are better thought of in terms of a wide array of underlying characteristics. After all, the use of flexible strategies to improve credibility in particular economic and political circumstances contributed to reducing inflation to historically low levels at the end of the 1990s.

## APPENDIX
# Survey Questions and Distribution of Scores

### Table A1. Economies Included in the Bank of England Survey

| *Industrialized* | *Transitional* | *Developing* | |
|---|---|---|---|
| Australia | Albania | Argentina | Lebanon |
| Austria | Armenia | Bahamas | Malta |
| Belgium | Bosnia-Herzegovina | Bahrain | Malaysia |
| Canada | Bulgaria | Bangladesh | Mauritius |
| Denmark | Croatia | Barbados | Mexico |
| Finland | Czech Republic | Belize | Mongolia |
| France | Estonia | Botswana | Mozambique |
| Germany | Georgia | Chile | Namibia |
| Greece | Hungary | China | Nigeria |
| Hong Kong | Kazakhstan | Cyprus | Peru |
| Iceland | Kyrgyz Republic | Eastern Caribbean | Sierra Leone |
| Ireland | Latvia | Ecuador | Sri Lanka |
| Israel | Lithuania | Egypt | South Africa |
| Italy | Macedonia | Fiji | Tanzania |
| Japan | Moldova | Ghana | Thailand |
| Korea | Poland | Guyana | Tonga |
| Netherlands | Russia | India | Turkey |
| New Zealand | Romania | Indonesia | Uganda |
| Norway | Slovakia | Jamaica | Uruguay |
| Portugal | Slovenia | Jordan | Vietnam |
| Singapore | Turkmenistan | Kenya | West African MU |
| Spain | Ukraine | Kuwait | Zambia |
| Sweden | | | |
| Switzerland | | | |
| Taiwan | | | |
| United Kingdom | | | |
| United States | | | |
| European Central Bank | | | |

APPENDIX (continued)

**Table A2. Measure of Policy Focus on Exchange Rate Objectives**

| *Question* | *Weight* | *Score* | *Category of answers and distribution of results* | *All economies* | *Industrialized* | *Transitional* | *Developing* |
|---|---|---|---|---|---|---|---|
| If you were to categorise your framework as one of the following, which would it be? | 1 | 100 | Mentioned exchange rate only | 26 | 11 | 7 | 8 |
| | | 50 | Not categorised as one target but mentioned exchange rate targeting with one other objective | 6 | 2 | 1 | 3 |
| | | 33 | Not categorised as exchange rate targeting but mentioned in the context of two other objectives | 3 | 1 | 1 | 1 |
| | | 0 | Did not mention exchange rate | 59 | 14 | 13 | 32 |
| To what extent is the exchange rate fixed to another currency? | 1 | 100 | Explicit point target or described by IMF as fixed to another currency | 18 | 1 | 6 | 11 |
| | | 75 | Explicit band narrower than 6%, or described by IMF as limited flexibility | 13 | 3 | 1 | 9 |
| | | 50 | Explicit band of 30% or less | 15 | 11 | 2 | 2 |
| | | 25 | No explicit target (but public knowledge that target exists) or described by IMF as managed floating | 21 | 3 | 10 | 8 |
| | | 0 | Freely floating | 27 | 10 | 3 | 14 |
| Rank the monetary policy objectives (other than price or monetary stability) that the central bank pursues; indicate if there is no fixed target. | 1 | 100 | Exchange rate first objective | 33 | 13 | 7 | 13 |
| | | 50 | Exchange rate mentioned as an objective | 35 | 5 | 11 | 19 |
| | | 0 | Other | 26 | 10 | 4 | 12 |
| In your current monetary framework, is there scope for other variables to prevail over the target in the event of policy conflicts? | 1 | 100 | Exchange rate always prevails over all other objectives | 17 | 6 | 5 | 6 |
| | | 75 | Exchange rate always prevails over money and inflation objectives | 6 | 1 | 1 | 4 |
| | | 50 | Exchange rate usually prevails | 12 | 8 | 1 | 3 |
| | | 25 | Exchange rate sometimes prevails | 38 | 6 | 10 | 22 |
| | | 0 | Exchange rate rarely or never prevails | 21 | 7 | 5 | 9 |

APPENDIX (continued)

**Table A3. Measure of Policy Focus on Money Objectives**

| *Question* | *Weight* | *Score* | *Category of answers and distribution of results* | *All economies* | *Industrialized* | *Transitional* | *Developing* |
|---|---|---|---|---|---|---|---|
| If you were to categorize your framework as one of the following, which would it be? | 1 | 100 | Money targeting | 23 | 4 | 5 | 14 |
| | | 50 | Could not categorize as one target but mentioned money targeting with one other objective | 6 | 1 | 1 | 4 |
| | | 33 | Mentioned in context of two other objectives | 2 | 1 | 1 | 0 |
| | | 0 | Other | 63 | 22 | 15 | 26 |
| Do you have a specific, numerical, publicly announced target or monitoring range for money or credit? | 1 | 100 | Yes | 39 | 8 | 12 | 19 |
| | | 0 | No | 55 | 20 | 10 | 25 |
| Rank the monetary policy objectives (other than price or monetary stability) that the central bank pursues; indicate if there is no fixed target. | 1 | 100 | Money is first objective | 14 | 2 | 5 | 7 |
| | | 50 | Money mentioned as an objective | 26 | 5 | 7 | 14 |
| | | 0 | Other | 54 | 21 | 10 | 23 |
| In your current monetary framework, is there scope for other variables to prevail over the target in the event of policy conflicts? If so, how often does money prevail as a target? | 1 | 100 | Money always prevails over all other objectives | 0 | 0 | 0 | 0 |
| | | 75 | Money always prevails over the exchange rate and inflation objectives | 1 | 0 | 0 | 1 |
| | | 50 | Money usually prevails | 19 | 3 | 4 | 12 |
| | | 25 | Money sometimes prevails | 21 | 3 | 5 | 13 |
| | | 0 | Money rarely or never prevails | 53 | 22 | 13 | 18 |

APPENDIX (continued)

**Table A4. Measure of Policy Focus on Inflation Objectives**

| *Question* | *Weight* | *Score* | *Category of answers and distribution of results* | *All economies* | *Industrialized* | *Transitional* | *Developing* |
|---|---|---|---|---|---|---|---|
| If you were to categorize your framework as one of the following, which would it be? | 1 | 100 | Inflation targeting | 15 | 6 | 4 | 5 |
| | | 50 | Could not categorize but mentioned inflation in the context of one other objective | 8 | 3 | 3 | 2 |
| | | 33 | Mentioned inflation in the context of two other objectives | 3 | 1 | 1 | 1 |
| | | 0 | Other | 68 | 18 | 14 | 36 |
| Do you have a specific, numerical, publicly announced target or monitoring range for inflation or credit? | 1 | 100 | Yes | 55 | 13 | 16 | 26 |
| | | 0 | No | 39 | 15 | 6 | 18 |
| Rank the monetary policy objectives (other than price or monetary stability) that the central bank pursues; indicate if there is no fixed target. | 1 | 100 | Inflation is first objective | 30 | 8 | 8 | 14 |
| | | 50 | Inflation mentioned as an objective | 33 | 11 | 6 | 16 |
| | | 0 | Other | 31 | 9 | 8 | 14 |
| In your current monetary framework, is there scope for other variables to prevail over the target in the event of policy conflicts? If so, how often does inflation prevail as a target? | 1 | 100 | Inflation always prevails over all other objectives | 4 | 3 | 1 | 0 |
| | | 75 | Inflation always prevails over the exchange rate and inflation objectives | 6 | 2 | 3 | 1 |
| | | 50 | Inflation usually prevails | 10 | 4 | 3 | 3 |
| | | 25 | Inflation sometimes prevails | 40 | 12 | 6 | 22 |
| | | 0 | Inflation rarely or never prevails | 32 | 5 | 9 | 18 |

APPENDIX (continued)

**Table A5. Measures of Central Bank Independence**

| *Question* | *Weight* | *Score* | *Category of answers and distribution of results* | *All economies* | *Industrialized* | *Transitional* | *Developing* |
|---|---|---|---|---|---|---|---|
| To what extent do statutory objectives provide the central bank with a clear focus on price stability? | 1 | 100 | Only goal is price, monetary, or currency stability | 24 | 9 | 9 | 6 |
| | | 75 | Price stability plus financial stability objectives an nonconflicting monetary stability objectives | 54 | 13 | 13 | 28 |
| | | 50 | Price stability plus conflicting objectives | 12 | 4 | 0 | 8 |
| | | 25 | No statutory objectives | 3 | 1 | 0 | 2 |
| | | 0 | Only goals other than price stability | 1 | 1 | 0 | 0 |
| To what extent does the central bank determine the setting of policy targets? | 1 | 100 | Only central bank sets an explicit target (for inflation, money, or the exchange rate) or there are no explicit targets | 27 | 7 | 6 | 14 |
| | | 50 | Both central bank and government have a role in setting an explicit target (for inflation, money, or the exchange rate) | 55 | 17 | 14 | 24 |
| | | 0 | Only government sets a target (for inflation, money, or the exchange rate) | 12 | 4 | 2 | 6 |
| To what extent does the central bank determine the adjustment of monetary policy instruments? | 2 | 100 | Central bank decides on changes in instruments and no representative of government attends the meeting of monetary policy makers, other than as an observer | 63 | 23 | 18 | 22 |
| | | 65 | Central bank decides on changes to instruments and a representative of government attends the meeting of monetary policy makers | 15 | 3 | 3 | 9 |
| | | 33 | Central bank and government have a role in setting instruments | 12 | 2 | 0 | 10 |
| | | 0 | Central bank role in setting instruments is limited | 4 | 0 | 1 | 3 |

APPENDIX (continued)

**Table A5. (continued)**

| *Question* | *Weight* | *Score* | *Category of answers and distribution of results* | *All economies* | *Industrialized* | *Transitional* | *Developing* |
|---|---|---|---|---|---|---|---|
| To what extent are there limits on central bank financing of the fiscal deficit? | 2 | 100 | Prohibited, never used, or amounts so small and for such short periods that independence in no way affected | 46 | 26 | 11 | 9 |
| | | 75 | Narrow, well enforced limits exist | 15 | 1 | 5 | 9 |
| | | 50 | Limits exist that are usually enforced | 25 | 1 | 4 | 20 |
| | | 25 | Wide limits exist and some procedures exist when limits are missed | 7 | 0 | 2 | 5 |
| | | 0 | No limits or little enforcement | 1 | 0 | 0 | 1 |
| How long is the term of office of the Governor? | 0.5 | 100 | 8 years or above | 5 | 3 | 1 | 1 |
| | | 86 | 7 years | 11 | 5 | 6 | 0 |
| | | 71 | 6 years | 21 | 6 | 9 | 6 |
| | | 57 | 5 years | 37 | 9 | 4 | 24 |
| | | 43 | 4 years | 6 | 2 | 1 | 3 |
| | | 29 | 3 years | 5 | 1 | 0 | 4 |
| | | 14 | term can exceed 3 years | 9 | 2 | 1 | 6 |
| Can the Central Bank formulate and implement policy without government constraint?[a] | 0 | 100 | Independent with no qualification | 36 | 16 | 10 | 10 |
| | | 75 | Independent with any qualification | 31 | 10 | 6 | 15 |
| | | 50 | Independent with significant qualification | 11 | 1 | 4 | 6 |
| | | 25 | Limited independence | 14 | 1 | 2 | 11 |
| | | 0 | Not possible or requires sanction of other person/body | 2 | 0 | 0 | 2 |

a. Scores are author's interpretation of general answer provided.

APPENDIX (continued)

**Table A6. Accountability of the Central Bank to Government**

| *Question* | *Weight* | *Score* | *Category of answers and distribution of results* | *All economies* | *Industrialized* | *Transitional* | *Developing* |
|---|---|---|---|---|---|---|---|
| *Accountability to a specific target* | | | | | | | |
| Is there a specific published target? | 1 | 100 | Yes | 83 | 25 | 22 | 36 |
| | | 0 | No | 11 | 3 | 0 | 8 |
| Does government have a role in setting any central bank target? | 1 | 100 | Yes | 67 | 21 | 16 | 30 |
| | | 0 | No | 27 | 7 | 6 | 14 |
| Do procedures exist for when the target is missed? | 1 | 100 | Recognized formal procedures exist | 17 | 8 | 4 | 5 |
| | | 50 | Informal procedures exist, or if central bank reports instruments set in conjunction with government | 31 | 5 | 6 | 20 |
| | | 0 | No | 46 | 15 | 12 | 19 |
| *Accountability to government or in general* | | | | | | | |
| Is central bank subject to monitoring by legislature? | 3 | 100 | Yes | 70 | 19 | 21 | 30 |
| | | 50 | Irregularly or if instrument independence limitedx | 6 | 4 | 1 | 1 |
| | | 0 | No | 18 | 5 | 0 | 13 |
| Procedures written when government can overrule | 0 | 100 | Formally written down | 20 | 6 | 2 | 12 |
| | | 50 | Informally | 3 | 0 | 0 | 3 |
| | | 0 | No | 71 | 22 | 20 | 29 |

## APPENDIX (continued)

### Table A7. Measure of Policy Explanations

| *Question* | *Weight* | *Score* | *Category of answers and distribution of results* | *All economies* | *Industrialized* | *Transitional* | *Developing* |
|---|---|---|---|---|---|---|---|
| Explanation of policy decisions[a] | | | | | | | |
| Does the central bank provide explanations on day policy changed? | 1.5 | 100 | Yes | 76 | 25 | 21 | 30 |
| | | 0 | No | 18 | 3 | 1 | 14 |
| Are explanations provided when policymakers meet and do not change policy? | 0.3 | 100 | Yes | 15 | 4 | 9 | 2 |
| | | 50 | Sometimes | 5 | 2 | 1 | 2 |
| | | 0 | No | 74 | 22 | 12 | 40 |
| Are policy decisions discussed in standard bulletins and reports? | 2 | 100 | At least twice a year | 61 | 21 | 15 | 25 |
| | | 50 | At least annually | 12 | 2 | 2 | 8 |
| | | 0 | No | 21 | 5 | 5 | 11 |
| Are minutes of policy meetings published? | 1 | 100 | Within a month of meeting | 12 | 7 | 2 | 3 |
| | | 50 | More than a month after | 5 | 2 | 2 | 1 |
| | | 0 | No | 77 | 19 | 18 | 40 |
| Are voting patterns published? | 0.5 | 100 | Yes | 6 | 5 | 1 | 0 |
| | | 0 | No | 88 | 23 | 21 | 44 |
| Published forward-looking analysis | | | | | | | |
| Forward-looking analysis in standard bulletins and reports | 2 | 100 | More than annually | 39 | 18 | 7 | 14 |
| | | 50 | At least annually | 24 | 4 | 4 | 16 |
| | | 25 | Unspecified | 10 | 2 | 4 | 4 |
| | | 0 | Other | 21 | 4 | 7 | 10 |
| Form of publication | 1.5 | 100 | Words plus numbers or graphs | 35 | 16 | 5 | 14 |
| | | 50 | Words, numbers, or graphs | 25 | 8 | 6 | 11 |
| | | 25 | Unspecified | 13 | 0 | 4 | 9 |
| | | 0 | None | 21 | 4 | 7 | 10 |
| Risks to forecast published | 1 | 100 | Words plus numbers or graphs | 9 | 7 | 2 | 0 |
| | | 50 | Words, numbers, or graphs | 23 | 9 | 4 | 10 |
| | | 0 | None | 62 | 12 | 16 | 34 |
| Discussion of past forecast errors | 1 | 100 | Yes | 21 | 8 | 3 | 10 |
| | | 50 | Sometimes | 9 | 7 | 2 | 0 |
| | | 0 | None | 64 | 13 | 17 | 34 |
| Assessment and analysis | | | | | | | |
| Analysis in standard bulletins and reports | 2 | 100 | More than annually | 86 | 28 | 20 | 38 |
| | | 50 | At least annually | 7 | 0 | 2 | 5 |
| | | 0 | Other | 1 | 0 | 0 | 1 |

APPENDIX (continued)

**Table A7. (continued)**

| *Question* | *Weight* | *Score* | *Category of answers and distribution of results* | *All economies* | *Industrialized* | *Transitional* | *Developing* |
|---|---|---|---|---|---|---|---|
| Frequency of speeches | 1.5 | 100 | At least monthly | 39 | 20 | 11 | 8 |
| | | 66 | At least quarterly | 26 | 6 | 5 | 15 |
| | | 33 | Less than quarterly or occasionally | 29 | 2 | 6 | 21 |
| | | 0 | Never, almost never | 0 | 0 | 0 | 0 |
| Working papers and other research publications | 1 | 100 | More than 10 each year | 35 | 18 | 5 | 12 |
| | | 66 | More than 5 each year | 19 | 9 | 3 | 7 |
| | | 33 | More than 2 or occasional | 18 | 1 | 8 | 9 |
| | | 0 | Never | 22 | 0 | 6 | 16 |

a. Weights refer to sub-total: each question has a weight of one-third in total score for policy explanations.

APPENDIX (continued)

**Table A8. Explicit Targets as of late 1998 and Dates Adopted**

| *Type of economy* | *Exchange rate target* | *Money target* | *Inflation target* |
|---|---|---|---|
| Total | 50 | 50 | 54 |
| Developing | | | |
| No. of countries | 22 | 18 | 25 |
| Country and date target adopted | Cyprus, 1960s<br>Fiji, 1960s<br>Tonga, 1960s<br>W. African States, 1960s Malta, 1971<br>Bahamas, 1973<br>Barbados, 1975<br>Jordan, 1975<br>Bahrain, 1980<br>Belize, 1980s<br>Kuwait, 1980s<br>E. Caribbean, 1983<br>Hong Kong, 1983<br>Chile, 1986<br>Argentina, 1991<br>Lebanon, 1993<br>Namibia, 1993<br>Ecuador, 1994<br>Vietnam, 1994<br>Uruguay, 1995<br>Malaysia, 1998<br>Turkey, 1998 | India, 1985<br>South Africa, 1986<br>Mozambique, 1987<br>Nigeria, 1987<br>Kenya, 1990<br>Guyana, 1990<br>Ghana, 1992<br>Jordan, 1992<br>Uganda, 1992<br>Indonesia, 1993<br>Bangladesh, 1994<br>China, 1994<br>Malta, 1994<br>Mauritius, 1994<br>Vietnam, 1994<br>Tanzania 1995<br>Zambia 1995<br>Jamaica, 1996 | Malaysia, 1970s<br>Tanzania, 1980s<br>Mozambique 1987<br>Chile, 1991<br>Egypt, 1991<br>India, 1991<br>Uganda, 1992<br>Indonesia, 1992<br>Guyana, 1993<br>Nigeria, 1993<br>Vietnam, 1993<br>Bangladesh, 1994<br>Ecuador, 1994<br>Mexico, 1994<br>Peru, 1994<br>Uruguay, 1995<br>Zambia, 1995<br>Jamaica, 1996<br>Mauritius, 1996<br>Sierra Leone, 1996<br>W. African States, 1997 China, 1998<br>Kenya, 1998?<br>Lebanon, 1998<br>Turkey, 1998 |
| Transitional | | | |
| No. of countries | 13 | 14 | 16 |
| Country and date target adopted | Poland, 1990<br>Estonia, 1992<br>Slovakia, 1993<br>Latvia, 1994<br>Lithuania, 1994<br>Hungary, 1995<br>Russia, 1995<br>Macedonia, 1996<br>Bosnia-Herz., 1997<br>Bulgaria, 1997<br>Turkmenistan, 1997<br>Mongolia, 1998<br>Ukraine, 1998 | Ukraine, 1991<br>Macedonia, 1992–95<br>Mongolia, 1992<br>Albania, 1993<br>Kyrgyz, 1993<br>Russia, 1993<br>Slovakia, 1993<br>Moldova, 1994<br>Georgia, 1995<br>Kazakhstan, 1997<br>Romania, 1997<br>Slovenia, 1997<br>Turkmenistan, 1997 | Armenia, 1998<br>Poland, 1992<br>Albania, 1993<br>Macedonia, 1993<br>Russia, 1993<br>Slovakia, 1993<br>Croatia, 1994<br>Armenia, 1995<br>Moldova, 1996<br>Georgia, 1996<br>Kazakhstan, 1997<br>Kyrgyz, 1996<br>Mongolia, 1997<br>Romania, 1997<br>Slovenia, 1997<br>Turkmenistan, 1997<br>Czech Rep., 1998 |

## APPENDIX (continued)

**Table A8. (continued)**

| *Type of economy* | *Exchange rate target* | *Money target* | *Inflation target* |
|---|---|---|---|
| Industrialized | | | |
| No. of countries | 15 | 8 | 13 |
| Country and date target adopted | Norway, 1960s, 1994<br>Belgium, 1971<br>Netherlands, 1971<br>Ireland, 1972<br>Denmark, 1997<br>Portugal, 1978<br>Finland, 1978, 1996<br>Italy, 1979, 1996<br>France, 1979<br>Austria, 1981<br>Taiwan, 1985<br>Israel, 1986<br>Spain, 1989<br>Iceland, 1989<br>Greece, 1995 | Greece, 1950s<br>Germany, 1975<br>Switzerland, 1975<br>France, 1977<br>Korea, 1979<br>United States, late 1970s<br>Italy, 1984<br>Taiwan, 1989 | New Zealand, 1988<br>Greece, 1990?<br>Taiwan, 1990?<br>Canada, 1991<br>Israel, 1991<br>United Kingdom, 1992<br>Australia, 1993<br>Finland, 1993<br>Sweden, 1993<br>France, 1994<br>Italy, 1995<br>Spain, 1994<br>Korea, 1998 |

Source: Bank of England Survey of Monetary Frameworks; Cottarelli and Giannini (1997).

a. Data from 92 responses to the Bank of England Survey of Monetary Frameworks. A full list of the economies in the sample is given in table A1. In 1998, the only economies in the sample that reported no explicit targets or monitoring ranges were Botswana, Japan, Singapore, Sri Lanka, and Thailand. Cyprus, Fiji, Norway, and Tonga were defined as having explicit exchange rate targets because while no particular number is announced, the targets are either legal ones or they are sufficiently strong to be defined by the IMF as fixed to another currency. In the case of exchange rate pegs, years in which devaluations took place are included, as are years in which the targeted currency was changed. Germany and Switzerland have explicit long-term objectives for inflation, but these are not included in the Table. A question mark is included for Greece and Taiwan because it is unclear whether inflation targets were used before 1990.

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# Monetary Policy under Flexible Exchange Rates: An Introduction to Inflation Targeting

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Both policymakers and economists increasingly accept that the main medium- to long-run goal of monetary policy is the pursuit of price stability, defined as maintaining a low and stable rate of inflation. A high and variable inflation rate is socially and economically costly. These costs include price distortions, lower savings and investment (which inhibits growth), hedging (into precious metals or land), and capital flight (into foreign assets). In addition, short-term manipulation of monetary policy instruments to achieve other goals—such as higher output and lower unemployment—may conflict with price stability. The attempt to achieve these conflicting goals tends to generate an inflationary bias in the conduct of monetary policy without, in the end, achieving systematically higher output and employment.

To achieve the goal of price stability, monetary policy in many countries was for a long time conducted by relying on intermediate targets such as monetary aggregates or exchange rates. During the 1990s, however, several industrial and developing countries began to focus directly on inflation itself. This new approach to the problem of controlling inflation through monetary policy is known as inflation targeting.[1] It essentially makes inflation—rather than output or unemployment—the primary goal of monetary policy. It also forces the central bank to predict the future behavior of prices in order to tighten policies before sustained inflationary pressures develop.

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1. As discussed below, two major reasons why countries chose to implement inflation targeting over alternative monetary policy frameworks were exchange rate crises and money demand instability.

A large literature examines the practical experience of industrial countries with inflation targeting (see, most recently, Bernanke, and others, 1999; Schaechter, Stone, and Zelmer, 2000). The purpose of this paper is to provide an overview of analytical issues associated with inflation targeting, with a focus on the policies, structural context, and recent experience of developing countries. Whether inflation targeting has a wider applicability to developing economies has been a matter of debate in recent years, with authors like Masson, Savastano, and Sharma (1997) taking a rather cautious view. They argue that poor data on prices and real sector developments, the absence of reliable procedures for forecasting inflation, the difficulty of maintaining de facto independence for the central bank, and the lack of an anti-inflationary history may preclude the establishment of a transparent framework for conducting monetary policy and therefore any attempt at inflation targeting. Other authors, however, including Mishkin (2000) and Morandé and Schmidt-Hebbel (1999), adopt a more favorable position at least for the case of high- and middle-income developing countries, where the financial system is sufficiently developed to permit the use of indirect monetary policy instruments. Understanding the terms of this debate is essential. Several developing countries have recently adopted floating exchange rates (often as the result of unsustainable exchange rate pressures on their adjustable peg regimes), and they must therefore find another nominal anchor to guide domestic monetary policy over the medium and long term.

The remainder of the paper is structured as follows. Section 1 presents an analytical framework for understanding the nature of an inflation-targeting regime, based on the important work of Svensson (1997a, 1999a). A closed-economy model provides the starting point for the discussion; the model is then extended to an open-economy setting to highlight the role of the exchange rate in the transmission process of monetary policy. Section 2 compares inflation-targeting regimes with money supply and exchange rate targeting regimes and highlights the risks associated with pursuing implicit exchange rate targets. Section 3 identifies three basic requirements for implementing an inflation-targeting framework, namely, central bank independence, the absence of implicit targeting of the exchange rate, and transparency in the conduct of monetary policy. The operational framework of inflation targeting is the focus of section 4. It discusses, in particular, issues associated with the measurement of inflation (including sources of imperfection in traditional measures), whether a

target band for inflation is more appropriate than a point target, the time horizon of monetary policy, the inherent difficulties associated with forecasting inflation, and whether asset prices should be taken into account in assessing inflationary pressures. Section 5 reviews the recent experience of both industrial and developing countries with inflation targets, with a particular emphasis on the latter group. The last section focuses on some unresolved analytical issues in the design of inflation-targeting regimes, namely, the role of nonlinearities and asymmetric effects (related to both the form of policy preferences and structural relationships, most notably the Phillips curve), uncertainty (about behavioral parameters and the transmission process of monetary policy), and the treatment of credibility and reputation in empirical macroeconomic models of inflation. New results regarding the convexity (or lack thereof) of the Phillips curve are also presented for six developing countries. The conclusion summarizes the main results of the analysis and offers some final remarks.

## 1. INFLATION TARGETING: A CONCEPTUAL FRAMEWORK

The first step in understanding the nature of an inflation-targeting framework is to analyze the relation between explicit policy goals, policy instruments, and preferences of the central bank (which affect the form of its reaction function).[2] This section begins by examining the link between inflation targets and the nominal interest rate—viewed as the main instrument of monetary policy—when the central bank is concerned only about deviations of actual inflation from its target value. The analysis is then extended to consider the case in which both output and inflation enter the central bank's loss function. In both cases the analysis focuses on a closed economy; open-economy considerations are discussed later in the section.

### 1.1 Strict Inflation Targeting

Following Svensson (1997a), consider a closed economy producing one composite good. The economy's structure is characterized by the following two equations, where all parameters are defined as positive:

2. In what follows, the term instrument is used in a broad sense to refer both to the operational target of monetary policy and to the actual instruments available to achieve this target.

$$\pi_t - \pi_{t-1} = \alpha_1 y_{t-1} + \varepsilon_t \text{ and} \tag{1}$$

$$y_t = \beta_1 y_{t-1} - \beta_2 \left( i_{t-1} - \pi_{t-1} \right) + \eta_t , \tag{2}$$

where $\pi_t \equiv p_t - p_{t-1}$ is the inflation rate at time $t$ (with $p_t$ denoting the logarithm of the price level), $y_t$ is the output gap (defined as the logarithm of actual to potential output), $i_t$ is the nominal interest rate (taken to be under the direct control of the central bank), and $\beta_1 < 1$. The variables $\varepsilon_t$ and $\eta_t$ are independently, identically distributed (i.i.d.) random shocks.

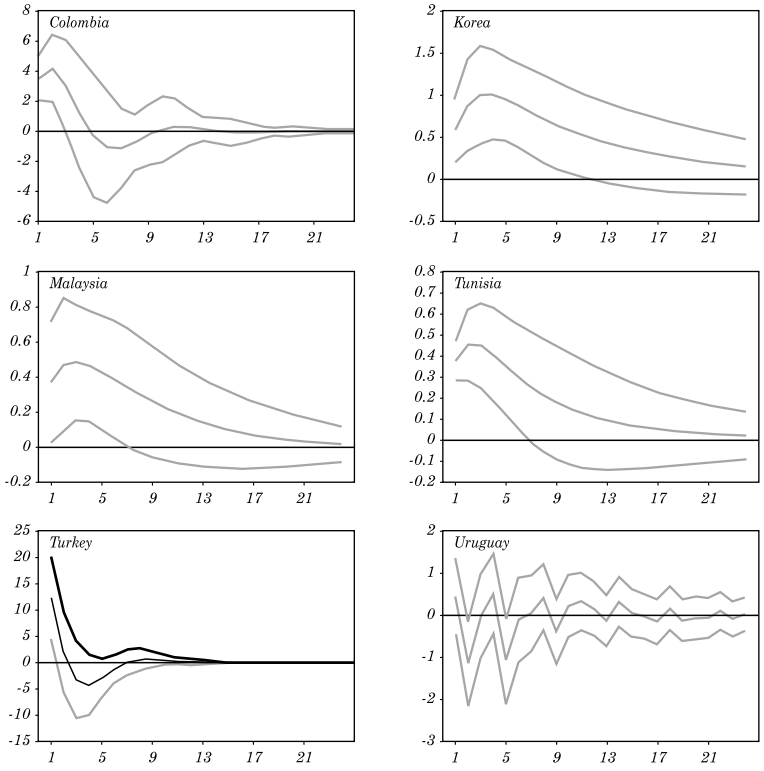
Equation 1 indicates that changes in inflation are positively related to the cyclical component of output, with a lag of one period. Equation 2 relates the output gap positively to its value in the previous period and negatively to the ex post real interest rate, again with a one-period lag. In this model, policy actions (that is, changes in the nominal interest rate) affect output with a one-period lag and, as implied by equation 1, affect inflation with a two-period lag.[3] In the discussion, I refer to the lag between a change in the policy instrument and inflation as the control lag or control horizon.

The assumption that the central bank directly controls the interest rate that affects aggregate demand warrants some discussion. In principle, what affects private consumption and investment decisions is the cost of borrowing; given the prevailing characteristics of the financial structure in many developing countries, this is equivalent to the bank lending rate. In general, bank lending rates depend on banks' funding costs, a key component of which is either the money market rate or (ultimately) the cost of short-term financing from the central bank.[4] To the extent that bank lending rates and money market rates respond quickly and consistently to changes in policy rates, the assumption that the central bank directly controls the cost of borrowing faced by private agents can simply be viewed as a conve-

3. Note that introducing a forward-looking element in equation 1 would imply that monetary policy has some effect on contemporaneous inflation; this would make the solution of the model more complicated but would not affect some of the key results discussed below. See appendix A for a discussion. Nevertheless, the assumption of model-consistent expectations has drawbacks, most notably that it downplays the role of model uncertainty—which, as discussed later, may be very important in practice.

4. Bank lending rates also depend on the perceived probability of default of potential borrowers and, in an open economy, on the cost of funding on world capital markets. See Agénor and Aizenman (1998) for a model that captures these features of bank behavior.

**Figure 1. Response of Money Market Rate to One Standard Deviation Innovations in Discount Rate[a]**




Source: Author's calculations.
a. +/- 2 standard errors.

nient shortcut.[5] What, then, is the evidence? Figure 1 reports impulse response functions of an increase of one standard deviation in the central bank's discount rate (taken to be the policy rate) in a group of six developing countries for which data are readily available. These responses are obtained from a bivariate vector autoregression (VAR) model that includes the policy rate and the money market rate (see appendix B for details). The figure shows that except for Uru-

5. A similar effect would arise if aggregate demand depends on longer-term interest rates. This is because longer-term rates are partly driven by expected future movements in short-term interest rates, which are, in turn, influenced by current and expected future policy decisions of the central bank.

guay, market interest rates respond relatively quickly and significantly to changes in official interest rates. It is thus a reasonable analytical approximation to assume that the central bank directly controls the interest rate that affects aggregate demand.

The central bank's period-by-period policy loss function, $L_t$, is taken for the moment to be a function only of inflation. It is given by

$$L_t = \frac{(\pi_t - \tilde{\pi})^2}{2}, \tag{3}$$

where $\tilde{\pi}$ is the inflation target. An alternative assumption would be that the price target is specified in terms of the price level, as opposed to the inflation rate. The conventional view is that a price-level target entails a major benefit, on the one hand, in that it reduces uncertainty about the future level of prices. On the other, if the economy is subject to supply shocks that alter the equilibrium price level, attempts to disinflate and lower the price level back to its pre-shock value may generate significant real costs and increased volatility in inflation and output.[6] In practice, as discussed later, all inflation-targeting central banks have opted to define their price objective in terms of the inflation rate; accordingly, it is assumed in the present that the price target is indeed specified in terms of the inflation rate.

The central bank's policy objective in period $t$ is to choose a sequence of current and future interest rates $\{i_h\}_{h=t}^{\infty}$ so as to minimize the expected sum of discounted squared deviations of actual inflation from its target value, $U_t$, subject to equations 1 and 2:

$$\min \; U_t = E_t \sum_{h=t}^{\infty} \delta^{h-t} L_h = E_t \left\{ \sum_{h=t}^{\infty} \delta^{h-t} \frac{(\pi_h - \tilde{\pi})^2}{2} \right\}, \tag{4}$$

where $\delta$ denotes a discount factor ($0 < \delta < 1$) and $E_t$ is the expectations operator conditional on the central bank's information set at period $t$.

The most direct way to solve this optimization problem is to use dynamic programming techniques. As shown by Svensson (1997a), however, problem 3 can be recast in a simpler form, which allows a

6. This argument has been challenged in some recent papers, however, including Dittmar, Gavin, and Kydland (1999), Svensson (1999b), and Vestin (2000). The latter two studies, in particular, show that under certain conditions, price-level targeting may deliver a more favorable trade-off between inflation and output variability than does inflation targeting.

more intuitive derivation of the optimal path of the policy instrument. Because the nominal interest rate affects inflation with a two-period lag, $\pi_{t+2}$ can be expressed in terms of period $t$ variables and shocks occurring at periods $t + 1$ and $t + 2$. Equation 1 can thus be written as

$$\pi_{t+2} = \pi_{t+1} + \alpha_1 y_{t+1} + \varepsilon_{t+2}.$$

Updating equation 2 in a similar manner and substituting the result in the above expression for $y_{t+1}$ yields

$$\pi_{t+2} = \left(\pi_t + \alpha_1 y_t + \varepsilon_{t+1}\right) + \alpha_1 \left[\beta_1 y_t - \beta_2 \left(i_t - \pi_t\right) + \eta_{t+1}\right] + \varepsilon_{t+2},$$

that is,

$$\pi_{t+2} = a_1 \pi_t + a_2 y_t - a_3 i_t + z_{t+2}, \tag{5}$$

where $z_{t+2} = \varepsilon_{t+2} + \varepsilon_{t+1} + \alpha_1\eta_{t+1}$, $\alpha_1 = 1 + \alpha_1\beta_2$, $\alpha_2 = \alpha_1(1 + \beta_1)$, and $\alpha_3 = \alpha_1\beta_2$.

From equation 5, it is clear that the interest rate set by the central bank at period $t$ will affect inflation in year $t + 2$ and beyond, but not in years $t$ and $t + 1$; similarly, the interest rate set in period $t + 1$ will affect inflation in periods $t + 3$ and beyond, but not in periods $t + 1$ and $t + 2$, and so on. The solution to the optimization problem described earlier can therefore be viewed as consisting of setting the nominal interest rate in period $t$ (and then $t + 1$, $t + 2$,...) so that the expected inflation in period $t + 2$ (and then $t + 3$, $t + 4$,...) is equal to the target rate. Put differently, because equation 5 implies that $\pi_{t+2}$ is affected only by $i_t$ and not by $i_{t+1}$, $i_{t+2}$, and so forth, the problem of minimizing the objective function $U_t$ in equation 4 boils down to a sequence of one-period problems,

$$\min_{i_t} \frac{\delta^2}{2} E_t \left(\pi_{t+2} - \tilde{\pi}\right)^2 + x_t, \tag{6}$$

subject to equation 5, with

$$x_t = E_t \left\{ \sum_{h=t+1}^{\infty} \min_{i_h} \delta^{h-t} E_t \left[ \frac{\left(\pi_{h+2} - \tilde{\pi}\right)^2}{2} \right] \right\}.$$

In equation 6, $x_t$ does not depend on $i_t$, such that the central bank's optimization problem at period $t$ consists simply of minimizing the ex-

pected, discounted squared value of $(\pi_{t+2} - \tilde{\pi})$ with respect to $i_t$:

$$\min_{i_t} \frac{\delta^2}{2} E_t (\pi_{t+2} - \tilde{\pi})^2 . \tag{7}$$

Standard statistical results yield[7]

$$E_t (\pi_{t+2} - \tilde{\pi})^2 = (\pi_{t+2|t} - \tilde{\pi})^2 + V_t (\pi_{t+2}), \tag{8}$$

where $\pi_{t+2|t} = E_t \pi_{t+2}$. This expression indicates that the central bank's optimization problem can be equivalently viewed as minimizing the sum of expected future squared deviations of inflation from target—the squared bias in future inflation, $(\pi_{t+2|t} - \tilde{\pi})^2$—and the variability of future inflation conditional on information available at $t$, $V_t(\pi_{t+2})$. Since $V_t(\pi_{t+2})$ is independent of the policy choice, the problem consists in minimizing the squared bias in future inflation.

Using equation 5, the first-order condition of problem 7 is given by

$$\delta^2 E_t \left\{ (\pi_{t+2} - \tilde{\pi}) \frac{\partial \pi_{t+2}}{\partial i_t} \right\} = -\delta^2 a_3 (\pi_{t+2|t} - \tilde{\pi}) = 0 ,$$

which implies that

$$\pi_{t+2|t} = \tilde{\pi} . \tag{9}$$

Equation 9 shows that, given the two-period control lag, the optimal policy for the central bank is to set the nominal interest rate such that the expected rate of inflation for period $t + 2$ (relative to period $t + 1$) based on information available at period $t$ be equal to the inflation target.

To explicitly derive the interest rate rule, note that because $E_t z_{t+2} = 0$ (from equation 5), $\pi_{t+2|t}$ is given by

$$\pi_{t+2|t} = a_1 \pi_t + a_2 y_t - a_3 i_t . \tag{10}$$

Given the definition of $a_1$, this implies that

$$i_t = \frac{-(\pi_{t+2|t} - \pi_t) + \alpha_1 \beta_2 \pi_t + a_2 y_t}{a_3} .$$

7. This standard result is $E(x\text{-}x^*)^2 = (Ex\text{-}x^*)^2 + V(x)$, that is, the expected squared value of a random variable equals the square of the bias plus the conditional variance. The decomposition in equation 8 is used below in the discussion of the role of uncertainty.

Because interest rate changes affect inflation with a lag, monetary policy must be conducted partly on the basis of forecasts; the larger the amount by which the current inflation rate (which is predetermined up to a random shock, as implied by equation 1) exceeds the forecast, the higher is the interest rate. The fact that the inflation forecast can be considered an intermediate policy target leads Svensson (1999a) to refer to inflation targeting as inflation forecast targeting. The use of conditional inflation forecasts as intermediate targets in the policy rule is optimal, given the quadratic structure of policy preferences.[8]

The inflation forecast can readily be related to the current, observable variables of the model. This requires setting expression 10 equal to $\tilde{\pi}$ and solving for $i_t$:

$$i_t = \frac{-\tilde{\pi} + a_1 \pi_t + a_2 y_t}{a_3}.$$

Given the definitions of the $a_h$ coefficients outlined above, this expression can be rewritten to give the following explicit form of the central bank's reaction function:

$$i_t = \pi_t + b_1 (\pi_t - \tilde{\pi}) + b_2 y_t, \tag{11}$$

where $b_1 = 1 / (\alpha_1 \beta_2)$ and $b_2 = (1 + \beta_1) / \beta_2$.

Equation 11 indicates that it is optimal for the central bank to adjust the nominal interest rate upward to fully reflect current inflation and the difference between current and desired inflation rates, as well as increases in the output gap. As emphasized by Svensson (1997a, p. 1119), current inflation appears in the optimal policy rule not because current inflation is a policy target, but because it helps (together with the contemporaneous output gap) predict future inflation, as implied by equation 10. In addition, rule 11 is certainty equivalent: the same interest rate rule would be optimal in the absence of shocks. Although the central bank cannot prevent temporary deviations of actual inflation from its target value, it can ensure that the effects of such shocks do not persist over time.[9]

8. As noted by Bernanke and Woodford (1997), this result does not imply that the central bank should react mechanically to private sector forecasts. Such forecasts carry the risk of perverse circularity, because private agents may find it optimal to forecast inflation equal to the announced policy target, thereby depriving their forecasts of any informational value for the central bank.

9. This results from the fact that shocks are assumed to be i.i.d. In practice, however, shocks are often persistent; as discussed later, this may have important implications under parameter uncertainty.

In equilibrium, actual inflation in year $t + 2$ will deviate from the inflation forecast, $\pi_{t+2|t}$, and the inflation target, $\tilde{\pi}$, only by the forecast error $z_{t+2}$, as a result of shocks occurring within the control lag, after the central bank has set the interest rate to its optimal value:

$$\pi_{t+2} = \pi_{t+2|t} + z_{t+2}, \text{ or}$$

$$\pi_{t+2} - \tilde{\pi} = z_{t+2}. \tag{12}$$

Even by following an optimal instrument-setting rule, the central bank cannot prevent deviations from the inflation target owing to shocks occurring within the control lag. This fact is important in assessing the performance of inflation-targeting regimes in practice.

## 1.2 Policy Trade-offs and Flexible Targeting

Consider now the case in which the central bank is concerned not only about inflation but also about the size of the output gap. Specifically, suppose that the instantaneous policy loss function of equation 3 is now given by

$$L_t = \frac{(\pi_t - \tilde{\pi})^2}{2} + \frac{\lambda y_t^2}{2}, \tag{13}$$

where $\lambda$ measures the relative weight attached to cyclical movements in output, with $\lambda > 0$.[10] The expected sum of discounted policy losses is now given by

$$U_t = E_t \left\{ \sum_{h=t}^{\infty} \delta^{h-t} \left[ \frac{(\pi_h - \tilde{\pi})^2 + \lambda y_h^2}{2} \right] \right\}. \tag{14}$$

Deriving the optimal interest rate rule when both inflation and output enter the objective function is more involved than was previously the case. Essentially, the problem of minimizing equation 14 cannot be broken down into a series of one-period problems because of the dependence of current inflation on lagged output and of current output on lagged inflation. Using standard dynamic programming techniques, Svensson (1997a, pp. 1140–43) shows that the first-order condition for minimizing equation 14 with respect to the nominal interest rate can be written as

10. Because the so-called bliss level of the output gap is zero, this specification has no built-in inflationary bias; see Cukierman (1992) and the discussion below.

$$\pi_{t+2|t} = \tilde{\pi} - \frac{\lambda}{\delta \alpha_1 \kappa} \; y_{t+1|t}\,, \tag{15}$$

where $\kappa > 0$ is given by $\kappa = \frac{1}{2}\left\{1 - \mu + \sqrt{(1+\mu)^2 + 4\lambda/\alpha_1^2}\right\}$, and

$\mu = \lambda(1-\delta)/\delta\alpha_1^2$.

Condition 15 implies that the inflation forecast, $\pi_{t+2|t}$, will be equal to the inflation target, $\tilde{\pi}$, only if the one-period ahead expected output gap is zero ($y_{t+1|t} = 0$). In general, as long as $\lambda > 0$, $\pi_{t+2|t}$ will exceed (fall short of) $\tilde{\pi}$ if the output gap is negative (positive). The reason is that if the output gap is expected to be negative for instance at $t + 1$, the central bank will attempt to mitigate the fall in activity by lowering interest rates at $t$ (given the one-period lag); this policy will therefore lead to higher inflation than otherwise at $t + 2$, thereby raising the inflation forecast made at $t$ for $t + 2$. For higher values of $\lambda$ (the relative weight on output fluctuations in the policy loss function), the impact of the expected output gap on the inflation forecast will be larger.[11]

An alternative formulation of the optimality condition 15 can be obtained by setting $E_t\varepsilon_{t+1} = 0$. Then, from equation 1,

$$y_{t+1|t} = \frac{\pi_{t+2|t} - \pi_{t+1|t}}{\alpha_1}.$$

Substituting this result into equation 15 and rearranging terms yields

$$\pi_{t+2|t} - \tilde{\pi} = c\left(\pi_{t+1|t} - \tilde{\pi}\right), \tag{16}$$

where

$$0 \le c = \frac{\lambda}{\lambda + \delta\alpha_1^2\kappa} < 1.$$

This expression indicates that the deviation of the two-year inflation forecast from the inflation target is proportional to the deviation of

11. The policy loss function 13 can be further extended to account for interest rate smoothing by adding the squared value of changes in $i_t$. As shown by Svensson (1997a), an instrument-smoothing objective would make the inflation forecast deviate further from the inflation target—this time to reduce costly fluctuations in interest rates.

the one-year forecast from the target; when $\lambda = 0$, $c = 0$ and the previous result (equation 9) holds. Thus when cyclical movements in output matter for the central bank, it is optimal to adjust the inflation forecast to the inflation target gradually. By doing so, the central bank reduces fluctuations in output. As shown again by Svensson (1997a, pp. 1143–44), the greater the weight on output in the policy loss function (that is, the higher $\lambda$), the more gradual will be the adjustment process (that is, the larger $c$).

The interest rate rule can be derived explicitly by noting that, from equations 1 and 2, $\pi_{t+1|t} = \pi_t + \alpha_1 y_t$, $\pi_{t+2|t} = \pi_{t+1|t} + \alpha_1 y_{t+1|t}$, and $y_{t+1|t} = \beta_1 y_t - \beta_2 (i_t - \pi_t)$. Substituting the first and third expressions into the second yields

$$\pi_{t+2|t} = \pi_t + \alpha_1 (1 + \beta_1) y_t - \alpha_1 \beta_2 (i_t - \pi_t). \tag{17}$$

Equating equations 16 and 17 and rearranging terms implies that

$$i_t = \pi_t + b'_1 (\pi_t - \tilde{\pi}) + b'_2 y_t, \tag{18}$$

where $b'_1 = (1 - c) / \alpha_1\beta_2$ and $b'_2 = (1 - c + \beta_1) / \beta_2$, from which it can be verified that $b'_1 = b_1$ and $b'_2 = b_2$ when $\lambda = 0$ (and thus $c = 0$). Equation 18 indicates that as before, the optimal instrument rule requires the nominal interest rate to respond positively to current inflation and the output gap, as well as the excess of current inflation over the target. However, an important difference between reaction functions 11 and 18 is that the coefficients of equation 18 are smaller, owing to the positive weight attached to cyclical movements in output in the policy loss function.[12] This more gradual response implies that the (expected) adjustment of current inflation to its target value, following a disturbance, will take longer than the minimum two periods given by the control horizon. The time it takes for expected inflation to return to target following a (permanent) unexpected shock is known as the implicit targeting horizon or simply as the target horizon. Naturally, the length of the implicit targeting horizon is positively related not only to the magnitude of the shock and its degree of persistence, but also to the relative importance of output fluctuations in the

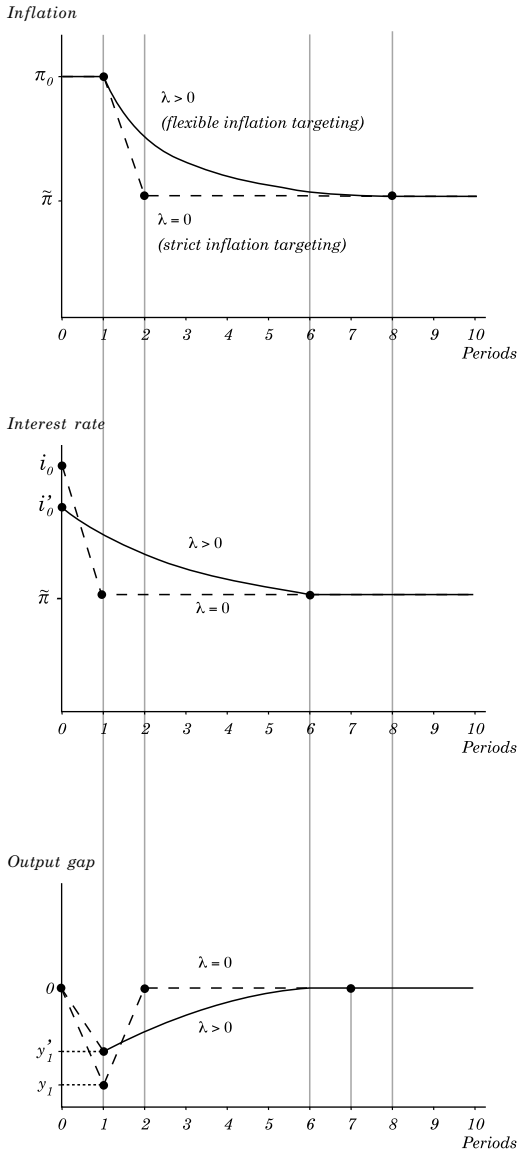
12. Certainty equivalence holds in both cases, such that the parameters characterizing the optimal policy rule continue to be independent of variances of the shocks affecting inflation and output (see the discussion below).

central bank's objective function. As can be inferred from the numerical simulations of Batini and Nelson (2000), it also depends on the origin of the shock—whether it is, for instance, an aggregate demand shock or a supply-side shock. This is because the transmission lag of policy adjustments generally depends on the type of shocks to which the economy is subject and the channels through which these shocks influence the behavior of private agents.

Figure 2 provides a simple illustration of the concepts of control lag and target horizon. Suppose that the inflation rate is initially on target at $\tilde{\pi}$, and the output gap is zero. From equations 11 and 18, the initial nominal interest rate is thus equal to $\tilde{\pi}$ under either form of inflation targeting. Now suppose that the economy is subject to an unexpected random shock at $t = 0$ (an increase in, say, government spending) that leads to an increase in the inflation rate to $\pi_0 > \tilde{\pi}$. As implied by the reaction function under both strict and flexible inflation targeting, the central bank will immediately raise the nominal interest rate, but because inflation is predetermined (monetary policy affects inflation with a two-period lag), actual inflation remains at $\pi_0$ in period $t = 1$. The behavior of inflation for $t > 1$ depends on the value of $\lambda$. If $\lambda = 0$ (that is, the central bank attaches no weight to movements in the output gap), then inflation will return to its target value at exactly the control horizon, namely, in period $t = 2$. The nominal interest rate initially increases to $i_0 = \pi_0 + b_1(\pi_0 - \tilde{\pi})$ and then returns to $\tilde{\pi}$ at period $t = 1$ and beyond; the output gap does not change at $t = 0$ but falls to $y_1 < 0$ in period $t = 1$, before returning to its initial value of 0 at period $t = 2$ and beyond. With $\lambda > 0$, convergence of inflation to its target value may take considerably longer; the figure assumes, to fix ideas, that convergence occurs at $t = 8$.[13] The interest rate initially increases to $i'_0 = \pi_0 + b'_1(\pi_0 - \tilde{\pi}) < i_0$, which limits the fall in the output gap to $y'_1 < y_1$. Although it falls over time, the interest rate remains above its equilibrium value, $\tilde{\pi}$, until period $t = 6$ (given the two-period control lag), whereas the output gap remains negative until period $t = 7$. In general, the path of inflation, interest rates, and the output gap for $t > 1$ will be flatter for higher values of $\lambda$.

13. With an instrument-smoothing objective in the policy loss function, returning inflation to its target value could take even longer because the central bank is also concerned about large movements in interest rates. Strictly speaking, convergence of actual inflation to target when $\lambda > 0$ occurs only asymptotically, for $t \to \infty$.

**Figure 2. Behavior of Inflation, Nominal Interest Rate, and Output Gap Following an Inflation Shock[a]**




Source: Author's calculations.
a. In percent.

The central bank's output stabilization goal thus has a crucial effect not only on the determination of short-term interest rates, but also on the speed at which the inflation rate adjusts toward its target after a shock. Policy preferences also affect the variability of output and inflation, and in the presence of supply shocks, flexible inflation targeting entails a trade-off between inflation variability and output-gap variability. By varying the relative weight that the central bank attaches to the two policy goals in its loss function, it is possible to derive an optimal policy frontier (or optimal trade-off curve), which can be defined (following Fuhrer, 1997a, p. 226) as the set of efficient combinations of inflation variability and output variability attainable by policymakers.[14] The slope of the output-inflation variability frontier is also related to the slope of the aggregate supply curve (Cecchetti and Ehrmann, 1999): the flatter the aggregate supply curve, the larger is the increase in output variability that accompanies a reduction in inflation variability. In addition, the higher the relative weight attached to output fluctuations in the policy loss function, the longer it will take for inflation to converge to its target value following a shock.

## 1.3 Inflation Targeting in an Open Economy

In an open economy, the exchange rate is an essential component of the transmission mechanism of monetary policy. It affects the target variables of monetary policy (inflation and the output gap) through a variety of channels—namely, a direct exchange rate channel via the impact of imported final goods prices on domestic consumer prices, generally with a relatively short lag, and two indirect channels, operating through both aggregate demand and aggregate supply. By altering the real exchange rate, the nominal exchange rate affects aggregate demand, typically with a lag stemming from the time it takes consumers to respond to relative price changes; this affects the output gap and, with another lag, inflation. The exchange rate may also affect aggregate supply (with or without a lag), because costs of production may depend on the cost of imported intermediate inputs, whereas nominal wages may depend on either actual or expected changes in consumer prices caused by exchange rate changes (see Agénor and Montiel, 1999, chap. 8). In turn, the exchange rate is affected by interest rate differen-

14. The existence of a long-run trade-off between the variances of output and inflation does not imply a long-run trade-off between the levels of these variables. In the present setting, such a trade-off only exists in the short run.

tials, foreign disturbances, and expectations of future exchange rates and risk premiums that depend on domestic factors, such as the size of the domestic public debt or the degree of credibility of the inflation target. The exchange rate is thus important under inflation targeting in an open economy, in transmitting both the effects of changes in policy interest rates and various disturbances.[15] Because foreign shocks are transmitted through the exchange rate, and the exchange rate affects consumer price inflation, stabilizing exchange rates has remained a key consideration under inflation targeting.

These various channels can be captured in a relatively simple generalization of the closed-economy model presented earlier. Suppose that the economy produces two goods, tradables and nontradables, with the foreign-currency price of tradables set on world markets. The economy's structure is characterized by the following set of equations:

$$\pi_t^N = \Delta e_t + \alpha_1 y_{t-1}^N + \varepsilon_t , \tag{19}$$

$$y_t^N = -\beta_2 \left( i_{t-1} - \pi_{t-1} \right) + \beta_3 \left( \Delta e_{t-1} - \pi_{t-1}^N \right) + \eta_t \ , \ \beta_3 > 0 , \tag{20}$$

$$\pi_t = \delta \pi_t^N + \left( 1 - \delta \right) \Delta e_t \ , \ 0 < \delta < 1 , \tag{21}$$

$$i_t = i^* + E_t \, e_{t+1} - e_t + \xi_t , \text{ and} \tag{22}$$

$$E_t \, e_{t+1} = e_t - \theta \left( \Delta e_t - \pi_t^N \right) , \ \theta > 0 , \tag{23}$$

where $e_t$ denotes (the logarithm of) the nominal exchange rate, $\pi_t^N$ the inflation rate in nontradables, $i^*$ the world interest rate, and $\xi_t$ an i.i.d. random disturbance.

Equation 19 is a Phillips curve relationship, which is now assumed to hold only for the nontradables sector. It differs from equation 1 in two respects: there is no lagged effect of nontradables inflation, and the rate of depreciation of the nominal exchange rate is taken to have a direct and immediate impact on the rate of increase of nontraded goods prices. As noted earlier, this effect may reflect the supply-side impact

15. The effects of interest rates and exchange rates on aggregate demand may also depend on the economy's structure of indebtedness. For instance, in a country with a large foreign debt, exchange rate changes may have important wealth and balance sheet effects, possibly offsetting their direct effects on aggregate demand.

of changes in the price of imported intermediate goods. Equation 20 is the aggregate demand for nontraded goods; it has a form similar to equation 2, with two modifications: there is no own lagged effect ($\beta_1 = 0$) and changes in the real exchange rate (as given by the difference between the rate of nominal depreciation and the rate of nontradables inflation) are assumed to positively affect the demand for home goods with a lag. Equation 21 defines aggregate inflation as a weighted average of inflation in nontradables and tradables; for simplicity, the world price of tradables is assumed constant so that its rate of change is zero. Equation 22 is the uncovered interest parity condition, which relates domestic interest rates to the world interest rate (assumed constant), the expected rate of depreciation of the nominal exchange rate, and a serially uncorrelated random term. Finally, equation 23 relates expectations of future nominal depreciation to contemporaneous movements in the real exchange rate: if nontradables inflation is rising faster than the rate at which the nominal exchange rate is depreciating, the current real exchange rate is appreciating; this, in turn, creates expectations of a future nominal depreciation.

Two types of issues can be explored by studying inflation targeting rules in an open-economy setting. The first is whether the exchange rate channel matters for output stability. To address this issue, suppose that the policy objective is given by equation 14, which assumes that the central bank targets aggregate inflation, $\pi_t$. If the model given by equations 19 through 23 and equation 14 is solved using the dynamic programming approach proposed by Svensson (1997a), then inflation targeting destabilizes output in an open economy. The reason is the effect of changes in the nominal exchange rate on inflation through tradables prices. Because it is the fastest channel from monetary policy to inflation in this model, large movements in the exchange rate can produce excessive fluctuations in output by inducing large changes in interest rates.[16] Given that the traded and nontraded sectors may react differently in the short run to movements in the (real) exchange rate, the destabilizing effect on aggregate output can be mitigated if the central bank attaches different weights to fluctuations in sectoral output in its objective function (see Leitemo, 1999). However, simulation studies generally tend to corroborate this prediction.

16. Ball (1999) is one of the first to establish this result. Jadresic (1999) also shows that targeting the overall price level may destabilize output in a model with staggered price setting if policymakers cannot observe current realizations of aggregate output and inflation. The generality of this result, however, is unclear at this stage.

The second issue that can be addressed with an open-economy model is whether targeting inflation in nontradables prices only is more appropriate than targeting aggregate inflation. The instantaneous policy loss function given by equation 13 assumes that the central bank targets aggregate inflation, $\pi_t$. If the central bank instead chooses to target nontradables inflation, its instantaneous loss function takes the form[17]

$$L_t = \frac{\left(\pi_t^N - \tilde{\pi}^N\right)^2}{2} + \frac{\lambda y_t^2}{2}. \tag{24}$$

To analyze this issue, consider a shock unrelated to fundamentals that causes a persistent depreciation of the nominal exchange rate—say, a large and sustained outflow of short-term capital resulting from an adverse shift in confidence (Bharucha and Kent, 1998). The immediate effect is an increase in inflation in the traded goods sector. If, for instance, firms producing home goods use imported intermediate inputs (or if nominal wages are indexed to the overall price level), then inflationary pressures will also develop in the nontradable goods sector and prices there may also rise, compounding the initial increase in tradables prices. Targeting aggregate inflation may involve substantial adjustment in the interest rate and increased volatility in output. By contrast, if the central bank is targeting only nontradables inflation, the adjustment of the interest rate would be of a lower magnitude, and output and nontradables inflation would be less variable—albeit at the cost of greater variability in the nominal exchange rate and aggregate inflation.

However, whether nontradables inflation targeting is strictly preferable to aggregate inflation targeting generally depends on the nature of the shocks hitting the economy, in addition to their relative size, as can be shown by solving the model described earlier using either equations

17. A more general specification than equation 24 would account for the possibility that the central bank is also concerned about large shifts in competitiveness. Its period-by-period policy loss function would therefore look like as follows, in case of aggregate inflation targeting:

$$L_t = \frac{\left(\pi_t - \tilde{\pi}\right)^2}{2} + \frac{\lambda y_t^2}{2} + \frac{\varphi\left(\Delta e_t - \pi_t^N\right)^2}{2},$$

where $\varphi > 0$. It is intuitively clear that concerns about real exchange rate fluctuations would also affect the optimal instrument rule—in the sense of making policy changes more gradual than they would otherwise be—as shown earlier when minimizing output fluctuations was introduced as an additional policy objective. See Svensson (1999a) for a discussion.

13 or 24 as the policy loss function. Targeting nontradables inflation may produce undesirable outcomes when the economy is subject to shocks other than to the exchange rate. For instance, in response to demand or supply shocks, a central bank with a nontradables inflation target is likely to attempt to restore inflation to its targeted path rapidly. This would occur through large adjustments in the interest rate, which would entail greater volatility in the exchange rate and aggregate inflation.

In sum, whereas an aggregate inflation target may induce excessive volatility in the interest rate (and thus output) to offset exchange rate shocks, a nontradables inflation target may induce excessive volatility in the exchange rate as the policy instrument is adjusted to offset supply or demand shocks. In the simulation results presented by Bharucha and Kent (1998), neither aggregate inflation targeting nor nontradables inflation targeting produced consistently lower volatility in both product and financial markets across all types of shocks.

## 2. Comparison with Intermediate Target Strategies

Price stability as a medium- to long-term goal can be achieved, in principle, not only by focusing directly on the final objective itself, namely, the inflation rate or the price level, but also by adopting either a pegged nominal exchange rate or a monetary target as an intermediate goal. This section reviews these two alternative frameworks for monetary policy and compares them with inflation targeting.

### 2.1 Monetary versus Inflation Targeting

Monetary targeting presumes the existence of a stable relationship between one or more monetary aggregates and the general level of prices. When this is the case, monetary policy can be directed at a particular growth rate in the monetary aggregate (the intermediate objective) that is compatible with low inflation. Specifically, monetary targeting requires adequate knowledge of the parameters characterizing the demand for money. These parameters—most notably the interest elasticity of money demand—may be highly unstable, however, in an economy undergoing rapid financial liberalization. Money then ceases to be a good predictor of future inflation; that is, the relation between the intermediate target and the final objective becomes unstable. In a context of disinflation, the demand for money may be subject to large and unpredictable shifts, and the information content of money for future inflation will therefore be very low. Both arguments suggest that rely-

ing on monetary aggregates can be potentially risky. If, in addition, monetary targeting is viewed as minimizing money growth variability around the money-growth target—a characterization that is fairly adequate if the policy loss is quadratic—then this policy goal may not be consistent with the objective of minimizing inflation variability: a conflict often arises between stabilizing inflation around the inflation target and stabilizing money growth around the monetary target (see Svensson, 1997a). In fact, monetary targeting generally implies greater inflation variability than inflation targeting. It also leads to increased variability in output by inducing higher volatility in interest rates (Clarida, Galí, and Gertler, 1999).[18]

Several industrial countries did indeed adopt inflation targeting after abandoning (or being abandoned by) their monetary targets as a result of increased distortions in the link between the money supply and overall prices, as documented by Estrella and Mishkin (1997).[19] However, although some researchers argue that the relationship between monetary aggregates and prices has also weakened in developing countries (see, for instance, Mishkin and Savastano, 2000, p. 22, for Latin America), systematic formal evidence on this issue remains limited, particularly for the late 1990s, and subject to different interpretations. The study by Arrau and others (1995), for instance, shows that the alleged instability in money demand documented in several studies of developing countries in the 1980s may well be the result of an omitted variable, namely financial innovation.

## 2.2 Exchange Rate versus Inflation Targeting

Many countries, particularly in the developing world, have viewed pegging their nominal exchange rate to a stable low-inflation foreign currency as a means of achieving domestic price stability, through a disciplining mechanism with two dimensions. First, to the extent that higher domestic relative to foreign inflation results in a real exchange

18. See McCallum (1999) for a further discussion of the lack of efficiency of monetary targeting.

19. It has also been argued that in practice, those countries that pursue monetary targeting recognize the lack of stability and predictability in the assumed relationships between interest rates and the target monetary aggregate and between the target aggregate and inflation. See, for instance, the discussion of German monetary policy in Bernanke and others (1999). Studies of the reaction function of the Bundesbank also suggest that in addition to monetary variables, real variables have had a significant influence on policy decisions. See Clarida, Galí, and Gertler (2000).

rate appreciation, the demand for domestic goods will fall, inducing a cyclical downswing that puts downward pressure on domestic prices. Second, to the extent that wage- and price-setting decisions anticipate these consequences of excessive wage and price increases, they should make higher domestic inflation less likely to occur in the first place. In a sense, countries that target their exchange rates against an anchor currency attempt to "borrow" the foreign country's monetary policy credibility.

In a world of high capital mobility and unstable capital movements, however, conventional pegged exchange rates have proved fragile (see Agénor and Montiel, 1999). Simply pegging the exchange rate does not substitute for maintaining monetary stability and credibility at home. In fact, recent experiences suggest that exchange rate pegs can be sustainable only when they are credible, and credibility is largely determined by domestic macroeconomic policies. From that perspective, an inflation-targeting regime may operate better than an exchange rate targeting framework. The domestic currency has been attacked in many developing countries because the central bank had an implicit or explicit exchange rate objective that was not perceived to be credible. In such cases, the adoption of inflation targeting may lead to a more stable currency if it signals a clear commitment to macroeconomic stability and a freely floating exchange rate.

A key characteristic of inflation-targeting regimes in comparison with other approaches to controlling inflation is that the adjustment of policy instruments relies on a systematic assessment of future (rather than past or current) inflation, as opposed to an arbitrary forecast. Under this regime, the central bank must explicitly quantify an inflation target and establish precise mechanisms for achieving this target. This implies that there is an important operational difference between an inflation-targeting regime, on the one hand, and monetary and exchange rate targeting, on the other.[20] Changes in monetary policy instruments usually affect the money supply and the exchange rate faster than inflation itself; as discussed earlier, this leads to the existence of a control lag and a reaction function that relates the policy instrument to an inflation forecast. The implication, as pointed out by Haldane

20. An important difference between exchange rate targeting and monetary targeting is that while it is possible to deviate temporarily from monetary targets if the underlying relationships appear to have changed, it is generally not possible to temporarily depart from an exchange rate peg (or a target band, for that matter) without incurring a loss of credibility and possibly a currency crisis.

(1998), is that the credibility of an inflation-targeting regime depends not on achieving a publicly observable, intermediate target that is viewed as a leading indicator of future inflation (as is the case under monetary or exchange rate targeting), but rather on the credibility of a promise to reach the inflation target in the future. This, in turn, depends on whether the public believes that the central bank will stick to the objective of price stability. The credibility and reputation of the monetary authorities may therefore play an even more crucial role in dampening inflation expectations under inflation targeting. At the same time, because performance can only be observed ex post, the need for transparency and accountability becomes more acute under inflation targeting, in order to help the public assess the stance of monetary policy and determine whether deviations from target are due to unpredictable shocks rather than policy mistakes.

## 3. Basic Requirements for Inflation Targeting

There are three basic requirements for implementing an inflation-targeting regime. The first is a high degree of central bank independence, not so much in choosing the inflation target itself but rather in the choice and manipulation of policy instruments. The second is the absence of a de facto targeting of the nominal exchange rate (or, equivalently, the predominance of the inflation target), and the third is increased transparency and accountability.

### 3.1 Central Bank Independence and Credibility

Inflation targeting requires that the central bank be endowed with a clear mandate to pursue the objective of price stability and, most importantly, with a large degree of independence in the conduct of monetary policy—namely, in choosing the instruments necessary to achieve the target rate of inflation.[21] This implies, in particular, the ability to resist political pressures to stimulate the economy in the short term and the absence of fiscal dominance, that is, of a situation in which fiscal policy considerations play an overwhelming role in monetary policy decisions. Such requirements are difficult to satisfy in countries that

21. Several countries, such as Israel and the United Kingdom, have followed a contractual approach to inflation targeting: the government sets an inflation target in a contract with the central bank and gives the central bank operational independence so that it can manipulate its policy instruments to achieve the agreed target.

systematically rely on seigniorage as a source of revenue, which is quite common in some developing countries where government borrowing from the central bank is large.[22] In such conditions, fiscally induced inflationary pressures will undermine the effectiveness of monetary policy, for instance by forcing the central bank to maintain low interest rates in an attempt to prevent unsustainable public debt dynamics. Alternatively, the government may force the central bank to adopt an inflation target that is dictated by seigniorage requirements as opposed to price stability.[23]

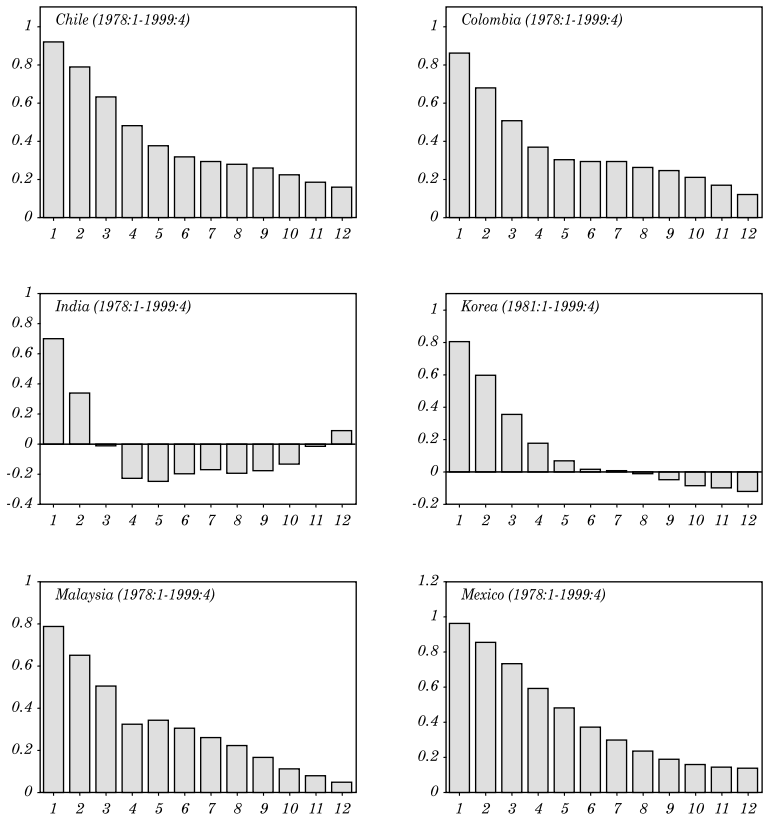
Inflation targeting calls not only for a high degree of central bank independence, but also for a sufficient degree of credibility—or more properly (following Drazen and Masson, 1994, and Agénor and Masson, 1999) an adequate anti-inflation reputation. Independence, credibility, and reputation are, of course, related, but they may evolve differently over a given period of time. In countries where the financial system is perceived to be highly vulnerable to, say, exchange rate shocks (as discussed below) and the central bank is perceived to be likely to inject liquidity to prevent a full-blown crisis, the credibility of an announced inflation target may be seriously undermined—even if the central bank is deemed independent. Lack of confidence in the policymakers' commitment to or ability to maintain low inflation may be one of the reasons why inflation often tends to display a strong degree of persistence in developing countries, as illustrated by the autocorrelation functions for twelve developing countries (with the exception of India, Korea, and the Philippines) displayed in figure 3.[24] But establishing credibility or improving reputation, particularly in countries with a history of high inflation and macroeconomic instability, is a difficult process. Analytically, it has been shown—most notably by Walsh (1995) and Svensson (1997b)—that inflation targets can be used to overcome credibility problems because they can mimic optimal performance incentive contracts. Furthermore, by increasing the accountability of monetary policy, inflation targeting may reduce the inflation bias inherent in discretion-

22. The ability of the central bank to conduct an independent monetary policy is also hampered in some countries by severe weaknesses in the financial system, which may force the central bank to repeatedly inject large amounts of liquidity to support ailing banks.

23. In practice, it has proved difficult to establish a close, stable relationship between fiscal deficits and inflation in developing countries. As discussed by Agénor and Montiel (1999), this may be the result of changes in deficit financing rules or shifts in expectations over time.

24. Inflation persistence may also be the result of backward-looking inflation expectations or overlapping and asynchronized wage and price contracts.

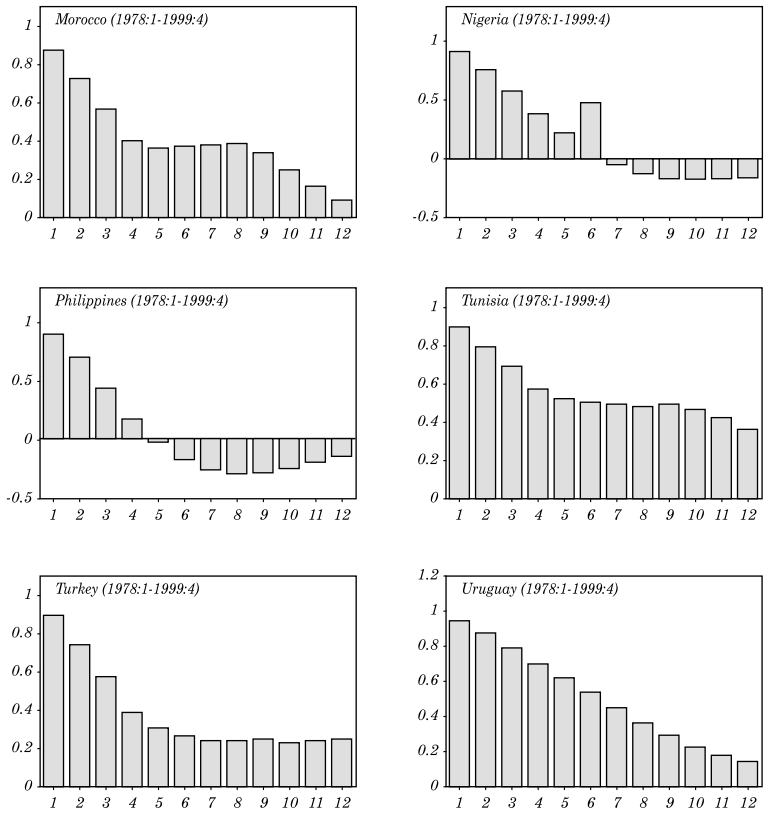
**Figure 3. Autocorrelation Function of Inflation Rate[a]**




ary policy regimes. The public announcement of inflation targets in itself may help to improve the credibility of the central bank when its policy preferences are uncertain (see Walsh, 1999).

However, the link between inflation performance and the degree of de jure central bank independence does not appear to be particularly strong in developing countries, at least not for the 1980s. Figure 4 illustrates this point for different measures of independence, and it is shown more formally in some recent research (see, for instance, Sikken and De Haan, 1998; De Haan and Kooi, 2000). What matters is de facto independence. For instance, to the extent that a lack of actual autonomy translates into uncertainty about the central bank's preferences over output and inflation, delegating monetary policy involves a trade-off

**Figure 3. (continued)**




Source: Author's calculations.
a. Quartely annualized growth rates.

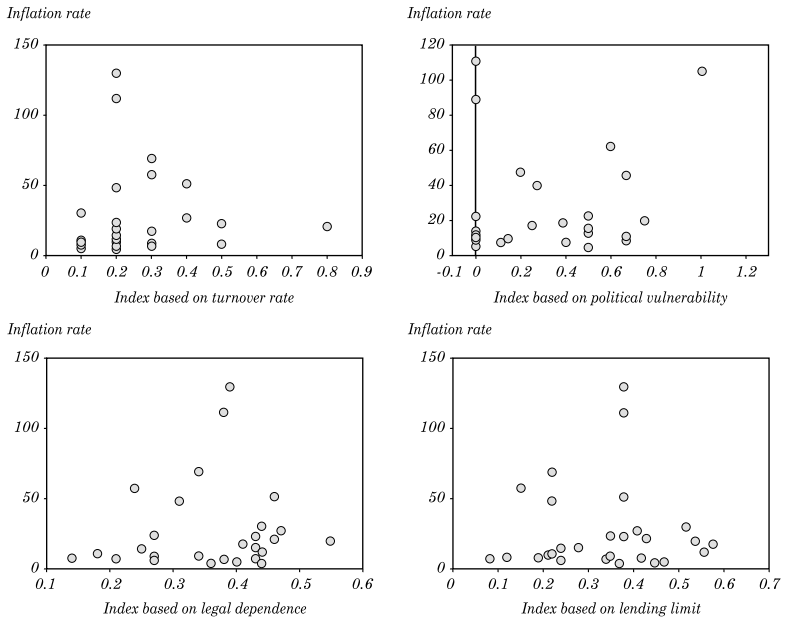
between credibility and stabilization, and an optimal contract can perform better than an inflation target (Beetsma and Jensen, 1998).[25]

## 3.2 Absence of De Facto Exchange Rate Targeting

Adopting a low, stable inflation rate as the main objective of monetary policy requires, in principle, the absence of any commitment to a particular value of the exchange rate, as is the case under a floating

25. Muscatelli (1998, 1999) argues that neither inflation targeting nor an optimal contract is likely to be superior to Rogoff-type conservatism if central bank preferences are uncertain.

**Figure 4. Average Inflation Rate and Central Bank Independence Index, 1980 - 89[a]**




Source: Author's calculations.

a. The countries are Barbados, Chile, Colombia, Costa Rica, Ethiopia, Ghana, Greece, Honduras, India, Indonesia, Israel, Kenya, Korea, Malaysia, Malta, Mexico, Morocco, Nepal, Pakistan, the Philippines, Portugal, South Africa, Tanzania, Thailand, Turkey, Uganda, Uruguay, and Venezuela.

exchange rate regime. In practice, however, in many of the developing countries that have opted for a de jure flexible exchange rate, monetary authorities have continued to pay considerable attention to the value of the domestic currency—often adopting a de facto target path or band. There are various reasons for the central bank to be concerned with nominal exchange rate movements, even when it enjoys a high degree of independence and is thus able to commit itself only to the pursuit of price stability. As noted earlier, the exchange rate has a direct impact on inflation and plays a key role in transmitting monetary policy shocks to prices. If the pass-through effect is indeed high, the central bank may be tempted to intervene on the foreign exchange market to limit currency fluctuations. A high degree of nominal exchange rate instability may also be of concern to policymakers to the extent that it translates into a high degree of variability in the real exchange rate and distorted relative price signals to domestic producers. Furthermore, in

partially dollarized economies such as Peru or Turkey, large fluctuations in exchange rates can lead to banking and financial instability by inducing large portfolio shifts between domestic- and foreign-currency denominated assets. Finally, in countries where the corporate and banking sectors hold large foreign-currency liabilities, exchange rate depreciations can have significant adverse effects on their balance sheets. This was, indeed, one of the important features of the Asia crisis.[26]

When limiting (or preventing) exchange rate fluctuations is a stated or implicit policy target, it will usually be very difficult for the central bank to credibly and transparently convey to the public its intention to give priority to price stability over other monetary policy objectives. Private agents are likely to discount public pronouncements heavily, and the lack of credibility will translate into higher inflation expectations. The absence of commitment (whether implicit or explicit) to a particular level for the exchange rate—or, equivalently, giving the inflation target unambiguous priority over other policy objectives—is thus an important prerequisite for adopting inflation targeting. In fact, a credible commitment to an inflation-targeting regime in developing economies, by enhancing macroeconomic and financial stability, may well provide a greater degree of stability to a flexible nominal exchange rate than a pegged arrangement that is subject to recurrent speculative pressures (and possibly frequent crises and forced devaluations) stemming from perceived inconsistencies in macroeconomic policy.

## 3.3 Transparency and Accountability

Openness and transparency in the conduct of monetary policy are important ways to improve credibility in an inflation-targeting framework. By making the central bank publicly accountable for its decisions, they raise the incentive to achieve the inflation target and therefore enhance the public's confidence in the ability of the monetary authorities to do so. They may also lead to improved decision-making on the part of the central bank by exposing to public scrutiny the process through which monetary policy decisions are taken (see Briault, Haldane, and King, 1997). The fact, for instance, that monetary authorities must announce policy changes and explain the reason for these

26. See, for instance, Alba and others (1999). These last two points can also be viewed as calling for adequate regulation and supervision of the domestic banking system, rather than as arguments in favor of rejecting inflation targeting as a policy regime.

changes to the public may increase the effectiveness of monetary policy under inflation targeting. Finally, transparency reduces uncertainty about the central bank's preferences, which may lead to a lower expected rate of inflation and a lower propensity to respond to supply shocks (see Eijffinger, Hoeberichts, and Schaling, 2000).[27]

Faust and Svensson (1998) examine the role of transparency in a model similar to the one developed by Cukierman and Meltzer (1986). The central bank in the model is tempted to deviate from an announced inflation target because of fluctuations in an idiosyncratic component of its employment target. The employment target is private information to the central bank and unobservable to the public. Private agents, nevertheless, observe macroeconomic outcomes (contemporaneous inflation and employment) and imperfectly infer the central bank's employment target. This inference process affects the central bank's perceived reputation by the public, which in turn affects private inflation expectations. In this setting, increased transparency allows the public to infer the bank's employment target with greater precision, thereby rendering the central bank's reputation and the private-sector inflation expectations more sensitive to its actions. This, in turn, increases the cost for the central bank of deviating from the announced inflation target and pursuing its idiosyncratic employment target. Consequently, increased transparency induces the central bank to stick more closely to the announced policy. It provides an implicit commitment mechanism that reduces the temptation for the monetary authorities to act in a discretionary fashion and deviate from the announced policy.

A potential problem with accountability in an inflation-targeting framework is related to the difficulty of assessing performance only on the basis of inflation outcomes. The lag between policy actions and their impact on the economy makes it possible (or tempting) for the central bank to blame unforeseen or totally unpredictable events for inadequate performance, instead of taking responsibility for policy mistakes. To mitigate this risk, the central bank in an inflation-targeting country is usually required to justify its policy decisions and publicly explain differences between actual outcomes and inflation targets.[28] In what is arguably the strongest case of central bank accountability in inflation-targeting countries, the government in New Zealand can dismiss the

27. This assumes that the public is familiar with the inflation target and the specific price index on which the target is based; see the discussion below.

28. The distinction between goal independence and instrument independence implies that the latter is essential for the accountability of the monetary authorities.

central bank governor if the inflation target is breached, even temporarily (see Archer, 2000). Openness and transparency have been promoted by the regular publication of an *Inflation Report*, which sets out the central bank's analysis of recent economic developments, and a forecast of inflation (as well as of other variables, including output) over the coming year or years. In the words of Archer (2000, p. 16),

> It is harder for the central bank to "cheat" on its mandate when it is forced to lay out an internally consistent basis for the decisions to be made. To be sure, a good publicist can make almost any position sound reasonable, but when it matters financial markets seem to have good noses for spin-doctoring.

Accountability has been promoted by providing public explanations (in the form of a public letter from the governor of the central bank to the government) of why the rate of inflation deviated from the target by more than a given percentage on either side, how long these deviations are expected to persist, and what policies the central bank intends to implement to bring inflation back to target.

## 4. The Operational Framework of Inflation Targeting

Establishing an operational framework for implementing an inflation-targeting regime requires monetary authorities to take various steps. They must, in particular, specify a price index to target and then quantify the target. They must also determine under what circumstances escape clauses or exemptions to the inflation target are warranted (taking into account the potential credibility loss that their discretionary nature may involve), decide ways through which they can convince the public that achieving the inflation target takes precedence over all other objectives of monetary policy, and devise a forward-looking operating procedure in which monetary policy instruments are adjusted (in line with the assessment of future inflation) to achieve the target. This section reviews these various requirements, with a particular emphasis on their implications for developing countries.

### 4.1 Establishing Inflation Targets

Establishing inflation targets requires that the central bank specify an index to target, set a level for the target, and identify an explicit quantitative target for inflation for some periods ahead—a process that

requires deciding whether to set the target as a point or as a band (for instance, between 2 and 4 percent) and choosing the number of quarters or years over which the target will be averaged. They must also set up a model or methodology for inflation forecasting that uses indicators containing information on future inflation.

## The Choice of a Price Index

How to measure inflation is naturally a key issue in the context of inflation targeting. A first question to ponder in this context is whether the chosen price index should reflect the prices of goods and services for current consumption only or for both current and future consumption. Economic theory suggests that a correct measure of inflation captures the prices of both present and future consumption, because only such an index can recognize the scope for intertemporal substitution in consumption (Alchian and Klein, 1973). In practice, however, price indexes do not include prices of present claims over goods and services for future consumption, except indirectly when they incorporate prices of services provided by consumer durables that can be acquired today. Markets for future goods and services generally do not exist, and producing such a comprehensive price index simply is not feasible.[29]

A second point is that the consumer price indexes typically found in developing countries are not adequate measures of the cost of living, despite several advantages such as general acceptance among the public, availability on a monthly basis, publication without long delays, and infrequent data revisions, unlike, say, GDP deflators. In almost all of these countries, consumer price indexes are typically fixed-weight averages of the prices of a basket of goods and services. Price data are gathered by statistical agencies through regular visits to specified sales outlets. The weights are based on the distribution of consumer expenditure by product and are revised at regular intervals to reflect changes in the composition of household expenditures. These indexes are not designed to measure the effect of changes in the types, amounts, and quality of the goods and services that households purchase.

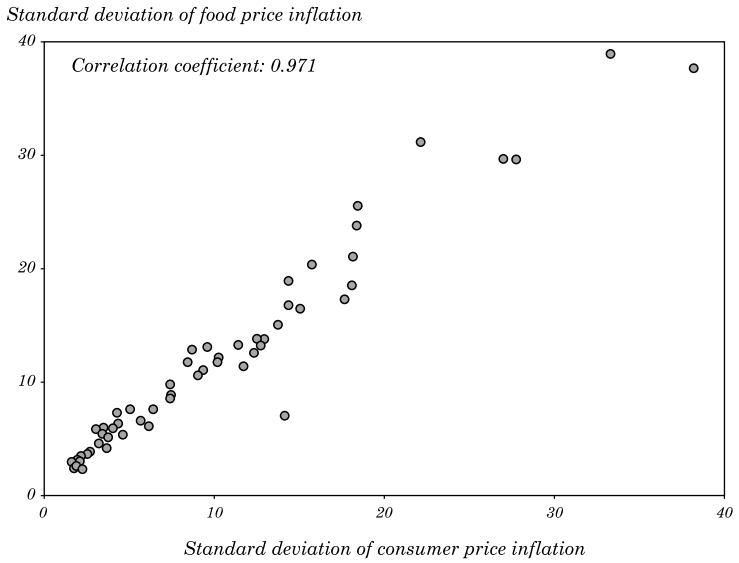
29. In addition, using asset prices (which can be viewed as reflecting the current money prices of claims on future consumption) is fraught with practical difficulties. However, excluding asset prices from the price index used for inflation targeting does not necessarily preclude the possibility of taking these prices into account in the formulation of monetary policy; see the discussion below.

Existing price indexes thus suffer from three main sources of bias, whose relative importance for measuring inflation varies across countries. Substitution bias arises because consumers switch expenditure away from more expensive products and stores toward cheaper ones. Regular reviews of the weights in the index and of the selection of outlets chosen for sampling purposes helps to reduce substitution bias, but the bias is likely to persist in the periods between these reviews. Quality bias arises because the quality of goods and services within a particular category may change, but the change may not be fully reflected in computing the price index. If quality increases over time (as tends to be the case for many products), failure to account for it fully will lead to overstatement of inflation. New products bias stems from the fact that new goods are continually introduced, whereas existing ones are continuously withdrawn. To the extent that new products widen choice opportunities for households and allow them to achieve a given level of utility at a lower cost than previously, failure to account for them will lead to an overestimate of inflation.

These sources of bias can be quite significant in practice. For instance, the Boskin Report estimates that in the United States, substitution bias (including outlet substitution bias) was about 0.5 percent a year in terms of CPI inflation, whereas quality and new products bias represented about 0.6 percent a year in 1995–96 (Boskin and others, 1996). Accounting for bias is generally very difficult, however. Estimates of bias tend to be very unreliable, and the intensity of bias may vary significantly over time.[30] Inflation targets are thus usually set with some degree of arbitrariness on the basis of price indexes that suffer from potentially significant measurement problems. In addition, the presence of a considerable amount of transitory noise makes the measurement of inflation difficult, particularly in developing countries. In many of these countries (as in most industrial countries), the consumer price index is a Laspeyres index, that is, an arithmetic mean of the relative prices of the goods and services contained

30. Gordon (1999, p. 17) suggests that the estimates of inflation bias published in the Boskin Report (of which he is a coauthor) were probably understated, in part because the sharp declines in the prices of new products were not fully taken into account. Cellular phones, for instance, appeared in 1985 in the United States as a consumer product, but they were introduced into the CPI only in 1998, by which time there were already 55 million subscribers to cellular phone services in the country. The price of these services dropped dramatically between 1985 and 1997.

**Figure 5. Developing Countries: Average Volatility of Consumer Price Inflation and Food Price Inflation, 1981 - 98[a]**




Source: World Bank.
a. The countries are Bangladesh, Benin, Botswana, Burkina Faso, Burundi, Central African Republic, Chad, Chile, Colombia, Congo Republic, Costa Rica, Dominican Republic, Ecuador, Egypt, Arab Rep., El Salvador, Ethiopia, Fiji, Gabon, Gambia, Ghana, Guatemala, Haiti, Honduras, India, Indonesia, Jamaica, Jordan, Kenya, Korea, Lesotho, Madagascar, Malawi, Malaysia, Mauritius, Mexico, Morocco, Namibia, Nepal, Nigeria, Panama, Paraguay, the Philippines, Saudi Arabia, Senegal, South Africa, Sri Lanka, Syria, Tanzania, Thailand, Trinidad and Tobago, Tunisia, Turkey, Uganda, Uruguay, Venezuela, and Zimbabwe.

in a representative basket of goods, with the mean being weighted according to expenditure shares in a base period.[31] The annual inflation rate is thus measured as the weighted average of the rates of change for individual prices. If the price of a particular component is subject to large short-term movements, then the measured rate of overall inflation will reflect the corresponding movements, in propor-

31. Formally, if $p_t^i$ denotes the price of good $i$ at period $t$ ($i = 1,...n$) and $q_t$ the quantity of good $i$ purchased at period $t$, then the Laspeyres price index between periods $t$ and $t + 1$ is $P_{t/t+1}^L = \sum_{i=1}^{n} p_{t+1}^i q_t^i \; / \; \sum_{i=1}^{n} p_t^i q_t^i$. This index tends to overstate inflation, because it assumes no substitution in consumption expenditures in response to changes in relative prices. By contrast, a current-weighted Paasche index, defined as $P_{t/t+1}^P = \sum_{i=1}^{n} p_{t+1}^i q_{t+1}^i \; / \; \sum_{i=1}^{n} p_t^i q_{t+1}^i$, uses current quantities as weights and thus tends to overstate substitution and to understate inflation.

tion with the relative weight of that component in the consumption basket. Such problems can be significant in countries where domestic food prices are a large component of the consumption basket, as they can be highly volatile. Figure 5 illustrates the high correlation between variability in food prices and variability in consumer prices in developing countries. Shocks to the exchange rate, wages, controlled prices, and external inflation that affect price developments can also be beyond the control of monetary authorities.

To alleviate the problem of noisy or erratic short-run movements in prices, inflation-targeting central banks often use a measure of core (or long-term) inflation as their policy target.[32] Such measures are generally calculated by removing some components of the price indexes, particularly those that appear to be substantially more volatile than prices of other goods and services. The argument is that short-term movements in these prices result from rapid adjustment to frequent real shocks that are often reversed, and so they contain substantially less information about the long-term trend in inflation. By choosing an adjusted price index instead of the general consumer price index, central banks may thus avoid unnecessary fluctuations in interest rates, employment, and output.

In general, inflation-targeting central banks have attempted to remove three types of price disturbances, of which the first two are particularly relevant for developing countries. The first group encompasses disturbances associated with temporary changes in the rate of inflation. Examples are movements in highly volatile, but eventually offsetting, CPI components, such as food and energy prices; shocks to the exchange rate; and changes in indirect taxes or regulated prices that lead to jumps in the price level, without sustained, longer-term effects on the inflation rate. The second type of disturbance involves shocks to inflation that may have long-lasting effects, but for which a strong monetary response would produce very large fluctuations in the real economy. Examples include natural disasters and large changes in prices of imported inputs. Finally, the central bank may seek to remove disturbances associated with the direct effects of policy changes on inflation, in cases in which the targeted price index contains components (such as mortgage payments) that vary directly with the level of short-term interest rates. The reason is that a tightening in monetary policy may translate into a spurious rise in inflation.

32. See Roger (1998) and Wynne (1999) for recent reviews of the literature on core inflation.

The identification of these three types of disturbance makes it possible to distinguish between core inflation (as defined above), cyclical inflation (caused, for instance, by food prices), and transitory inflation (price increases generated by specific shocks, such as changes in indirect taxes and imported energy prices, or by shocks to the exchange rate and controlled prices).

In practice, there are several techniques for calculating core inflation (see Wynne, 1999). One method, used by the Bank of Canada, consists of using weights that are linked to the relative price variability of individual goods and services in the consumption basket. Each expenditure weight is divided by the standard deviation of its relative price change (calculated as the difference between the inflation rate of the subcomponent and the overall index), and they are all renormalized (using a single- or double-weighted method) to ensure that they add up to unity. The higher the standard deviation of any given component (that is, the higher its volatility), the lower is its adjusted weight. In this way, all components are kept in the basket, but the effect of the more volatile ones on the overall index is reduced.

Nevertheless, the practical difficulties involved in the calculation of adjusted measures of underlying inflation should not be underestimated.[33] Truly temporary shocks are rare in practice, and characterizing shocks as such may be the result of an incorrect assessment of general equilibrium effects. Consider, for instance, a rise in indirect taxes that lowers the inflation rate for a limited period of time, after which inflation returns to its previous level. Such changes in taxes will generally also affect the rest of the economy; they may reduce aggregate demand and production, which could have an additional downward effect on inflation in the longer term; they may also alter inflation expectations or wage settlements and thereby affect price-setting decisions. These second-round effects may be protracted, and they must be taken into consideration when establishing an inflation forecast. The proper response to an increase in indirect taxes may not be to refrain from increasing interest rates, but indeed to lower them, if the inflation forecast has fallen below target. A similar argument can be made in relation to temporary energy price shocks. Mechanically excluding certain components of the consumer price index from the policy reaction function can translate into a loss of potentially important information regarding future inflation developments.

33. There remains some disagreement in the literature regarding the very definition of core inflation. Quah and Vahey (1995), for instance, define core inflation as the component of inflation that does not affect real output in the long run. They propose a structural VAR approach for calculating it.

Differences in price movements between adjusted inflation and total CPI inflation could potentially generate conflict or uncertainty. If the target is not easy for the public to understand and follow, these differences can create credibility problems, particularly in countries with a history of high inflation and a poor reputation for the central bank (see the discussion of the Brazilian experience below). Under such conditions, a headline inflation target, which is more familiar to the public, would make monetary policy more transparent—even if it is subject to some defects in measuring underlying price pressures.

## Width of the Target Band

Many inflation-targeting countries have chosen to specify their inflation target in the form of a band rather than a single point target. A key reason for doing so is the recognition that because economic behavior and outcomes are not completely predictable, it is difficult to hit a single point target continuously. Trying to do so could cause interest rates to be excessively volatile and could destabilize financial markets. By recognizing uncertainty, a target band for inflation can stabilize price expectations. At the same time, a band introduces some degree of flexibility in the conduct of monetary policy. It gives the central bank some discretion over which point in the band it aims for in taking its policy decisions, and it allows the bank to accommodate transitory shocks to inflation—which can provide a partial substitute for targeting a core inflation rate (Orphanides and Wieland, 2000, p. 1383). This flexibility is important not only for stabilizing output fluctuations, but also for accommodating movements in the nominal exchange rate. A large depreciation, for instance, puts upward pressure on domestic prices (as discussed earlier) and thus requires a rise in policy interest rates that may be sizable with a point target. However, the depreciation may weaken corporate balance sheets if firms are highly indebted in foreign currency, pushing them into bankruptcy; the rise in interest rates would only exacerbate the problem. A sufficiently wide band would allow the central bank to accommodate the inflationary impact of exchange rate market pressures (at least to some extent) without large and potentially destabilizing policy changes.

The foregoing discussion suggests that the width of the band should depend on the variability of the inflation rate (which itself depends on the nature, size, and variability of underlying shocks to prices and changes in behavioral patterns), the policy horizon (the further ahead the horizon, the more difficult it is to forecast inflation and predict the

effects of monetary policy actions), and the degree of discretion that the central bank maintains in the conduct of monetary policy. There is obviously a trade-off between credibility and flexibility in the choice of the optimal target band: the wider the bands, the more likely it is that the target will be achieved, but the less credible is the target.[34]

Another issue is whether the band should be asymmetric. In practice, inflation-targeting countries have tended to adopt symmetric bands on announcing a central target. The signal that central banks attempt to convey in doing so is that they view deflation as being as costly as inflation. Asymmetry may sometimes be desirable, however. If, for instance, the central bank believes that the credibility loss associated with overshooting the target is higher than the loss incurred by undershooting it, an asymmetric band may provide a somewhat higher degree of flexibility.[35]

## Horizon of the Inflation Target

Because inflation is subject to unpredictable shocks and monetary policy operates with a lag, inflation-targeting central banks cannot continuously achieve their target. At what time horizon, then, should monetary policy aim to achieve the inflation target?

Suppose, for instance, that the inflation forecast indicates that with unchanged interest rates inflation will rise above target in the first year of the forecast period and fall below target in later years. If interest rate changes implemented today affect inflation only after a lag of, say, two years, then it is too late to prevent a rise in inflation above target in the first year and interest rates should be lowered so as to bring inflation in the second year and beyond up to target. But suppose now that the control lag is only six months. Increasing interest rates today may therefore allow the central bank to bring inflation down toward target in the second half of the first year of the forecast. At the same time, however, the increase in interest rates today is likely to reduce inflation even further below the forecast at the beginning of the second year. If the lag between policy actions and their effect on inflation are distributed over a period of time, rather than being concen-

34. In a sense, the choice of an optimal inflation target band is reminiscent of the problem of choosing the optimal width of an exchange rate target zone, as discussed by Cukierman, Kiguel, and Leiderman (1994). See Orphanides and Wieland (2000) for a different perspective.

35. As discussed below, asymmetric policy preferences may also lead to an asymmetric optimal instrument rule, regardless of whether a formal band is in place.

trated at a particular lag length, inflation will remain below forecast for at least part of the second year. The central bank has to use interest rates to manage the path of inflation relative to the inflation target, starting from the point at which monetary policy decisions taken today start affecting inflation in the future. Thus the target horizon cannot be shorter than the control horizon.

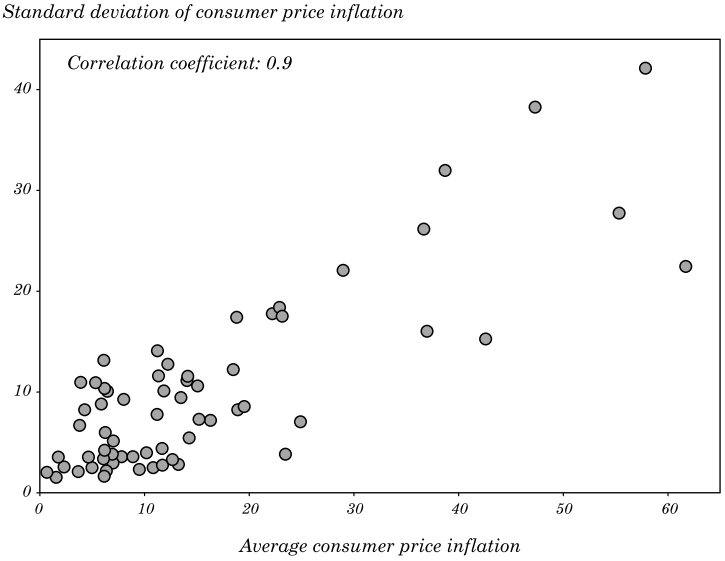
At the same time, the central bank needs to take into account the trade-off that may arise between reducing deviations of inflation from target and preventing a high degree of output variability. Suppose an adverse supply shock causes inflation to increase above target. How quickly should the central bank aim to bring inflation back to target? As discussed earlier, there are two conflicting considerations (see figure 2). On the one hand, the quicker the disinflation, the shorter is the period during which inflation is above target; on the other, the quicker the disinflation, the greater are the potential fluctuations in output. The optimal length of the target horizon therefore depends on policy preferences, in addition to the magnitude of the shocks affecting inflation. The greater the relative importance attached to output stabilization relative to inflation stabilization, the longer the optimal length.[36] If there is an inflationary bias, however, a longer targeting horizon will hamper the credibility of monetary policy, because agents will understand the central bank's greater temptation to inflate and create surprise inflation. This creates a trade-off between credibility and flexibility (Garfinkel and Oh, 1993). Whether a finite targeting period is desirable depends on the cost of limiting flexibility so as to reduce the severity of the credibility problem.

## Forecasting Procedure

Inflation targeting requires that the monetary authorities have the technical and institutional capacity to model and forecast inflation, that they understand the monetary transmission mechanism, and that they are able to estimate the time lag between the adjustment of monetary instruments and their effect on output and prices. This, in turn, implies greater reliance on forward indicators of inflation than in other monetary policy regimes, together with a continuous assessment of the relationship between the instruments of monetary policy and the inflation target.

36. See Batini and Haldane (1999) and Isard and Laxton (2000) for recent quantitative research on policy trade-offs of this type. In practice, stabilizing movements in output can also be achieved by a temporary widening of the target band, if one is in place.

**Figure 6. Developing Countries: Average Consumer Price Inflation and Inflation Volatility, 1981 - 98[a]**




Source: World Bank.
a. For the list of countries represented in this figure, see the note to figure 5.

Establishing an accurate inflation forecast and a relatively precise estimate of how inflation is likely to be affected by changes in monetary policy instruments is not an easy task when the structure of the economy is unstable and behavioral relationships are unreliable.[37] Moreover, at higher levels of inflation, the inflation rate tends to be more volatile (as shown in figure 6), and it is thus more difficult to predict future price developments accurately. Under such conditions, setting point targets may actually damage the central bank's credibility. In practice, inflation-targeting central banks have combined economic models (generally small in size) with qualitative judgement regarding how economic behavior and relationships are likely to differ in the future from what has been observed in the past. They have also increasingly recognized

37. In many developing countries, administered or controlled prices are an important component of aggregate price indexes and are thus important factors in the short-run behavior of inflation. A proper inflation-forecasting procedure also needs to incorporate explicit assumptions about the timing and magnitude of changes in these prices.

in their inflation reports the uncertainty surrounding economic forecasts, that is, the fact that forecasts embody probability distributions of future values of economic variables. The Bank of England, for instance, and many other central banks in its wake—including those of Brazil, Chile, and Sweden—have used a so-called fan chart to present their forecasts (see, for instance, Blix and Sellin, 1998). De-emphasizing, or even not providing, point forecasts helps communicate to the public the inherent uncertainties associated with forecasting.

Releasing an inflation forecast does not necessarily enhance the transparency of the decision process of monetary policy, however. Repeated forecasting errors can eventually reduce the credibility of the central bank by raising doubts about the bank's ability to assess the future behavior of prices.[38] Another issue is how best to establish and release forecasts to the public. The Bank of England recently began releasing inflation projections based on market expectations of future interest rates. In contrast, many inflation-targeting central banks publish forecasts based on the assumption that policy interest rates will remain constant over the projection horizon. If the predicted path for inflation is too high relative to target, this gives a signal that interest rates will be raised in the near future, which may influence economic conditions and potentially make the forecasts internally inconsistent.[39] Basing the inflation forecast on endogenous monetary policy responses would make the forecast itself irrelevant, because it would always be on target at the horizon over which the central bank acts to achieve its goals. Public interest would therefore shift to the implied sequence of policy rates embedded in the forecasts. However, central banks may not be willing to release projections of future short-term interest rates, because this may carry the risk that any deviation of policy rates from the forecast level (even if caused by new information) could be perceived as inconsistent behavior by the central bank, thereby harming its credibility. Finally, information regarding the expected path of interest rates is not necessarily useful to the public unless it is specified how short-term interest rates are determined in the first place. Knowledge of the central bank's policy reaction function is essential for determining the implications of new information for the setting of policy instruments.

38. Releasing inflation forecasts can be problematic if they have an undesirable effect on nominal wages, for instance by becoming a floor for centralized wage negotiations.

39. Market observers may also wonder why the future tightening implied by publishing a forecast that shows inflation moving above target has not yet been implemented—and this may hurt the central bank's credibility.

## 4.2 Interest Rates Rules in Practice

As shown earlier, under strict inflation forecast targeting, the optimal rule is to set the interest rate so as to bring expected inflation in line with the inflation target at the control horizon. By contrast, the optimal rule under flexible inflation forecast targeting is to close less than fully any gap between expected inflation and the inflation target. In practice, inflation-targeting central banks have tended to use simple feedback interest rate rules rather than complicated, optimal targeting rules. Simple feedback rules have some clear advantages. They tend to be more robust when there is uncertainty about the true structure of the economy, they are easier to monitor, and they may help improve credibility. These factors are important in the context of inflation targeting. However, simple rules are also subject to one major weakness: they tend to be less efficient than an optimal rule in the use of information, most notably about the economy's structure.

Two additional issues to consider in this context are, first, whether simple rules display evidence of flexible inflation targeting and, second, whether they embed forward-looking components. Regarding the first issue, some recent research attempts to determine whether the behavior of inflation-targeting central banks can be characterized as strict or flexible inflation targeting. This is done in some cases by testing whether the output gap enters significantly in an empirically estimated interest rate rule. Leiderman and Bar-Or (2000), for instance, estimate the policy reaction function of the Central Bank of Israel using monthly data for the period 1994–99; they find that interest rates are positively related to current inflation, lagged changes in output, and the previous period's interest rate. However, the fact that a significant coefficient is attached to output in an estimated interest rate reaction function does not necessarily imply that in practice monetary policy is guided in part by an output stabilization objective. To the extent that current inflation is only an imperfect proxy for future inflation, and to the extent that the latter depends on the level of economic activity, it is possible for output to appear in the reaction function with a significant coefficient—without, by itself, being indicative of a departure from strict inflation targeting. Indeed, the derivation of the optimal interest rate rule in Svensson's model given above shows that even when the output gap does not enter the policy loss function ($\lambda = 0$), it will (together with current inflation) affect the value of the instrument, because both variables help predict future inflation.

The second issue relates to the role of forward-looking components in actual policy reaction functions. This is important because simple forecast-based rules have some clear similarities with the type of optimal flexible inflation-forecast targeting rules derived earlier; monetary policy under both types of rules seeks to offset deviations between expected inflation and the inflation target at some horizon.[40] The Reserve Bank of New Zealand's policy projections, for instance, are based on an explicit, forward-looking policy reaction function that takes a relatively simple form (Archer, 2000). Econometric studies show that monetary policy in the United States, Japan, and Germany can be characterized fairly well by a reaction function that includes a forward-looking measure of inflation, the contemporaneous output gap, and lagged interest rates (to account for smoothing considerations) (see Clarida, Galí, and Gertler, 1998, 2000). The kind of policy rule that underlies this specification is what Clarida, Galí, and Gertler call soft-hearted inflation targeting: in response to a rise in expected inflation relative to target, the central bank raises nominal interest rates sufficiently to push up real rates, but each rule also contains a pure stabilization component. Mehra (1999) estimates a policy reaction function for the Federal Reserve Board that contains both backward- and forward-looking elements; the federal funds rate is shown to depend on actual inflation, increases in expected future inflation, the expected output gap, and the long-term bond rate. The latter variable, which captures the effect of long-term inflation expectations on policy decisions, became particularly important after 1979, the beginning of the Volcker-Greenspan era.

## 4.3 Asset Prices and Inflation Targeting

The role of asset prices—stock prices, house prices, and bond yields—in the conduct of monetary policy has been the subject of renewed debate in industrial countries (see Cecchetti and others, 2000). Part of the reason is the growing importance of equities in households' financial wealth, as documented, for instance, by Boon, Giorno, and Richardson (1998), and the high degree of volatility exhibited by stock prices in recent years. In the specific context of inflation targeting, (unexpected) movements in asset prices may affect the central bank's inflation forecast. There are at least two reasons why that should be so (see Bernanke and Gertler, 1999;

40. Batini and Haldane (1999), Isard and Laxton (2000), Parrado (1999), and Rudebush and Svensson (1999) analyze the dynamic properties of both simple and optimal forecast-based rules using simulation techniques.

Smets, 1997). First, changes in asset prices may have a direct impact on aggregate demand. For instance, changes in stock prices may affect private consumption expenditure (through their impact on wealth) and investment spending (by affecting the ability of firms to pledge collateral and raise funds). Second, higher house prices may increase the ability of households to borrow and spend, whereas sharp changes in exchange rates may affect the demand for foreign goods and the ability of firms to sell domestic goods abroad.

To the extent that movements in asset prices are not the result of changes in underlying fundamentals, offsetting these changes through adjustments in monetary policy instruments (essentially a lean-against-the-wind interest rate policy) may avoid costly fluctuations in output and prices. In addition, asset prices are strongly influenced by expectations of future returns, which, in turn, are related to expectations of future economic activity, inflation, and monetary policy. Even if their impact on aggregate demand is limited, they may contain useful information about current and future economic conditions. This information may be used to improve the inflation forecast on which the direction of monetary policy is based.

The information contained in asset price movements may be limited, however, because the movements may reflect erratic changes in expectations. It may be difficult to gauge the extent to which this is actually the case, because existing asset price models are based on unobserved variables; their empirical predictions are subject to wide margins of error. This makes it difficult to specify the "right" price (reflecting, say, future profit growth rates or productivity shocks) and, therefore, to correctly identify an erratic movement or speculative bubble. Under such conditions, systematically incorporating asset prices in monetary policy feedback rules may be unwarranted (see Fuhrer and Moore, 1992). Moreover, the risk premium that is typically embedded in asset prices tends to vary over time. Basing monetary policy on a broader, asset-based measure of prices or monetary conditions may actually lead to greater variability in current and future output and inflation.

## 5. Recent Experiences

As noted in the introduction, a number of industrial and developing countries have adopted an inflation-targeting regime in recent years. To put matters in perspective, consider the results of the survey of monetary policy frameworks conducted in late 1998 by the

Bank of England and summarized by Sterne (1999). The survey covers ninety-one countries, of which forty-three are considered developing countries. Almost all the central banks surveyed directly targeted either the money supply, the exchange rate, or inflation. Several central banks in both industrial and developing countries stated that instability in the velocity of money (often induced by financial liberalization) led them to abandon money targeting. In 1998, fifty-four countries used an explicit inflation target (compared with eight in 1990), thirty-seven used an explicit monetary aggregate target, and forty-seven used an explicit exchange rate target. Explicit targets (whether for money, inflation, or the exchange rate) became more widespread between 1990 and 1998. Of the fifty-four countries that had inflation targets, thirteen (or 14 percent of the total sample) had inflation targets only; thus many countries had more than one explicit target.[41] The majority of countries that abandoned their exchange rate target, including Mexico in 1995 and Russia in 1998, did so in response to a currency crisis. The fastest growing regime was the combined use of explicit money and inflation targets: 24 percent of the countries in the sample in 1998 employed this regime—more than the combined total of inflation targets only (14 percent) and money targets only (5 percent). In a related study, Morandé and Schmidt-Hebbel (1999) list a total of forty-five countries that adopted some form of inflation target in the 1990s, including twelve industrial countries, twelve transition economies and twenty-one developing countries. They also identify thirty-four countries that targeted primarily money and thirty-six that targeted primarily the exchange rate. Although there is some scope for disagreement with the classification schemes used in these two studies, the broad message is quite clear: a growing number of countries have turned to inflation targeting as a monetary policy framework.

There is now a large literature assessing country experiences with inflation targeting, particularly in the industrial world. Among the most recent publications are those of Bernanke and others (1999), Blejer and others (2000), Landerretche, Morandé, and Schmidt-Hebbel (1999), and Schaechter, Stone, and Zelmer (2000). This section provides a brief summary of these experiences, with a focus on developing countries—most notably Brazil, Thailand, and South Africa.

41. The use of multiple explicit targets may reflect the fact that in practice, monetary authorities view targets more as benchmarks against which outcomes are measured than as objectives that must be achieved.

## 5.1 Industrial Countries

The first country to introduce inflation targeting was New Zealand in late 1989. Other countries followed suit, including Canada (February 1991), Israel (January 1991), the United Kingdom (late 1992), Australia, Finland, and Sweden (all in 1993), and Spain (January 1995).[42] These countries adopted inflation targeting in response to either increased instability in the relationship between monetary aggregates and prices or exchange rate crises. In the United Kingdom, for instance, inflation targeting was introduced after the country left the European exchange rate mechanism in September 1992. With the exception of Israel and Spain, all countries implementing inflation targeting did so in the context of a highly flexible exchange rate regime. Israel, for instance, has maintained a diagonal exchange rate band since 1991; the presence of this band acts as a constraint on the inflation objective, and the economy has experienced episodes over the past few years in which the level of interest rates necessary to achieve the inflation target was inconsistent with the level required to maintain the nominal exchange rate within the band (Leiderman and Bufman, 2000). Spain also maintained an exchange rate commitment in the 1990s and therefore cannot be viewed as a pure inflation targeter. In any case, both Spain and Finland dropped formal targets for domestic inflation when they joined the European single currency in 1999.

Table 1 provides a concise summary of the basic elements of the inflation-targeting regimes in eight industrial countries with explicit targets for inflation, including the date their inflation target was first introduced. The table reveals the following facts:

—Most industrial countries specify their inflation target as a range, and the desired target is usually the middle of that range, even if this is not always made explicit. Several countries, such as New Zealand, established intermediate target ranges to reflect an initially high level of inflation and the desire for gradual disinflation.

—Australia, Spain, and the United Kingdom explicitly exclude mortgage interest payments from their headline measures; Australia also excludes government-controlled prices and energy prices. Canada excludes indirect taxes, as well as food and energy prices, while Fin-

42. See Allen (1999) for a review of the United Kingdom's experience with inflation targeting, Freedman (2000) for Canada, Archer (2000) for New Zealand, Leiderman and Bar-Or (2000) for Israel, and the various chapters in Blejer and others (2000). Schaechter, Stone, and Zelmer (2000) provide a general overview. Note that the European Central Bank's monetary policy framework also incorporates elements of inflation targeting.

land excluded housing capital costs, indirect taxes, and government subsidies. Sweden has no formal exemptions.

—Formal escape clauses (that is, conditions under which the inflation target may be missed) are rarely specified or used. Shocks to inflation have typically been accommodated by allowing fluctuations within the target band or by relying on a measure of core inflation.

—The inflation target typically is not a legislated objective, except in New Zealand, but rather represents an understanding between the government and the governor or president of the central bank. It can be changed either by an amendment to central bank legislation or by a decision of the government.

—Only three of the eight central banks listed in the table now define a term over which the inflation target is to be met, following a transitional period during which an explicit horizon was specified. In most cases the target horizon is indefinite.

—Responsibility for setting the inflation target varies across countries. The target is determined by the central bank in four of the eight countries, whereas the government sets the target in two countries (Australia and the United Kingdom). The decision is joint in the two remaining cases (Canada and New Zealand).

—In six of the eight countries, the central bank provides a formal report on inflation prospects, either voluntarily or by mandate. Four out of eight central banks make explicit inflation forecasts available to the public.

Inflation was on a downward trend in many of these countries prior to the introduction of inflation targets, and inflation persistence continued to drop significantly after the adoption of inflation targets (Siklos, 1999). Furthermore, the degree of risk aversion to inflation volatility in inflation-targeting countries increased significantly in the 1990s (Cecchetti and Ehrmann, 1999). The available evidence does not conclusively indicate, however, whether inflation targeting has lowered inflationary expectations and enhanced credibility, thereby mitigating the real output costs that disinflation typically entails. In fact, sacrifice ratios, which measure the cumulative loss in actual output relative to trend output per percentage point fall in inflation, do not appear to have been much affected by inflation targeting.[43] In addition, the

43. The computation of the sacrifice ratio is fraught with difficulty, however, as can be inferred from the previous discussion on the measurement of potential output. Empirical estimates often fail to disentangle the impact of disinflation policies from other shocks. Conceptually, the sacrifice ratio also suffers from serious shortcomings; in particular, it focuses only on short-run costs and therefore does not capture the longer-run benefits of disinflation.

## Table 1. Industrial Countries: Basic Features of Inflation Targeting Regimes

| *Country* | *Inflation measure* | *Items excluded from inflation measure* | *Inflation target* | *Calculation period* | *Contingencies for breaches of the inflation target* | *Targeting horizon* | *Adoption date* | *Separate inflation report* | *Who sets target* | *Published inflation forecast* |
|---|---|---|---|---|---|---|---|---|---|---|
| Australia | CPI | Mortgage interest; government controlled prices; energy prices | 2–3 percent, on average, over the business cycle | Over the cycle | None | None | 1 Jan 1993 | No[a] | Government | No |
| Canada | CPI[b] | Indirect taxes; food and energy prices | 2–4 percent by the end of 1992<br>1.5–3.5 percent by June1994 (original)<br>1–3 percent Dec 1993 to Feb 2001[c] (revised) | Annual | None | Yes | 26 Feb 1991 | Yes | Joint | No |
| Finland | CPI | Housing costs; capital indirect taxes; government subsidies | 2 percent annual average from 1995 | Annual | None | No | 02 Feb 1993 | No[d] | Central bank | No |
| Israel | CPI | None | 14–15 percent (1991–92)<br>8–11 percent (1995) | Annual | Short-term influences embodied in certain components of the price index (e.g., prices of fruits and vegetables, housing, and imports) | Yes | 1 Jan 1991 | Yes | Central bank | Yes |

**Table 1. (continued)**

| *Country* | *Inflation measure* | *Items excluded from inflation measure* | *Inflation target* | *Calculation period* | *Contingencies for breaches of the inflation target* | *Targeting horizon* | *Adoption date* | *Separate inflation report* | *Who sets target* | *Published inflation forecast* |
|---|---|---|---|---|---|---|---|---|---|---|
| New Zealand | CPI[e] | Commodity prices; government-controlled prices; interest, credit charges | 3–5 percent (Dec 1990); 2.5–4.5 percent (Dec 1991) 1.5–3.5 percent (1992:1–1992:4) 0–2 percent (1993–96) 0–3 percent since Dec 1996[f] | Annual | Unusual events that do not generate general inflationary pressures | Yes | 02 Mar 1990[g] | Yes | Joint | Yes |
| Spain | CPI | Mortgage interest costs | 3.5–4 percent (June 1996) 3.0–3.25 percent (1997:1) 3 percent upper limit for 1997 2.50–2.75 percent upper limit for late 1997 2 percent for 1998[h] | Annual | None | Yes | 1 Jan 1995 | Yes | Central bank | No |
| Sweden | CPI | Nominally none, but conditional on indirect taxes, subsidies | 1–3 percent since 1995 | Annual | None | No | 15 Jan 1993 | Yes | Central bank | Yes |

**Table 1. (continued)**

| *Country* | *Inflation measure* | *Items excluded from inflation measure* | *Inflation target* | *Calculation period* | *Contingencies for breaches of the inflation target* | *Targeting horizon* | *Adoption date* | *Separate inflation report* | *Who sets target* | *Published inflation forecast* |
|---|---|---|---|---|---|---|---|---|---|---|
| United Kingdom | RPI | Mortgage interest payments | 1–4 percent until June 1997 elections 2.5 percent since June 1997 | Annual | None | No | 08 Oct 1992 | Yes[i] | Gover-nment | Yes |

Source: Author's compilation, based on Allen (1999); Archer (2000); Leiderman and Bar-Or (2000); Schaechter, Stone, and Zelmer (2000); and national central bank reports.

a. However, the Governor is available to report on the conduct of monetary policy twice a year to the House of Representatives Standing Committee on Financial Institutions and Public Administration.

b. Although the target is officially specified in terms of overall CPI, the Bank of Canada focuses on the CPI excluding food, energy, and the effect of indirect taxes.

c. Renewed in February 1998.

d. Finland reports quarterly on the inflation outlook in its Monthly Bulletin.

e. Since December 1997, the CPI excluding credit services is targeted. Before that date, overall CPI was targeted. In late 1999, mortgage interest rates were removed from the index.

f. The term of the new Policy Targets Agreement (PTA) coincides with the current term of the Governor, which expires August 31, 2003. The PTAs were specified in December.

g. The Reserve Bank's announced policy included a specific target for inflation and a specific date for that target to be achieved as early as mid-1989 (Archer, 2000).

h. The Law of Autonomy was put in place in June 1994, and although the inflation target was announced in December 1994, it was formally adopted only as of 1 January 1995. Between 1995 and 1997 the aim was to reduce inflation to the 2 percent range. In 1998, the aim was to keep the annual inflation rate close to 2 percent throughout the year.

i. Only since 12 June 1997.

introduction of inflation targets does not appear to have dramatically affected inflation expectations, as revealed either by surveys or by the level of long-term nominal interest rates (Bernanke and others, 1999). Inflation expectations have come down, in most cases, mainly because inflation-targeting central banks were able to demonstrate that they were capable of achieving and maintaining low inflation. A recent quantitative analysis of the performance of inflation targeting in Canada, New Zealand, and the United Kingdom provides some support for this view (Honda, 2000). Honda estimates an unrestricted VAR model with four variables (namely, inflation, deviations of output from trend, the short-term nominal interest rate, and the rate of change of the nominal exchange rate) over a sample period prior to the introduction of inflation targeting and then simulates the model dynamically over the period following the adoption of inflation targeting. If predicted values from the model tend to overestimate actual values of inflation and the other variables in the system, then inflation targeting can be deemed to have had some favorable impact on inflation and other macroeconomic variables. On this basis, Honda finds no evidence that inflation targeting had an effect on either inflation or any other variable in the system. The power of alternative stability tests in a VAR context is an open issue, but Honda's analysis appears to be a promising way of analyzing the impact of inflation targeting on actual inflation performance.

## 5.2 Developing Countries

Few developing countries have adopted inflation targeting to date, but the number of potential candidates appears to have risen significantly in the past two or three years. Not all developing countries that have floated their currency in recent years have adopted an inflation-targeting framework, whether explicit or implicit. Mexico is a case in point. Carstens and Werner (2000) argue, for instance, that the high frequency and incidence of both domestic and external exogenous shocks to domestic prices, including nominal exchange rate fluctuations and movements in wages and public sector prices, make the adoption of an explicit inflation-targeting framework unfeasible in the case of Mexico. In Peru, the central bank has announced an annual inflation target since 1994, but it does not pursue a formal inflation-targeting regime. Nevertheless, both countries have been viewed by some observers as moving toward the adoption of such a framework (see Mishkin and Savastano, 2000). By contrast, Chile has a long history of announcing one-year-ahead inflation targets that goes back to 1990, although the

authorities only recently started to make its inflation report publicly available (in May 2000).[44] Brazil, South Africa, and Thailand recently adopted such a regime, and several other countries, including those in East Asia that adopted a floating exchange rate following the 1997–98 financial crisis, are currently pondering the feasibility of such an approach.[45] Chile's experience is well documented by Landerretche, Morandé, and Schmidt-Hebbel (1999); this section therefore provides a brief discussion of the cases of Brazil, South Africa, and Thailand.

Table 2 summarizes the main characteristics of inflation-targeting regimes in Chile, Brazil, South Africa, and Thailand. Brazil adopted an inflation-targeting framework for monetary policy on 21 June 1999, following the real crisis of January 1999 and the adoption of a floating exchange rate (see Bogdanski, Tombini, and Werlang, 2000). The inflation targets, as well as the tolerance bands, are set by the National Monetary Council, on the basis of a proposal by the Finance Minister. In principle, these targets must be set two years in advance. The price index chosen for setting the inflation targets is the Broad Consumer Price Index (IPCA), reported by the National Bureau of Geography and Statistics (IBGE), although monthly measures of core inflation have also been published since March 2000 (see Figueiredo, 2000). The choice of a full index was dictated by the need to mitigate potential credibility problems associated with perceptions of deliberate manipulation of the index.

The operational framework of Brazil's inflation-targeting program consists of a set of models to support the monetary policy decisionmaking process, including a small-scale structural econometric model and short-term univariate forecasting models. The models are supplemented with surveys of market expectations of major macroeconomic variables, including inflation and growth. The econometric model focuses on the aggregate demand channel of monetary policy, with a direct effect through changes in nominal interest rates and an indirect effect through relative prices induced by the effect of changes in the nominal interest rate on the exchange rate.

The targets are considered to be met whenever the observed accumulated inflation during the period January to December of each year (measured on the basis of variations in the IPCA) falls within the band.

44. Because Chile maintained a crawling peg exchange rate regime until September 1999, some observers have argued that the adoption of a full-fledged inflation-targeting framework is only a recent phenomenon; see Schaechter, Stone, and Zelmer (2000, p. 12).

45. In countries like Korea, for instance, the central bank is now required by law to set a price stability target every year, in consultation with the government.

## Table 2. Developing Countries: Basic Features of Inflation Targeting Regimes

| | *Country* | | | |
|---|---|---|---|---|
| *Feature* | *Brazil* | *Chile* | *South Africa* | *Thailand* |
| Inflation measure | CPI | CPI | CPI | CPI |
| Items excluded from inflation measure | None | None | Mortgage interest costs | Raw food and energy prices |
| Inflation target | 1999: 8 percent ± 2 percent<br>2000: 6 percent ± 2 percent<br>2001: 4 percent ± 2 percent<br>2002: 3.5 percent ± 2 percent | 1991: 18 percent<br>2000: 3.5 percent<br>2001 onwards: 3 percent ± 1 percent | 2002: 3–6 percent | 2000–01: 0–3.5 percent |
| Calculation period | Annual | Annual | Annual | Annual |
| Contingencies for breaches of the inflation target | None | None | Major unforeseen events outside central bank control | None |
| Targeting horizon | Yes | No | Yes | Yes |
| Adoption date | 21 June 1999 | 1 Sept 1990 | 1 Feb 2000 | 1 May 2000 |
| Separate inflation report | Yes | Yes[a] | Yes[c] | Yes[b] |
| Who sets target | Joint | Central bank | Joint | Central bank |
| Publishes inflation forecast | Yes | Yes | No | Yes |

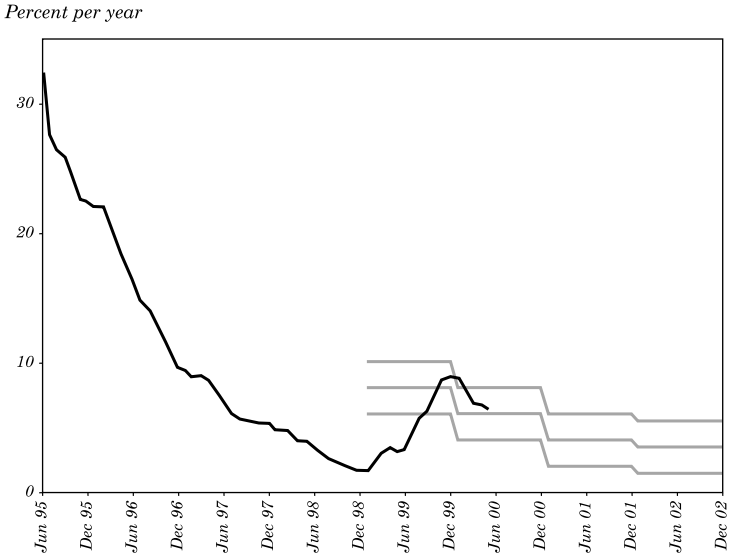
Source: Author's compilation, based on Landerretche, Morandé, and Schmidt-Hebbel (1999); Bogdanski, Tombini, and Werlang (2000); Schaechter, Stone, and Zelmer (2000); and national central bank reports.

a. The first inflation report was published in May 2000 and will be released three times a year (January, May, September).

b. The first inflation report was published in July 2000.

c. The Reserve Bank has prepared an inflation report since the end of 1996. At this stage, the report is not distributed outside the Bank.

**Figure 7. Brazil: Consumer Price Inflation and Inflation Targets, 1995 - 2002**




Source: International Monetary Fund and Banco Central do Brasil.

If the target is missed, the Central Bank Governor must issue an open letter to the Finance Minister explaining the causes of the breach, the measures to be adopted to ensure that inflation returns to the target band, and the period of time that will be needed for these measures to have the intended effect. Since September 1999, the Central Bank also issues a quarterly inflation report (in both Portuguese and English) that provides information on current and future inflation performance and on the effect of monetary policy on prices. Minutes of the monthly Monetary Policy Committee meetings are released with a two-week lag, which is soon to be reduced to one week. In June 1999, official inflation goals were announced for the coming three years: 8 percent in 1999, 6 percent in 2000, and 4 percent in 2001 (accumulated annual variations by year-end). Tolerance intervals were set at 2 percent for each year. As shown in figure 7, inflation has been on a downward path since the introduction of the inflation-targeting regime and has remained well within the target band.

South Africa adopted a full-fledged inflation-targeting framework in February 2000, at a time when the country's inflation performance

was continuing to improve—falling to 5.2 percent in 1999 from 8.6 percent in 1997 and 6.9 percent in 1998.[46] A key reason for doing so was the perceived growing instability between monetary aggregates and inflation in a context of financial liberalization (Schaechter, Stone, and Zelmer, 2000). The inflation objective is currently expressed in terms of an adjusted inflation rate, namely, the headline consumer price index excluding mortgage interest costs. Escape clauses include major unforeseen events deemed to be outside the control of the Reserve Bank. The target range for the year 2002 is a band of 3 to 6 percent average inflation. This medium-term target was set in view of estimated lags between monetary policy decisions and their impact on inflation: changes in interest rates in South Africa have been estimated to take from eighteen to twenty-four months to affect inflation. The relatively large width of the band was chosen to account for the fact that the targeted price index includes a large number of volatile items, whose movements are beyond the control of the Reserve Bank. Attempts to improve transparency have taken the form of public explanations of the monetary policy stance following meetings of the Monetary Policy Committee of the Reserve Bank (although full minutes of the deliberations are not yet released), the creation of a Monetary Policy Forum that meets twice a year (in May and November), and the publication of a semiannual Monetary Policy Review beginning in 2001, which will represent the Reserve Bank's inflation report. At this stage, inflation forecasts and the underlying forecasting models are not released to the public.

Thailand, in turn, adopted a floating rate regime after the collapse of the Thai baht in July 1997, after almost five decades of pegged exchange rate regimes. The new regime initially contemplated monetary targeting, with quarterly monetary base targets (agreed with the IMF) that were implemented and achieved through daily liquidity management. However, growing evidence of instability in the relationship between money, output, and inflation led Thailand to announce the adoption of inflation targeting as a monetary policy framework in May 2000. Under this regime, monetary policy is decided by the Monetary Policy Board (MPB), which was appointed in April 2000 and comprises both high-level central bank officials and external experts. A recent amendment to the Bank of Thailand's charter gives the MPB official status and operational independence in conducting monetary policy; it also

46. Before February 2000, the Reserve Bank had an informal goal of maintaining inflation at a level that would be more or less in line with the average inflation rate in South Africa's major trading partners and international competitors.

reaffirms that price stability is the overriding objective of monetary policy. The price index targeted by the central bank is an index of core inflation, which excludes raw food and energy prices from headline inflation as both components are deemed to be highly volatile. The target core inflation rate is set in the form of a band (between 0 and 3.5 percent for 2000–01) that explicitly aims to give the Bank of Thailand room for cushioning temporary shocks and reduce interest rate volatility. At the time of the adoption of inflation targeting, annual headline and core inflation were at 2 percent and 1.2 percent, respectively. Deviations from the target band are monitored on the basis of quarterly averages of core inflation, to avoid the high degree of volatility that may characterize monthly observations. If core inflation breaches the target band, the MPB must explain why the breach occurred, identify the measures that it intends to take in response, and estimate the amount of time required to bring inflation back within the desired range. Finally, the first quarterly inflation report was issued in July 2000; risks associated with inflation forecasts are shown in fan charts, as is now the practice among several other inflation-targeting central banks.

## 6. Unresolved Analytical Issues

Analytical and operational aspects of inflation-targeting regimes continue to generate a large amount of research. How best to measure core inflation, for instance, continues to be actively discussed. This section focuses on three important issues of debate in the analytical literature: the implications of asymmetries for the design and operation of an inflation-targeting regime; the implications of uncertainty (regarding the variables to be measured, behavioral parameters, and policy lags); and the treatment of credibility and reputational factors in empirical models of inflation.

### 6.1 Effects of Asymmetries

This section considers two types of asymmetries: those related to policy preferences and those dealing with the slope of the trade-off between inflation and the output gap.

#### Nonquadratic Policy Preferences

The central bank's instantaneous policy loss functions, as defined by equations 3 and 13, were taken to be symmetric; positive output

gaps, for instance, were considered to be just as costly as negative output gaps. Adopting this approach is justified not only because of its tractability but also because it is a reasonable approximation of an underlying utility-based welfare function (Rotemberg and Woodford, 1999). In general, however, the short-run cost of disinflation may matter a great deal to the central bank and may lead to a situation in which a higher weight is attached to negative output gaps—for instance by adding a term that is linear in $-y$ in equation 13. As a result, the optimal inflation rate may be greater than $\tilde{\pi}$ even if there is no long-run trade-off between output and inflation.

More fundamentally, Orphanides and Wieland (2000) question the use of a quadratic objective function for policymakers in the analysis of inflation-targeting regimes. They begin by noting that in practice, most inflation-targeting central banks specify a target band as opposed to point targets, as discussed above. They then argue that the existence of a target range implies a nonlinear optimal policy rule. A simple way to specify policy preferences that are consistent with a target band is to write the instantaneous loss function as follows, replacing equation 13:

$$L_t = \frac{\left(\pi_t - \tilde{\pi}\right)^2}{2} + \frac{\lambda y_t^2}{2} + \frac{\phi \left| y_t \right|}{2}, \tag{25}$$

where $\phi > 0$. As shown by Orphanides and Wilcox (1996), this specification implies an asymmetric policy response: as long as inflation is relatively close to target, the optimal interest rate policy is simply to stabilize output. Otherwise, policy should keep inflation within a range, which varies positively with $\lambda$, and then wait for favorable supply shocks (positive shocks to $\varepsilon_t$) to move it closer to the desired value of $\tilde{\pi}$.

Orphanides and Wieland (2000) consider a more general specification than equation 25, namely, a zone-quadratic policy loss function. In this type of specification, the loss function assigns a quadratic loss to inflation deviations outside an explicit target band and a near-zero loss as long as inflation fluctuates within the band. If the central bank assigns some weight to fluctuations in output (as is generally the case in practice), the output objective will dominate during periods in which inflation is within the band and will lose some importance when inflation is outside the band. They argue that this specification of policy preferences is consistent with the often-observed tendency of central banks to show overwhelming concern with inflation only when it is beyond some range. Using numerical analysis, Orphanides and Wieland also find that with nonquadratic preferences (and a nonlinear infla-

tion-output trade-off, as discussed below), uncertainty with regard to unexpected shocks has important effects on the width of the target band and on the relative size of the policy response inside and outside the band. The optimal policy rule under uncertainty does not call for a mechanical response only when inflation falls outside the band. Rather, it is optimal to respond to inflation deviations that are still within the band and then to respond more aggressively if inflation continues to evolve outside the desired range.[47]

Although intuitively appealing, Orphanides and Wieland's results deserve further scrutiny. Growing evidence appears to support nonlinearities regarding aggregate behavioral functions, such as the Phillips curve discussed below, but the empirical research on the structure of policy preferences is less conclusive. Other recent studies support the standard approach. Chadha and Schellekens (1999), for instance, compare several alternative specifications of the central bank's loss function; they suggest that the assumption of quadratic losses may not be too far off the mark. Of course, such results may also be model specific.

## The Convex Phillips Curve

As discussed earlier, establishing forecasts in the context of inflation targeting requires a reasonable understanding of the structure of the economy and adequate parameterization of some key aggregate relationships, most notably between interest rates and output and between output and inflation. A growing literature appears to indicate that the relationship between changes in the output gap and inflation may be nonlinear in industrial countries. Specifically, it suggests that the Phillips curve has a convex shape, that is, positive deviations of aggregate output from potential (or booms) tend to be more inflationary than negative deviations (or recessions) are disinflationary. As discussed in detail by Dupasquier and Ricketts (1998), several analytical models may justify the existence of an asymmetric relationship between inflation and the output gap. One of these models emphasizes the role of capacity constraints, that is, the fact that some firms may find it difficult to increase their capacity to produce beyond a certain range in the very short run. As a result, when aggregate demand is increasing, the impact on inflation will tend to be greater than during periods of low demand, and the Phillips curve will have a convex shape.

47. In addition, they show that in the case in which the Phillips curve is linear, the width of the band increases with the variance of shocks to inflation.

These nonlinearities in inflation targeting may imply the need for possible asymmetries in monetary policy decisions. For instance, the policy response to deviations of inflation above target may need to be stronger than actions taken when inflation is lower than target. Recent analytical research on this issue includes the study by Schaling (1999), who extends Svensson's basic closed-economy model presented earlier to consider the case of a convex Phillips curve of the type proposed by Chadha, Masson, and Meredith (1992) and Laxton, Meredith, and Rose (1995). He shows that the optimal instrument-setting rule is asymmetric and implies a higher level of nominal interest rates than the rule derived by Svensson.

Specifically, suppose that the Phillips curve takes the convex form

$$\pi_t - \pi_{t-1} = \theta\left(y_{t-1};\omega\right) = \frac{\alpha_1 y_{t-1}}{1-\alpha_1 \omega y_{t-1}}, \tag{26}$$

where, as before, $\alpha_1 > 0$ and $0 \le \omega < 1$ is a parameter that measures the degree of convexity of the curve. This specification is consistent with the capacity constraint argument stated earlier. The $\theta(\cdot)$ function is such that $\theta(0; \omega) = 0$, and the slope of the output-inflation trade-off is given by

$$\theta' = \frac{\alpha_1}{\left[1-\alpha_1 \omega y_{t-1}\right]^2},$$

with $\theta'(0; \omega) = \alpha_1$ and limit values of

$$\lim_{\omega \to 0} \theta' = \alpha_1, \quad \lim_{y_{t-1} \to 1/\alpha_1 \omega} \theta' = \infty, \text{ and } \lim_{y_{t-1} \to -\infty} \theta' = 0.$$

The quantity $1/\alpha_1\omega$ thus represents an upper bound that the output gap cannot exceed in the short run. As $\omega \to 0$, equation 26 tends to a linear relationship between the (lagged) output gap and (changes in) inflation. Figure 8 summarizes the properties of this curve.

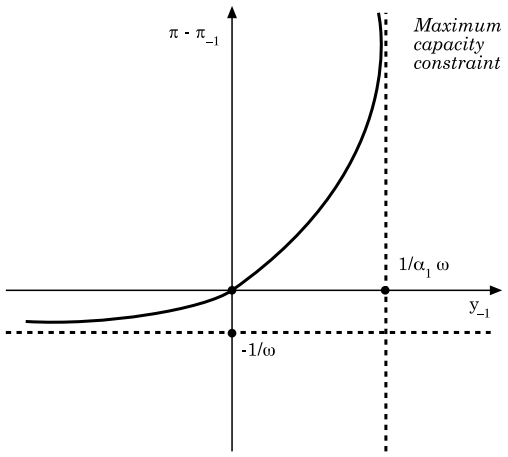
In addition to equation 26, suppose that the output gap evolves in a way similar to equation 2 with, for simplicity, $\beta_2 = 1$:

$$y_t = \beta_1 y_{t-1} - \left(i_{t-1} - \pi_{t-1}\right) + \eta_t, \tag{27}$$

where the aggregate demand disturbance, $\eta_t$, is again assumed to be an i.i.d. shock.

Assuming that the monetary authorities pursue pure inflation target-

**Figure 8. The Convex Phillips Curve**




Source: Schaling (1999, p. 11).

ing and that the loss function takes the quadratic form of equation 3, the optimal interest rate rule can again be found by solving a period-by-period problem (as shown in equation 7), that the first-order condition is again $\pi_{t+2|t} = \tilde{\pi}$ (see Schaling, 1999). The instrument rule, however, is now a nonlinear relationship given by

$$r_t - \frac{1-\alpha_1\,\omega\left(\beta_1\,y_t - r_t\right)}{\alpha_1}\left(\pi_t - \tilde{\pi}\right) + \frac{1+\beta_1-\alpha_1\,\omega\left(2\beta_1\,y_t - r_t\right)}{1-\alpha_1\,\omega\,y_t}\,y_t = 0\,,$$

where $r_t = i_t - \pi_t$ denotes the real interest rate. From this equation it can be verified that for $\omega \to 0$, the interest rate rule boils down to

$$r_t = \frac{1}{\alpha_1}\left(\pi_t - \tilde{\pi}\right) + \left(1+\beta_1\right)y_t\,,$$

which is identical to equation 11. In general, however, the optimal short-term interest rate is a nonlinear function of both deviations of current inflation from target and the output gap.[48] As shown by Schaling (1999),

48. Bean (2000) proposes a specification of a convex Philips curve that results in a linear policy rule. In general, however, the optimal rule will be nonlinear if the Phillips curve is nonlinear.

positive deviations from the inflation target imply larger movements in interest rates (in absolute terms) than negative deviations. Positive output gaps imply larger increases in interest rates (in absolute terms) than negative output gaps. In addition, the nonlinear rule implies that increases in interest rates—for instance, in response to positive output shocks—are larger than those obtained with the linear rule, which implies that the latter underestimates the appropriate level of the policy instrument.

The notion that the output-inflation trade-off depends on the initial state of the economy is crucial in an inflation-targeting framework. All the available evidence, however, pertains to industrial countries (see Laxton, Meredith, and Rose, 1995; Pyyhtia, 1999). Following Laxton, Meredith, and Rose (1995), tables 3 and 4 present estimates of linear and nonlinear Phillips curves (using ordinary least squares in the first case and nonlinear least squares in the second), using quarterly data for six developing countries (Colombia, Korea, Mexico, Nigeria, the Philippines, and Turkey). The explained variable is the rate of inflation, INF = $\Delta^4 \ln P$, where $P$ is the consumer price index. The explanatory variables are as follows (see appendix B for details):

—Lagged inflation (one and two periods), to capture persistence and expectations.

—The output gap, given by the log of the ratio of actual output, $Y$, to potential output, $Y_T$. The latter is measured using two different filters: the standard Hodrick-Prescott filter (with a smoothing parameter of 1600) and a quadratic trend. For the nonlinear Phillips curve, the specification is

$$f(GAP) = \frac{\omega^2}{\omega - GAP} - \omega,$$

where $\omega$ is a parameter to be estimated.[49]

—Current and lagged values of the rate of change of the nominal effective exchange rate, to assess the direct pass-through effect of currency depreciations.

49. As noted by Laxton, Meredith, and Rose (1995, p. 353), using detrended actual output may result in downward-biased estimates of potential output because positive output gaps have larger effects on inflation than negative output gaps. To correct for this bias, they measure the output gap in their empirical results as $\ln [Y/(1+ \alpha)Y_T]$, where $\alpha$ is a parameter to be estimated. Here, however, preliminary regressions yielded an estimated value of $\alpha$ that was very small and never significantly different from zero. Accordingly, the output gap was specified simply as $\ln (Y/Y_T)$.

**Table 3. Estimation Results: Linear Phillips Curve[a]**

| | *Colombia* | | *Korea* | | *Mexico* | | *Nigeria* | | *Philippines* | | *Turkey* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Explanatory variable* | *HP* | *QT* | *HP* | *QT* | *HP* | *QT* | *HP* | *QT* | *HP* | *QT* | *HP* | *QT* |
| Constant | 0.026 | 0.026 | 0.007 | 0.008 | 0.021 | 0.017 | 0.021 | 0.025 | 0.015 | 0.020 | 0.012 | 0.022 |
| | (2.237) | (2.289) | (3.216) | (3.232) | (2.956) | (2.454) | (1.951) | (2.218) | (2.618) | (3.707) | (0.802) | (1.165) |
| $INF_{t-1}$ | 1.097 | 1.096 | 0.822 | 0.794 | 1.312 | 1.284 | 1.461 | 1.454 | 1.207 | 1.119 | 0.872 | 0.866 |
| | (9.490) | (9.474) | (27.641) | (19.011) | (14.429) | (12.962) | (15.514) | (15.371) | (11.325) | (11.454) | (18.009) | (17.145) |
| $INF_{t-2}$ | –0.226 | –0.266 | | | –0.465 | –0.436 | –0.566 | –0.572 | –0.443 | –0.389 | | |
| | (–1.955) | (–1.956) | | | (–6.401) | (–5.534) | (–5.958) | (–6.012) | (–5.048) | (–4.781) | | |
| $GAP_t$ | 0.019 | –0.002 | –0.019 | 0.021 | | | | | –0.018 | 0.002 | | |
| | (0.465) | (–0.283) | (–0.473) | (1.009) | | | | | (–0.283) | (0.154) | | |
| $GAP_{t-1}$ | | | | | –0.136 | 0.021 | | | | | 0.107 | –0.040 |
| | | | | | (–0.619) | (1.380) | | | | | (1.356) | (–0.815) |
| $GAP_{t-2}$ | | | | | | | 0.101 | –0.011 | | | | |
| | | | | | | | (0.873) | (–0.649) | | | | |
| $NEERGR_t$ | | | 0.107 | 0.109 | 0.180 | 0.190 | | | 0.118 | 0.097 | 0.387 | 0.374 |
| | | | (6.582) | (6.834) | (5.687) | (6.401) | | | (5.385) | (4.530) | (8.825) | (8.152) |
| $NEERGR_{t-1}$ | | | –0.052 | –0.048 | –0.058 | –0.072 | | | | | –0.275 | –0.276 |
| | | | (–2.900) | (–2.658) | (–1.408) | (–1.830) | | | | | (–5.333) | (–5.290) |
| $GAP_t$*$NEERGR_t$ | | | | | | | | | 0.807 | 0.733 | | |
| | | | | | | | | | (1.832) | (3.388) | | |
| $GAP_{t-1}$*$NEERGR_{t-1}$ | | | | | 0.753 | –0.030 | | | | | | |
| | | | | | (1.935) | (–0.632) | | | | | | |
| $PMGR_t$ | | | | | | | | | 0.074 | 0.045 | | |
| | | | | | | | | | (3.418) | (2.017) | | |
| $PMGR_{t-1}$ | | | 0.094 | 0.086 | | | | | | | 0.058 | 0.047 |
| | | | (5.026) | (4.457) | | | | | | | (1.190) | (0.925) |

**Table 3. (continued)**

| | *Colombia* | | *Korea* | | *Mexico* | | *Nigeria* | | *Philippines* | | *Turkey* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Explanatory variable* | *HP* | *QT* | *HP* | *QT* | *HP* | *QT* | *HP* | *QT* | *HP* | *QT* | *HP* | *QT* |
| $PXGR\_DEVED_t$ | | | | | | | 0.063 | 0.070 | | | | |
| | | | | | | | (0.761) | (0.844) | | | | |
| *Summary statistic* | | | | | | | | | | | | |
| Adjusted $R^2$ | 0.792 | 0.792 | 0.958 | 0.958 | 0.982 | 0.981 | 0.897 | 0.896 | 0.946 | 0.953 | 0.925 | 0.923 |
| Standard error of regression | 0.015 | 0.015 | 0.011 | 0.011 | 0.031 | 0.032 | 0.055 | 0.056 | 0.021 | 0.020 | 0.038 | 0.038 |
| No. observations | 76 | 76 | 79 | 79 | 79 | 79 | 81 | 81 | 64 | 64 | 75 | 75 |
| Period | 1980:1 – 1998:4 | | 1980:2 – 1999:4 | | 1980:2 – 1999:4 | | 1979:3 – 1999:3 | | 1981:1 – 1999:3 | | 1981:2 – 1999:4 | |

Source: Author's calculations.

a. Dependent variable is the inflation rate; regressions are an ordinary least squares estimation; *t*-statistics are in parentheses. INF is the inflation rate. GAP is the log difference of output and trend component of output which is calculated using either Hodrick and Prescott method (HP) or quadratic trend method (QT). NEERGR is the growth rate of nominal effective exchange rate. PMGR is the growth rate of the import price index. PXGR_DEVED is the growth rate of the export price index of industrial countries.

## Table 4. Estimation Results: Nonlinear Phillips Curve[a]

| | *Colombia* | | *Korea* | | *Mexico* | | *Nigeria* | | *Philippines* | | *Turkey* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Explanatory variable* | *HP* | *QT* | *HP* | *QT* | *HP* | *QT* | *HP* | *QT* | *HP* | *QT* | *HP* | *QT* |
| Constant | 0.028 | 0.027 | 0.007 | 0.007 | 0.022 | 0.016 | 0.023 | 0.022 | 0.015 | 0.026 | 0.013 | 0.016 |
| | (2.380) | (2.291) | (3.183) | (3.296) | (3.119) | (2.205) | (2.137) | (1.878) | (2.621) | (4.395) | (0.847) | (1.010) |
| $INF_{t-1}$ | 1.096 | 1.093 | 0.823 | 0.821 | 1.289 | 1.332 | 1.489 | 1.455 | 1.209 | 1.125 | 0.880 | 0.873 |
| | (9.531) | (9.351) | (27.486) | (27.228) | (14.253) | (14.205) | (15.881) | (15.251) | (11.375) | (11.472) | (17.784) | (18.010) |
| $INF_{t-2}$ | –0.234 | –0.225 | | | –0.446 | –0.473 | –0.599 | –0.566 | –0.448 | –0.430 | | |
| | (–2.029) | (–1.923) | | | (–6.176) | (–6.284) | (–6.323) | (–5.877) | (–5.105) | (–5.043) | | |
| $f(GAP_t)$ | –0.001 | 0.002 | –0.004 | 0.002 | | | | | 0.017 | 0.067 | | |
| | (–0.195) | (0.105) | (–0.748) | (0.232) | | | | | (0.724) | (1.721) | | |
| $f(GAP_{t-1})$ | | | | | –0.073 | –0.026 | | | | | –0.022 | 0.026 |
| | | | | | (–0.458) | (–0.774) | | | | | (–0.542) | (0.548) |
| $f(GAP_{t-2})$ | | | | | | | 0.087 | 0.015 | | | | |
| | | | | | | | (1.605) | (0.146) | | | | |
| ω | 0.049 | 0.052 | 0.047 | 0.055 | 0.081 | 0.060 | 0.051 | 0.043 | 0.045 | 0.042 | 0.048 | 0.044 |
| | (48.498) | (2.782) | (19.978) | (13.177) | (5.713) | (10.175) | (27.717) | (4.806) | (13.894) | (19.390) | (15.601) | (26.268) |
| $NEERGR_t$ | | | 0.110 | 0.109 | 0.207 | 0.197 | | | 0.119 | 0.095 | 0.389 | 0.382 |
| | | | (6.819) | (6.795) | (5.855) | (6.365) | | | (5.340) | (4.564) | (8.601) | (8.719) |
| $NEERGR_{t-1}$ | | | –0.052 | –0.050 | –0.080 | –0.091 | | | | | –0.289 | –0.281 |
| | | | (–2.922) | (–2.796) | (–1.840) | (–2.308) | | | | | (–5.464) | (–5.458) |
| $GAP_t$*$NEERGR_t$ | | | | | | | | | 0.763 | 0.835 | | |
| | | | | | | | | | (2.120) | (4.146) | | |
| $GAP_{t-1}$*$NEERGR_{t-1}$ | | | | | 0.642 | –0.008 | | | | | | |
| | | | | | 2.102) | (–0.189) | | | | | | |
| $PMGR_t$ | | | | | | | | | 0.072 | 0.039 | | |
| | | | | | | | | | (3.305) | (1.804) | | |
| $PMGR_{t-1}$ | | | 0.092 | 0.096 | | | | | | | 0.053 | 0.069 |
| | | | (5.019) | (5.150) | | | | | | | (1.076) | (1.401) |

**Table 4. (continued)**

| *Explanatory variable* | *Colombia* | | *Korea* | | *Mexico* | | *Nigeria* | | *Philippines* | | *Turkey* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *HP* | *QT* | *HP* | *QT* | *HP* | *QT* | *HP* | *QT* | *HP* | *QT* | *HP* | *QT* |
| $PXGR\_DEVED_t$ | | | | | | | 0.028 | 0.070 | | | | |
| | | | | | | | (0.343) | (0.829) | | | | |
| *Summary statistic* | | | | | | | | | | | | |
| Adjusted $R^2$ | 0.794 | 0.789 | 0.958 | 0.958 | 0.983 | 0.981 | 0.900 | 0.895 | 0.946 | 0.956 | 0.923 | 0.924 |
| Standard error of regression | 0.015 | 0.015 | 0.011 | 0.011 | 0.031 | 0.032 | 0.054 | 0.056 | 0.021 | 0.019 | 0.039 | 0.038 |
| No. observations | 76 | 76 | 79 | 79 | 79 | 79 | 81 | 81 | 64 | 64 | 75 | 75 |
| Period | 1980:1 – 1998:4 | | 1980:2 – 1999:4 | | 1980:2 – 1999:4 | | 1979:3 – 1999:3 | | 1981:1 – 1999:3 | | 1981:2 – 1999:4 | |

Source: Author's calculations.

a. Dependent variable is the inflation rate; regressions are a nonlinear least squares estimation; *t*-statistics are in parentheses. INF is inflation rate. GAP is the log difference of output and trend component of output which is calculated using either Hodrick and Prescott method (HP) or quadratic trend method (QT). *f*(GAP) is a function of GAP such that $[\omega^2/(\omega - GAP)] - \omega$. The parameter $\omega$ identifies maximum short-run level of GDP; its starting value is 0.049. NEERGR is the growth rate of nominal effective exchange rate. PMGR is the growth rate of the import price index. PXGR_DEVED is the growth rate of the export price index of industrial countries.

—An interactive term given by the product of the nominal effective exchange rate and the output gap. This term is included in the regressions to test the possibility of a nonlinear effect of exchange rate movements on inflation, following Leiderman and Bar-Or (2000). The assumption is that the strength of the pass-through effect depends on the state of the economy, such that the pass-through may be larger in booms than in recessions, when falls in aggregate demand tend to put downward pressure on prices.[50]

—Foreign inflation, measured by the price of imported goods.

Consider first the results for the linear Phillips curve given in table 3. Overall, the regressions fit the data fairly well. Lagged values of inflation are significant in all cases, whereas the value of the interactive term is significant only for the Philippines and Mexico (using the Hodrick-Prescott estimate of trend output). Foreign inflation is significant only for Korea. The rate of depreciation of the nominal effective exchange rate is highly significant for both current and one-period lagged values, except in the cases of Colombia and Nigeria. Finally, the output gap is not significant in any equation, regardless of the detrending method used or the lag considered.[51]

Consider now the results for the nonlinear Phillips curve shown in table 4. The explanatory power of the regressions (as measured by the adjusted $R$-squared and the standard error of the regression) is about the same as before, and the degree of significance and size of the coefficients estimated for all variables, except the output gap, are very similar. With regard to the output gap, the results now suggest that the coefficient $\omega$ is significantly different from zero in virtually every case, regardless of the detrending technique used. The coefficient of the function $f$(GAP), however, is significant only at the 10 percent level and only for the Philippines (where the current value of GAP is used, with a quadratic trend to measure potential output) and Nigeria (where a two-period lag is used, with the Hodrick-Prescott filter).

50. An alternative assumption worth exploring in future research is the possibility that low inflation itself may result in a lower pass-through, owing to reduced perceived persistence of exchange rate movements (as suggested by Taylor, 2000). Another possibility to consider is that the strength of the pass-through effect may decline over time as the inflation-targeting regime gains credibility. This may explain why in Chile, for instance, the large exchange rate depreciation that followed the Asian and Russian crises in mid-1997 and mid-1998 did not translate into major upward pressure on domestic prices.

51. Higher-order lags than those shown in the table were also tried, with no success. In addition, following Pyyhtia (1999), the model was estimated by entering separately positive and negative output gaps; the results remained qualitatively similar to those reported in the table.

The linear and nonlinear specifications are compared using a nonnested test, namely, the *J* test developed by MacKinnon, White, and Davidson (1983), which is briefly discussed in appendix B. The results indicate that for Colombia, the linear model is rejected against the nonlinear alternative, regardless of whether the Hodrick-Prescott filter or quadratic trend filter is used. For Korea, neither model hypothesis is rejected, suggesting that the data do not provide enough information to discriminate between them. For Mexico, although the linear model is rejected against the nonlinear one when the Hodrick-Prescott filter is used, both models are rejected when the quadratic trend method is used. For Nigeria, the nonlinear model is accepted against the linear alternative when the Hodrick-Prescott filter is used; but neither model is rejected when the quadratic trend method is used. In the case of the Philippines, the nonlinear model is accepted against the linear specification. Finally, in the case of Turkey, the nonlinear model is rejected against the linear alternative using the Hodrick-Prescott filter and at a 10 percent significance level. Neither model can be rejected when the quadratic trend is used in the regressions.

The above results should be viewed as preliminary. Further testing is clearly needed to assess other possible sources of nonlinearities in the Phillips curve, as discussed by Dupasquier and Ricketts (1998). While this is a difficult task, the source of the nonlinearity in the Phillips curve is important from a policy viewpoint, because different sources may have very different policy implications. With nonlinearities, the policy rule is state contingent; parameters (elasticities) that capture the response of interest rates to movements in the output gap and deviations of current inflation from target depend on the current levels of inflation and the output gap. This has considerable practical implications in the present context, given the relative lack of experience that inflation-targeting central banks have with the conduct of monetary policy during a cyclical downturn, particularly in developing countries.

## 6.2 Uncertainty and Optimal Policy Rules

The implications of uncertainty for the design of policy rules under inflation targeting receives considerable attention in the most recent literature. Analytically, it is convenient to distinguish between four sources of uncertainty. First, uncertainty about some of the determinants of inflation arises because some economic series are unobservable and must be estimated. The most obvious example in the present case is the measurement of potential output in the calculation of the output gap.

Potential output is very often approximated by trend output (as done earlier), but alternative detrending techniques may sometimes give large discrepancies.[52] Second, uncertainty about the parameters of the model can be interpreted in two ways: either the underlying model itself is uncertain, or the true model is deterministic but policymakers cannot be certain that this is so and therefore must estimate it. Econometric techniques normally provide a sense of the degree of uncertainty that accompanies empirical estimates, because they yield not only point estimates of parameters but also their variances and covariances. The third source is uncertainty about the transmission lag and the timing of policy actions. The transmission lag depends on a variety of economic and institutional factors, such as the degree of development of financial markets and the intensity of competition on both the supply and demand sides, the degree of trade openness, and the composition of private agents' financial wealth.[53] Finally, uncertainty about the nature and degree of persistence of shocks to which the economy is subject encompasses whether the shocks are on the supply or demand side of the economy and whether they are temporary or permanent.

Whereas some of these sources of uncertainty cause optimal policy to become more cautious, others have the opposite effect. To illustrate these results and their implications for inflation targeting, it is sufficient to consider two analytical examples: uncertainty about parameters and uncertainty about the degree of persistence of macroeconomic variables, including inflation.

In a seminal paper, Brainard (1967) argues that when policymakers are uncertain about the effect of their actions, it may be optimal to adopt a more gradual policy stance than when they are certain (or, more generally, under certainty equivalence, which holds in a linear model with a quadratic loss function and additive shocks). The impli-

52. The error in measuring potential output is not necessarily problematic if it takes an additive form and is uncorrelated over time. A related problem is the significant revisions in economic time series (owing to changes in seasonal adjustment factors, redefinitions, and so on) that often occur after a preliminary release of data, particularly those dealing with the real sector. Large revisions in the variables entering the instrument rule, in particular, may complicate the use of preliminary data as a basis for policy decisions.

53. As discussed earlier, there are lags in the response of aggregate demand to changes in interest rates, as well as lags in the response of inflation to the output gap. There are also lags in the response of inflation expectations to policy changes, lags in the response of inflation to changes in inflation expectations, lags in the response of aggregate demand to changes in relative prices induced by exchange rate changes, and lags in response of supply to exchange-rate-induced movements in the domestic price of imported inputs.

cations of Brainard-type uncertainty can be illustrated using Svensson's model of strict inflation targeting described in equations 1 through 4. To simplify the analysis, suppose that output immediately affects inflation, $\alpha_1 = 1$, $\beta_1 = 0$, and that there are no supply shocks ($\varepsilon_t = 0$ for all $t$). The behavioral equations of the model therefore become

$$\pi_t - \pi_{t-1} = \alpha_1 y_t \text{ and} \tag{28}$$

$$y_t = -\beta_2 \left( i_{t-1} - \pi_{t-1} \right) + \eta_t , \tag{29}$$

where the demand shock, $\eta_t$, is once again an additive, serially uncorrelated shock with zero mean. Substituting equation 28 into equation 29 yields

$$\pi_{t+1} = \gamma_1 \pi_t - \gamma_2 i_t + \eta_{t+1} ,$$

where $\gamma_1 = (1+ \alpha_1\beta_2)$ and $\gamma_2 = \alpha_1\beta_2$. By assuming the same intertemporal loss function as before (equation 4) and for simplicity setting the target $\tilde{\pi} = 0$ , I obtain the following optimal interest rate rule:

$$i_t = \frac{\gamma_1}{\gamma_2} \pi_t . \tag{30}$$

This rule is certainty equivalent: the same interest rate rule would be optimal in a world with no uncertainty about aggregate demand shocks. But suppose that the central bank does not know for sure the values of $\gamma_1$ and $\gamma_2$; all that is known is that these parameters are drawn from independent, normal distributions with means $\bar{\gamma}_1$ and $\bar{\gamma}_2$ and variances $\sigma_1^2$ and $\sigma_2^2$, respectively. In this case, as shown by Martin (1999), the optimal instrument rule becomes

$$i_t = \frac{\bar{\gamma}_1 \bar{\gamma}_2}{\bar{\gamma}_2^2 + \sigma_2^2} \pi_t . \tag{31}$$

This equation indicates that as uncertainty about the parameters in the transmission process of policy shocks increases (that is, as $\sigma_2^2$ rises), the optimal instrument response to movements in current inflation becomes smaller.[54] The fundamental reason for this result is the following. The per-period loss function can be decomposed into the sum of the squared expected deviation of each variable from its target (or the squared bias), and the conditional variance of that variable (see

54. As $\sigma_2^2$ tends to zero, equation 31 becomes identical to equation 30.

equation 8). With additive uncertainty, the variance is independent of the policy rule, and so policy decisions aim only at minimizing expected deviations in inflation. By contrast, under uncertainty about the parameters of the model, the variance of future inflation depends on the level of nominal interest rates. Large movements in the policy instrument in response to deviations between actual and targeted inflation tend to reduce bias, as implied by the first term in equation 8—at the cost, however, of increasing the variance of inflation, the second term in equation 8. The central bank therefore internalizes this effect by choosing a lower optimal level of interest rates.[55] A similar result would hold in a more general, linear-quadratic setting in which the central bank pursues several policy objectives simultaneously.

Model-based simulation studies generally confirm the practical importance of the Brainard effect (see Ha, 2000; Martin and Salmon, 1999; Sack, 2000). The optimal interest rate rule calls for more gradual adjustment in the presence of parameter uncertainty. Ha (2000) uses a numerical model for New Zealand to examine the impact of uncertainty about the transmission lag of monetary policy (that is, lag uncertainty regarding the timing of policy actions, as opposed to the effect of these actions, as in Brainard's analysis) on the setting of monetary policy instruments in the context of inflation-forecast-based rules. His analysis shows that less aggressive policy rules are indeed more robust, in the sense that they are less affected by uncertainty about the monetary policy transmission lag. At the same time, however, more aggressive rules tend to produce lower inflation variability. Sack (2000) shows that accounting for parameter uncertainty in deriving an optimal interest rule from an estimated VAR model and a quadratic loss function in inflation and unemployment helps to explain the observed tendency for the Federal Reserve to change its policy rate (the federal funds rate) only gradually, despite the fact that interest rate smoothing is not a consideration for the central bank.

Several authors show that policy may be more aggressive when the degree of persistence in the economy is uncertain than when it is certain. Notable studies include Soderstrom (1999) and Shuetrim and Thompson (1999). In Soderstrom's model, for instance, uncertainty about the degree of persistence of inflation itself may lead to this result. Without full information regarding inflation persistence, a cautious monetary

55. Brainard himself qualifies this result by showing that it does not necessarily hold when the covariance between parameters (the policy multiplier, in his example) and the additive disturbance is sufficiently negative.

policy may cause inflation to approach the target at below the desired rate or even to diverge from the target. The central bank can lower this risk by implementing large adjustments in interest rates, thereby reducing uncertainty regarding the path of inflation. This more aggressive policy leads to the expectation that inflation will return to target more quickly, so that the implicit targeting horizon is shortened.[56]

The sharp differences in these results suggest that more quantitative research is needed to fully understand the impact of uncertainty on policy rules under inflation targeting. In particular, the impact of uncertainty on the optimal policy rule may depend on which parameter, or which behavioral relationship, is being considered in the structural model. Put differently, uncertainty about particular parameters may be of relatively limited importance for the conduct of monetary policy, whereas others may have an unduly large effect on the setting of policy instruments. Identifying which parameters matter may well be model specific.

## 6.3 Endogenizing Reputation and Credibility

The foregoing discussion highlights the need, in setting policy instruments in an inflation-targeting framework, to account for the trade-off between the cost of having inflation above target (which is reduced if disinflation is faster) and the cost of output fluctuations (which is increased if disinflation is faster). The trade-off stems from the assumption that to reduce inflation the central bank must necessarily induce a (temporary) reduction in output. The extent and duration of the reduction in output depend crucially on the credibility of the commitment to the inflation target and its evolution. The more credible the commitment becomes over time, the faster inflation expectations will fall, and the lower will be the output cost of reducing inflation. More generally, accounting for changes in credibility in forecasting inflation and simulating policy shocks may be important in the first stages of implementing an inflation-targeting framework, particularly in countries where the degree of confidence in the central bank's commitment to low inflation is not well established.

Nevertheless, relatively few studies attempt to endogenize credibility in empirical macroeconomic models used for forecasting and policy analysis under inflation targeting. One reason may be the difficulty of

56. Note that if the central bank cares only about stabilizing inflation, the implicit targeting horizon is already as short as possible (that is, equal to the control lag). In this case, it is not affected by uncertainty about the persistence of inflation.

operationalizing theoretical concepts of credibility and its determinants. A simple approach is to assume that the expected inflation rate, $\pi_{t\,|\,t-1}$, is a weighted sum of lagged inflation, $\pi_{t-1}$, and the inflation target, $\tilde{\pi}$, with relative weights of $1-\sigma_t$ and $\sigma_t$, respectively:

$$\pi_{t\,|\,t-1} = \left(1-\sigma_t\right)\pi_{t-1} + \sigma_t\,\tilde{\pi}\,. \tag{32}$$

The weight on the announced inflation target $\sigma_t$ can be viewed as a measure of policy credibility, which can be modeled as

$$\sigma_t = \Lambda\sigma_{t-1} + \psi\left(\pi_{t-1}-\tilde{\pi},\,\pi_{t-2}-\tilde{\pi},\ldots\right) \rightarrow \begin{cases} \Lambda\sigma_{t-1} & \text{when } \psi \rightarrow 0 \\ \Lambda\sigma_{t-1}+1 & \text{when } \psi \rightarrow 1\,, \end{cases} \tag{33}$$

where $0 < \Lambda < 1$ and $\psi(.)$ is a function of past inflation forecast errors, with the properties that $\psi \rightarrow 1$ when these errors become very small and $\psi \rightarrow 0$ when these errors become very large. Expectations are thus completely backward-looking when $\psi \rightarrow 0$ (because $\sigma_t \rightarrow 0$ as well), whereas when $\psi \rightarrow 1$ full credibility is achieved ($\sigma_t \rightarrow 1$), with expectations depending only on the announced target. Isard, Laxton, and Eliasson (2001) provide a more elaborate treatment of this approach to endogenizing credibility. A key conclusion that emerges from simulation studies based on expectations formation schemes similar to equations 32 and 33 is that endogenous policy credibility strengthens the case for the type of forward-looking inflation-forecast-based rules discussed above.

An alternative and conceptually appealing approach to endogenizing credibility and learning in a tractable manner is that pursued by Drazen and Masson (1994) and Agénor and Masson (1999), who view credibility as consisting of two elements: an assessment of the central bank's type (which could be termed reputation) and, for a given type, an assessment of the probability that the central bank will actually decide to stick to the announced policy (that is, to maintain inflation close to target) in the presence of adverse shocks to prices.[57] In this setting, inflation expectations reflect assessments about the central bank's type, as captured by the relative weights that the authorities attach to each of their policy objectives, which are not known by the public. Because private agents know that random shocks will alter the balance of costs

57. An alternative approach consists in defining credibility as the ability of the central bank to precommit its actions, that is, its capacity to convince private agents that it will carry out policies that may be time inconsistent. See, for instance, Cukierman (1992).

and benefits associated with maintaining the inflation rate close to target, they will reevaluate on the basis of observed variables the probabilities that a particular type of policymaker will decide to stick to the inflation target in the future. Put differently, if there is significant persistence in the effects of policies, then a restrictive policy carried out today (which lowers inflation but also reduces output) may make it less likely that such a policy will be continued in the future.

To illustrate this approach, consider again the per-period policy loss function under flexible inflation targeting described in equation 13. The first component of (lack of) credibility, namely, the probability that the central bank places a high weight on limiting output fluctuations, can be modeled using Bayesian updating, under the assumption that there are two possible types of policymaker, each with a known set of weights on its objectives: a weak central bank, which sets $\lambda = \lambda_W$, and a tough central bank, whose value of $\lambda$ is $\lambda_T < \lambda_W$. The policy loss function can thus be written as

$$L_t = \frac{\left(\pi_t - \tilde{\pi}\right)^2}{2} + \frac{\lambda y_t^2}{2}, \quad \lambda = \begin{cases} \lambda_W \\ \lambda_T < \lambda_W \end{cases}. \tag{34}$$

In each period private agents calculate ex ante the likelihood of each type deciding to deviate from the inflation target. If inflation remains close to target ex post, this would give information about whether the central bank is weak (even if the shocks cannot be observed), so that initial priors about that probability are updated on the basis of the relative likelihood that each policymaker would have deviated from target, given the distribution of the unobserved shocks.

In this framework, inflation expectations depend on the probability that the central bank is weak or tough, as well as the ex ante probability that a given type will decide to deviate from the inflation target as a result of random supply shocks, as captured by $\varepsilon_t$. Private agents do not observe the supply shock; they form their expectations using an information set that includes variables known as of the end of $t - 1$, that is, the lagged values of output, interest rates, and inflation, and whether the policymaker has allowed inflation to deviate from target or not. The central bank observes the supply shock and chooses whether to adjust interest rates and keep inflation close to target. In general, the central bank will allow inflation to deviate significantly from target when a negative shock to output is so large that the cost of maintaining inflation close to its target value will exceed the costs associated with flexibility (that is, higher inflation). Formally, let $L_t^F$ be the

value of the loss function if inflation is kept close to target through changes in interest rates, and $L_t^D$ the value when it is allowed to deviate significantly from target with no change in policy instruments. The central bank will maintain interest rates constant when $L_t^D - L_t^F < 0$. The results derived by Agénor and Masson (1999) establish that when equations 1 and 2 characterize the economy as above, then for $L_t^D - L_t^F$ to be negative, the supply shock $\varepsilon_t$ must be relatively large compared to a threshold value, $\tilde{\varepsilon}_t^h$, which depends on the type of central bank and other variables in the model. The threshold level is lower for a weak central bank than for a tough central bank $\left(\tilde{\varepsilon}_t^W < \tilde{\varepsilon}_t^T\right)$.

The expected inflation rate in this setting is the product of the probability of deviating from target, $\rho_t$, and the size of the deviation from target, $x_t$, which may or may not be constant over time. In turn, the private sector's assessment of $\rho_t$ is equal to the probability of a weak central bank, $\theta_t$, times the probability that a weak central bank will devalue, $\rho_t^W$, plus a corresponding term for a tough central bank:

$$\rho_t = \theta_t \rho_t^W + \left(1 - \theta_t\right)\rho_t^T . \tag{35}$$

Expected inflation is thus

$$\rho_t x_t = \left[\theta_t \rho_t^W + \left(1 - \theta_t\right)\rho_t^T\right] x_t . \tag{36}$$

Given knowledge of the authorities' objective function and of the distribution of the supply shock, the private sector can calculate the probabilities $\rho_t^W$ and $\rho_t^T$, which can be defined as

$$\rho_t^h = \Pr\left(\varepsilon_t > \tilde{\varepsilon}_t^h\right).$$

Finally, the probability that a policymaker is weak, $\theta_t$, can be assumed to be updated using a Bayesian rule, starting from a prior estimate, $\theta_{t-1}$. Specifically, because private agents observe the absence of deviations of inflation from target at time $t - 1$, they will revise $\pi_{t-1}$ on the basis of the relative likelihood that the two types would have chosen not to deviate from the inflation target:

$$\theta_t = \frac{1 - \rho_{t-1}^W}{\left(1 - \rho_{t-1}^W\right)\theta_{t-1} + \left(1 - \rho_{t-1}^T\right)\left(1 - \theta_{t-1}\right)}\ \theta_{t-1} . \tag{37}$$

The above approach may prove useful for endogenizing credibility and reputation in macroeconomic models designed to predict inflation and analyzing the performance of alternative policy rules, particularly in countries where the initial degree of confidence in the central bank's

ability to maintain its commitment to price stability is relatively low. Other approaches are also possible, however, and sorting out the advantages and limitations of each remains a matter for further research.

## 7. Summary and Conclusions

In the past few years a number of central banks in industrial and developing countries alike have adopted an explicit inflation-targeting framework for the conduct of monetary policy. This paper has attempted to provide an analytical discussion of the issues involved in designing such a framework, with some emphasis on the particular features and recent experiences of developing countries. The first part of section 1 described an analytical framework for a closed economy, essentially drawing on Svensson (1997a, 1999a). The analysis generated two main results. First, because of lags in the transmission process of short-term interest rates to prices, inflation targeting implies inflation forecast targeting. The central bank's forecast becomes an explicit intermediate target. Inflation targeting can then be viewed as a monetary policy framework under which policy decisions are guided by expected future inflation relative to an announced inflation target; the forward-looking instrument rule takes into account lags in the transmission process. Second, if the central bank, aims at stabilizing output in addition to seeking to achieve its inflation target, it should allow for a slower adjustment of the inflation forecast to the target value than in a situation in which the inflation target is the only goal. Extension of the analysis to an open-economy setting showed that given the critical role of the exchange rate in the transmission process of monetary policy, inflation targeting may lead to a relatively high degree of output volatility by inducing excessive fluctuations in interest rates.

Section 2 compared inflation-targeting regimes with money supply and exchange rate targeting regimes. Monetary targeting requires a stable relationship between monetary aggregates and the price level, but such stability has become elusive as a result of financial liberalization and abrupt changes in inflation expectations. With regard to exchange rate targeting, a number of developing countries have been forced to abandon their exchange rate pegs in recent years as a result of unsustainable speculative pressures. These developments led in many cases to the adoption of inflation targeting as an operational framework for conducting monetary policy.

Section 3 discussed three basic requirements for implementing an inflation-targeting framework, namely, central bank independence, the

absence of implicit exchange rate targeting, and transparency in the conduct of monetary policy. It is now well recognized that openness and transparency play an important role in achieving credibility in monetary policy. The announcement of inflation targets communicates the central bank's intentions to the financial markets and to the public, and in so doing it helps to reduce uncertainty about the future course of inflation. Transparency and accountability thus act as constraints on the temptation to adopt discretionary policies. The risks associated with the pursuit of an implicit exchange rate target were also highlighted. It is crucial for the central bank to be able to convince the public that the inflation target will take precedence over other policy goals in case of conflict. In particular, if the central bank is also concerned about fluctuations in the nominal exchange rate (as may be the case in countries where the pass-through rate to domestic prices is high or when the short-term foreign-currency liabilities of the private sector are large), there is a risk that inflation targets may lack credibility, thereby undermining the operation of the inflation-targeting framework.

The operational framework of inflation targeting was discussed in section 4. Among the issues reviewed were the measurement of inflation (including sources of imperfection in traditional measures), whether a target band for inflation should be chosen, the time horizon of monetary policy, difficulties associated with forecasting inflation, and whether asset prices should be taken into account in targeting inflation. The width of the inflation target range, in particular, depends on the variability of shocks to inflation, the policy horizon, and the desired speed of adjustment to economic disturbances, which itself depends on the relative weight the central bank attaches to output fluctuations and the desired degree of interest rate smoothing. There is also a trade-off between credibility and flexibility: if the band is made too wide to provide more flexibility (that is, more scope to accommodate transitory shocks to inflation), then the inflation target may lose credibility and inflation expectations may remain high. The section also noted that central banks may want to respond to financial prices in their pursuit of price stability for several reasons. Shocks to financial prices that are not driven by fundamentals may destabilize the economy through their effects on aggregate demand, in which case the central bank may want to offset them. However, asset prices are determined by arbitrage equations in which expectations of future returns play an important role. If expectations are subject to large and unpredictable shifts, these prices may contain limited additional information about current and future economic conditions. Finally, inflation forecasts are, in practice, based on a combination of quantitative

models (generally small in size), indicator variables (such as survey expectations), and qualitative judgement.

Section 5 reviewed the recent experience of industrial and developing countries with inflation targets, with a particular emphasis on Brazil, South Africa, and Thailand. The evidence clearly suggests that the adoption of an inflation-targeting regime was not by itself sufficient to dampen inflation expectations and help countries deliver consistently better inflation performance. Nevertheless, for a subset of countries (most notably Canada, New Zealand, Sweden, and the United Kingdom), inflation persistence dropped significantly after the adoption of inflation targets, perhaps as a result of a significant and credible shift in policy preferences.

The last section focused on some ongoing issues of debate in inflation targeting, namely, the role of nonlinearities and asymmetric effects (related to both the structure of policy preferences and structural relationships, most notably the Phillips curve), uncertainty (about behavioral parameters and the transmission process of monetary policy), and how to account for credibility and reputational factors in empirical macroeconomic models. The first two issues have important implications for the design of optimal instrument rules and the operation of a state-contingent targeting regime. Specifically, whereas uncertainty about parameters may lead to more caution in the manipulation of policy instruments, uncertainty about the degree of inflationary persistence may lead to a more aggressive, as opposed to a more gradual, interest rate policy. New results regarding the convexity of the Phillips curve were also presented for six developing countries (Colombia, Korea, Mexico, Nigeria, the Philippines, and Turkey). Comparison of the linear and nonlinear specifications using the MacKinnon-White-Davidson nonnested test provided mixed support for the latter. Finally, accounting for changes in credibility in forecasting inflation and simulating policy shocks may be important, particularly in countries implementing an inflation-targeting framework from an initial position of low confidence in the central bank's commitment to price stability.

The main conclusion of this paper is broadly in line with several existing studies: inflation targeting is a flexible policy framework that allows the central bank to exercise constrained discretion, as emphasized by Bernanke and others (1999, p. 293). In middle- and high-income developing economies that have relatively low initial inflation and reasonably well-functioning financial markets and that can refrain from implicit exchange rate targeting, it has the potential to improve the design and performance of monetary policy compared with alternative

operational procedures available to central banks. There are, of course, technical requirements (such as adequate data on prices, sufficient understanding of the links between monetary policy instruments and targets, and the ability to forecast relatively well price developments), which may not be satisfied in all countries and to the same extent. But such requirements should not be overstated; forecasting capability, for instance, can never be perfect and sensible projections always involve qualitative judgement. A more important and difficult task, in many cases, may be to design or improve the institutional framework in order to allow the central bank an effective degree of independence in pursuing the goal of low and stable inflation without undue pressure to stabilize output fluctuations or alleviate the public debt burden through low interest rates.

## APPENDIX A

### The Optimal Instrument Rule under Forward-Looking Expectations

This appendix discusses the derivation of the optimal interest rate rule implied by inflation targeting under rational, forward-looking expectations. Following Clarida, Galí, and Gertler (1999), consider a closed economy in which the Phillips curve and aggregate demand are given by the following equations:

$$\pi_t = \alpha_1 y_t + \alpha_2 E_t \pi_{t+1} + \varepsilon_t , \tag{A1}$$

$$y_t = E_t y_{t+1} - \beta \left( i_t - E_t \pi_{t+1} \right) + \eta_t , \tag{A2}$$

where $0 < \alpha_2 < 1$ and, as before, $\pi_t$ is the inflation rate, $y_t$ is the output gap, $i_t$ is the nominal interest rate, and $\varepsilon_t$ and $\eta_t$ are disturbances that obey

$$\varepsilon_t = \rho_\varepsilon \varepsilon_{t-1} + \nu_t \text{ and} \tag{A3}$$

$$\eta_t = \rho_\eta \eta_{t-1} + \xi_t , \tag{A4}$$

where $0 \leq \rho_\varepsilon , \rho_\eta \leq 1$, and $\nu_t$ and $\xi_t$ are random shocks with zero mean and constant variances, given respectively by $\sigma_\nu^2$ and $\sigma_\xi^2$.

Equation A1 relates inflation to the current value of the output gap (as opposed to the lagged value) and the one-period ahead expected future inflation rate. It can be derived from a Calvo-Taylor model with staggered nominal wage and price setting (see Roberts, 1995; Fuhrer, 1997a, 1997b).[1] Equation A2 relates output to its future value and the ex ante real interest rate. It can be derived by log-linearizing the first-order condition for consumption maximization obtained in a representative agent model and imposing equilibrium of the goods market (see Clarida, Galí, and Gertler, 1999). For simplicity, changes in interest rates are assumed to affect current output immediately.

The key difference in this specification with forward-looking expectations—which is readily apparent by iterating equations A1 and A2

1. It can also be shown that $\alpha_1$ is inversely related to the degree of price rigidity; the longer prices are held fixed, on average, the less responsive is inflation to cyclical fluctuations in output.

forward—is that output depends on current and future values of the real interest rate (and thus on future policy decisions), whereas inflation depends on current and future values of the output gap. This dependence makes calculation of the optimal instrument rule more involved.

The central bank's policy objective is, as in equation 14,

$$\min U_t = E_t \left\{ \sum_{h=t}^{\infty} \delta^{h-t} \left[ \frac{\left(\pi_h - \tilde{\pi}\right)^2 + \lambda y_h^2}{2} \right] \right\}, \tag{A5}$$

where $\lambda > 0$.

Under discretion, the central bank takes expectations as given in solving its optimization problem. Deriving the optimal policy rule proceeds in two stages. First, the objective function A5 is minimized by choosing $y_t$ and $\pi_t$, given the Phillips curve A1. This is possible because no endogenous-state variable appears in the objective function; thus future inflation and output are not affected by today's policy decisions and the central bank cannot directly affect private expectations. Second, the value of $i_t$ implied by the aggregate demand equation A2 is determined, conditional on the optimal values of $y_t$ and $\pi_t$.

The first stage thus consists in choosing $y_t$ and $\pi_t$ to minimize

$$\frac{\left(\pi_t - \tilde{\pi}\right)^2 + \lambda y_t^2}{2} + x_t ,$$

where

$$x_t = E_t \left\{ \sum_{h=t+1}^{\infty} \delta^{h-t} \left[ \frac{\left(\pi_h - \tilde{\pi}\right)^2 + \lambda y_h^2}{2} \right] \right\},$$

subject to (using equation A1)

$$\pi_t = \alpha_1 y_t + z_t ,$$

where $z_t = \alpha_2 \, \mathrm{E}_t \pi_{t+1} + \varepsilon_t$. The first-order conditions for the first-stage problem are $\pi_t - \tilde{\pi} + \mu_t = 0$ and $\lambda y_t - \mu_t \alpha_1 = 0$, where $\mu_t$ is a Lagrangian multiplier. Combining these conditions gives

$$\pi_t = \tilde{\pi} - \left( \frac{\lambda}{\alpha_1} \right) y_t . \tag{A6}$$

Substituting this expression into equation A1 for $y_t$ yields

$$\pi_t = -\frac{\alpha_1^2}{\lambda}\left(\pi_t - \tilde{\pi}\right) + \alpha_2 E_t\,\pi_{t+1} + \varepsilon_t\,,$$

that is,

$$\pi_t = \frac{\alpha_1^2\,\tilde{\pi}}{\lambda + \alpha_1^2} + \frac{\alpha_2\,\lambda\,E_t\,\pi_{t+1}}{\lambda + \alpha_1^2} + \frac{\lambda\,\varepsilon_t}{\lambda + \alpha_1^2}\,. \tag{A7}$$

This equation can be solved by using the method of undetermined coefficients. Conjecturing a solution of the form

$$\pi_t = \kappa_1\,\tilde{\pi} + \kappa_2\,\varepsilon_t\,, \tag{A8}$$

implies that $\pi_{t+1} = \kappa_1\,\tilde{\pi} + \kappa_2\,\varepsilon_{t+1}$, such that, using equation A3,

$$E_t\,\pi_{t+1} = \kappa_1\,\tilde{\pi} + \kappa_2\,E_t\,\varepsilon_{t+1} = \kappa_1\tilde{\pi} + \kappa_2\,\rho_\varepsilon\,\varepsilon_t\,.$$

Substituting this expression into equation A7 and rearranging terms yields

$$\pi_t = \frac{\left(\alpha_1^2 + \alpha_2\,\lambda\,\kappa_1\right)}{\lambda + \alpha_1^2}\;\tilde{\pi} + \frac{\lambda\left(1 + \alpha_2\,\kappa_2\,\rho_\varepsilon\right)}{\lambda + \alpha_1^2}\;\varepsilon_t\,. \tag{A9}$$

Equating coefficients in equations A8 and A9 yields

$$\kappa_1 = \frac{\alpha_1^2 + \alpha_2\,\lambda\,\kappa_1}{\lambda + \alpha_1^2} \quad \text{and}$$

$$\kappa_2 = \frac{\lambda\left(1 + \alpha_2\,\kappa_2\,\rho_\varepsilon\right)}{\lambda + \alpha_1^2}\,,$$

which can be rearranged to give

$$\kappa_1 = \frac{\alpha_1^2}{\lambda\left(1 - \alpha_2\right) + \alpha_1^2} < 1 \quad \text{and}$$

$$\kappa_2 = \frac{\lambda}{\lambda\left(1 - \alpha_2\,\rho_\varepsilon\right) + \alpha_1^2}\,.$$

Thus the solution for $\pi_t$ is

$$\pi_t = \kappa_1\,\tilde{\pi} + \lambda\,\theta\,\varepsilon_t\,, \tag{A10}$$

where

$$\theta = \frac{1}{\lambda\left(1 - \alpha_2\,\rho_\varepsilon\right) + \alpha_1^2}\,.$$

Substituting equation A10 in equation A6 yields

$$y_t = -\left(\frac{\alpha_1}{\lambda}\right)\left(\pi_t - \tilde{\pi}\right) = -\left(\frac{\alpha_1}{\lambda}\right)\left\{\left(\kappa_1 - 1\right)\tilde{\pi} + \lambda\,\theta\,\varepsilon_t\right\},$$

that is

$$y_t = \Lambda\,\tilde{\pi} - \alpha_1\,\theta\,\varepsilon_t,\ \Lambda = \frac{\alpha_1\left(1-\kappa_1\right)}{\lambda}. \tag{A11}$$

The second stage of the solution procedure consists in rewriting equation A2 as

$$i_t = \frac{1}{\beta}\left[\left(E_t\,y_{t+1} - y_t\right) + \eta_t\right] + E_t\,\pi_{t+1}, \tag{A12}$$

and substituting for $E_t y_{t+1}$-$y_t$. From equations A3 and A10, $E_t\pi_{t+1}$ is given by

$$E_t\,\pi_{t+1} = \kappa_1\,\tilde{\pi} + \lambda\,\theta\,E_t\,\varepsilon_{t+1} = \kappa_1\,\tilde{\pi} + \lambda\,\theta\,\rho_\varepsilon\,\varepsilon_t, \tag{A13}$$

whereas from equations A3 and A11

$$E_t\,y_{t+1} = \Lambda\,\tilde{\pi} - \alpha_1\,\theta\,\rho_\varepsilon\,\varepsilon_t.$$

Using this expression together with equation A11 yields

$$E_t\,y_{t+1} - y_t = \alpha_1\left(1-\rho_\varepsilon\right)\theta\,\varepsilon_t. \tag{A14}$$

Equation A13 can be rewritten as

$$\theta\,\varepsilon_t = -\frac{\kappa_1\,\tilde{\pi}}{\lambda\,\rho_\varepsilon} + \frac{E_t\,\pi_{t+1}}{\lambda\,\rho_\varepsilon}.$$

Substituting this result into equation A14 yields

$$E_t\,y_{t+1} - y_t = -\frac{\alpha_1\,\kappa_1\left(1-\rho_\varepsilon\right)}{\lambda\,\rho_\varepsilon}\,\tilde{\pi} + \left[\frac{\alpha_1\left(1-\rho_\varepsilon\right)}{\lambda\,\rho_\varepsilon}\right]E_t\pi_{t+1}. \tag{A15}$$

Substituting equation A15 into equation A12 and rearranging terms yields the optimal interest rate rule,

$$i_t = -\frac{\alpha_1\,\kappa_1\left(1-\rho_\varepsilon\right)}{\beta\lambda\,\rho_\varepsilon}\,\tilde{\pi} + \frac{1}{\beta}\left[\frac{\alpha_1\left(1-\rho_\varepsilon\right)}{\lambda\,\rho_\varepsilon}\,E_t\,\pi_{t+1} + \eta_t\right] + E_t\,\pi_{t+1},$$

or equivalently

$$i_t = \Omega\,\tilde{\pi} + \delta\,E_t\,\pi_{t+1} + \frac{\eta_t}{\beta}, \tag{A16}$$

where

$$\Omega = -\frac{\alpha_1\,\kappa_1\left(1-\rho_\varepsilon\right)}{\beta\lambda\rho_\varepsilon},$$

$$\delta = 1 + \frac{\alpha_1\left(1-\rho_\varepsilon\right)}{\beta\lambda\rho_\varepsilon} > 1.$$

Thus the optimal policy rule A16 also calls for inflation forecast targeting. Because $\delta > 1$, an expected increase in future inflation calls for a more-than-proportional increase in the current nominal interest rate, in order to lower the real interest rate today and reduce aggregate demand now. If $\lambda \to 0$ (strict inflation targeting), then $1/\delta \to 0$, $\lambda\theta\rho_\varepsilon \to 0$, and $\kappa_1 \to 1$, and equation A13 then yields

$$E_t\,\pi_{t+1} = \tilde{\pi},$$

which is analogous to what Svensson's model would predict in the absence of a lag between changes in the output gap and inflation (see equation 9 in the text). Put differently, strict inflation targeting is optimal—in the sense of equating the inflation target and the one-period-ahead expected value of inflation—only if the central bank has no concern for output fluctuations. Otherwise, convergence to inflation back to target following a shock will be gradual, as implied by the discussion of flexible inflation targeting in the text. The optimal rule also calls for completely offsetting aggregate demand shocks because they do not imply a short-run trade-off between output and inflation.[2]

Both backward- and forward-looking components can be incorporated in a more general specification of the Phillips curve derived in equation A1 and the aggregate demand equation A2, as, for instance, in the new-Keynesian models discussed by Fuhrer (1997a, 1997b):

2. Equations A10 and A11 can be used to illustrate the output-inflation variability trade-off that arises in the presence of supply shocks. In general, $\sigma_y^2 = \alpha_1^2\,\theta^2\,\sigma_\varepsilon^2$, and $\sigma_\pi^2 = \lambda^2\,\theta^2\,\sigma_\varepsilon^2$. When $\lambda \to 0$ (the case of strict inflation targeting), $\theta \to 1/\alpha_1^2$, $\sigma_\pi \to 0$, and $\sigma_y \to \sigma_\varepsilon/\alpha_1$. When $\lambda \to \infty$ (the case in which stabilizing output is the only policy goal), $\theta \to 0$ and (by applying L'Hospital's rule) $\lambda\theta \to 1/\left(1-\alpha_2\,\rho_\varepsilon\right)$. As a result, $\sigma_y \to 0$ and $\sigma_\pi \to \sigma_\varepsilon/\left(1-\alpha_2\,\rho_\varepsilon\right)$.

$$\pi_t = \alpha_1 y_t + \varphi \pi_{t-1} + (1-\varphi)\alpha_2 E_t \pi_{t+1} + \varepsilon_t \text{ and}$$

$$y_t = \phi \beta_1 y_{t-1} + (1-\phi) E_t y_{t+1} - \beta_2 (i_t - E_t \pi_{t+1}) + \eta_t ,$$

where $0 < \varphi$ and $\phi \leq 1$. Equations A1 and A2 can be obtained from the above specifications by setting $\varphi = \phi = 0$. The qualitative properties of the optimal instrument rule derived earlier remain essentially the same (see Clarida, Galí, and Gertler, 1999, pp. 1691–95).

## APPENDIX B

### Data Sources, Causality Tests, and Nonnested Tests for the Phillips Curve

The data used to produce figure 1 are obtained from the quarterly database compiled by Agénor, McDermott, and Prasad (2000). The bivariate VAR includes the money market rate and the discount rate, in that order. Estimation periods are 1995:1–1999:4 for Colombia, 1978:1–1999:3 for Korea, 1978:1–1996:4 for Malaysia, 1983:2–1996:4 for Tunisia, 1986:2–1996:2 for Turkey, and 1994:1–1999:4 for Uruguay. The optimal lag length, chosen on the basis of the Akaike Criterion, was 2 for Colombia, 2 for Korea, 2 for Malaysia, 2 for Tunisia, 1 for Turkey, and 5 for Uruguay. Standard, bivariate Granger causality tests also showed that the discount rate causes the money market rate only in Korea ($F$ statistic 3.122, $P$ value 0.049). There is two-way causality in Malaysia and Turkey, and no statistically significant evidence of causality in Colombia, Tunisia, and Uruguay.[1]

The variables used in the regressions reported in tables 3 and 4 are defined as follows. Inflation (INF) is the log difference of the consumer price index (International Financial Statistics, or IFS, code 64) between periods $t$ and $t - 4$. GAP is the log difference between the seasonally adjusted industrial production index (IFS code 66c or 66ey) and its trend value, calculated by using either the Hodrick-Prescott method or a quadratic trend (obtained by regressing output on a constant term, time and time squared). The growth rate of the nominal effective exchange rate (NEERGR) is the log difference of the nominal effective exchange rate (IFS code eneer) between periods $t$ and $t - 4$. An increase in the nominal effective exchange rate is a depreciation. The growth rate of import prices (PMGR) is the log difference of the import price index (IFS code 75 or 75d) between periods $t$ and $t - 4$. For Nigeria, imported inflation is measured by the growth rate of export prices in developed countries (PXGR_DEVED), which is the log difference of the export price index (IFS series code 74d and country group code 110) of these countries between periods $t$ and $t - 4$.

1. These results should be treated with some caution because during the estimation period, monetary policy procedures changed significantly in some of the countries considered. In Turkey, for instance, the repurchase rate has become the main interest rate instrument in recent years.

The estimates of the linear and nonlinear Phillips curve models reported in tables 3 and 4 are compared using the *J* test proposed by MacKinnon, White, and Davidson (1983). Specifically, suppose that the hypotheses to be tested are

$H_{0:}\, y = \alpha_{0+} \beta_0 f(\mathbf{x},\gamma) + \varepsilon_0$ and

$H_1: y = \alpha_1 + \beta_1 \mathbf{x} + \varepsilon_1,$

where $y$ is the endogenous variable, $\mathbf{x}$ is a vector of exogenous variables, $\alpha_i$, $\beta_i$, and $\gamma$ are the parameters to be estimated, and $\varepsilon_i$ represents error terms with classical properties.

The basic idea of the *J* test is that if one of the models (say, the model specified under $H_0$) is the correct one, then the fitted values from the other model (corresponding to $H_1$) should not have any explanatory power when estimating the $H_0$ model. In practical terms, testing the $H_0$ model against the $H_1$ model proceeds as follows. First, estimate the $H_1$ model and retrieve the fitted values. Next, estimate the $H_0$ model including the fitted values from the $H_1$ model. If the fitted values from the $H_1$ model enter significantly in the $H_0$ model, reject the $H_0$ model.

Similarly, the $H_1$ model can be tested against the $H_0$ model by first estimating the $H_0$ model, calculating the fitted values, and then estimating the $H_1$ model including the fitted values from $H_0$. If the fitted values from the $H_0$ model enter significantly in the $H_1$ model, reject the $H_1$ model. If only one of the models is not rejected by the test, this model is said to be superior to the other one. If both models are rejected against the alternative, this suggests that another model is needed. If neither model is rejected, the data do not provide enough information to discriminate between the two alternatives. The results are reported in the text.

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# A Decade of Inflation Targeting in the World: What Do We Know and What Do We Need to Know?

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The emergence of inflation targeting over the last ten years represents an exciting development in central banks' approach to the conduct of monetary policy. After initial adoption by New Zealand in 1990, a growing number of central banks in industrial and emerging economies have opted for inflation targeting, and many more are considering future adoption of this new monetary framework.

A full decade of inflation targeting in the world offers lessons on the design and implementation of inflation-targeting regimes, the conduct of monetary policy, and country performance under inflation targeting. In section 1, this paper briefly reviews the main design features of eighteen inflation targeting experiences, statistically analyzes whether countries under inflation targeting are structurally different from industrialized countries that do not target inflation, and considers the existing evidence on the success of inflation targeting. The interaction of inflation targeting design features and the conduct of monetary policy during the transition to low inflation are tackled in section 2. The paper then focuses on unresolved issues in the design and implementation of inflation targeting and their relation to the conduct of monetary policy (section 3). Brief conclusions close the paper.

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## 1. What Do We Know about Inflation Targeting after a Decade of World Experience?

To discuss what we know about the inflation-targeting experience, we address three questions: (1) who targets inflation and how? (2) are inflation targeters different? and (3) is inflation targeting a success?

### 1.1 Who Targets Inflation and How?

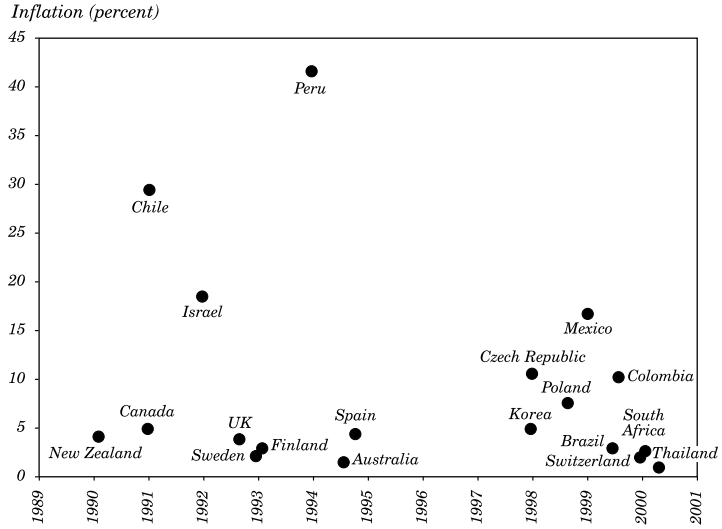
Inflation targeting started a decade ago, with public announcements of inflation targets in New Zealand and Chile. According to our count, nineteen countries have implemented inflation targeting as of November 2000. They include industrial and emerging economies, transition and steady-state inflation targeters, semi and full-fledged targeters, early and recent starters, and current and former targeters.[1] Figure 1 depicts adoption dates and initial inflation rates (at year of adoption) for the nineteen-country sample.[2]

We introduce two country groups as the basis for our empirical analysis conducted of the 1990s, a sample of inflation targeters and a control group of non-targeters (see table 1). The first sample, inflation targeters, comprises a heterogeneous group of eighteen industrial and emerging economies: Australia, Brazil, Canada, Chile, Colombia, the Czech Republic, Finland, Israel, Korea, Mexico, New Zealand, Peru, Poland, South Africa, Spain, Sweden, Thailand, and the United Kingdom. (Finland and Spain dropped out of this group when they relinquished monetary policy on adopt-

1. Classifying country cases into inflation-targeting and other monetary regimes involves subjective choices for two reasons. First, there is lack of full agreement on the main conditions and features of inflation targeting and how they apply during transition to low inflation—an issue that we discuss below. Second, some countries have simultaneously used inflation targets and other nominal anchors (the exchange rate or a monetary aggregate or both), particularly in their early years of inflation targeting. IMF (2000), Mahadeva and Sterne (2000), and Sterne (2000) discuss and present comprehensive country classifications of monetary regimes. The different classification criteria is reflected in the different country samples of recent cross-country studies of inflation-targeting experiences. See, for example, Bernanke and others (1999); Schaechter, Stone, and Zelmer (2000); Corbo, Landerretche, and Schmidt-Hebbel (in this volume); Corbo and Schmidt-Hebbel (2000).

2. Starting dates are defined by the first month of the first period for which inflation targets have been announced previously. For example, the starting date for Chile is January 1991 (the first month of calendar year 1991, for which the first inflation target was announced in September 1990). The initial inflation level is defined as the year-on-year consumer price index (CPI) inflation rate of the last quarter before the first month of inflation targeting (for example, the fourth quarter of 1990 in the case of Chile).

**Figure 1. Inflation at Adoption of Inflation Targeting in Nineteen Countries, 1988-2000[a]**




Source: Authors' calculations, based on data from IMF, *International Financial Statistics*, various issues; country sources; Schaechter, Stone, and others (2000).
a. Annual inflation rates are those observed one quarter before adopting inflation targeting.

ing the euro in 1999.[3] The second sample is a control group of nine industrial economies that were not inflation targeters during the 1990s: Denmark, France, Germany, Italy, Japan, Norway, Portugal, Switzerland, and the United States. Among these, Germany and Switzerland had explicit monetary targets in place throughout most of the 1990s and could thus be classified as implicit inflation targeters (as argued by Bernanke and others, 1999).[4] Japan and the United States had no explicit targets, and the remaining five European countries targeted their exchange rate to the deutsche mark before adopting the euro in 1999.[5]

3. The sample includes eighteen inflation targeters, as opposed to the nineteen listed in figure 1, because Switzerland did not adopt inflation targeting until 2000.

4. Germany adopted the euro in early 1999 and Switzerland adopted explicit inflation targeting in 2000.

5. The use of this control group of high-income industrial economies with alternative monetary frameworks in place reflects our objective of linking the adoption of inflation targeting with structural features, as observed in the world sample of eighteen industrial and higher-middle-income countries. Defining a control group of high-performing economies with similar features to those that have adopted inflation targeting makes it statistically more difficult to identify significant determinants of the choice of inflation targeting than if we had chosen a control group including developing countries that do not target inflation.

**Table 1. Inflation Targeters and Nontargeters**

| *Inflation targeters* | | *Nontargeters* |
|---|---|---|
| Australia | Mexico | Denmark |
| Brazil | New Zealand | France |
| Canada | Peru | Germany |
| Chile | Poland | Italy |
| Colombia | South Africa | Japan |
| Czech Republic | Spain | Norway |
| Finland | Sweden | Portugal |
| Israel | Thailand | Switzerland |
| Korea | United Kingdom | United States |

Inflation targeters exhibit some commonalities and many differences in the preconditions, target design, and operational features of their inflation-targeting regimes. Four stylized facts emerge from country experiences and features, as summarized in table A1 in the appendix. First, full-fledged inflation targeting is based on five pillars: absence of other nominal anchors, an institutional commitment to price stability, absence of fiscal dominance, policy instrument independence, and policy transparency and accountability. While the second through the fifth of these pillars are necessary for effective conduct of monetary policy under any regime, they are particularly important prerequisites for effective policy under inflation targeting. The success of inflation targeting depends strongly on high market credibility in the central bank's resolve and ability to put into place policies geared at meeting the target, and credibility is fostered by the five institutional pillars.

Second, the adoption of inflation targeting ranges from evolutionary to revolutionary. Many countries adopted inflation targeting without satisfying one or more of the above conditions. For example, Chile and Israel targeted the exchange rate during most of the 1990s (as Israel still does today). The Bank of England started inflation targeting well before attaining instrument independence. Most countries adopted inflation targeting before achieving high levels of policy transparency (including the publication of inflation reports, inflation projections, and monetary policy meeting minutes) and full accountability, and some countries, including Colombia, Israel, Korea, Mexico, Peru, and South Africa, still do not publish inflation forecasts. On the other extreme is Brazil, who adopted full-fledged inflation targeting right from the start.

Country experience suggests that the adoption of inflation targeting in the 1990s represented a monetary policy learning process. There is now a broad consensus about the conditions that should be in place

for effective full-fledged inflation targeting. These prerequisites were less obvious in the first half of the 1990s, however, when early inflation targeters perfected their frameworks by learning from their own and the other inflation targeters' cumulative experience.

Third, inflation at the moment of adopting an inflation targeting framework ranges from moderately high to very low. Some countries adopted inflation targeting when their inflation rates were well above steady-state levels, using inflation targeting as the main device to build up credibility, bring down inflation expectations, and pursue a path of convergence to low, stationary inflation. This is the case of early inflation targeters in emerging countries that started at initial inflation rates of 15 to 45 percent (Chile, Israel, Peru) and subsequent emerging countries that adopted inflation targeting when initial inflation was in the range of 7 to 20 percent (the Czech Republic, Colombia, Mexico, Poland). This stands in contrast to all industrialized and some emerging inflation targeters that started at initial inflation close to stationary low levels.

Multi-year transitions toward steady-state inflation pose serious challenges and difficulties to inflation targeting, including the need for announcing annual inflation targets (that are much harder to meet) under conditions of high inflation expectations and limited policy credibility. We discuss the issues related to transition to low inflation in section 2.2 below.

Fourth, inflation targeters vary widely with regard to implementation features, including the target price index, target width, target horizon, escape clauses, accountability of target misses, goal independence, and overall transparency and accountability of the conduct of policy. Some of these differences can be attributed to country variation in institutions and history; others reflect the differences between inflation targeting in transition to low inflation versus inflation targeting at low inflationary levels. Additional differences in the design features of inflation targeting stem from divergent views among policymakers and academics about how monetary policy under inflation targeting should be conducted in conditions of low inflation.

## 1.2 Are Inflation Targeters Different?

Are the structural conditions and macroeconomic performance of countries that adopt inflation targeting different from those of industrial countries that do not target inflation? To tackle this question we compare the sample of eighteen inflation targeters to the

control group of nine industrialized nontargeters, focusing on the relation between having an inflation-targeting framework in place and exhibiting a set of structural, institutional, and macroeconomic features. The empirical analysis presented here is necessarily preliminary because (as discussed in footnote 1) it is not always easy to decide whether a country should be classified as engaging in inflation targeting.[6] Furthermore, determining the exact date at which an inflation-targeting regime was adopted is often quite difficult. Officials at many of the central banks we consulted give adoption dates that are earlier than those given by outsiders (see, for example, Bernanke and others, 1999). The uncertainty of dating often follows from the fact that inflation targeting is adopted gradually, making the exact date of adoption difficult to determine.

Our data set consists of annual variables for twenty-seven countries over ten years (1990–99). The focus is on a discrete variable for an inflation-targeting regime, which takes a value of 1 when an inflation-targeting regime is in place or 0 when an alternative monetary regime is in place, together a set of variables that could be associated with the choice of an inflation-targeting regime.[7] The latter variables include measures of the use of alternative nominal anchors (a measure of exchange rate band width and a monetary target dummy), structural conditions (trade openness), measures of central bank independence (formal independence, instrument independence, and goal independence), and macroeconomic variables (the inflation rate and the fiscal surplus ratio to GDP).

Table 2 reports cross-country and panel statistics and correlations for inflation targeting and related variables. The data reflect large variation in all variable categories across countries and over time in our sample of twenty-seven countries. Panel correlations are sometimes very different from cross-country correlations, including cases changing signs. This is likely the result of the noise encountered in annual country data; we therefore focus on cross-country correlations.

6. For example, although the central banks of Peru and Colombia announce inflation targets, their monetary policy frameworks do not contain many crucial features of an inflation-targeting regime (Mishkin and Savastano, 2000). Korea is classified as an inflation targeter because it announces an inflation target, yet it appears to have pursued a de facto exchange rate peg in the first two years of its inflation-targeting regime, which is inconsistent with inflation targeting. Dropping these three countries from the sample does not appreciably affect the empirical results.

7. Similar definitions are used for other discrete variables used here (see the appendix for variable definitions and data sources).

**Table 2. Descriptive Statistics and Simple Correlations for Cross-Section and Panel Samples, 1990–99[a]**

| *Statistic* | *IT* | *Inf* | *Open* | *Fiscal* | *BW* | *MT* | *CBFI* | *CBGI* | *CBII* |
|---|---|---|---|---|---|---|---|---|---|
| *Cross-section statistics* | | | | | | | | | |
| Mean | 0.29 | 0.11 | 0.50 | –0.02 | 0.56 | 0.25 | 0.30 | 0.30 | 0.59 |
| Standard deviation | 0.46 | 0.37 | 0.19 | 0.04 | 0.45 | 0.43 | 0.46 | 0.46 | 0.49 |
| Maximum | 1.00 | 5.55 | 0.85 | 0.06 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Minimum | 0.00 | 0.00 | 0.03 | –0.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| *Panel statistics* | | | | | | | | | |
| Mean | 1.00 | 0.97 | 0.85 | 0.06 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Standard deviation | 0.00 | 0.00 | 0.03 | –0.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Maximum | 0.30 | 0.08 | 0.50 | –0.02 | 0.58 | 0.26 | 0.31 | 0.30 | 0.61 |
| Minimum | 0.46 | 0.15 | 0.19 | 0.04 | 0.45 | 0.44 | 0.46 | 0.46 | 0.49 |
| *Variable correlations: panel/cross-section* | | | | | | | | | |
| IT | 1.00 | –0.11 | 0.35 | 0.10 | 0.24 | –0.29 | –0.03 | –0.07 | 0.23 |
| *Inf* | –0.20 | 1.00 | –0.10 | –0.17 | –0.01 | –0.04 | –0.10 | –0.12 | –0.18 |
| *Open* | 0.25 | –0.42 | 1.00 | 0.16 | –0.08 | –0.13 | –0.11 | 0.08 | –0.03 |
| *Fiscal* | 0.21 | –0.22 | 0.27 | 1.00 | –0.01 | 0.11 | 0.12 | 0.15 | 0.19 |
| *BW* | 0.02 | –0.07 | –0.32 | 0.16 | 1.00 | 0.08 | –0.01 | 0.01 | 0.14 |
| *MT* | –0.45 | 0.22 | 0.07 | 0.19 | 0.26 | 1.00 | 0.04 | 0.02 | –0.01 |
| *CBFI* | –0.22 | –0.08 | –0.09 | 0.25 | –0.22 | 0.09 | 1.00 | 0.68 | 0.51 |
| *CBGI* | –0.13 | –0.23 | –0.01 | 0.22 | –0.35 | –0.18 | 0.79 | 1.00 | 0.50 |
| *CBII* | 0.30 | –0.15 | 0.18 | 0.35 | –0.06 | –0.03 | 0.40 | 0.52 | 1.00 |

Source: Authors' calculations.

a. The panel sample comprises ten years of data (1990–99) for each of the twenty-seven countries identified in the text. Panel sample correlations are reported in the upper-half matrix triangle, while cross-section correlations are reported in the lower-half matrix triangle. Standard errors are 0.06 for the panel sample and 0.19 for the cross section.

Having inflation targeting in place is positively and significantly correlated with no individual variable and negatively and significantly correlated only with monetary growth targets (*MT*). Inflation targeting is positively and not significantly correlated with trade openness (*Open*), the ratio of the fiscal surplus to GDP (*Fiscal*), the width of the exchange rate band (*BW*), and instrument independence of the central bank (*CBII*). It is negatively and not significantly correlated with normalized inflation (*Inf)*, formal independence of the central bank (*CBFI*), and goal independence of the central bank (*CBGI*).[8] .

Next we introduce a multivariate probit model for the likelihood of having an inflation-targeting regime in place, based on the observation of the variables identified above. The model specifies the probability of having an inflation-targeting regime in place (Pr (*IT* | …) as a function of these variables:

Pr (*IT* | …) = f (*Inf, Open, Fiscal, BW, MT, CBFI, CBGI , CBII*)

Expected coefficient signs are positive for *Fiscal*, *BW*, and the three measures of central bank independence, negative for *MT*, and ambiguous for *Inf* and *Open*.

Before turning to the results, we note that caution should be exercised in the causal interpretation of this equation. While certain structural features may be exogenous to the choice of inflation targeting, it is very likely that adoption of inflation targeting requires—and thus contributes to—renouncing the use of other nominal targets, improving macroeconomic performance (such as reducing inflation and improving the fiscal stance), and strengthening central bank independence. Potential reverse causation means that the empirical results should be interpreted carefully.

The full-panel probit regression produced noisy results. We therefore report cross-country results only, based on country decade-averages for each variable, including the dependent variable, that is, the choice of an inflation-targeting regime. We start by discussing the full-sample results in the first column of table 3.

Inflation targeting is positively and significantly associated with the level of normalized inflation. This result reflects the fact that inflation targeting has been adopted by countries that, on average, exhibited higher levels of inflation than have industrial nontargeters. Indeed, most emerging countries adopted inflation targeting as a device for bringing inflation down to low, single-digit levels, and most inflation targeters—both

8. There are only a few large positive or negative correlations among variables other than inflation targeting. In particular, the three measures of central bank independence are highly and positively correlated with each other.

**Table 3. Empirical Results for the Likelihood of Implementing an Inflation-Targeting Regime**

| | *Full sample (27 countries)* | | *Restricted sample 1*[b] *(24 countries)* | | *Restricted sample 2*[c] *(24 countries)* | |
|---|---|---|---|---|---|---|
| *Variable* | *(1)* | *(2)* | *(3)* | *(4)* | *(5)* | *(6)* |
| *Cons.* | –9.7 | –5.8* | –13.4*** | –5.7* | –12.5 | –4.7** |
| | (8.2) | (2.2) | (7.5) | (2.0) | (8.2) | (2.1) |
| *Inf* | 45.2*** | 33.6* | 69.2** | 43.7* | 69.1** | 46.9* |
| | (25.2) | (12.3) | (28.5) | (13.5) | (27.8) | (15.7) |
| *Open* | 11.5*** | 7.6** | 11.4** | 7.1* | 10.5*** | 5.3*** |
| | (6.7) | (3.0) | (5.0) | (2.7) | (6.0) | (3.1) |
| *Fiscal* | –20.4 | | –49.7 | | –46.7 | |
| | (45.1) | | (45.7) | | (46.8) | |
| *BW* | 0.3 | | 3.4 | | 3.2 | |
| | (3.0) | | (3.2) | | (3.3) | |
| *MT* | –12.9** | –9.3* | –13.4* | –9.6* | –12.5** | –7.9* |
| | (5.7) | (3.0) | (4.3) | (2.8) | (5.3) | (3.0) |
| *CBFI* | 2.2 | | 1.3 | | 1.0 | |
| | (1.9) | | (1.7) | | (2.0) | |
| *CBGI* | –14.7* | –9.6* | –11.3* | –9.8* | –10.5* | –8.2* |
| | (5.4) | (3.2) | (2.6) | (2.8) | (3.8) | (3.1) |
| *CBII* | 12.0** | 8.5* | 11.9* | 8.4* | 11.0** | 6.7** |
| | (6.0) | (2.7) | (4.2) | (2.3) | (5.1) | (2.7) |
| Wald chi-squared | 9.8 | 10.8 | 23.0 | 13.7 | 18.3 | 11.9 |
| Pseudo $R^2$ | 0.61 | 0.57 | 0.63 | 0.57 | 0.63 | 0.58 |
| No. observations | 27 | 27 | 24 | 24 | 24 | 24 |

Source: Authors' calculations.

* Statistically significant at the 1 percent level.

** Statistically significant at the 5 percent level.

*** Statistically significant at the 10 percent level.

a. Probit regressions for 1990–99 cross-country sample. Standard errors for the full and restricted samples are reported in parentheses.

b. Restricted sample 1 excludes three countries with very high inflation in the early 1990s (Brazil, Peru, and Poland).

c. Restricted sample 2 excludes three countries that may not be classified as inflation targeters (Colombia, Korea, and Peru).

emerging and industrial countries—made major progress in reducing inflation either during or shortly before or after adopting inflation targeting (Bernanke and others, 1999; Corbo, Landerretche, and Schmidt-Hebbel, in this volume). Countries that trade relatively more (because they are more open or smaller than nontargeters) are significantly more likely to adopt inflation targeting, while most large industrial countries are not inflation targeters.

Inflation targeting is negatively associated with the ratio of fiscal surplus to GDP. This result again follows from having a control group of nontargeters comprised by nine industrial countries that, on average, show a stronger fiscal position than the eighteen inflation targeters. This association does not attain conventional significance levels, however.

Inflation targeting is positively but not significantly associated with the width of the exchange rate band. As expected, inflation targeting is negatively and significantly associated with the adoption of monetary growth targets, reflecting the incompatibility of having explicit monetary and inflation targets in place at the same time.

Finally, the likelihood of having inflation targeting in place is associated positively with the formal independence of the central bank (although its coefficient is not significant at conventional levels) and significantly with instrument independence. However, inflation targeting is negatively and significantly associated with central bank goal independence. The latter result suggests that when central banks have the freedom to determine their target levels, they are more likely to be operating under exchange rate or monetary-growth anchors than under inflation targets. Inflation targeting is thus associated with surrendering goal independence to governments. The second column of table 3 reports a regression that drops the less significant variables. All five remaining regressors become more significant.

The preceding results are based on the full sample of twenty-seven countries, which includes three countries with very high inflation rates in the early 1990s, namely Brazil, Peru, and Poland. Dropping the three from the sample yields regression results for a restricted sample (reported in columns 3 and 4 of table 3). Coefficient signs, values, and significance levels change little from those reported for the full sample. Thus our results are robust to exclusion of high-inflation outliers. We perform one more robustness test by dropping Colombia, Korea, and Peru from the sample. As discussed in footnote 5, there are some questions about whether these three countries should be classified as inflation targeters. The regression results for this alternative restricted sample, reported in columns 5 and 6 of table 3, also confirm our full-sample results.

## 1.3 Is Inflation Targeting a Success?

Many analysts argue that the structural features and macroeconomic performance of inflation-targeting countries differ in some respects from those of countries that have adopted alternative monetary

frameworks.[9] Others find that some industrial countries without formal inflation targets (such as Germany before the euro, Switzerland before 2000, and the United States) pursue a monetary policy that is close to explicit inflation targeting (Mishkin, 1999a). This raises the question of whether inflation targeting is observationally equivalent to alternative monetary frameworks with regard to the conduct of policy and its results. To address this issue, we review the recent empirical literature evaluating a decade of worldwide experience with inflation targeting. Far from attempting a comprehensive evaluation, we identify a few tentative conclusions that provide a partial view of the relative success of inflation targeting.[10]

Central bank independence and inflation targeting are mutually reinforcing. Country experience in the 1990s suggests that extending larger degrees of independence to central banks often supports the adoption of inflation targeting. In some countries inflation targeting was adopted after granting formal and instrument independence to central banks, as was the case in New Zealand and Chile. In other countries, like the United Kingdom, instrument independence came after inflation targeting. Our empirical results confirm the positive association for formal and instrument independence, but not for goal independence.

Communication, transparency, and accountability are improved under inflation targeting. Adoption of inflation targeting has typically been followed (and sometimes preceded) by major improvement in central bank communication with the public and markets and by significant upgrade in monetary policy transparency. Most inflation targeters publish inflation reports, monetary policy statements, the minutes of central bank board meeting, central bank models, and inflation forecasts (see table A1). This major communication effort on the part of central banks is arguably more important under inflation targeting than under alternative monetary regimes, considering the central role played by policy credibility and inflation expectations in attaining inflation targets (Bernanke and others, 1999).

9. See, for example, Bernanke, and others (1999); Cecchetti and Ehrmann (2000); Schaechter, Stone, and Zelmer (2000); Corbo and Schmidt-Hebbel (2000); Corbo, Landerretche, and Schmidt-Hebbel (in this volume).

10. Inferences about inflation targeters' success are still highly tentative, in view of the ambiguities surrounding the sample definitions for inflation-targeting countries, the possible systemic equivalence of some features of inflation targeting with those of alternative monetary regimes, the relevant potential and counterfactual selection bias, and mutual causation of inflation-targeting adoption and country performance.

Inflation targeting helps countries reduce inflation below the levels they would have attained in the absence of inflation targeting. However, it does not yield inflation below the levels attained by industrial countries that have adopted other monetary regimes, as shown by Bernanke and others (1999) and our own results above. The adoption of inflation targeting is typically associated with a major up-front investment in inflation reduction (Corbo, Landerretche, and Schmidt-Hebbel, in this volume).

Inflation targeting has been tested favorably by adverse shocks. With the exception of the emerging country financial crises of 1997–99, the 1990s were very favorable to the world economy, led by the largest U.S. expansion in the post–World War II era. Many observers therefore argue that inflation targeting is as yet untested, since no major adverse shocks have strained the achievement of low, stable inflation in many inflation targeters. This is incorrect, however. Many inflation targeters are small, open economies that were subject to severe shocks in the aftermath of the 1997 Asian crisis, in contrast to the large industrial nontargeters that were unaffected by these shocks. The combined adverse financial and terms-of-trade shocks suffered by Australia, Chile, Israel, and New Zealand, among other inflation targeters, led to major exchange rate devaluation in these countries and thus significantly tested the attainment of their inflation targets. They weathered this storm successfully, by recording little pass-through from devaluation to inflation. The 1999–2000 oil price shock represented the second test for oil-importing inflation targeters, including the countries mentioned above as well as Brazil, the Czech Republic, and Poland. Significant increases in imported inflation—through both energy prices and exchange rate devaluation—could put these countries' targets in jeopardy. The effects of the oil shock on core inflation appear to have been minor, however, and only temporary and modest increases in headline inflation have been observed.

Inflation targeting has helped reduce sacrifice ratios and output volatility in countries that have adopted inflation targeting, bringing them to levels close to those in industrial nontargeters. Bernanke and others (1999) find that inflation targeting does not make disinflation less costly in industrialized countries, as it does not alter sacrifice ratios and Phillips curves. Corbo, Landerretche, and Schmidt-Hebbel (in this volume), however, examine new evidence for a larger sample of inflation targeters and nontargeters. They conclude that sacrifice ratios have declined in emerging countries after the adoption of inflation targeting and that output volatility has fallen in both emerging and industrialized economies after adopting inflation targeting, reaching

levels that are similar to (and sometimes lower than) those observed in industrial countries that do not target inflation.

Inflation targeting may help bring down and guide inflation expectations and deal better with inflation shocks. According to Almeida and Goodhart (1998) and Bernanke and others (1999), inflation targeting does not reduced inflation expectations quickly, but rather does so gradually over time. Corbo, Landerretche, and Schmidt-Hebbel (in this volume) report that inflation forecast errors, based on country vector autoregression (VAR) models, fall consistently with the adoption of inflation targeting, approaching the low levels prevalent in nontargeting industrial countries. They also find that inflation persistence declined strongly among targeters in the 1990s, which suggests that inflation targets strengthen forward-looking expectations on inflation and thus weaken the weight of past inflation.

Monetary policy under inflation targeting is flexible inasmuch as it responds symmetrically to inflation shocks and accommodates temporary inflation shocks that do not affect the medium-term attainment of the target. Inflation targeters are not inflation nuts, as King (1996) holds, because they typically react symmetrically to positive and negative shocks, pursue disinflation gradually, and react to temporary output shocks. Cecchetti and Ehrmann (2000) show that output deviations have a positive weight in all objective functions of inflation targeters.

Monetary policy is more clearly focused on inflation under inflation targeting and may be toughened by inflation targeting. Central bank mandates to focus on price stability tend to be strengthened by inflation targeting (Bernanke and others, 1999). Cecchetti and Ehrmann (2000) provide evidence that central banks' aversion to inflation shocks (relative to output shocks) is toughened with the adoption of inflation targeting, a conclusion that is partly confirmed by Corbo, Landerretche, and Schmidt-Hebbel (in this volume).

We conclude that inflation targeting has proved to be a very successful new monetary framework, both in comparison to inflation targeters' preceding experience and relative to alternative monetary regimes adopted by a control group of highly successful industrial countries that pursued other monetary arrangements in the 1990s.

## 2. Revisiting Operational Design Issues

The previous section outlined some elements of the operational design of inflation-targeting regimes. Four design issues deserve detailed discussion: the interaction of the length of the target horizon, the width

of the target range, and the use of escape clauses; inflation targeting during the transition from high to low inflation; the designation of who should set the medium-term inflation target; and the role of the exchange rate and other asset prices. We discuss each of these in turn.

## 2.1 Interaction of the Target Horizon, Width of Target Range, Escape Clauses, and Choice of Core Inflation Targets

A central problem for the design of inflation-targeting regimes is that monetary policy affects the economy and inflation with long lags. For countries that have already achieved low inflation, the lags are estimated to be quite extended, at two years or even longer. Shorter time horizons are quite common in inflation-targeting regimes, however, which frequently specify annual inflation targets.

Using a time horizon that is too short can lead to a controllability problem, particularly when combined with a narrow target range of an inflation. The result may be frequent misses of the inflation target even when monetary policy is being conducted optimally. This occurred in New Zealand in 1995, when the Reserve Bank overshot its inflation target range of 0 to 2 percent by a few tenths of a percentage point in the one year horizon. This overshoot made the governor subject to dismissal under the central banking law, even though it was widely recognized that the overshoot was likely to be short-lived and that inflation would soon fall, as it later did. Although the breach of the inflation target range did not result in a substantial loss of credibility in the New Zealand case, under other circumstances or in an emerging market country, such an event could result in a serious loss of credibility for the central bank.

Combining too short a horizon with a narrow target range can also lead to instrument instability, in which excessive swings in the monetary policy instruments occur when the central bank tries to hit the inflation target. This problem can be especially serious in a small, open economy, where it results in greater reliance on manipulating the exchange rate to achieve the inflation target because exchange rate movements have a faster impact on inflation than do interest rates. The annual target in New Zealand and the 2 percentage point range for the inflation target were important factors in the Reserve Bank emphasis on exchange rates in the conduct of monetary policy. This resulted in overly tight monetary policy at the end of 1996—the overnight cash rate reached 10 percent because of fears that inflation would rise above

the target range in 1997. Another consequence of New Zealand's overly tight monetary policy was that it contributed to the recession in 1997 and 1998, which was made worse by the negative terms-of-trade shock resulting from the East Asian crisis. Too short a horizon and too narrow a range can thus induce undesired output fluctuations, as well.

Central banks can take four routes to avoid controllability and instrument instability problems in an inflation-targeting regime. First, they can build in formal escape clauses in their inflation-targeting regime to allow for misses of the inflation target under particular circumstances. Second, they can target core inflation rather than headline inflation. Third, they can widen the range of the inflation target. Fourth, they can set inflation targets for several years ahead.

Only New Zealand has incorporated formal escape clauses into its inflation-targeting regime by allowing for misses of the inflation target range when there are significant changes in the terms of trade, changes in indirect taxes that affect the price level, or supply shocks such as a major livestock epidemic. Note that the New Zealand escape clauses are designed to deal exclusively with supply shocks because they are the only shocks that can be readily identified as being exogenous. Aggregate demand shocks may be exogenous, but they are just as likely to be induced by monetary policy. Allowing central banks to use them to justify misses of an inflation target would likely destroy central bank credibility and undermine the inflation-targeting regime. Thus formal escape clauses, although providing some increased flexibility, are only able to partially cope with the controllability and instrument instability problems from too short a horizon and too narrow a target range.

The second alternative for coping with supply shocks is to target a core inflation measure that excludes items such as food and energy from the price index, as they are especially subject to supply shocks. Using a core inflation measure has the advantage that it involves no discretion after a supply shock occurs. The use of such discretion, as in the case of escape clauses, can lead the public to question the central bank's honest commitment to achieving the inflation targets. Instead, which items are to be excluded from the construction of the inflation measure are decided ex ante. This is probably why targeting core measures of inflation has been used more widely than the specification of escape clauses.

Like escape clauses, however, targeting core inflation measures has the disadvantage of dealing only with instrument instability and controllability problems arising from supply shocks, and not those stemming from aggregate demand shocks. Furthermore, core inflation measures are not as well understood by the public as headline inflation

measures, thus making core inflation targets a somewhat weaker communication vehicle than headline inflation targets. Core inflation measures also exclude items that consumers care a lot about, particularly poorer consumers for whom food and energy form a larger share of their budget. If these items are excluded from the targeted inflation measure, the central bank may be subjected to criticisms that it does not care sufficiently about poorer members of society.

The third option, widening the target range, is similarly not, by itself, a solution to controllability and instrument instability problems. Estimates of the irreducible uncertainty around an inflation target with a one-year horizon are on the order of 5 percentage points, although over time, success with inflation targeting might decrease the volatility of inflation expectations and hence inflation.[11] Choosing such a wide range for the inflation target is highly problematic because it will likely confuse the public about the central bank's intentions. The resulting high ceiling for the range is likely to make the commitment to low inflation less clear-cut, thereby reducing the credibility of monetary policy. This type of problem occurred in the United Kingdom in 1995, when inflation exceeded the target midpoint of 2.5 percent by over one percentage point, but without breaching the 4 percent ceiling. This gave the Chancellor of the Exchequer cover to resist the Bank of England's recommendation for tightening of monetary policy (see Bernanke and others, 1999).

Finally, lengthening the target horizon to correspond more closely to the lags in the effect of monetary policy on inflation would seem to be the best solution to the problems of controllability and instrument instability. Given the problems encountered in New Zealand 1997 and 1998, the Reserve Bank of New Zealand now emphasizes a target horizon of six to eight quarters in their discussion of monetary policy (see Sherwin, 1999; Drew and Orr, 1999). Other central banks, including the Bank of Canada and the Bank of England, have for a long time, emphasized a target horizon of closer to two years; this has recently become a feature of the Chilean targeting regime, as well (Central Bank of Chile, 2000b).

As Svensson (1997) emphasizes, however, if central banks are concerned about output fluctuations and include a weight on output fluctuations in their loss function, then the inflation forecast should approach the long-run inflation target gradually. This implies that a horizon even longer than the policy lags might be appropriate for the inflation target. Such a long horizon for the inflation target may create problems for an inflation-targeting regime in that the long period be-

11. See, for example, Haldane and Salmon (1995); Stevens and Debelle (1995).

fore there is verification of hitting the target may weaken credibility, particularly if credibility of the central bank is not high to begin with. One possible way to deal with this is to recognize that the optimal horizon and the target range interact: the target horizon could be kept relatively short, say two years, if the target range is widened. The Reserve Bank of New Zealand, for example, now acknowledges that widening the target range from 2 to 3 percentage points improved the inflation-targeting regime, even though the Bank initially did not support this change. Widening the target range is not without its problems, however, because it can also increase confusion and weaken the credibility of the targeting regime.[12]

Another way to allow for longer horizons is to use multi-year annual targets, such that the path of the inflation target can approach the long-run inflation goal more gradually. Both Brazil and Mexico recently adopted this strategy (Central Bank of Brazil, 1999; Bank of Mexico, 2000). An alternative approach is for the central bank to continue to announce only one medium-term inflation target while also announcing a long-run target with a specific date as to when it should be achieved. A third alternative for the central bank is to announce only one long-term inflation target and to publish inflation forecasts for future years, thus describing the expected path of inflation toward the long-run target. Chile recently adopted this approach, following other industrial countries (Central Bank of Chile, 2000a).

## 2.2 Inflation Targeting during the Transition from High to Low Inflation

The credibility of the central bank is likely to be low when inflation starts out well above the long-run inflation goal consistent with price stability. In addition, with initially high inflation rates (say, over 10 percent), the monetary authorities cannot easily control inflation. In-

12. Mishkin (2000c) argues that a point target for inflation may be more desirable than a target range because the edges of the target range can take on a life of their own. Politicians, financial markets, and the public often focus on whether inflation is just outside or inside the edge of a range, rather than on the magnitude of the deviation from the midpoint. As discussed above, the opposite problem occurred in the United Kingdom in 1995, when inflation exceeded the target midpoint by over one percentage point, but without breaching the upper band. Too much focus on the edges of the range can lead the central bank to concentrate on keeping the inflation rate just within the bands rather than on trying to hit the midpoint of the range. It is difficult to imagine a sensible objective function for policymakers that would justify such asymmetric reactions to inflation rates just inside and outside the bands.

flation targeting faces extra challenges to achieve a disinflation from a high inflation rate.

One way to address the complications arising from an initially high inflation rate is to phase in inflation targeting gradually, making it more formal in line with increasing success on the disinflation front, as suggested by Masson, Savastano, and Sharma (1997). This is exactly the strategy that emerging market countries with initially high inflation have pursued (Mishkin, 2000b; Mishkin and Savastano, 2000).[13] For example, when Chile adopted inflation targeting in 1991, inflation exceeded 20 percent, and the inflation target was treated more as an official inflation projection rather than as a formal hard target (Morandé and Schmidt-Hebbel, 1997, 2000; Morandé, in this volume). Over time, the Central Bank put greater emphasis on the price stability objective. The Central Bank's success in both lowering inflation and meeting its inflation objectives eventually led the public to interpret those objectives as hard targets for which the Central Bank could be held accountable. Finally, in May 2000, the Central Bank of Chile began to issue an inflation report, with all the features seen in similar documents in industrialized countries. For example, not only does the *Monetary Policy Report* outline developments on the inflation front and how the Bank intends to achieve its inflation target, but it also includes inflation and output forecasts, along with confidence intervals for these forecasts displayed in the famous fan charts pioneered by the Bank of England.

Mexico has also followed a gradual approach to implementing inflation targeting. Senior officials of the Bank of Mexico recently characterized Mexico's monetary policy framework as being in "a transition period toward a clear-cut inflation targeting scheme" (Carstens and Werner, 1999). The Bank of Mexico has increasingly emphasized the inflation goal as the central objective of its monetary policy. For a number of years, Mexico has made public an explicit inflation objective, which was initially announced when the Minister of Finance submitted to Congress the government's economic program for the following year. In 1999, after annual inflation fell below the 13 percent target to 12.3 percent, the central bank announced the 10 percent inflation target for the year 2000 before the Ministry of Finance submitted the year's economic program to Congress. Starting in April 2000, the Bank of Mexico has issued an *Inflation Report*, which documents what has

13. It has even been a feature of the adoption strategy of industrialized countries that adopted inflation targeting when inflation was at rates of less than 10 percent (Bernanke and others, 1999).

been happening on the inflation front and how the Bank of Mexico intends to achieve its inflation objectives, but which does not provide inflation and output forecasts. The third *Inflation Report*, published in October 2000, announced multi-year, annual targets that converge to a long-run target of 3 percent by December 2003.

Weak credibility stemming from high initial inflation increases the likelihood that the public and markets will not believe that the central bank is serious about hitting its targets if verification has to wait for more than one year in the future. This problem may make it very difficult for a central bank adopting inflation targeting under circumstances to choose inflation targets with horizons longer than a year. As discussed in the previous subsection, this presents the central bank with a dilemma, because the lags in transferring the effects of monetary policy to inflation are likely to be longer than one year. A solution to this dilemma is to specify a path for the inflation target with multi-year targets, which is what the central banks of Brazil, the Czech Republic, Mexico, and Poland have done since 1998. However, specifying a multi-year path for the annual inflation targets carries its own risk: even though a central bank is making good progress toward its long-run inflation goal, the greater uncertainty of controlling inflation at high rates might still cause inflation to deviate substantially from the multi-year path. This problem helps explain why the Central Bank of Chile chose not to specify multi-year inflation targets when it embarked on its inflation-targeting regime in 1991.

When countries are in the transition from high to low inflation, there appears to be a strong rationale for adopting a wide range for inflation targets to reflect the substantial uncertainty of controlling inflation when it is initially high. However, as discussed above, a wide range for the inflation target can lead to credibility problems, because the government may be willing to advocate that all is well on the inflation front when the inflation rate is substantially above the midpoint of the target range, but is still below the ceiling of the range. A point target makes this behavior on the part of the government less likely. Making sure that the government does not weaken its commitment to lowering inflation is especially important for inflation-targeting regimes when inflation is high because credibility is so much more precarious in these situations. This strengthens the argument for choosing a point target over a target range in an inflation-targeting regime during the transition from high to low inflation. Interestingly, the Central Bank of Chile switched from target ranges to point targets in 1994 in the process of hardening its inflation-targeting regime.

Imperfect credibility during the transition from moderately high to low inflation implies that inflation expectations are more geared to higher past inflation than to the lower official inflation targets. Inflation inertia is thus potentially larger, and rapid disinflation potentially more costly, in the transition to low inflation. Evidence for Chile, based on counterfactual simulations carried out by Corbo, Landerretche, and Schmidt-Hebbel (in this volume) and Morandé (in this volume), suggests that a quicker pace of disinflation toward the long-term 2–4 percent target would have involved a larger output sacrifice.

As argued in Mishkin (2000a), focusing on not undershooting the inflation target is likely to improve the performance of inflation-targeting regimes. When inflation approaches levels that are consistent with price stability, a symmetric approach to inflation targeting, which seeks to avoid undershoots just as strongly as overshoots, reduces the likelihood of output declines and deflation. It also indicates that the central bank cares appropriately about output fluctuations and thus helps maintain support for its independence. However, an asymmetric approach to inflation targeting may have some advantages when credibility is weak as a result of relatively high inflation rates, which is often the situation for emerging market countries adopting inflation targeting. Overshooting the target when inflation is still high may create fears that monetary policy is going back to its old, high-inflation ways; they could thus have devastating effects on central bank credibility. Given high inflation, therefore, the central bank may want to be particularly aggressive if it thinks that inflation could possibly overshoot the target. This bias to preventing overshoots of the target necessarily implies that the central bank's preferences would be somewhat asymmetric, with overshoots receiving a greater weight in the loss function than undershoots. For example, the behavior of the Bank of Israel in recent years seems to be consistent with asymmetric preferences of this type.

Asymmetric preferences can be taken too far, however. If the central bank is not sufficiently concerned about undershooting the targets, uncertainty about inflation may increase and thus interfere with private sector planning. Undershooting the target can also lead to sharp declines in aggregate output, which is not only harmful to the economy, but can also lead to decreased public support for the central bank and the inflation-targeting regime. Even if asymmetric preferences make sense at high inflation rates, they are no longer appropriate once the transition from high to low inflation is complete.

## 2.3 Who Should Set the Medium-Term Inflation Target?

Debelle and Fischer (1994) and Fischer (1994) make the useful distinction between goal independence, in which the central bank sets the goals of monetary policy, and instrument independence, in which the central bank controls monetary policy instruments. Instrument independence for central banks is supported by the need to insulate the central bank from short-run political pressures that may lead it to pursue time-inconsistent, expansionary policy that produces bad long-run outcomes. However, the argument that a central bank's long-run preferences should coincide with society's preferences suggests that a central bank should be goal dependent. Having the government decide on the long-run inflation target for the central bank thus receives a lot of support.

Whether the government rather than the central bank should set the medium-term inflation target is a trickier question. If inflation is currently low, the medium-term target is likely to be the same as the long-run target and so there is no conflict between them. This makes it easier to argue that the government should set the medium-term target, as it does in many inflation-targeting regimes. If inflation is currently far from the long-run target, however, the designation of who sets the medium-term target is more complicated. The length of the lags from monetary policy to inflation is a technical issue that the central bank is far more qualified to determine than are politicians. How long it should take for inflation to return to the long-run target necessarily requires judgement about these lags; such decisions should be insulated from short-term political pressure if time-inconsistent policies are to be avoided. This points to having the central bank set the medium-term inflation target, because how quickly it approaches the long-run target reflects the lags of monetary policy effects on inflation.

On the other hand, preferences on the weight given to minimizing output fluctuations relative to inflation fluctuations affect the speed at which inflation should be adjusted toward the long-run goal (Svensson, 1997). Thus if the government's long-run preferences are to be reflected in monetary policy, the government should have a role in setting the medium-term target, because this determines how fast inflation converges to the long-run target.

Clearly, there is a tradeoff with regard to who should set medium-term inflation targets when inflation is far from the long-run goal. The argument for instrument independence suggests that the central bank should set the medium-term target, while the argument for goal depen-

dence indicates that the government should set the medium-term target. For industrial countries, this may not represent much of a dilemma because medium-term targets and long-run targets are likely to be quite close. For countries in the transition from high to low inflation, however, it is far less obvious that the government should determine the medium-term inflation target.

## 2.4 The Role of the Exchange Rate and Other Asset Prices

Movements of the exchange rate are clearly a major concern of central banks in both inflation-targeting and non-inflation-targeting countries. Changes in the exchange rate can have a major impact on inflation, particularly in small, open economies. For example, depreciations lead to a rise in inflation as a result of the pass-through from higher import prices and greater demand for exports, while an appreciation of the domestic currency can make domestic business uncompetitive. A depreciation is often seen as a sign of failure on the part the central bank, as has recently been the case for the European Central Bank, even if this view is an unfair one. In addition, the public and politicians pay close attention to the exchange rate, and this puts pressure on the central bank to alter monetary policy.

Emerging market countries, quite correctly, have an even greater concern about exchange rate movements. Not only can a real appreciation make domestic industries less competitive, but it can lead to large current account deficits which can make the country more vulnerable to currency crisis if capital inflows turn to outflows. Depreciations in emerging market countries are particularly dangerous because they can trigger a financial crisis along the lines suggested in Mishkin (1996b, 1999b). These countries have much of their debt denominated in foreign currency; when the currency depreciates, the debt burden of domestic firms increases. Since assets are typically denominated in domestic currency and so do not increase in value, net worth declines. This deterioration in balance sheets then increases adverse selection and moral hazard problems, which leads to financial instability and a sharp decline in investment and economic activity. This mechanism explains why the currency crises in Mexico in 1994–95 and East Asia in 1997 pushed these countries into full-fledged financial crises, with devastating effects on their economies.

The fact that exchange rate fluctuations are a major concern in so many countries raises the danger that monetary policy may put too much

focus on limiting exchange rate movements, even under an inflation-targeting regime. The first problem with a focus on limiting exchange rate movements is that it can transform the exchange rate into a nominal anchor that takes precedence over the inflation target. For example, as part of its inflation-targeting regime, Israel established an intermediate target of a quite narrow exchange rate band around a crawling peg, whose rate of crawl was derived from the inflation target for the coming year. Although the Bank of Israel downplayed the exchange rate target relative to the inflation target over time, the use of a secondary target slowed the Bank's efforts to win support for disinflation and the lowering of the inflation targets (see Bernanke and others, 1999).

The second problem that results from a focus on limiting exchange rate fluctuations is that the impact of changes in exchange rates on inflation and output can differ substantially depending on the nature of the shock that causes the exchange rate movement. Different types of shocks call for different monetary policy responses. If the domestic currency depreciates because of a pure portfolio shock, inflation is likely to rise; the appropriate response to keep inflation under control is for the monetary authorities to tighten monetary policy and raise interest rates. If the depreciation occurs in an emerging market country which has a substantial amount of foreign-denominated debt, tightening monetary policy to prevent a sharp depreciation may be even more necessary to avoid financial instability. On the other hand, if the exchange rate depreciation occurs because of real shocks, the impact is less likely to be inflationary and a different monetary policy response is warranted. Even here, however, the response depends on the nature of the shock. A negative terms-of-trade shock, which lowers the demand for exports, reduces aggregate demand and is thus likely to be deflationary. In this situation, the correct interest rate response is to lower interest rates to counteract the drop in aggregate demand, and not to raise interest rates. If the negative terms-of-trade shock is instead due to a rise in import prices, the result is a negative income effect, which could be offset by lowering interest rates. But there is also a direct inflationary effect, particularly if there is high indexation and pass-through, which might suggest that interest rates should rise to prevent second-round effects.

One graphic example of a focus on limiting exchange rate fluctuations that induced the wrong policy response occurred in New Zealand in 1997 and 1998. As mentioned above, the short horizon for the inflation target in New Zealand led the Reserve Bank to focus on the exchange rate as an indicator of the monetary policy stance because of the direct impact of exchange rate movements on inflation. By early

1997, the Reserve Bank institutionalized this focus by adopting as its primary indicator of monetary policy a Monetary Conditions Index (MCI) similar to that developed by the Bank of Canada. The idea behind the MCI, which is a weighted average of the exchange rate and a short-term interest rate, is that both interest rates and exchange rates on average have offsetting impacts on inflation, on the assumption that portfolio shocks dominate exchange rate movements. The adoption of the MCI in 1997 led to a questionable monetary policy response to the East Asian crisis. When the crisis began in July 1997 after the devaluation of the Thai baht, depreciation set in and the MCI began a sharp decline, indicating that the Reserve Bank needed to raise interest rates, which it did by over 200 basis points. The result was very tight monetary policy, and the overnight cash rate exceeded 9 percent by June of 1998. Because the depreciation was due to a substantial negative terms-of-trade shock that decreased aggregate demand, the tightening of monetary policy, not surprisingly, led to a recession and an undershooting of the inflation target range, with actual deflation occurring in 1999.[14] The Reserve Bank of New Zealand eventually reversed its course: it lowered interest rates sharply beginning in July 1998 after the economy had entered a recession. It also recognized the problems with using an MCI as an indicator of monetary policy and abandoned the measure in 1999. Now the Reserve Bank operates monetary policy more conventionally, using the overnight cash rate as its policy instrument and placing far less emphasis on the exchange rate in its monetary policy decisions.

Another example is the case of Chile in 1998. At that time Chile's inflation-targeting regime included a focus on limiting exchange rate fluctuations by having an exchange rate band with a crawling peg that was loosely tied to lagged domestic inflation. In response to the combined financial and terms-of-trade shock stemming from the Asian crisis, the Central Bank of Chile adopted a stringent monetary policy and a defense of the peso, with a narrowing of the exchange rate band and intervention in the foreign exchange market. When the economy entered into a mild recession in late 1998, the tight monetary policy was reversed, interest rates were lowered, and the peso was allowed to decline. The exchange rate band was abolished in September 1999 and the peso now floats freely.

14. The terms-of-trade shock, however, was not the only negative shock the New Zealand economy faced during that period. The farm sector experienced a severe drought that also hurt the economy. Thus a mistake in monetary policy was not the only source of the recession; bad luck played a role too. See Drew and Orr (1999); Brash (2000).

The experiences of New Zealand and Chile during this period contrast sharply with that of Australia, another small open economy with an inflation-targeting regime. Prior to adopting its inflation-targeting regime in 1994, the Reserve Bank of Australia adopted a policy of allowing the exchange rate to fluctuate without interference, particularly if the source of the exchange rate change was a real shock, such as a terms-of-trade shock. When faced with the devaluation in Thailand in July 1997, the Reserve Bank recognized that it would face a substantial negative terms-of-trade shock because of the large component of its foreign trade conducted with the Asian region and that it should not fight the inevitable depreciation of the Australian dollar.[15] It thus immediately lowered the overnight cash rate by 50 basis points to 5 percent and kept it near this level until the end of 1998, when it was lowered again by another 25 basis points.

The adoption of the inflation-targeting regime probably helped the Reserve Bank of Australia to be even more aggressive in its easing in response to the East Asian crisis, and it helps explain why their response was so rapid. The Reserve Bank was able to make clear that easing was exactly what inflation targeting called for in order to prevent an undershooting of the target, so that the easing was unlikely to have an adverse effect on inflation expectations. The outcome of the Reserve Bank's policy actions was extremely favorable. In contrast to New Zealand and Chile, real output growth remained strong throughout this period. Furthermore, there were no negative consequences for inflation despite the substantial depreciation of the Australian dollar against the U.S. dollar by close to 20 percent: inflation remained under control and actually fell during this period, finishing slightly under the target range of 2 to 3 percent.

Targeting the exchange rate is thus likely to worsen the performance of monetary policy. This does not imply, however, that central banks should pay no attention to the exchange rate. The exchange rate serves as an important transmission mechanism for monetary policy, and its level can have important effects on inflation and aggregate demand, depending on the nature of the shocks. This is particularly true in small, open economies. The control of inflation and aggregate demand therefore requires monitoring exchange rate developments and factoring them into decisions on setting monetary policy instruments. A depreciation of the exchange rate resulting from portfolio shocks requires a tightening of monetary policy to keep inflation

15. See MacFarlane (1999); Stevens (1999).

from rising. On the other hand, a depreciation from a negative terms-of-trade shock stemming from falling export prices requires a different response, namely, an easing of monetary policy as pursued in Australia in 1997.

Mishkin (2000b) and Mishkin and Savastano (2000) emphasize another reason why central banks should not pursue a benign neglect of exchange rates. As mentioned above, emerging market countries with large foreign-denominated debt may not be able to afford sharp depreciations of their currencies, which can destroy balance sheets and trigger a financial crisis. Central banks in these countries may thus have to smooth excessive exchange rate fluctuations, although without attempting to prevent the exchange rate from reaching its market-determined level over longer horizons. Exchange rate smoothing via foreign exchange market interventions might sometimes be necessary because such interventions can prevent dynamics in the microeconomic structure of this market that may lead to exchange rate fluctuations that are divorced from fundamentals. Continuing exchange market interventions, particularly unsterilized ones, are likely to be counterproductive, however, because they are not transparent. Instead, exchange rate smoothing via changes in the interest rate instrument are more transparent, and they indicate that the nominal anchor—and not the exchange rate—continues to be the inflation target. Central banks can also explain to the public the rationale for exchange rate intervention in a manner analogous to that for interest rate smoothing, that is, as a policy aimed not at resisting market-determined movements in an asset price, but at mitigating potentially destabilizing effects of abrupt and sustained changes in that price.

The conclusion that targeting the exchange rate is likely to worsen the performance of monetary policy also applies to targeting other asset prices. Clearly, setting monetary policy instruments to achieve inflation targets requires factoring in asset price movements. Changes in asset prices such as common stock, housing or long-term bonds have important effects on aggregate demand and inflation, and they thus act as important transmission mechanisms for monetary policy (see Mishkin 1996a). The response to fluctuations in these asset prices cannot be mechanical, however, because optimal monetary policy responds in different ways depending on the nature of the shocks driving these asset prices. Furthermore, because many asset prices matter, targeting just one would be suboptimal.

It is also highly problematic for a central bank to target variables that are hard to control—and asset prices such as housing and stock

prices clearly fall into this category. Central banks look foolish if they act to control asset prices and then are unable to do so. Furthermore, when central banks act as if they can control asset prices such as common stocks, the public may begin to fear that central banks are too powerful and thus to question support for central bank independence. Some researchers (such as Cecchetti and others, 2000) suggest that the monetary authorities should act to limit asset price bubbles to preserve financial stability. However, this requires that the monetary authorities identify appropriate asset values. It is, to say the least, highly presumptuous to think that government officials, even if they are central bankers, know better than private markets what the asset prices should be, given that markets have stronger incentives to get things right. Furthermore, as pointed out in Bernanke and Gertler (1999), an inflation-targeting approach that does not target asset prices, but instead makes use of an information-inclusive strategy in setting policy instruments, has the ability to make asset price bubbles less likely, thereby promoting financial stability.

The bottom line is that the optimal conduct of monetary policy requires that many asset prices, whether the exchange rate, stock prices, housing prices, or long-term bond prices, be factored into decisions about the setting of monetary policy instruments. Doing so is completely consistent with inflation targeting, which is an information-inclusive strategy for the conduct of monetary policy. Targeting asset prices, on the other hand, is likely to lead to serious mistakes in monetary policy, and it may weaken not only the commitment to the inflation target as a nominal anchor, but also the support for central bank independence.

## 3. Some Unresolved Issues

Inflation-targeting regimes are continually evolving as experience and new research suggests better ways to conduct monetary policy. Two unresolved issues that are central to inflation-targeting regimes are currently high on the research agenda of monetary economists: the specification of the optimal long-run inflation goal and the merit of targeting the price level rather than inflation.

### 3.1 Long-Run Inflation Goal

A key question for any central bank pursuing an inflation-targeting strategy is what the long-run goal for inflation should be. Much research finds a negative relationship between inflation and economic

growth.[16] As pointed out in Bruno and Easterly (1996), however, the evidence for this negative relationship is weak at low inflation rates.

Because the empirical evidence on the direct relationship between inflation and growth is unlikely to help discriminate between different long-run goals that are under 10 percent, another approach to deciding on the appropriate long-run inflation target is to ask the deeper question of what price stability means. Alan Greenspan has provided a widely-cited definition of price stability: a rate of inflation that is sufficiently low that households and businesses do not have to take it into account in making everyday decisions. This definition of price stability is a reasonable one, and, operationally, any inflation number between 0 and 3 percent seems to meet this criterion. Some economists, such as Feldstein (1997) and Poole (1999), argue for a long-run inflation goal of 0 percent, which has a psychological appeal. Indeed, one concern is that an inflation goal greater than zero might lead to a decline in central bank credibility and an increase in the instability of inflation expectations, which could, in turn, trigger an upward creep in inflation. However, Bernanke and others (1999) suggest that maintaining an inflation target above zero—but not too far above (less than 3 percent)—for an extended period does not lead to instability in the public's inflation expectations or to a decline in central bank credibility.

One prominent argument against setting the long-run inflation target at zero is that setting inflation at too low a level produces inefficiency and will result in a higher natural rate of unemployment (Akerlof, Dickens, and Perry, 1996). The authors argue that downward rigidity of nominal wages, which they say is consistent with the evidence, indicates that reductions of real wages can occur only through inflation. The implication is that a very low rate of inflation might prevent real wages from adjusting downward in response to declining labor demand in certain industries or regions, thereby leading to increased unemployment and hindering the re-allocation of labor from declining sectors to expanding sectors.

The evidence for the Akerlof-Dickens-Perry mechanism through which low inflation raises the natural rate of unemployment is not at all clear-cut. Carruth and Oswald (1989), Ingrams (1991), McLaughlin (1994), and Yates (1995) all find little evidence for downward nominal rigidities in wages in the United States and the United Kingdom. As pointed out by Groshen and Schweitzer (1996, 1999), inflation can not

16. For example, see Kormendi and Meguire (1985); Grier and Tullock (1989); Cozier and Selody (1992); Fischer (1993); Andersen and Gruen (1995); Barro (1995); Andres and Hernando (1999).

only "grease" the labor markets and allow downward shifts in real wages in response to a decline in demand along the lines of Akerlof, Dickens, and Perry (1996), but it can also put in "sand" by increasing the noise in relative real wages. This noise reduces the information content of nominal wages and hence the efficiency of the process by which workers are allocated across occupations and industries.

A more persuasive argument for a long-run inflation goal above zero is that the economy is less likely to experience episodes of deflation. Deflation is a key factor promoting episodes of financial instability in industrialized countries (Mishkin, 1991, 1997). Because debt contracts in industrialized countries frequently have long maturities, a deflation leads to an increase in the real indebtedness of firms and households, which in turn leads to a decline in their net worth and a deterioration of their balance sheets. Irving Fisher (1933) named this phenomenon debt deflation (although it might more accurately be referred to as debt inflation in real terms through deflation) and saw it as a major factor promoting the economic downturn of the Great Depression.[17] With decreased net worth, adverse selection and moral hazard problems increase for lenders, who therefore cut back on lending. The decline in net worth also leads to a decline in the amount of collateral a lender can grab if the borrower's investments turn sour, and the reduction in collateral therefore increases the consequences of adverse selection, because loan losses resulting from default are likely to be more severe. In addition, the decline in net worth increases moral hazard incentives for borrowers to take on excessive risk because they now have less to lose if their investments fail. This reasoning indicates that deflation can promote financial instability in industrialized countries through the debt-deflation mechanism. A recent example of this phenomenon is the case of Japan in the last decade (Mishkin, 1998; Bernanke, 1999).

Another reason for choosing an inflation goal that reduces the likelihood of deflation is that deflation may make it more difficult to conduct monetary policy. Frequent periods of deflation resulting from too low a level of the inflation target will cause short-term interest

17. Technically this debt-deflation mechanism requires that the deflation be unanticipated, that is, it must come as a surprise after the debt contracts have been written. Because in industrialized countries many of these contracts are quite long, a deflation that becomes anticipated after a period of time may still be unanticipated from the point of view of many debt contracts, such that the debt-deflation story still holds. If debt contracts are of very short duration, as is typically the case in emerging market countries, then deflations are less likely to be unanticipated, and so the debt deflation mechanism is inoperative (see Mishkin 1997).

rates to hit a floor of zero during deflations, as occurred during the Great Depression and recently in Japan. Some economists argue that monetary policy becomes ineffective when the interest rate hits a floor of zero.[18] This argument is a fallacy for the reasons outlined in Meltzer (1995) and Mishkin (1996a). Monetary policy works through many other asset prices besides those of short-term debt securities. Even when short-term interest rates hit the floor of zero, monetary policy can still be effective, and indeed was so during the Great Depression (see Romer, 1992).

Nonetheless, monetary policy becomes more difficult during deflationary episodes when interest rates hit a floor of zero because the usual guides to the conduct of monetary policy are no longer relevant. In recent years, much of the research on how central banks should optimally conduct monetary policy focus on so-called Taylor rules, in which the central bank sets the short-term interest rates at a level that depends on both output and inflation gaps. The Taylor (1999) volume is an excellent example of this type of research. Once the interest rate hits a floor of zero, however, this entire class of research on optimal monetary policy rules is no longer useful because manipulating short-term interest rates ceases to be an effective tool of monetary policy. In such a deflationary environment, central banks do have the ability to lift the economy out of recession by pursuing expansionary policy and creating more liquidity, but it becomes much less clear how far they need to go. This rightfully makes central bankers quite uncomfortable. Therefore, an important disadvantage of too low a level of the long-run inflation target is that it makes deflationary environments more likely to occur, leaving central bankers at sea without the usual knowledge to guide them and thus making it harder for them to get monetary policy exactly right.

Another reason why central banks might be better off with a long-run inflation goal above zero is that it is crucial that they not be perceived as being overly obsessed with controlling inflation at the expense of output stability. A central bank is likely to lose the support of the public if it is perceived as being inflation nutters, in Mervyn King's (1996) terminology, and putting no weight on output fluctuations in making its decisions about monetary policy. Too low an inflation target, say, 0 or even 1 percent, may signal to the public that the central bank does not care sufficiently about the public's concerns.

18. Summers (1991) is one prominent example, and officials of the Bank of Japan recently used this argument to indicate that expansionary monetary policy is likely to be ineffective in promoting Japanese recovery.

On the other hand, Fischer (1986), Feldstein (1997), and the papers in Feldstein (1999) find that lowering the inflation rate from currently low levels to zero in industrialized countries reduces distortions caused by the interaction of inflation with the tax system. This can produce substantial welfare gains, on the order of 1 percent of GDP.[19] However, these distortions can also be eliminated by changes in the tax code, so they do not provide a clear justification for choosing a zero long-run inflation goal.

Emerging market countries that grow at high levels may be better off having inflation rates that are slightly higher than those in industrialized countries. High-growth countries typically experience real exchange rate appreciation that is proportional to the difference in the productivity growth of the traded and nontraded sectors relative to the rest of the world (the Harrod-Belassa-Samuelson effect). If it is appropriate for these countries to aim for a long-run traded goods inflation similar to that of industrialized countries, then trend real appreciation requires a domestic nontraded goods inflation that is somewhat higher. Hence, the long-run inflation goal in high-growth economies might need to be slightly higher than would be desirable for average-growth countries. This explains why Chile, a high-growth country, has chosen a long-term inflation target range of 2–4 percent per year.

Given these conflicting arguments, the definition of an appropriate long-run goal for inflation is still an open question. As a practical matter, all inflation-targeting countries have chosen long-run inflation goals slightly above zero, with the midpoints of the long-run target ranges lying between 1 and 3 percent. Future research may help central banks decide whether a long-run goal outside this range is appropriate and provide more precision as to what this goal should be.

## 3.2 Price-Level versus Inflation Targets

All countries that currently implement an inflation-targeting regime have chosen to target inflation rather than the price level. However, which of these two targets would result in better economic performance is an open question.

A price-level target has two key advantages relative to an inflation target. First, a price-level target can reduce the uncertainty about what

19. Welfare costs arising from inflation because interest is not paid on high-powered money (the so-called shoe leather costs) are estimated to be an order of magnitude smaller than costs stemming from tax distortions, and they are thus unlikely to be important for deciding the optimal long-run inflation goal. See Lucas (1981, 2000); Fischer (1986); Cooley and Hansen (1989).

the price level will be over long horizons. With an inflation target, misses of the inflation target are not reversed by the central bank. Consequently, inflation will be a stationary stochastic process, that is, integrated of the order zero, I(0), while the price level will be nonstationary, an I(1) process. The uncertainty regarding the future price level thus grows with the forecast horizon. This uncertainty can make long-run planning difficult and may therefore lead to a decrease in economic efficiency. Although McCallum (1999) argues that the amount of long-run uncertainty about the future price level arising from successful adherence to an inflation target may not be all that large, it still complicates the planning process and may lead to more mistakes in investment decisions.

The second possible advantage of a price-level target is that it produces less output variance than an inflation target in models with a high degree of forward-looking behavior on the part of firms.[20] However, empirical evidence (such as that presented in Fuhrer, 1997) does not clearly support the formation of forward-looking expectations, and models with forward-looking behavior have counterintuitive properties that seem to be inconsistent with inflation dynamics (Estrella and Fuhrer, 1998).

The traditional view, forcefully articulated by Fischer (1994), argues that a price-level target produces more output variability than an inflation target because unanticipated shocks to the price level are not treated as bygones and must be offset.[21] A price-level target requires that overshoots or undershoots of the target must be reversed, which could impart significantly more volatility to monetary policy and, with sticky prices, to the real economy in the short run. Although the models with forward-looking price setting cited above do not find that this feature of a price-level target increases output variability, they do not focus on one particular problem with a price-level target: the fact that a price-level target may lead to more frequent episodes of deflation. As demonstrated in the previous subsection, episodes of deflation present policymakers with two problems, namely, a possible increase in financial instability with potentially high output losses for the economy and an increased likelihood that nominal interest rates hit a floor of zero, which complicates the conduct of monetary policy.

20. For example, Svensson (1999); Woodford (1999); Svensson and Woodford (1999); Clarida, Galí, and Gertler (1999); Dittmar and Gavin (2000); Dittmar, Gavin, and Kydland (1999); Vestin (2000).

21. This view is supported by simulations of macroeconometric models with backward-looking expectations, which typically find that a price-level target leads to greater variability of output and inflation than an inflation target. See, for example, Haldane and Salmon (1995).

Another problem for a price-level target that has received little attention in the literature is the presence of measurement error in inflation. Most research on measurement error takes the view that it is inflation that is measured with error rather than the price level. This was the approach taken by the Boskin Commission.[22] This implies that the measurement error in the price level is I(1), such that a price-level target results in growing uncertainty about the true price level as the forecast horizon lengthens. Many of the arguments that a price-level target results in lower long-run uncertainty about the true price level may thus be overstated.

Such conflicting arguments indicate that whether price-level rather than inflation targets would produce better outcomes is an open question. Given this uncertainty about the benefits of price-level targeting, it is not surprising that no central bank has decided to target the price level in recent years. However, the arguments made here for preferring an inflation target over a price-level target do not rule out hybrid policies that combine features of an inflation target and a price-level target and so might provide the best of both worlds. For example, an inflation target could be announced with a commitment to some error correction in which target misses would be offset to some extent in the future. Recent research shows that an inflation target with a small amount of error correction can substantially reduce the uncertainty about the price level in the long run, while generating very few episodes of deflation (Black, Macklem, and Rose, 1997; King, 1999; Batini and Yates, 1999). Furthermore, putting a small weight on the price-level error correction term improves the trade-off between output and inflation fluctuations (see Williams, 1999; Smets, 2000; Gaspar and Smets, 2000; McLean and Pioro, 2000). Evaluating hybrid policies of this type is likely to be a major focus of future research.

One issue that would have to be addressed if such a hybrid policy were adopted is how to explain the mechanism to the public. As emphasized in Bernanke and Mishkin (1997), Mishkin (1999a), and Bernanke and others (1999), a critical factor in the success of inflation targeting is that it provides a vehicle for more effective communication with the public. The public will clearly not understand the technical jargon of error correction models. However, an error correction feature of an inflation-targeting regime could be communicated fairly easily by not only announcing an intermediate-term inflation target, but also indi-

22. See, for example, Boskin and others (1996); Moulton (1996); Shapirio and Wilcox (1996).

cating that there is a target for the average inflation rate over a longer period, say five years.

Another possible hybrid policy would be to pursue an inflation target under normal conditions, but to provide an escape clause that activates a price-level target only when the unusual condition of deflation sets in, particularly if interest rates near a floor of zero. The inflation target under normal conditions would not require that overshoots of the inflation target be reversed and so would not increase the likelihood of deflation. On the other hand, if deflation sets in, then activating a price-level target to induce expectations of reflation of the economy would not only make it less likely that nominal interest rates would hit a floor of zero, but would also lead to higher inflation expectations. This would lower real interest rates, thereby stimulating the economy, and would help induce a rise in the price level, which would repair balance sheets. Given the success of a price-level target in ameliorating the effects of the Great Depression in Sweden in the 1930s (Berg and Jonung, 1998), price-level targets have recently been proposed to help jumpstart the Japanese economy (Bernanke, 1999; Blinder, 1999; Goodfriend, 1999; Svensson, 2000).

## 4. Conclusions

The emergence of inflation targeting over the last ten years is an exciting development in the central banks' approach to the conduct of monetary policy. The review in this paper has indicated that inflation targeting has been quite successful in controlling inflation and improving the performance of the economy. However, our discussion of operational design issues for inflation targeting and unresolved issues indicates that there is still much to learn about how best to operate inflation-targeting regimes. We expect that future experience and research will help refine the inflation targeting approach and further improve the process of monetary policymaking.

## APPENDIX A

# Summary of Inflation-Targeting Regimes

### Table A1. Implementation and Design of Inflation Targeting in Nineteen Countries

| *Country* | *Date introduced* | *Target price index* | *Target width* | *Target horizon* | *Escape clauses* | *Accountability of target misses* | *Entity that sets target* | *Publications and accountability* |
|---|---|---|---|---|---|---|---|---|
| Australia | Sept. 1994 | Core CPI | 2–3% | Over one business cycle | None | None | Jointly by government and central bank | Inflation report; inflation projections (2-year point estimate) |
| Brazil | Jun. 1999 | Headline CPI | 1999: 8% (±2%)<br>2000: 6% (±2%)<br>2001: 4% (±2%) | 1 year | None | Issuance of open letter to Minister of Finance explaining target breach and measures taken to bring inflation within the target (and the time required) | Government in consultation with central bank | Inflation report; inflation projections (2-year fan chart); extract of board meetings; models used for inflation outlook |
| Canada | Feb. 1991 | Core CPI (excl. food, energy, and indirect taxes) | 1991: 3–5%<br>1992: 2–4%<br>Jun. 94: 1.5–3.5%<br>1995-2001: 1–3% | 1991: 22 months; since 1992: multi-year | Revision of target path under exceptional circumstances (e.g., major oil price shock, natural disaster) | Public explanation | Jointly by government and central bank | Monetary policy report; inflation projections (1-year point estimate) |

## APPENDIX A (continued)

| *Country* | *Date introduced* | *Target price index* | *Target width* | *Target horizon* | *Escape clauses* | *Accountability of target misses* | *Entity that sets target* | *Publications and accountability* |
|---|---|---|---|---|---|---|---|---|
| Chile | Jan. 1991 | Headline CPI | 1991: 15–20%<br>1992: 13–16%<br>1993: 10–12%<br>1994: 9–11%<br>1995: 8%<br>1996: 6.5%<br>1997: 5.5%<br>1998: 4.5%<br>1999: 4.3%<br>2000: 3.5%<br>2001 onwards: 2–4% | 1991–2000: 1 year; 2001 onwards: indefinite | None | None | Central bank in consultation with government | Inflation report (2000); minutes of monetary policy meetings; inflation projections (2-year fan chart) |
| Colombia | Sept. 1999 | Headline CPI | 1999: 15%<br>2000: 10%<br>2001: 8%<br>2002: 6% | 1 year | None | None | Jointly by government and central bank | Inflation report |
| Czech Republic | Jan. 1998 | Core CPI (excl. regulated prices and indirect taxes) | 1998: 5.5–6.5%<br>1999: 4–5%<br>2000: 3.5–5.5%<br>2001: 2–4% | 1 year | Natural disasters, global raw material price shocks, exchange rate shocks unrelated to domestic economic fundamentals and monetary policy, and agricultural production shocks | None | Central bank | Inflation report (1998); minutes of monetary policy meetings; inflation projections (1-year range) |

## Appendix A (continued)

| *Country* | *Date introduced* | *Target price index* | *Target width* | *Target horizon* | *Escape clauses* | *Accountability of target misses* | *Entity that sets target* | *Publications and accountability* |
|---|---|---|---|---|---|---|---|---|
| Finland | Feb. 1993 to Jun. 1998 | Core CPI (excl. indirect taxes, subsidies, housing prices, and mortgage interest) | Annual average of 2% by 1995 | Until 1995: multi-year; since 1996: indefinite | None | None | Central bank | None |
| Israel | Jan. 1992 | Headline CPI | 1992: 14–15%<br>1993: 10%<br>1994: 8%<br>1995: 8–11%<br>1996: 8–10%<br>1997: 7–10%<br>1998: 7–10%<br>1999: 4%<br>2000: 3–4%<br>2001: 2.5–3.5% | 1 year | None | Public explanation of deviation of inflation forecast from target in excess of 1% | Government in consultation with central bank | Inflation report (1998) |
| Korea | Jan. 1998 | | 1998: 9% (±1%)<br>1999: 3% (±1%)<br>2000: 2.5% (±1%)<br>2001 onwards: 2.5% | 1998–2000: 1 year; 2001 onwards: indefinite | None (before 2000: changes caused by major forces) | None | Government in consultation with central bank | Inflation report (and submission to Parliament); monthly announcement of monetary policy direction; minutes of monetary policy meetings |

## APPENDIX A (continued)

| *Country* | *Date introduced* | *Target price index* | *Target width* | *Target horizon* | *Escape clauses* | *Accountability of target misses* | *Entity that sets target* | *Publications and accountability* |
|---|---|---|---|---|---|---|---|---|
| Mexico | Jan. 1999 | Headline CPI | 1999: 13%<br>2000: < 10%<br>2001: 6.5%<br>2002: 4.5%<br>2003: similar to trade partners' inflation (3%) | 1998–2002: 1 year; 2002 onwards: indefinite | None | None | Central bank | Inflation report (2000) |
| New Zealand | Mar. 1990 | Headline CPI (since 1999, headline CPI excludes interest charges; prior to 1999, targets were defined in terms of headline CPI less interest charges and other first-round-effect prices) | 1990: 3–-5%<br>1991: 2.5–4.5%<br>1992: 1.5–3.5%<br>1993-1996: 0–2%<br>Since 1997 0–3% | 1990–92: 1 year; 1993–96: multi-year; since 1997: indefinite | Unusual events, provided they do not cause general inflationary pressures | Public explanation of target breach and measures taken to bring inflation within the target (and the time required); Minister of Finance may ask for resignation of RBNZ Governor | Jointly by government and central bank | Inflation report (1990); inflation projections |
| Peru | Jan. 1994 | Headline CPI | 1994: 15–20%<br>1995: 9–11%<br>1996: 9.5–11.5%<br>1997: 8–10%<br>1998: 7.5–9%<br>1999: 5–6%<br>2000: 3.5–4%<br>2001: 2.5–3.5%<br>2002: 1.5–2.5%<br>2003: 1.5–2.5% | 1 year | None | None | Central bank in consultation with government | None |

## APPENDIX A (continued)

| *Country* | *Date introduced* | *Target price index* | *Target width* | *Target horizon* | *Escape clauses* | *Accountability of target misses* | *Entity that sets target* | *Publications and accountability* |
|---|---|---|---|---|---|---|---|---|
| Poland | Oct. 1998 | Headline CPI | 1998: < 9.5%<br>1999: 6.6–7.8%<br>2000: 5.4–6.8%<br>2003: < 4% | 1998-2000: 1 year; 2000–03: multi-year; 2003 onwards: indefinite | None | None | Central bank | Inflation report; inflation guidelines; report on monetary policy implementation |
| South Africa | Feb. 2000 | Core CPI (excl. Interest costs) | 2003: 3–6% | Multi-year | Major unforeseen events outside central bank's control | None | Central bank | Inflation report |
| Spain | Nov. 1994 to Jun. 1998 | Headline CPI | Jun. 1996: 3.5 – 4%<br>1997: 2.5%<br>1998: 2% | Until 1996: multi-year; 1997–98: 1 year | None | None | Central bank | Inflation report (1995); governor reports regularly to Parliament |
| Sweden | Jan. 1993 | Headline CPI | Since 1995: 2% (±1%) | Until 1995: multi-year; since 1996: indefinite | None | None | Central bank | Inflation report (1997); minutes of monetary policy meetings; inflation projections (2-year fan chart); submission of monetary policy report to Parliament |

## APPENDIX A (continued)

| *Country* | *Date introduced* | *Target price index* | *Target width* | *Target horizon* | *Escape clauses* | *Accountability of target misses* | *Entity that sets target* | *Publications and accountability* |
|---|---|---|---|---|---|---|---|---|
| Switzerland | Jan. 2000 | Headline CPI | < 2% | 3 years | Unusual events, provided they do not cause general inflationary pressures | None | Central bank | Inflation report; inflation projections (3 years) |
| Thailand | Apr. 2000 | Core CPI (excl. raw food and energy prices) | 2000: 0–3.5% | Indefinite | None | Public explanation of target breach and measures taken to bring inflation within the target (and the time required) | Government in consultation with central bank | Inflation report (2000); inflation projections (2-year fan chart); minutes of monetary policy meetings |
| United Kingdom | Oct. 1992 | RPIX (excl. mortgage interest) | 1992–95: 1–4% Since 1996: 2.5% | Until 1995: multi-year; since 1996: indefinite | None | Issuance of open letter to the Minister of Finance explaining target breach and measures taken to bring the inflation within the target (and the time required) | Government | Inflation report; inflation projections (2-year fan chart); models used for inflation outlook |

Source: J.P. Morgan, "Guide to Central Bank Watching;" country sources; central banks' Web pages; Schaechter, Stone, and Zelmer (2000).

## APPENDIX B
## Specification of the Data Set

This appendix defines the variables and outlines the data sources used for the analysis in section 1.

*IT:* a dummy variable for implementing inflation targeting. Specifies a value of 1 (0 otherwise) for a year in which at least six months are covered by a previously announced inflation target. Source: country sources; Schaechter, Stone, and Zelmer (2000).

*Inf*: CPI inflation, normalized as the percentage variation of the annual average CPI divided by one plus the percentage variation of the average annual CPI. Source: IMF, *International Financial Statistics,* various issues (code 64e).

*MT:* a dummy variable for pursuing monetary growth targets. Specifies a value of 1 (0 otherwise) for a year in which any month is covered by a previously announced monetary target. Source: country sources; J.P. Morgan, "Guide to Central Bank Watching."

*BW:* the width of the exchange rate band, normalized as the band width divided by one plus the band width. Source: IMF, "Exchange Arrangements and Exchange Restrictions," various issues.

*Fiscal:* the ratio of the government surplus to GDP. Source: country sources; IMF, *International Financial Statistics*, various issues (codes 80 and 99b).

*Fin:* financial depth, measured as the ratio of M2 to GDP. Source: country sources; IMF, *International Financial Statistics*, various issues (codes 80 and 99b).

*Open:* trade openness, measured as the ratio of the sum of exports and imports to GDP. Source: country sources; IMF, *International Financial Statistics*, various issues (codes 90c, 98c, and 99b).

*CBFI:* a dummy for formal independence of the central bank. Specifies a value of 1 (0 otherwise) for a year in which any month is covered by central bank formal independence. Formal independence is attained when a central bank is established as a legally independent or autonomous state institution. Source: country sources; J.P. Morgan, "Guide to Central Bank Watching."

*CBGI:* a dummy for goal independence of the central bank. Specifies a value of 1 (0 otherwise) for a year in which any month is covered by central bank goal independence. Goal independence is attained when the central bank alone determines the levels for its monetary policy targets (that is, the exchange rate, monetary growth, and inflation targets). When target levels are determined separately by the government or

congress, jointly by the bank and either government or congress, or by a government representative who casts votes on central bank board decisions, the central bank is considered goal dependent. Source: country sources; J.P. Morgan, "Guide to Central Bank Watching."

*CBII:* a dummy for instrument independence of the central bank. Specifies a value of 1 (0 otherwise) for a year in which any month is covered by central bank instrument independence. Instrument independence is attained when the central bank freely sets its instrument in its pursuit of monetary policy goals. When central bank policy decisions are either subject to government approval or can be reversed by the government, instrument independence is not in place. Source: country sources; J.P. Morgan, "Guide to Central Bank Watching;" Schaechter, Stone, and Zelmer (2000).

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# Does Inflation Targeting Make a Difference?

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Inflation targeting is the new kid on the block of monetary regimes. Since New Zealand and Chile first adopted the regime in 1990, a growing number of industrial and developing countries have followed suit, anchoring their monetary policy to explicit targets for inflation. Even the Deputy Chairman of the Federal Reserve System recently suggested introducing inflation targeting in the United States (Meyer, 2001).

Does the adoption of inflation targeting make a difference? While inflation-targeting countries have reduced their inflation levels, careful evidence provides a more cautious picture. Bernanke and others (1999) show that the adoption of inflation targeting did not make a difference with regard to the cost and speed of price stabilization. Cecchetti and Ehrmann (2002) report that inflation-targeting countries exhibit degrees of inflation aversion that are not higher, on average, than those of nontargeters. Mishkin and Schmidt-Hebbel (in this volume) provide evidence that countries under inflation targeting exhibit some structural differences in comparison with countries under alternative monetary frameworks.

A large number of questions on the results of inflation targeting remain open. How successful have countries been in reducing infla-

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tion? How costly has disinflation been under inflation targeting? Does inflation targeting improve the ability to predict inflation? Does the behavior of the macroeconomy change under inflation targeting? Does inflation targeting change central bank aversion to inflation? Does inflation targeting change central bank behavior? What is the transmission mechanism of inflation targeting? This paper addresses these questions by conducting a wide empirical analysis of the features and effects of inflation targeting, by comparing the performance of countries with and without inflation targets, and by carrying out a case study of Chile, the emerging market economy with the most extensive experience.

Section 1 introduces the sample of inflation targeters used in this paper and compares their performance with that of other groups of countries, focusing on their success in meeting inflation targets, sacrifice ratios, and output volatility. Section 2 investigates whether inflation targeting improves the ability to predict inflation by studying differences in vector autoregression (VAR) structures between targeters and nontargeters. Section 3 studies whether the behavior of the macroeconomy changes under inflation targeting. Section 4 draws on the methodology of Cecchetti and Ehrmann (2002) to analyze whether central banks' degree of aversion toward inflation is different among targeters and nontargeters. Section 5 examines whether inflation targeting changes central bank behavior. Section 6 outlines the experience of Chile, the emerging market economy that introduced inflation targeting in 1990. Section 7 summarizes the main conclusions.

## 1. Differences among Inflation Targeters and Nontargeters

Much recent work describes the design features and general results of inflation targeting in the small but quickly growing number of countries that have adopted inflation targeting since 1990.[1] In this section we complement this literature by describing the sample of inflation targeters and comparing their performance with that of other country groups. We focus, in particular, on their inflation performance and success in meeting their targets, as well as on their output sacrifice and output volatility.

1. See, in particular, Leiderman and Svensson (1995); Mishkin and Posen (1997); Bernanke and others (1999); Kuttner and Posen (1999); Haldane (1999); Mishkin (2000); Mishkin and Savastano (2000); Schaechter, Stone, and Zelmer (2000); Agénor (in this volume); Mishkin and Schmidt-Hebbel (in this volume).

## 1.1 Who Targets Inflation?

Inflation targeting is based on the central bank's commitment to attaining a publicly announced quantitative inflation target over the relevant policy horizon. Its two crucial prerequisites are absence of fiscal dominance and absence of conflict with other nominal policy objectives. Central bank independence, policy transparency, and central bank accountability to political bodies and society at large strengthen the exercise of constrained discretion under inflation targeting (Bernanke and others, 1999).

While the literature exhibits a broad consensus on this general definition of inflation targeting, it is still controversial to apply this definition to identify an empirically relevant sample of inflation targeting experiences. The reason for disagreement on sample selection and the start dates for inflation-targeting regimes is that the adoption of inflation targeting has been more evolutionary than revolutionary. Most countries have adopted this new monetary framework gradually, learning over time and from other countries what exactly defines a full-fledged inflation targeting framework.

According to Schaechter, Stone, and Zelmer (2000), thirteen countries had implemented full-fledged inflation-targeting regimes as of February 2000: Australia, Brazil, Canada, Chile, the Czech Republic, Finland, Israel, New Zealand, Poland, South Africa, Spain, Sweden, and the United Kingdom. Of these, Finland and Spain abandoned inflation targeting in January 1999 when they joined the European Monetary Union (EMU). We follow Schaechter, Stone, and Zelmer in classifying countries, though not always in dating the start of inflation-targeting experiences. We also add two recent newcomers to their thirteen countries, namely, Korea and Thailand, thus including fifteen full-fledged inflation-targeting countries through August 2000.

For our empirical analysis of the 1980–99 period, we introduce three country groups. Group 1 comprises nine countries that had inflation targeting in place by 1995 (called inflation targeters). This group is divided into two subsamples: two emerging countries that are transition inflation targeters, in the sense that they started inflation targeting at inflation levels substantially above stationary levels (Chile and Israel) and seven industrial countries that are stationary inflation targeters, in the sense that they started inflation targeting at inflation levels close to stationary levels (Australia, Canada, Finland, New Zealand, Spain, Sweden, and the United Kingdom).

Group 2 includes four emerging economies that were on their way to inflation targeting in the 1990s, that is, countries that recently

adopted inflation targeting or that currently have a partial inflation-targeting framework in place. These are Colombia, Korea, Mexico, and South Africa. We call these countries potential inflation targeters in view of their transition toward inflation targeting in the 1990s.[2]

Group 3 is a set of control countries encompassing ten industrial economies that are not inflation targeters: Denmark, France, Germany, Italy, Japan, the Netherlands, Norway, Portugal, Switzerland, and the United States. These countries have no explicit inflation targets in place; in the case of EMU members, they adopted the euro after targeting their exchange rates to the deutsche mark for most of the 1990s.[3] We label this control group nontargeters.

Figure 1 depicts the adoption dates and inflation rates at adoption for twenty-one countries that had inflation-targeting experiences as of August 2001: our thirteen sample countries, four countries that were omitted from our sample (Brazil, the Czech Republic, Peru, and Poland), and four countries that adopted inflation targeting very recently (Iceland, Norway, Switzerland, and Thailand).[4] The following facts are apparent from inspection of figure 1.

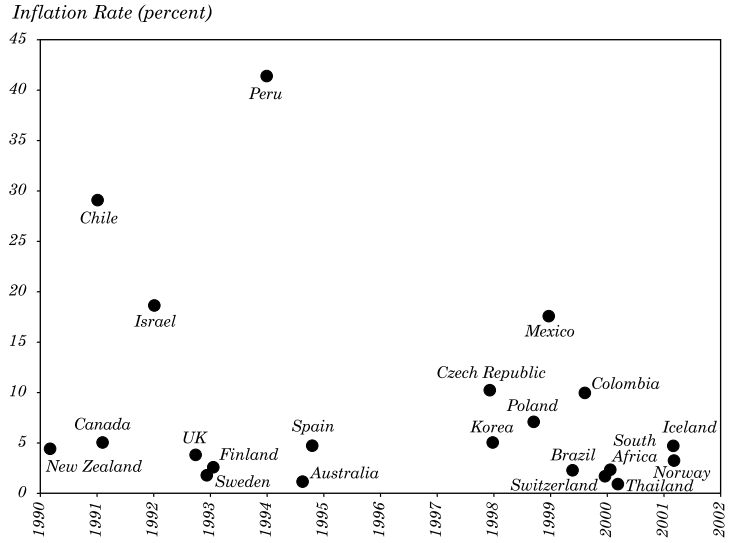
Among the nineteen countries that had inflation targeting in place as of August 2001, eight are industrial countries and eleven are emerging economies. About four countries per year have adopted inflation targeting since 1998. A salient feature of the international inflation-targeting experience is that many emerging countries adopted inflation targeting when they were still at inflation levels well above stationary inflation rates. In Chile and Israel, inflation stood at 29 percent and 19 percent, respectively, when inflation targeting was adopted in the early 1990s. In more recent cases of inflation-targeting adoption, Colombia and Mexico had initial inflation rates of 10 percent and 18

2. Because of data problems, we omitted from this group three full-fledged inflation targeters that were, for example, included in the samples of inflation-targeting countries in Schaechter, Stone, and Zelmer (2000) and Mishkin and Schmidt-Hebbel (in this volume). Brazil was not included because of its hyperinflation experience in the 1980s and early 1990s, while the Czech Republic and Poland were omitted owing to lack of information for the 1980s.

3. Because our empirical analysis is carried out through 1999, the control group of nontargeters includes Switzerland, which adopted inflation targeting in December 2000, and Norway, which adopted inflation targeting in March 2001.

4. Start dates are defined by the first month of the first period for which inflation targets were previously announced. For example, the start date for Chile is January 1991, that is, the first month of calendar year 1991, for which the first inflation target was announced in September 1990. The initial inflation level is defined as the year-on-year consumer price index inflation rate of the last quarter before the first month of inflation targeting (1990:4 in the case of Chile).

**Figure 1. Inflation at Adoption of Inflation-Targeting Framework in Twenty-One Countries, 1990–2001[a]**




Source: Authors' calculations, based on data from IFS, country sources, and Schaechter, Stone, and Zelmer (2000).
a. Inflation attained one quarter before the adoption of inflation targeting.

percent, respectively, Korea had initial inflation close to 5 percent, and Brazil and South Africa had initial inflation close to 3 percent.[5] The subsequent success of emerging countries in bringing inflation toward low stationary levels is prima facie evidence that inflation targeting can be successfully employed to reduce inflation from low double-digit levels toward low single-digit rates, as discussed in the next section.

## 1.2 Countries' Success under Inflation Targeting

We measure the success of inflation targeting in three simple dimensions: the reduction of inflation shortly before and after adopting inflation targeting, the speed at which inflation was brought down from the start of inflation targeting through the attainment of stationary inflation, and the average deviation of inflation outcomes from target levels.

5. Inflation attained one quarter before the adoption of inflation targeting.

## Table 1. Alternative Measures of Initial Disinflation in Inflation-Targeting Countries

| *Country* | *(t – 1 to t + 1)* | *(t – 2 to t + 1)* | *(t – 3 to t + 1)* |
|---|---|---|---|
| Australia | 0.9 | –1.3 | –5.4 |
| Canada | –3.3 | –3.5 | –2.5 |
| Colombia[a] | –17.5 | –16.0 | –17.3 |
| Chile | –10.6 | –1.6 | 0.8 |
| Finland | –1.5 | –3.0 | –5.0 |
| Israel | –8.1 | –6.2 | –9.3 |
| Korea | –3.6 | –4.1 | –3.7 |
| Mexico[a] | –8.7 | –13.4 | –27.2 |
| New Zealand | –5.8 | –4.7 | –14.1 |
| Spain | –1.2 | –1.0 | –2.4 |
| Sweden | –0.1 | –7.1 | –8.3 |
| South Africa[a] | –1.4 | –3.1 | –4.8 |
| United Kingdom | –1.3 | –3.9 | –7.0 |
| **Average** | **–4.8** | **–5.3** | **–8.2** |

Source: Authors' calculations, based on data from International Financial Statistics (IFS) and J.P. Morgan.
a. Based on projected inflation.

## Table 2. Convergence to Stationary Inflation under Inflation Targeting, 1989–2000[a]

| *Country* | *Initial inflation* | *Date* | *Final inflation* | *Date* | *Quarters of convergence* | *Inflation change* | *Average inflation per quarter* |
|---|---|---|---|---|---|---|---|
| **Inflation targeters** | | | | | | | |
| Australia | 1.2 | 1993:1 | 1.2 | 1993:1 | 0 | 0.0 | — |
| Canada | 4.9 | 1990:4 | 1.6 | 1992:1 | 5 | –3.3 | –0.7 |
| Chile | 29.0 | 1990:4 | 2.5 | 1999:4 | 36 | –26.5 | –0.7 |
| Finland | 2.5 | 1992:4 | 2.0 | 1993:3 | 3 | –0.5 | –0.2 |
| Israel | 18.5 | 1991:4 | 1.9 | 1999:4 | 24 | –16.7 | –0.7 |
| New Zealand | 4.4 | 1989:2 | 2.8 | 1991:2 | 8 | –1.6 | –0.2 |
| Spain | 4.7 | 1994:3 | 1.6 | 1997:2 | 11 | –3.1 | –0.3 |
| Sweden | 1.8 | 1992:4 | 1.8 | 1992:4 | 0 | 0.0 | — |
| United Kingdom | 3.6 | 1992:3 | 1.8 | 1993:1 | 2 | –1.8 | –0.9 |
| **Average** | **7.8** | | **1.9** | | **9.9** | **–5.9** | **–0.5** |
| **Potential inflation targeters** | | | | | | | |
| Colombia | 10.0 | 1999:2 | 10.6 | 2000:2 | 4 | 0.6 | 0.2 |
| Korea | 5.1 | 1997:4 | 0.7 | 1999:1 | 5 | –2.4 | –0.5 |
| Mexico | 17.6 | 1998:4 | 10.6 | 2000:1 | 5 | –7.0 | –1.4 |
| South Africa | 2.0 | 1999:4 | 2.0 | 1999:4 | 0 | 0.0 | — |
| **Average** | **8.7** | | **6.0** | | **3.5** | **–2.2** | **–0.6** |
| **Overall average** | **8.1** | | **3.2** | | **7.9** | **–4.8** | **–0.5** |

Source: Authors' calculations, based on data from IFS, country sources, and Schaechter, Stone, and Zelmer (2000).
a. Convergence refers to most recent available observation. Stationary inflation for countries that do not explicitly announce a long-term inflation target is defined as inflation attained by industrial countries (2–3 percent).

A general feature of inflation targeting is that countries prepare for its adoption by reducing inflation around the implementation date (noted as year $t$ in table 1). This feature is generally observed throughout the sample, including among inflation targeters and potential inflation targeters, industrial and emerging economies, and transition and stationary targeters. Depending on the selected period, thirteen inflation targeters reduced inflation rates by measures ranging, on average, from 5.3 percent (between years $t - 2$ and $t + 1$) to 8.2 percent (between years $t - 3$ and $t + 1$). Our sample of inflation targeters reduced inflation by 5.9 percent, on average, in the period from three years before to one year after the adoption date and by 3.4 percent from one year before to one year after the adoption date. Similar results are observed in the sample of potential inflation targeters, which reduced inflation, on average, by 13.3 percent and 7.8 percent during the two periods.

Table 2 displays the speed of convergence to stationary inflation among inflation targeters and potential inflation targeters. The nine inflation targeters reached stationary inflation levels in ten quarters, on average. Chile and Israel had the longest transition periods (thirty-six and twenty-four quarters, respectively), which is not surprising considering their high initial inflation rates. Australia and Sweden represent the other extreme, as they adopted inflation targeting when they had already attained stationary inflation.

Inflation targeters have been successful in meeting their targets (see table 3). As measured by the average relative deviation of actual annual inflation from target inflation, the nine inflation-targeting countries missed only 12 basis points, on average, a figure that rises to 66 basis points when considering the average absolute deviation. Canada, the United Kingdom, and Chile were closest to target, while Israel, Sweden, and Finland scored the highest deviations. Similar results are obtained when scaling relative and absolute deviations to annual inflation rates, which is a necessary correction to account for large country differences in inflation levels during transition to stationary inflation. Using this alternative measurement, Israel and Spain join Chile and the United Kingdom as the countries that were most on target, while Finland, Australia, and Sweden show the largest deviations.

## 1.3 The Cost of Disinflation under Inflation Targeting

A straightforward measure of the costs of disinflation under inflation targeting is the sacrifice ratio—that is, the percentage output loss

**Table 3. Annual Average Deviation of Actual from Target Inflation under Inflation Targeting, 1989–2000[a]**

| | *Percentage points* | | *As a ratio to current inflation* | |
|---|---|---|---|---|
| *Country* | *Relative* | *Absolute* | *Relative* | *Absolute* |
| **Inflation targeters** | | | | |
| Australia | –0.18 | 1.13 | 1.25 | 1.44 |
| Canada | –0.15 | 0.20 | –0.60 | 0.67 |
| Chile | –0.12 | 0.40 | –0.08 | 0.12 |
| Finland | –0.69 | 0.69 | –2.12 | 2.12 |
| Israel | 0.46 | 1.62 | 0.02 | 0.14 |
| New Zealand | 0.06 | 0.40 | –0.08 | 0.25 |
| Spain | 0.15 | 0.45 | –0.01 | 0.21 |
| Sweden | –0.71 | 0.71 | 1.05 | 1.05 |
| United Kingdom | 0.09 | 0.31 | 0.00 | 0.12 |
| **Average** | **–0.12** | **0.66** | **–0.06** | **0.68** |
| **Potential inflation targeters** | | | | |
| Colombia | –5.23 | 5.23 | –0.54 | 0.54 |
| Korea | –2.30 | 2.30 | –0.71 | 0.71 |
| Mexico | –0.68 | 0.68 | –0.06 | 0.06 |
| South Africa | n.a. | n.a. | n.a. | n.a. |
| **Average** | **–2.74** | **2.74** | **–0.44** | **0.44** |
| **Overall Average** | **–0.78** | **1.18** | **–0.16** | **0.62** |

Source: Authors' calculations, based on data from IFS, country sources, and Schaechter, Stone, and Zelmer (2000).
a. Subperiods vary by country. Relative (absolute) deviation: sum of relative (absolute) deviations divided by number of periods. Relative (absolute) deviation as a ratio to current inflation: sum of relative (absolute) deviations as ratios to inflation divided by number of periods. The inflation target is defined as either a range or a point, depending on the inflation-targeting framework.

per percentage unit of inflation reduction. Table 4 computes sacrifice ratios for gross domestic product (GDP) and industrial production and for inflation targeters and potential inflation targeters, using the period ranging from three years before to one year after the adoption of inflation targeting (as represented in table 1).[6] Among the nine inflation targeters, the sacrifice ratio averaged 0.60 (based on GDP), 6.6 (based on industrial output), and 3.1 (based on industrial output but excluding Chile and Spain, two large outliers). Among five potential inflation targeters, the sacrifice ratio averaged –0.4 when using GDP and –0.2 when using industrial production. Country dispersion is moderate when using GDP and high when using industrial production, ranging from –2.3 to 2.5 and from –4.2 to 23.3, respectively.

6. Sacrifice ratios were computed as ratios of the sum of deviations of potential from actual output divided by the reduction in consumer price index inflation. They were based on annual frequency for GDP-based measures and quarterly data for industrial-output-based measures. Average sacrifice ratios based on industrial output are calculated with and without two large outliers (Chile and Spain).

## Table 4. Sacrifice Ratios during Inflation Stabilization with Inflation Targeting, 1980–2000[a]

| *Inflation targeters* | | | *Potential inflation targeters* | | |
|---|---|---|---|---|---|
| *Country* | *GDP* | *Industrial production* | *Country* | *GDP* | *Industrial production* |
| Australia | 1.1 | 3.3 | Colombia | 0.2 | 1.8 |
| Canada | –2.3 | –4.2 | Korea | 0.4 | 1.7 |
| Chile | –0.4 | 23.3 | Mexico | –0.0 | –2.7 |
| Finland | 2.4 | 6.2 | South Africa | –2.3 | –1.5 |
| Israel | 0.6 | 4.6 | | | |
| New Zealand | 0.2 | –2.1 | | | |
| Spain | 2.5 | 18.2 | | | |
| Sweden | 0.6 | 6.6 | | | |
| United Kingdom | 0.9 | 3.8 | | | |
| **Average** | **0.6** | **6.6** | **Average** | **–0.4** | **–0.2** |

Source: Authors' calculations, based on data from IFS and country sources.
a. Based on annual GDP and quarterly industrial production data; subperiods vary by country. Sacrifice ratios calculated as cumulative GDP (industrial production) variation (to a trend calculated by a Hodrick-Prescott filter) divided by inflation change between three years before and one year after the year in which inflation targeting was adopted.

## Table 5. GDP-Based Sacrifice Ratios during Inflation Stabilization, 1980–2000[a]

| *Inflation targeters* | | | *Potential inflation targeters* | | *Nontargeters* | |
|---|---|---|---|---|---|---|
| *Country* | *Before* | *After* | *Country* | *1990s* | *Country* | *1990s* |
| Australia | –1.41 | 0.01 | Colombia | 0.00 | Denmark | 0.90 |
| Canada | –6.84 | 0.64 | Korea | 0.15 | France | –0.45 |
| Chile | 0.37 | –0.7 | Mexico | –3.06 | Germany | –0.12 |
| Finland | 0.03 | –4.74 | South Africa | –5.69 | Italy | 0.25 |
| Israel | 0.17 | –0.14 | | | Japan | 1.46 |
| New Zealand | –0.67 | 0.22 | | | Netherlands | 1.47 |
| Spain | –0.85 | 0.82 | | | Norway | –0.87 |
| Sweden | 0.08 | 0.22 | | | Portugal | –0.39 |
| United Kingdom | 0.75 | 0.02 | | | Switzerland | 0.87 |
| | | | | | United States | 0.78 |
| **Average[b]** | **–0.22** | **0.06** | **Average** | **–2.15** | **Average** | **0.39** |

Source: Authors' calculations, based on data from IFS and country sources.
a. Based on annual GDP data; subperiods vary by country among inflation targeters. Sacrifice ratios are calculated as the cumulative GDP variation (to a trend calculated by a Hodrick-Prescott filter) divided by inflation change in any disinflation period. Inflation targeters' sacrifice ratios are calculated before and after the adoption of the inflation-targeting framework, with the former period measured from 1980 to the year of adoption. Outlier observations are excluded.
b. Excluding Canada and Finland.

**Table 6. Industrial Production Sacrifice Ratios during Inflation Stabilization, 1986–2000[a]**

| *Inflation targeters* | | | *Potential inflation targeters* | | *Nontargeters* | |
|---|---|---|---|---|---|---|
| *Country* | *Before* | *After* | *Country* | *1990s* | *Country* | *1990s* |
| Australia | –1.3 | 0.1 | Colombia | –0.1 | Denmark | –0.8 |
| Canada | –1.2 | 1.4 | Korea | –0.4 | France | –1.2 |
| Chile | –0.5 | –0.6 | Mexico | –0.6 | Germany | 3.0 |
| Finland | 3.2 | –4.5 | South Africa | –2.9 | Indonesia | –3.3 |
| Israel | 3.5 | 0.0 | | | Italy | 3.7 |
| New Zealand | –0.2 | –0.2 | | | Japan | 2.8 |
| Spain | 1.8 | –4.9 | | | Netherlands | 3.7 |
| Sweden | 0.0 | –2.2 | | | Norway | –0.7 |
| United Kingdom | –0.8 | 0.3 | | | Portugal | –0.1 |
| | | | | | Switzerland | 2.0 |
| | | | | | United States | –0.7 |
| **Average** | **0.5** | **–1.2** | **Average** | **–1.0** | **Average** | **1.2** |

Source: Authors' calculations, based on data from IFS and country sources.

a. Based on quarterly industrial production data; subperiods vary by country. Sacrifice ratios are calculated as the cumulative Industrial Production variation (to a trend calculated by a Hodrick-Prescott filter) divided by inflation change in any disinflation period. Inflation targeters' sacrifice ratios are calculated before and after the adoption of the inflation-targeting framework, with the former period measured from 1980 to the year of adoption. Outlier observations are excluded.

An alternative method is to compare sacrifice ratios for disinflation periods under inflation targeting with sacrifice ratios before adopting inflation targeting in the same country group and with comparable sacrifice ratios among potential inflation targeters and nontargeters (tables 5 and 6). Despite large country variation, the set of nine inflation targeters does not demonstrate a clear difference in GDP-based sacrifice ratios before and after the adoption of inflation targeting. Excluding outliers, average sacrifice ratios before and after adoption are –0.2 and 0.1, respectively. These figures are lower than the average sacrifice ratio of 0.5 recorded by nontargeters during disinflation periods in the 1990s and substantially larger than the average figure of –2.2 observed among potential inflation targeters (table 5).

A different result emerges, however, when using industrial production. On average, sacrifice ratios after the adoption of inflation targeting were highly negative (–1.2) among inflation targeters and hence much lower than those recorded by the same country group before the adoption of inflation targeting (0.5). They were also lower than the average sacrifice ratios observed among nontargeters (1.2) and potential inflation targeters (–1.0). This result represents preliminary evidence suggesting that inflation targeting contributed to lowering output costs

**Table 7. Output Volatility, 1980–2000[a]**

| *Inflation targeters* | | | *Potential inflation targeters* | | | *Nontargeters* | |
|---|---|---|---|---|---|---|---|
| *Country* | *Before* | *After* | *Country* | *Before* | *After* | *Country* | *1990s* |
| Australia | 2.8 | 1.2 | Colombia | 4.5 | — | Denmark | 2.8 |
| Canada | 4.4 | 2.2 | Korea | 3.6 | 9.4 | France | 1.6 |
| Chile | 6.2 | 3.1 | Mexico | 4.0 | — | Germany | 2.4 |
| Finland | 3.1 | 2.5 | South Africa | 3.2 | — | Italy | 2.3 |
| Israel | 2.9 | 1.7 | | | | Japan | 3.3 |
| New Zealand | 3.4 | 3.1 | | | | Netherlands | 2.2 |
| Spain | 2.4 | 1.7 | | | | Norway | 2.8 |
| Sweden | 3.1 | 3.4 | | | | Portugal | 10.8 |
| United Kingdom | 2.4 | 1.3 | | | | Switzerland | 2.8 |
| | | | | | | United States | 2.3 |
| **Average** | **3.4** | **2.2** | **Average** | **3.8** | **9.4** | **Average** | **3.3** |

Source: Authors' calculations, based on data from IFS and country sources.
a. Based on quarterly industrial production data; subperiods vary by country. Volatility is calculated as standard deviation of industrial production variation (to a trend calculated by a Hodrick-Prescott filter).

of inflation stabilization, at least when considering higher-frequency measures of industrial output (table 6).

A related result is obtained with output volatility. We compare the volatility of industrial output before and after the adoption of inflation targeting in nine inflation targeters and only one potential inflation targeter (see table 7). Output volatility fell in eight of the nine countries, and in six of them the reduction in the standard deviation of industrial output was significant at least at the 10 percent level. Output volatility among inflation targeters is similar to that observed among nontargeters during the 1990s.

## 2. Inflation Targeting and the Ability to Predict Inflation

In countries that have introduced inflation targeting to converge to steady-state levels of inflation, inflation targets carry information on the monetary stance of the central bank. The announcement of the inflation target should be news for the market, and inflation expectations should be affected by the target set by the bank. The target signals how aggressive disinflation will be during the relevant period, acting as a coordination mechanism and a commitment device. As a coordination mechanism, central bank announcement of the inflation target could contribute to lowering the inflation forecast error since agents

benefit from lower uncertainty regarding the parameters of the economy in which they are operating. The target carries less information in countries that are close at steady-state inflation than in those that are converging to steady-state levels. However, the credible commitment of the monetary authority to a numerical target may also contribute to better coordination among agents and markets. For example, announcing inflation targets may reduce agents' reaction to inflation news or the dependence of specific prices on formal or informal indexation mechanisms, thereby aligning expectations closer to central bank actions.

In this section, we estimate country VAR models, show differences in VAR structures between inflation targeters and nontargeters, and report how one-step-ahead inflation forecast errors (constructed from the country VARs) have evolved over time in the three country groups. We have put together a database of quarterly data for the period 1980–99 for five relevant macroeconomic variables: industrial production (IP)[7] , money (M), consumer prices (CPI), interest rates (IR), and the nominal exchange rate (NER). To avoid estimating different cointegration structures for different countries, we specify all variables (except the interest rate) as deviations from a potentially nonstationary trend measured by the standard Hodrick-Prescott filter.[8]

We assume that the structure of the economy can be adequately described by a nonstructural vector autoregressive simultaneous equation system. We run a comprehensive model, common to all economies, described by the stationary components of their major macroeconomic variables. The unrestricted VAR is based on five endogenous variables ordered from more to less endogenous: CPI, IP, M, NER, IR.[9] We also include two exogenous variables: international interest rates and oil prices. The inflation equation of the VAR is used to generate a one-period-ahead out-of-sample forecast of inflation, which is our proxy of inflation expectations. To make robust inferences, we estimate two types of VARs, namely, a seven-year moving window and a recursive estimation based on additional sample information.

7. We use industrial production to construct a measure of the output gap because of the availability of quarterly data for some of our emerging market economies.

8. The filter is estimated with a 1600 penalty parameter on the second derivative of the trend. Each variable is measured as the logarithmic deviation from trend, which allows us to focus on the relationships among the stationary components of the set of macroeconomic variables. In the case of industrial production, the resulting series is an approximation of the gap between actual and potential output; in the case of inflation the resulting series is a deviation from trend inflation.

9. In other words, the short-term interest rate is the most exogenous variable. We assume this rate is closely aligned with the policy interest rate of the central bank.

As discussed above, we take central banks' declared inflation-targeting start dates at face value. Although true inflation-targeting regime requires high credibility that is only built up over time, we do not attempt to measure credibility in this paper. However, all the statistics that we generate are dynamic in that they are generated from rolling or recursive VARs, which allows economic structures to change over time as we add more periods under an inflation targeting regime.[10]

Our VAR results are used for generating inflation deviation forecasts for each country, based on the rolling or recursive estimations.[11] We use four lags in the estimations, which come from the rolling and recursive estimations using the Akaike, Schwartz, and Hannan-Quinn information criteria for each country.[12]

To assess the effect of the inflation-targeting regime on the formation of inflation expectations, we generate the square of the forecast errors from the VARs and average them across inflation targeters and nontargeters. To control for the fact that high inflation forecast errors could be related to high inflation levels, we divide by the trend level of inflation that we have estimated before aggregating by country.[13]

Figures 2 and 3 depict average quadratic inflation forecast errors for different samples of inflation targeters and nontargeters. In panels I, III

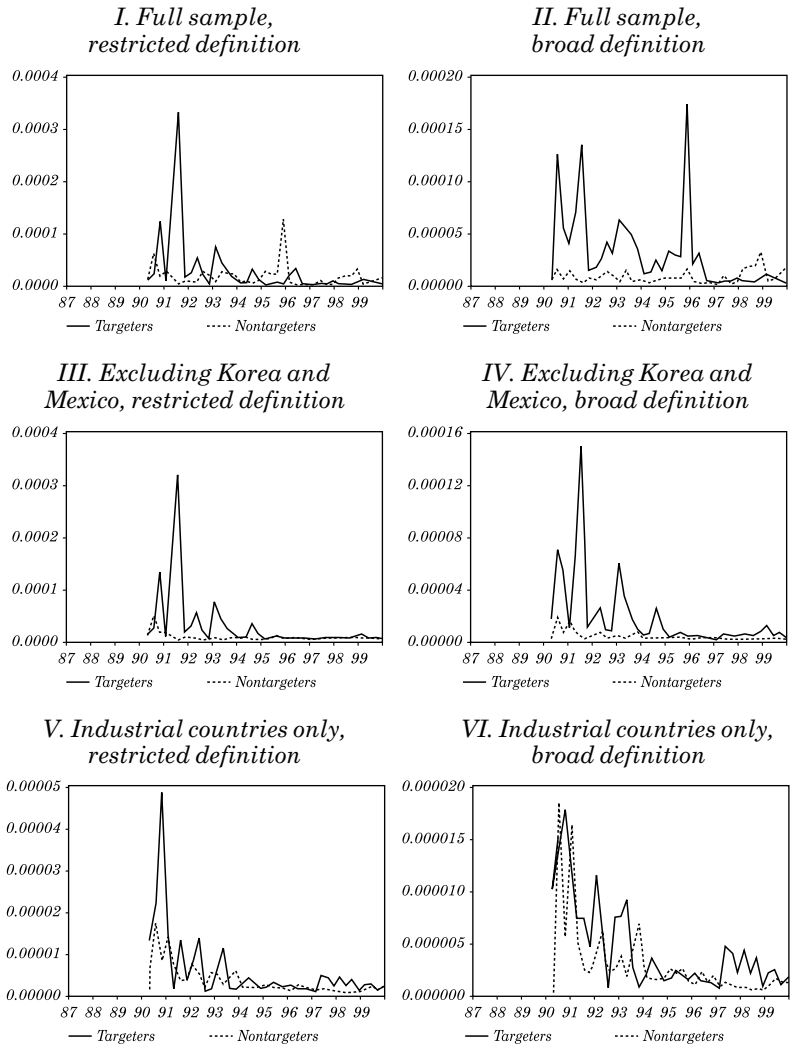
10. It would be conceivable to conduct robustness tests for alternative inflation targeting starting dates or to test whether the results hold when countries shift from potential inflation targeting to inflation targeting categories at different dates. This would be equivalent to testing for the date at which the countries became full-fledged inflation targeters, with full credibility in the new regime. Such dating is nearly impossible to establish, however, as it would require a nearly infinite number of dating combinations for the large number of countries and potential dates to be included in our sample.

11. The dynamic properties and thus the importance of characteristics such as the ordering of the endogenous variables become relevant in the following sections.

12. The Kullback-Liebler distance is a measure of the distance from the maximum likelihood fit of the model; it is calculated as the sum (the integral) of the deviations of the maximum likelihood function evaluated at the estimated parameters from the true fit. This measure is usually used to evaluate the fit of a time-series model and is usually approximated by the Akaike information criteria (AIC). The AIC is inconsistent in that it picks larger-than-optimal lags. There are many ways to correct this, most commonly by penalizing the number of lags in the statistic. We use two such solutions: the Schwartz (SIC) and the Hannan-Quinn information criteria (HQIC).

13. This exercise is clearly not able to identify the effect of inflation targeting on credibility or the ability of the markets to predict inflation outcomes, which would require an identification strategy that could be consistently applied to all sample countries. We do not develop such a strategy but rather limit ourselves to a simple correlation exercise between inflation forecast errors and adoption of inflation targeting. However, we test for robustness below by changing country samples and the definition of inflation targeters.

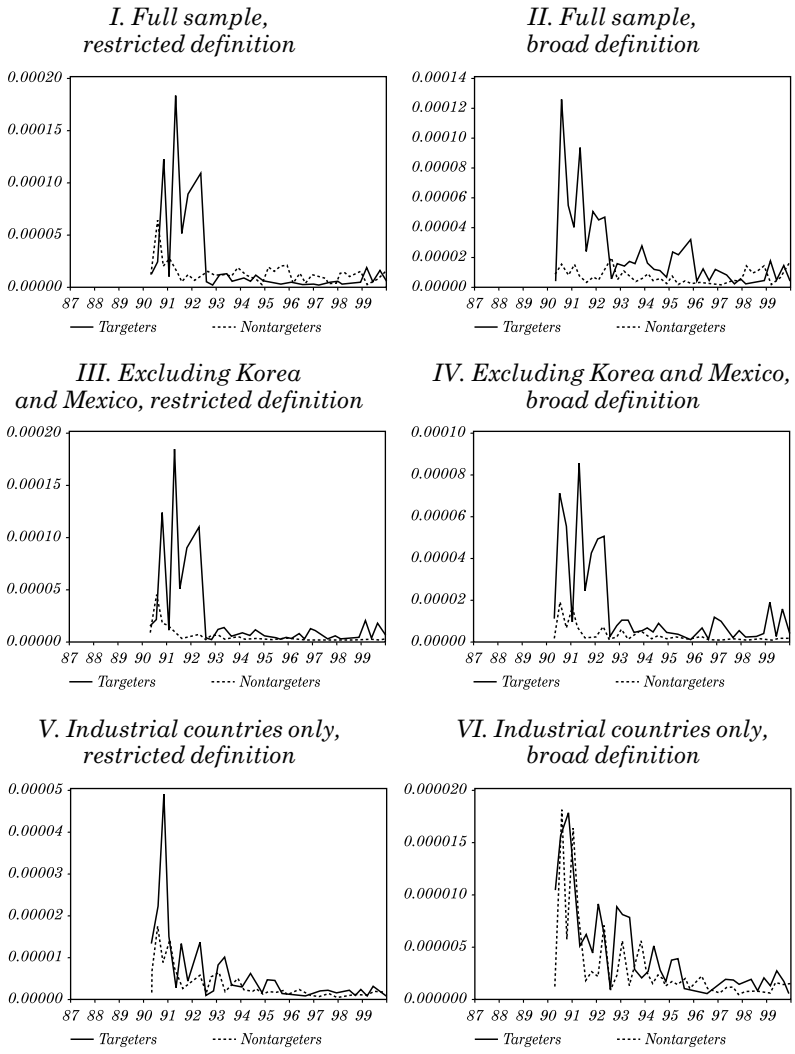
**Figure 2. Average Quadratic Errors of Inflation Deviation Forecasts for Inflation Targeters and Nontargeters, Rolling VARs, 1990–99[a]**




Source: Authors' calculations.

a. Obtained from out-of-sample forecasts of a rolling VAR and divided by the level of trend inflation, based on quarterly data. Under the restricted definition of inflation targeting, an inflation-targeting country is included in the group of targeters only in the periods in which it had inflation targeting in place; in all other periods, it is included among the nontargeters. Under the broad definition, the group of targeters includes every country that had inflation targeting in place during some period in 1980–99.

**Figure 3. Average Quadratic Errors of Inflation Deviation Forecasts for Inflation Targeters and Nontargeters, Recursive VARs, 1990–99[a]**




Source: Authors' calculations.

a. Obtained from out-of-sample forecasts of a recursive VAR and divided by the level of trend inflation, based on quarterly data. Under the restricted definition of inflation targeting, an inflation-targeting country is included in the group of targeters only in the periods in which it had inflation targeting in place; in all other periods, it is included among the nontargeters. Under the broad definition, the group of targeters includes every country that had inflation targeting in place during some period in 1980–99.

and V of each figure, an inflation-targeting country is included in the group of inflation targeters only in the periods in which it had inflation targeting in place; in all other periods, it is included among the nontargeters. In panels II, IV and VI, however, the group of inflation targeters includes every country that had inflation targeting in place during some period in 1990–99. Panels I and II represent the full country sample. Panels III and IV exclude Korea and Mexico because of high volatility during the sample period. Panels V and VI represent an even smaller sample of industrial countries only, thus excluding Chile and Israel.

The results suggest a positive effect of inflation targeting on the accuracy of inflation forecasts. We consistently observe that countries that adopted inflation targeting have converged to a level of accuracy similar to that observed in the control group of nontargeters. This convergence occurred towards 1994, despite the improved accuracy observed in the group of nontargeters. This convergence process was important for non-industrial inflation-targeting countries, such as Chile, Israel, and Mexico. Furthermore, countries converging to steady-state inflation levels—rather than steady-state inflation targeters—enjoyed a bonus of higher accuracy (and presumably more credibility). Inflation targeters thus achieved a significant convergence of inflation expectations to their actual inflation rates in the last decade. The similarity of results reported in figures 2 and 3 supports the robustness of this conclusion.

Most of the time-series structure of the inflation errors has been removed from the VARs on which the quadratic inflation deviation forecast errors are based. We still find, however, that some time-series structure remains in the inflation series for some countries, as indicated by correlograms. Since we are not able to address this problem by including more lags, we filtered the resulting forecast errors by the time-series structure suggested by the correlograms, recalculating the group averages of quadratic inflation deviation forecast errors for inflation targeters and nontargeters. The exercise maintained the results of panels I through V, while the result corresponding to panel VI provides evidence of inflation expectations convergence. Whereas in figures 2 and 3 industrialized inflation targeters and nontargeters exhibit a similar reduction of forecast errors over the 1990s, the exercise showed a clear convergence of inflation targeters to nontargeters, as the latter had already achieved low forecast errors in the early 1990s.

To test the robustness of our results for one-quarter forecasts, we generated similar statistics to those reported in figures 2 and 3 for two to six-quarter forecasts. Our unreported results are similar to those shown above, confirming that the predictability of inflation is improved for the overall

sample that includes emerging economies, for forecasts up to six quarters ahead. For the sample of industrialized inflation targeters (panel VI in figures 2 and 3), the result continues to stand for two-quarter-ahead forecasts of inflation. It does not hold, however, for longer inflation forecasts (three to six quarters), since inflation forecast errors are very similar for both inflation targeters and nontargeters. This may reflect the larger gains from adopting inflation targeting that accrue to emerging economies, in comparison with those reaped by mature industrialized economies that adopt inflation targeting among other available monetary regimes.

## 3. The Behavior of the Macroeconomy under Inflation Targeting

This section assesses whether inflation targeting has changed the structure of economies and their response to shocks, using the results of dynamic variance decompositions based on the rolling country VARs estimated in the preceding section.[14] We report the average share of the orthogonalized innovation of one variable in the variance of another variable using estimated VAR parameters and the orthogonalized components of each of the endogenous variables.[15] We report aggregate results for our samples of inflation targeters and nontargeters, for two different country samples: the full sample of twenty-three countries listed in section 1.1 and the smaller sample of seventeen industrial countries only (see figures 4 and 5).[16]

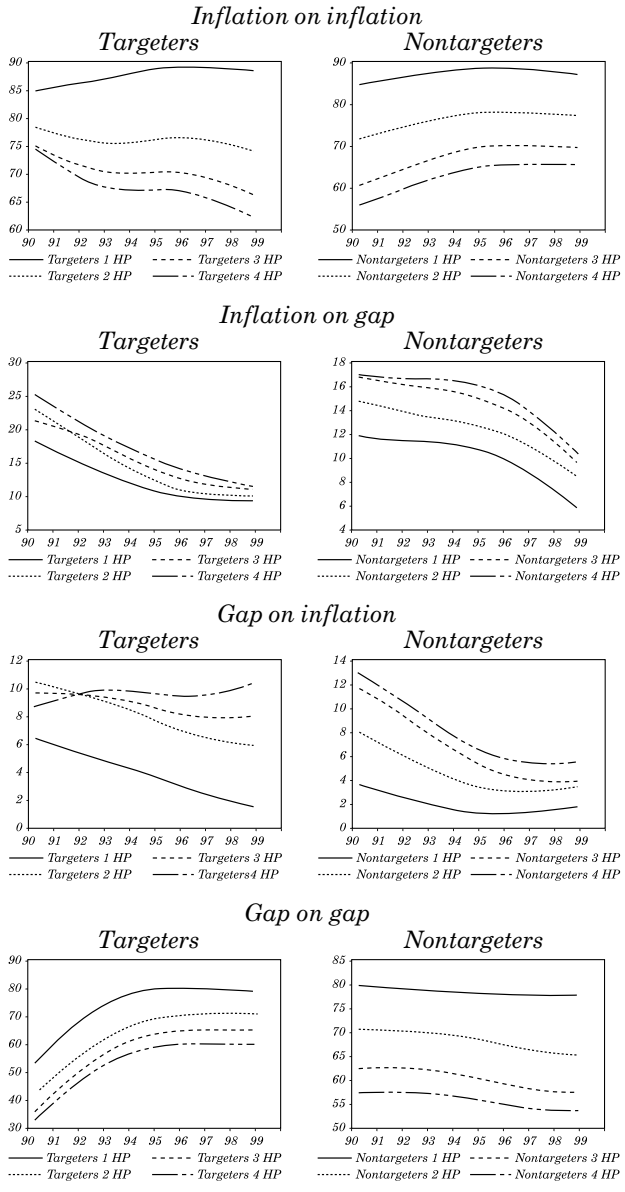
The figures show the shares of orthogonalized innovations in inflation and the output gap in the variance of inflation innovations, considering both own and cross innovations. Each figure separately reports the

14. Since we did not find major differences between rolling VARs and recursive VARs, here we perform the exercise on rolling VARs only to maximize observed changes in economic structure.

15. The variance decomposition presents a dynamic simulation of the estimated system in which a shock to an endogenous variable is separated into the orthogonal component shocks to the endogenous variables of the VAR. As usual, the orthogonalized errors are constructed decomposing the estimated errors according to a Cholesky decomposition of the variance-covariance matrix. The variance decomposition provides information about the relative importance of each random innovation to each variable in the VAR, describing the reduced-form effects and trade-offs that are present in an economy. If the VAR model is an adequate description of the economy, it will provide the reduced-form response of the macroeconomy that combines the interplay of private and public sector actions, including the monetary policy reactions of the central bank.

16. The smaller sample comprises the twenty-three countries listed in section 1.1 less Chile, Colombia, Israel, Korea, Mexico, and South Africa.

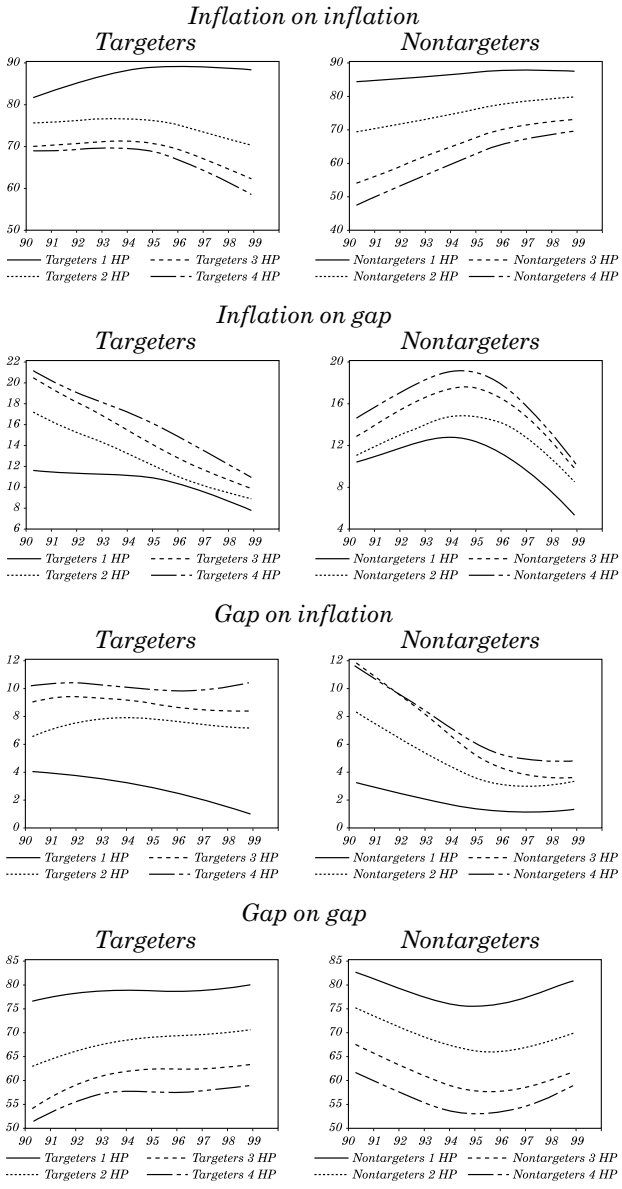
**Figure 4. Dynamic Variance Decomposition for Inflation and Output Gaps, Full Sample, 1990–98[a]**




Source: Authors' calculations.

a. Obtained from out-of-sample forecasts of a rolling VAR, based on quarterly data.

**Figure 5. Dynamic Variance Decomposition for Inflation and Output Gaps, Industrial Countries, 1990–98[a]**




Source: Authors' calculations.

a. Obtained from out-of-sample forecasts of a rolling VAR, based on quarterly data.

dynamic variance decomposition effects for the four different lags included in the VARs. The results for rolling VARs are given for fixed windows of forty quarters (depending on availability of data per country VAR), starting with 1980:1–1989:4 and ending with 1990:1–1999:4.

The results show revealing commonalties and differences across country groups and over time. An innovation in the first inflation lag (reflecting first-order inflation persistence) shows some increase over time but not much difference across country groups of inflation targeters and nontargeters. However, the role of innovations in higher-order lags on inflation has fallen among inflation targeters, on average, but increased among nontargeters—for both sample definitions. This suggests that inflation targeting partly substitutes forward-looking inflation expectations (influenced by the official inflation target) for the backward-looking roots of the inflation process.

We do not find differences between inflation targeters and nontargeters regarding the cross-effects of inflation shocks on output gap variances. In both country groups, the effects are small, and they tended to decrease during the 1990s. More significant differences emerge between both country groups when we examine the opposite cross effect from inflation innovations to output gap variances. Among inflation targeters, a large reduction in the impact of inflation innovations on output variance took place in the 1990s, falling closer to the levels of nontargeters. Inflation targeting may thus have contributed to anchoring inflation expectations and helping to isolate the output gap from inflation innovations.

A third and final difference among country groups is observed in the effect of lagged output gap innovations on the current output gap variance. On average, output persistence increased by a sizable amount at every lag among inflation targeters throughout the 1990s, reaching levels comparable to those of nontargeters, whose output persistence did not change much during the decade.

The effect of innovations in the nominal exchange rate on inflation variance can be interpreted as the reduced-form pass-through from devaluation to inflation. No major differences are observed either at the aggregate level of country samples or over time.[17]

17. Some interesting results were obtained at the country level, however, for the two transition inflation targeters that have converged to steady-state inflation during the 1990s: Chile and Israel. They show a decline in the share of exchange rate innovations in inflation variance during the decade. This result supports the notion that the devaluation-inflation pass-through has declined in both countries during the 1990s, as a result of recent (Chile) or ongoing (Israel) convergence toward a flexible exchange rate regime and the achievement of stationary inflation in both countries.

Finally, no major differences between inflation targeters and nontargeters are observed for the effects of innovations in or on other variables, with the exception of the effects of innovations on interest rates, which are discussed in section 5.

## 4. The Effect of Inflation Targeting on Central Bank Aversion to Inflation

Cecchetti and Ehrmann (2002) develop a simple, useful model to derive and measure the aversion of central bankers to inflation variability relative to their aversion to output variability. By maximizing a standard quadratic loss function subject to linear aggregate supply and aggregate demand equations, they derive the following equation that relates the relative aversion to inflation variability, $\alpha$, to the slope of the aggregate supply curve, $\gamma$, and the variance of inflation, $\sigma_{\pi}^2$, and output, $\sigma_{y}^2$:

$$\frac{\sigma_y^2}{\sigma_\pi^2} = \left( \frac{\alpha}{\gamma(1-\alpha)} \right)^2 . \tag{1}$$

Cecchetti and Ehrmann calculate the inflation-aversion coefficient, $\alpha$, using equation 1 and country data for inflation and output variances and estimating aggregate supply slopes from impulse response functions that derive the output effects of demand shocks. They generate country-by-country results based on quarterly data for the 1980s and 1990s for nine inflation targeters and fourteen nontargeters, On that basis, they conclude that the inflation aversion of inflation targeters is not higher, on average, than in the control group of nontargeters. By using rolling regressions for shorter subsamples, however, they also find that inflation aversion increased significantly in most inflation targeters shortly before, during, or after the adoption of inflation targeting.

When we performed Cecchetti and Ehrmann's calculation for our samples of inflation targeters and nontargeters, we departed from their empirical procedures in four important ways. First, our sample differs from theirs in country composition and time coverage. With regard to the latter, our quarterly sample extends from 1980 through 1999, which is longer than theirs. Second, Cecchetti and Ehrmann define the deviation of inflation (and the corresponding variance) relative to a constant 2 percent annual inflation rate, while we define it as the deviation from an estimated Hodrick-Prescott (HP) trend for nontargeters (as discussed

in section 2) or the deviation from inflation target levels for targeters. This has important consequences for the time-varying measures of inflation variance, as discussed below. Third, we reestimate output supply slopes from impulse response functions based on the country VARs run in section 2 and add alternative estimates based on simple Phillips-curve estimations. Finally, we reestimate inflation and output variances from our country samples.

Our results of cumulative impulse responses of output to interest rate shocks at quarterly leads, ranging from one to thirteen quarters, show a wide range of period and country responses, from large positive to large negative supply slopes. The time averages over the thirteen lead responses for each country (excluding the 5 percent tails of the cross-country time-series distribution) vary between –7.2 (France) and 10.7 (the Netherlands). We rescale the latter ordering linearly to obtain a ranking of output slope coefficients in the range spanned from 0.1 to 6.0.

As an alternative to the previous results we estimate supply slope coefficients from the two following variants of the simple Phillips curve:

$$y\text{GAP}_t = \delta_0 + \delta_1(\pi_t - \pi_{t-1}) \text{ and} \tag{2}$$

$$y\text{GAP}_t = \delta_0 + \delta_1(\pi_t - E_{t-1}\pi_t)\,, \tag{2'}$$

where last period's expectation of current inflation is obtained from our out-of-sample inflation forecasts reported in section 2.

Two measures for the output gap (*y*GAP) were derived, based on the deviations from HP trend levels of GDP and industrial output. The combinations of equations and output measures were estimated by ordinary and two-stage least squares.[18] The sample period extends from 1980 to 1999, using quarterly data. The eight slope coefficients for the corresponding combinations of equations, output measures, and estimation techniques vary widely by estimated equation and country. We again linearly rescaled the averages for each country for the eight estimations (outliers were defined as observations in the 5 percent tails), obtaining slope coefficients in the 0.1 to 6.0 range.

The first four columns in table 8 report supply slope coefficients ($\gamma$) according to four available measures: Cecchetti and Ehrmann's origi-

18. For the two-stage least squares estimations the interest rate was used as the instrument for the inflation deviation, to be consistent with the VAR impulse response estimates.

nal average cross-country measure (2.83); Cecchetti and Ehrmann's original individual country measure for those countries included by Cecchetti and Ehrmann or 2.83 for the excluded countries; our first country measure from VAR impulse responses; and our second country measure from Phillips curves. The output slopes vary considerably across countries. The variation is smaller across our three country groups, although the $\gamma_s$ appear to be consistently higher, on average, in inflation targeters than in potential inflation targeters and nontargeters.

Finally, table 8 also lists the country inflation aversion coefficients ($\alpha$) obtained by applying equation 1, based on the $\gamma_s$ shown in the table and on country output and inflation variances. Our estimates for $\alpha$ are much higher, on average, than Cecchetti and Ehrmann's figures, reflecting the fact that our inflation variance is much lower, as discussed above. The average $\alpha$ is close to 0.91 across different measures and countries. There are no differences in $\alpha_s$ between inflation targeters, potential inflation targeters, and nontargeters, which confirms Cecchetti and Ehrmann's result.

Next we investigate whether the relative aversion to inflation changed over the 1990s. Like Cecchetti and Ehrmann, we focus on time-varying country estimates of inflation aversion coefficients from rolling five-year windows. To minimize contamination from mismeasurement of output supply coefficients, we use a common $\gamma$ for all countries (2.83, obtained directly from Cecchetti and Ehrmann). Our discussion centers on the time pattern of $\alpha_s$ starting about 1990 (and thus with five-year windows before 1991) because much noise characterized policies and outcomes until the mid-1980s.

Inflation aversion rose during the 1990s in many countries across various groups. Among inflation targeters, revealed inflation aversion rose significantly in Chile, Finland, Israel, and Sweden. Inflation aversion also increased significantly among many nontargeters in the 1990s, including Denmark, France, Germany, the Netherlands, Norway, Switzerland, and the United States. Such a trend is not observed among potential inflation targeters; in fact, $\alpha_s$ declined in Brazil and Mexico during the decade. Many of these country results differ significantly from those reported by Cecchetti and Ehrmann.

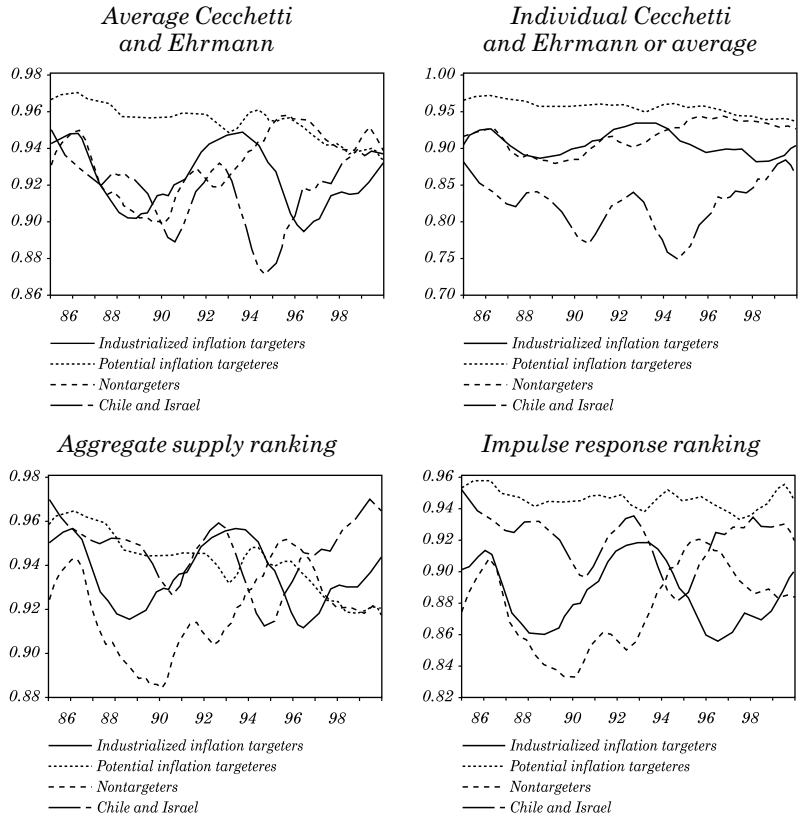
Figure 6 plots aggregate dynamic inflation aversion coefficients ($\alpha$) for four country groups and our four alternative estimates for output supply coefficient $\gamma$, based on five-year estimation windows and our inflation variances. The country group results are quite robust across different $\gamma$ estimates. The average $\alpha$ of the subgroup of industrialized inflation

## Table 8: Estimates of Central Bank Inflation Aversion: Robustness Exercise

| | *Supply slope coefficient ($\gamma$)* | | | | *Inflation aversion coefficients ($\alpha$)* | | | |
|---|---|---|---|---|---|---|---|---|
| *Country* | *Average Cecchetti and Ehrmann* | *Individual Cecchetti and Ehrmann or average* | *Ranking of aggregate supplies* | *Ranking of impulse responses* | *Average Cecchetti and Ehrmann* | *Individual Cecchetti and Ehrmann or average* | *Ranking of aggregate supplies* | *Ranking of impulse responses* |
| **Inflation targeters** | **2.83** | **3.39** | **3.83** | **2.63** | **0.92** | **0.89** | **0.94** | **0.89** |
| Australia | 2.83 | 4.65 | 3.71 | 2.80 | 0.88 | 0.92 | 0.90 | 0.88 |
| Canada | 2.83 | 1.80 | 2.71 | 2.72 | 0.93 | 0.90 | 0.93 | 0.93 |
| Chile | 2.83 | 0.84 | 6.00 | 2.73 | 0.95 | 0.85 | 0.98 | 0.95 |
| Finland | 2.83 | 3.76 | 3.14 | 1.68 | 0.94 | 0.95 | 0.94 | 0.90 |
| Israel | 2.83 | 1.42 | 4.07 | 3.23 | 0.88 | 0.79 | 0.92 | 0.90 |
| New Zealand | 2.83 | 0.67 | 3.25 | 0.60 | 0.92 | 0.74 | 0.93 | 0.72 |
| Spain | 2.83 | 1.22 | 4.59 | 5.65 | 0.96 | 0.90 | 0.97 | 0.98 |
| Sweden | 2.83 | 2.35 | 3.33 | 1.91 | 0.94 | 0.93 | 0.95 | 0.92 |
| United Kingdom | 2.83 | 13.76 | 3.70 | 2.34 | 0.89 | 0.97 | 0.91 | 0.87 |
| **Potential inflation targeters** | **2.83** | **2.83** | **2.77** | **2.18** | **0.94** | **0.94** | **0.94** | **0.93** |
| Colombia | 2.83 | 2.83 | 3.43 | 1.19 | 0.97 | 0.97 | 0.98 | 0.94 |
| Korea | 2.83 | 2.83 | 3.40 | 1.75 | 0.92 | 0.92 | 0.93 | 0.87 |
| Mexico | 2.83 | 2.83 | 1.90 | 2.70 | 0.91 | 0.91 | 0.88 | 0.91 |
| South Africa | 2.83 | 2.83 | 2.34 | 3.07 | 0.97 | 0.97 | 0.97 | 0.98 |
| **Nontargeters** | **2.83** | **3.24** | **2.66** | **2.53** | **0.93** | **0.91** | **0.92** | **0.87** |
| Denmark | 2.83 | 0.70 | 3.29 | 2.32 | 0.94 | 0.80 | 0.95 | 0.93 |
| France | 2.83 | 6.15 | 2.59 | 0.10 | 0.94 | 0.97 | 0.93 | 0.41 |
| Germany | 2.83 | 5.72 | 2.57 | 1.61 | 0.91 | 0.95 | 0.90 | 0.85 |
| Italy | 2.83 | 4.89 | 2.25 | 2.90 | 0.94 | 0.97 | 0.93 | 0.95 |
| Japan | 2.83 | 1.09 | 3.16 | 2.38 | 0.94 | 0.87 | 0.95 | 0.93 |
| Netherlands | 2.83 | 2.03 | 2.96 | 6.00 | 0.91 | 0.88 | 0.91 | 0.95 |
| Norway | 2.83 | 2.83 | 3.10 | 2.73 | 0.93 | 0.93 | 0.94 | 0.93 |
| Portugal | 2.83 | 2.83 | 2.19 | 2.89 | 0.95 | 0.95 | 0.94 | 0.95 |
| Switzerland | 2.83 | 5.08 | 1.42 | 2.52 | 0.92 | 0.95 | 0.86 | 0.91 |
| United States | 2.83 | 1.10 | 3.12 | 1.90 | 0.92 | 0.83 | 0.93 | 0.89 |

Source: Authors' estimations.

**Figure 6. Dynamic Inflation Aversion Coefficients**




Source: Authors' calculations.

targeters does not exhibit any time trend during the 1990s, although there are cyclical swings. However, inflation aversion exhibits an upward trend in the two transition inflation targeters—Chile and Israel—since 1990. Although α declines temporarily in the mid-1990s, which largely reflects a strong temporary decline in Israel, the average α is 4 percentage points higher in the late 1990s than around 1990.

The group of nontargeters also exhibits a trend rise in inflation aversion in the 1990s, and also by a magnitude close to 4 percentage points. The only group that shows a trend decline in their inflation aversion is the potential inflation targeters, by an average total reduction of about 2 percentage points.

Our results for time trends of aversion coefficients are thus strikingly different from Cecchetti and Ehrmann's. Only transition inflation targeters (Chile and Israel) show a trend increase in their $\alpha_s$ during the 1990s. In this respect, they behave similarly to other industrialized nontargeters, rather than to other inflation targeters.

## 5. How Inflation Targeting Affects Central Bank Behavior

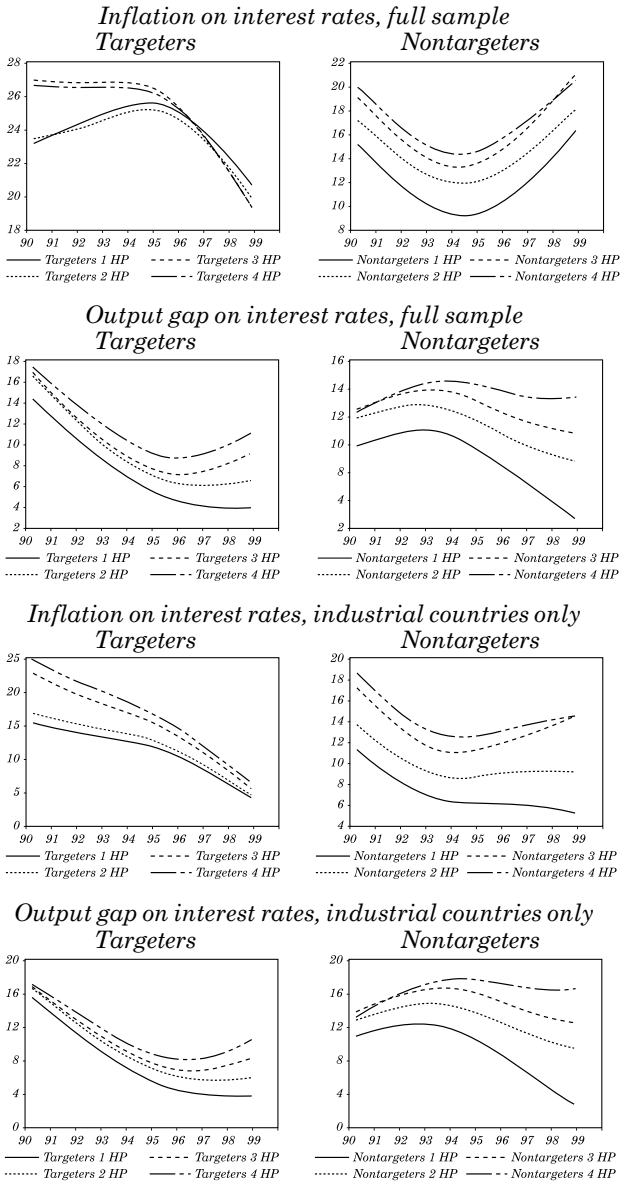
This section analyzes whether the behavior of central banks in setting their policy instrument, namely, the interest rate, differs in inflation targeters and nontargeters. We approach this question from two angles. First, we report the results of inflation and output innovations on the variance of interest rates, based on dynamic variance decompositions performed on the rolling VARs estimated in section 2. Second, we report econometric results for simple Taylor policy rules to infer the weights of inflation and output gaps in the evolution of short-term interest rates.

Figure 7 presents the dynamic variance decomposition for the gap and inflation pressure on the interest rate. The two top panels are for the full samples of inflation targeters and nontargeters, while the two bottom panels are for the industrial-country subsamples of inflation targeters and nontargeters. Inflation targeters were able to lower the reaction of the interest rate to innovations in both inflation and the gap during the 1990s. This result is robust to the inclusion or exclusion of nonindustrial countries in the groups of inflation targeters and nontargeters. It suggests that inflation targeters have gradually gained credibility, which allows them to achieve their inflation targets with gradually smaller changes in interest rates. Among nontargeters, however, the impact of inflation innovations on interest rates did not decline in the 1990s, although they show some decline in the effect of output gap innovations on interest rates at the first and second lags.

Next we estimate a simple Taylor rule consistent with a reduced-form partial-adjustment equation for the reaction of the central bank to inflation and output gaps.[19] This equation is consistent with a central bank that determines its policy rate, r, as a weighted average of the one-period lagged rate and the optimal rate. The latter is a function

19. On the robustness of simple Taylor rules, see Taylor (2000).

**Figure 7. Dynamic Variance Decomposition for Interest Rates, 1990-1998[a]**




Source: Authors' calculations.

a. Obtained from out-of-sample forecasts of a rolling VAR, based on quarterly data.

of both contemporaneous gaps, giving rise to the following reduced-form equation:

$$r_t = \delta_0 + \delta_1 r_{t-1} + \delta_2 \pi \text{GAP}_t + \delta_3 y \text{GAP}_t \quad (3)$$

where $\pi\text{GAP}_t$ (the inflation gap) is the difference between actual and target inflation for inflation targeters and between actual and trend inflation for nontargeters, and $y\text{GAP}_t$ (the output gap) is the difference between actual and trend industrial output. Expected coefficient signs are positive.

Quarterly data for the 1990–99 period are used for each country. Country-by-country ordinary least squares (OLS) results for equation 3 are reported in table 9. The only result that is common across most countries is that the lagged quarterly interest rate coefficient is numerically close to 1, reflecting a high degree of monetary policy inertia. There are thus proportionally large differences between short- and long-term effects of the inflation gap and the output gap on interest rates. While most gap coefficients are positive, as expected, they exhibit large cross-country variation in their sizes, and not many are significantly different from zero.

The interest rate is a nominal rate in all countries, except Chile. In all countries with nominal interest rates, the coefficient of the short-term inflation gap is smaller than 1, signaling that central banks raise nominal interest rates by less than a contemporaneous increase in inflation. In the case of Chile, the estimated coefficient of less than 1 is consistent with a coefficient of 1 plus the estimate under nominal interest rates. These results are similar to previous findings on Taylor rule estimations for various countries (Restrepo, 1998; Taylor, 2000; Corbo, 2002).

The long-term inflation gap coefficient is positive and significantly different from zero in three inflation targeters (Australia, Israel, and the United Kingdom), four nontargeters (Japan, the Netherlands, Portugal, and the United States), and three potential inflation targeters (Brazil, Colombia, and Korea). Country output gap coefficients are positive in most countries and positive and significantly different from zero in ten countries. Among the three groups, inflation targeters exhibit the largest inflation gap coefficients, on average, relative to the output gap coefficients.

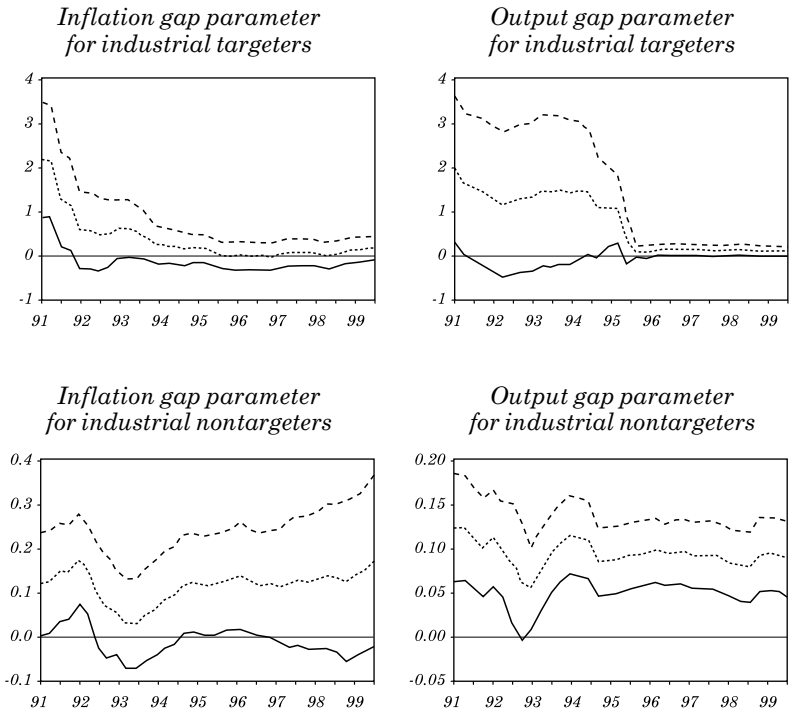
Next we perform rolling estimations of country Taylor rules for ten-year windows. The regressions are performed for the same samples of total inflation targeters and nontargeters for which the variance decompositions for interest rates were reported in figure 7. The inflation

## Table 9. Estimation Results of Simple Taylor Rules for Inflation Targeters and Nontargeters, 1990:1–1999:4[a]

| *Country* | *Lagged interest rate* | *Inflation gap*[b] | *Activity gap*[c] | *Adjusted* $R^2$ |
|---|---|---|---|---|
| **Nontargeters** | | | | |
| Denmark | 0.94* | 0.06 | 0.12 | 0.81 |
| | (0.09) | (0.95) | (0.13) | |
| France | 0.97* | –0.12 | 0.07* | 0.98 |
| | (0.02) | (0.11) | (0.02) | |
| Germany | 0.98* | 0.04 | 0.10* | 0.99 |
| | (0.01) | (0.03) | (0.01) | |
| Italy | 0.94* | 0.27 | 0.02 | 0.85 |
| | (0.08) | (0.32) | (0.09) | |
| Japan | 0.98* | 0.09** | 0.02 | 0.99 |
| | (0.02) | (0.06) | (0.01) | |
| Netherlands | 0.97* | 0.34** | 0.08** | 0.97 |
| | (0.03) | (0.21) | (0.05) | |
| Norway | 0.82* | –0.51 | 0.09 | 0.67 |
| | (0.10) | (0.69) | (0.14) | |
| Portugal | 0.98* | 0.36* | 0.02 | 0.98 |
| | (0.03) | (0.14) | (0.06) | |
| Switzerland | 0.95* | 0.12 | 0.07** | 0.96 |
| | (0.04) | (0.12) | (0.04) | |
| United States | 0.78* | 0.21* | 0.22* | 0.97 |
| | (0.04) | (0.08) | (0.03) | |
| **Inflation targeters** | | | | |
| Australia | 0.79* | 0.17* | 0.09* | 0.98 |
| | (0.03) | (0.06) | (0.04) | |
| Canada | 0.97* | –0.14 | 0.17* | 0.92 |
| | (0.05) | (0.12) | (0.06) | |
| Chile | 0.65* | 0.68 | 0.00 | 0.40 |
| | (0.13) | (1.05) | (0.41) | |
| Finland | 0.97* | 0.17 | 0.01 | 0.98 |
| | (0.04) | (0.11) | (0.03) | |
| Israel | 0.71* | 0.23* | –0.19 | 0.80 |
| | (0.08) | (0.08) | (0.13) | |
| New Zealand | 0.92* | –0.07 | 0.17* | 0.86 |
| | (0.08) | (0.17) | (0.08) | |
| Spain | 0.99* | 0.27 | 0.05 | 0.97 |
| | (0.03) | (0.25) | (0.05) | |
| Sweden | 0.54* | 0.26 | 0.04 | 0.26 |
| | (0.16) | (0.38) | (0.24) | |
| United Kingdom | 0.87* | 0.27* | 0.04 | 0.97 |
| | (0.04) | (0.11) | (0.08) | |
| **Potential inflation targeters** | | | | |
| Colombia | 0.85* | 0.62* | 0.08 | 0.76 |
| | (0.09) | (0.19) | (0.15) | |
| Korea | 0.68* | 0.56* | 0.09 | 0.60 |
| | (0.15) | (0.28) | (0.09) | |
| Mexico | 0.59* | –0.07 | –0.94 | 0.57 |
| | (0.14) | (0.16) | (0.51) | |
| South Africa | 0.80* | 0.12 | 0.13** | 0.81 |
| | 0.08 | 0.14 | 0.08 | |

Source: Authors' calculations.
a. Standard errors are in parentheses.
b. As a deviation from an HP1600 trend.
c. Annualized deviations from inflation target or an HP1600 trend.
* Significant at the 5 percent level.
** Significant at the 10 percent level.

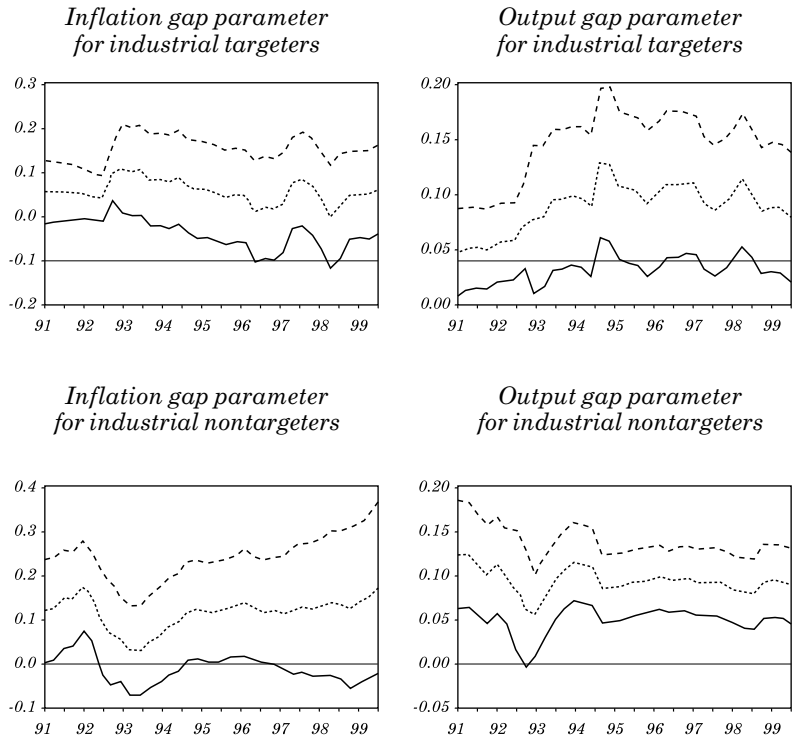
**Figure 8. Rolling Taylor Rule Coefficients, Full Sample: 1990:1–1999:4[a]**




Source: Authors' calculations.
a. Taylor rule estimated with contemporary inflation and activity as independent variables. The sample of industrial targeters includes Chile and Israel.

and output gap coefficients have declined consistently among inflation targeters—but this is due to the inclusion of the two transition inflation targeters (Chile and Israel) in the full sample of inflation targeters (figure 8). When the latter countries are excluded, thereby restricting the inflation targeting sample to industrial countries, neither coefficient exhibits a downward trend in the 1990s (figure 9). The same lack of any trend is observed among nontargeters. These results confirm that transition inflation targeters (Chile and Israel) gradually established credibility, initially requiring larger changes in interest rates in response to inflation or output shocks than have been necessary since the mid-1990s, when the two countries had firmly established their inflation-targeting regimes and inflation was lower.

**Figure 9. Rolling Taylor Rule Coefficients, Excluding Chile and Israel: 1990:1–1999:4[a]**




Source: Authors' calculations.
a. Taylor rule estimated with contemporary inflation and activity as independent variables. The sample of industrial targeters includes Chile and Israel.

## 6. Does the Introduction of Inflation Targeting Make a Difference? A Case Study of Chile [20]

Chile was the first developing country to implement inflation targeting, and it was the first to complete its transition toward a full-fledged inflation-targeting framework and to converge to stationary inflation. Using a small dynamic macroeconomic model for Chile, we study whether inflation targeting has contributed to reducing inflation

20. This section draws on Corbo and Schmidt-Hebbel (2000).

and made a difference in the speed and cost of price stabilization. We also investigate the main channels through which inflation targeting could contribute to reduce inflation. In this framework, inflation targeting affects inflation dynamics through its effect on inflation expectations. The latter variable, in turn, affects price and wage dynamics.

The model extends that developed by Corbo (1998) by introducing inflation expectations (measured as the difference between nominal and real interest rates on similar instruments), which explicitly enter the wage and inflation equations. Inflation expectations are specified as a linear combination of a four-quarter moving average of preceding inflation, the inflation target, and the inflation forecast error.

The full model is given by the following equations:

$$\pi_t^S = \alpha_0 + \alpha_1\omega_t + \alpha_2\hat{e}4_t + \alpha_3\mathrm{GAP}_{t-1} + \alpha_4\mathrm{D2} + \alpha_5\mathrm{D3} + \alpha_6\mathrm{D4} + \alpha_7\pi_t^E + \alpha_8\pi_t^*, \tag{4}$$

$$\omega_t = \beta_0 + \beta_1\pi_t^E + \beta_2\pi_{t-2} + \beta_3\mathrm{D2} + \beta_4\mathrm{D3}, \tag{5}$$

$$\mathrm{GAP}_t = \gamma_0 + \gamma_1\mathrm{GAP}_{t-1} + \gamma_2\mathrm{TOT}_t + \gamma_3\mathrm{PRBC}_{t-2} + \gamma_4\mathrm{KGDP}_t \times \mathrm{D96}, \tag{6}$$

$$\mathrm{UNEMP}_t = \delta_0 + \delta_1\mathrm{GAP}_t + \delta_2\mathrm{UNEMP}_{t-1} + \delta_3\mathrm{D2} + \delta_4\mathrm{D3} + \delta_5\mathrm{D4}, \tag{7}$$

$$\mathrm{CAD}_t = \chi_0 + \chi_1\mathrm{GAP}_t + \chi_2\mathrm{CAD}_{t-1}, \tag{8}$$

$$\hat{e}_t = \phi_0 + \phi_1\pi_{t-1} + \phi_2\pi_{t-1}^* + \phi_3\Delta\mathrm{FRES}_t + \phi_4\mathrm{DEV}_t + \phi_5\mathrm{KGDP}_t \times \mathrm{D96}, \tag{9}$$

$$\pi_{t+1}^E = \mu_0 + \mu_1\mathrm{TAR}_{t+4} + \mu_2\left[\left(\pi_t + \pi_{t-1} + \pi_{t-2} + \pi_{t-3}\right)/4\right] + \mu_3\left[\left(\pi_t + \pi_{t-1} + \pi_{t-2} + \pi_{t-3}\right)/4 - \pi_{t-4}^E\right], \text{ and} \tag{10}$$

$$\pi_t = \lambda_0 + \lambda_1\pi_t^S + \lambda_2\mathrm{D3} + \lambda_3\mathrm{D4} + \lambda_4\mathrm{A93} + \lambda_5\mathrm{A94} + \lambda_6\mathrm{A96} + \lambda_7\mathrm{A98}, \tag{11}$$

where $\pi_t^S$ is the quarterly rate of change of core inflation; $\pi_t$ is the quarterly rate of change of headline CPI inflation; $\pi_{t-1}^E$ is the expected quarterly rate of headline CPI inflation for period $t + 1$, based on information available at period $t$; $\omega_t$ is the quarterly rate of change of the wage rate; $\hat{e}_t$ is the quarterly rate of change of the nominal exchange rate, in

Chilean pesos per U.S. dollar; $\hat{e}4_t$ is the four-quarter moving average of $\hat{e}_t$; $\pi_t^*$ is the quarterly rate of change in international inflation, in U.S. dollars; $GAP_t$ is the gap between the seasonally adjusted quarterly GDP and its trend, as a percentage of the trend, measured by applying the Hodrick-Prescott filter; $TOT_t$ is the four-quarter moving average of the log of the terms of trade; $PRBC_t$ is the real annual interest rate of Central Bank ninety-day debt paper (the PRBC-90); $KGDP_t$ is capital inflows as a percentage of nominal GDP; $UNEMP_t$ is the quarterly unemployment rate; $CAD_t$ is the current account deficit of the year ending in quarter $t$, as percentage of nominal GDP; $FRES_t$ is the quarterly change in Central Bank foreign reserves, in US dollars; $DEV_t$ is the difference between the log of the market nominal exchange rate and the log of the central parity of the exchange rate band; $TAR_t$ is the quarterly inflation rate implicit in the inflation target announced by the Central Bank;[21] D2, D3, and D4 are seasonal dummies for the second, third, and fourth quarter, respectively; D96 is a dummy variable that takes a value of 1 from the first quarter of 1996 to the sample end (the third quarter of 2000), to control for the sharp change in capital inflows; and A93, A94, A96, and A98 are dummy variables that take a value of 1 for 1993, 1994, 1996, and 1998, respectively, for specific supply shocks that could affect the difference between core and headline CPI inflation.

Equation 4 for core inflation is specified as the weighted average of inflation equations for tradable and nontradable goods and services, including expected inflation. Equation 5 for wage inflation includes lagged inflation to reflect backward indexation schemes in wage contracts and expected inflation to reflect forward-looking wage contracts. Equation 6 for the output gap is a function of its own lag, the terms of trade, the lagged value of the real interest rate, and capital inflows. Equation 7 relates the unemployment rate to the output gap (Okun's law). Equation 8 for the ratio of the current account deficit to GDP is a function of the output gap and its lagged value. Equation 9 describes the nominal exchange rate devaluation within the exchange rate band that was in place until late 1999. Equation 10 relates expected inflation to the forward-looking inflation target, a moving average of lagged inflation levels, and an inflation forecast error term. Equation 11 relates actual inflation to core inflation and also introduces seasonal dummies and annual dummies for particular weather and oil-related shocks. Model estimation results are reported in table 10.

21. Computed by linearizing the annual inflation target announced as the December-to-December rate of change.

**Table 10. Estimated Model Coefficients for Chile[a]**

| *Equation and parameter* | *Estimated value* | *Standard error* | *Equation and parameter* | *Estimated value* | *Standard error* |
|---|---|---|---|---|---|
| Equation 4 | | | Equation 9 | | |
| $\alpha_0$ | –0.632 | 0.363 | $\phi_0$ | –0.326 | 1.059 |
| $\alpha_1$ | 0.432 | 0.119 | $\phi_1$ | 0.379 | 0.191 |
| $\alpha_2$ | 0.141 | 0.041 | $\phi_2$ | –0.070 | 0.116 |
| $\alpha_3$ | 0.105 | 0.048 | $\phi_3$ | –0.002 | 0.0005 |
| $\alpha_4$ | 1.394 | 0.325 | $\phi_4$ | –0.245 | 0.097 |
| $\alpha_5$ | 0.686 | 0.344 | $\phi_5$ | –0.079 | 0.060 |
| $\alpha_6$ | 0.517 | 0.307 | $R^2 = 0.42$ | | |
| $\alpha_7$ | 0.285 | 0.135 | Equation 10 | | |
| $\alpha_8$ | 0.141 | 0.041 | $\mu_0$ | 0.426 | 0.082 |
| $R^2 = 0.80$ | | | $\mu_1$ | 1 | – |
| Equation 5 | | | $\mu_2$ | 0 | – |
| $\beta_0$ | 1.378 | 0.186 | $\mu_3$ | 0.125 | 0.074 |
| $\beta_1$ | 0.826 | 0.099 | $R^2 = 0.79$ | | |
| $\beta_2$ | 0.174 | – | Equation 11 | | |
| $\beta_3$ | –1.221 | 0.347 | $\lambda_0$ | –0.347 | 0.249 |
| $\beta_4$ | –1.249 | 0.326 | $\lambda_1$ | 1.078 | 0.123 |
| $R^2 = 0.75$ | | | $\lambda_2$ | 0.982 | 0.212 |
| Equation 6 | | | $\lambda_3$ | 1.093 | 0.214 |
| $\gamma_0$ | 1.621 | 1.074 | $\lambda_4$ | –0.711 | 0.355 |
| $\gamma_1$ | 0.675 | 0.093 | $\lambda_5$ | –0.762 | 0.300 |
| $\gamma_2$ | 0.059 | 0.022 | $\lambda_6$ | –0.617 | 0.276 |
| $\gamma_3$ | –0.427 | 0.149 | $\lambda_7$ | –0.702 | 0.271 |
| $\gamma_4$ | 0.055 | 0.041 | $R^2 = 0.82$ | | |
| $R^2 = 0.70$ | | | Equation 12 | | |
| Equation 7 | | | $\psi_0$ | 6.718 | 0.281 |
| $\delta_0$ | 1.292 | 0.314 | $\psi_1$ | 0.628 | 0.140 |
| $\delta_1$ | –0.126 | 0.032 | $\psi_2$ | 0.361 | 0.097 |
| $\delta_2$ | 0.843 | 0.038 | $\psi_3$ | 5.055 | 0.119 |
| $\delta_3$ | 0.604 | 0.197 | $\rho$ | 0.563 | 0.048 |
| $\delta_4$ | 0.207 | 0.204 | $R^2 = 0.76$ | | |
| $\delta_5$ | –1.214 | 0.205 | | | |
| $R^2 = 0.92$ | | | | | |
| Equation 8 | | | | | |
| $\chi_0$ | –0.278 | 0.133 | | | |
| $\chi_1$ | 0.219 | 0.043 | | | |
| $\chi_2$ | 0.850 | 0.033 | | | |
| $R^2 = 0.88$ | | | | | |

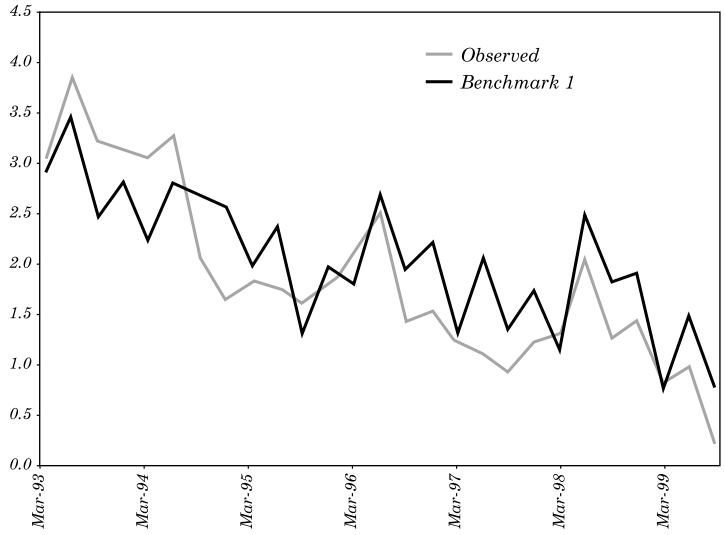
Source: Authors' estimations.

a. Based on inflation expectations estimated from the difference between nominal and real interest rates. The values presented here were used for the simulations and the counterfactuals. All the restrictions over the coefficients were tested before they were imposed, including homogeneity of degree one of all nominal variables in the price and wage equations (equations 4 and 5, respectively).

We now proceed to compare simulated values (obtained from the model's dynamic simulation) and actual values for core inflation. In the first simulation we take the actual real interest rate as given. Fig-

**Figure 10. Core Inflation: Observed and Benchmark 1**

*Quarterly rate of change, in percent*




Source: Authors' calculations.

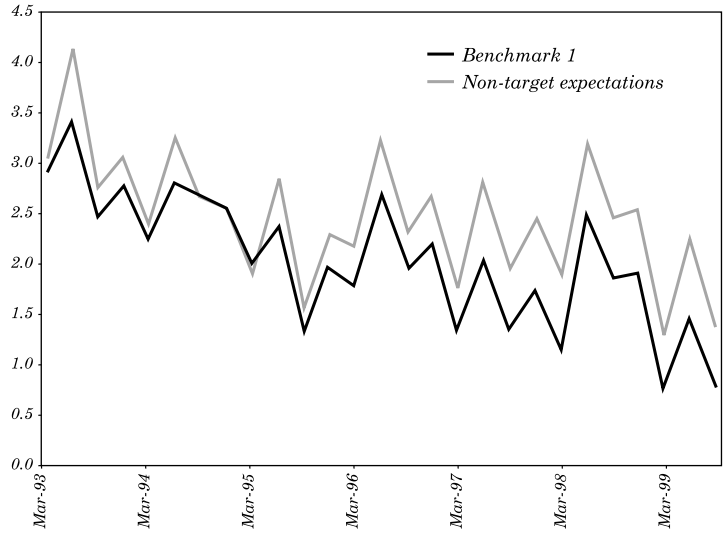
ure 10 depicts the simulated values (noted as benchmark 1 values) and observed values for core inflation during 1993–99. Model simulations are close to actual values.

The first counter-factual simulation, which uses the benchmark 1 values, shows the path of core inflation that would have been observed if the inflation target had not been made public and therefore had not affected expectations.[22] In other words, we simulate the dynamic response of the Chilean economy if inflation expectations in the 1990s had been formed in the way they were formed in the 1980s. The comparison of simulated values (called nontarget expectations) with benchmark 1 values is presented in figure 11. Simulated values are almost always above benchmark values. These results support the hypothesis that introducing explicit inflation targets helped reduce inflation. The mechanism at work is the effect of the inflation target on inflation expectations, and of the latter on wage inflation and core price inflation.

22. For this purpose, we first estimate an equation for inflation expectations for the period before the introduction of inflation targeting (until the fourth quarter of 1990) and use this equation to model inflation expectations in the 1990s.

**Figure 11. Core Inflation: Benchmark 1 and Nontarget Expectations Simulation**

*Quarterly rate of change, in percent*




Source: Authors' calculations.

A clearer picture emerges when we compare the benchmark 1 values with the cumulative sum of quarterly inflation rates over four quarters, obtained by the nontarget expectations simulation (see table 11). A clear break occurred in 1996, when benchmark 1 inflation levels (based on inflation expectations influenced by the inflation target) start to fall well below conterfactual simulation values.[23] The inflation target thus appears to have affected actual inflation only some time after the introduction of inflation targeting, probably because at early stages of inflation targeting the public was still uncertain about the Central Bank's commitment to attaining the target.

To address the issue of macroeconomic effects of alternative stabilization paths, we run two counter-factual simulations for the speed and intensity of price stabilization in the 1990s: a more gradualist disinflation

23. This break coincided with the Central Bank's announcement in September 1995 of a more aggressive target of 6.5 percent for 1996. (For 1995 the target had been set at 9 percent and actual inflation was 8.2 percent.)

**Table 11. Core Inflation in Chile: Benchmark 1 and Nontarget Expectations Simulation[a]**

| *Date* | *Benchmark* | *Simulation* |
|---|---|---|
| December 1993 | 11.6 | 12.9 |
| June 1994 | 10.3 | 11.5 |
| December 1994 | 10.2 | 10.9 |
| June 1995 | 9.6 | 10.0 |
| December 1995 | 7.6 | 8.6 |
| June 1996 | 7.7 | 9.2 |
| December 1996 | 8.6 | 10.4 |
| June 1997 | 7.5 | 9.5 |
| December 1997 | 6.4 | 8.9 |
| June 1998 | 6.6 | 9.4 |
| December 1998 | 7.3 | 10.0 |
| June 1999 | 5.9 | 8.5 |

Source: Authors' calculations, based on model simulations.
a. Four-quarter sum of quarterly percentage rates of core CPI change.

**Table 12. Actual and Counterfactual Paths for the Inflation Target in Chile[a]**

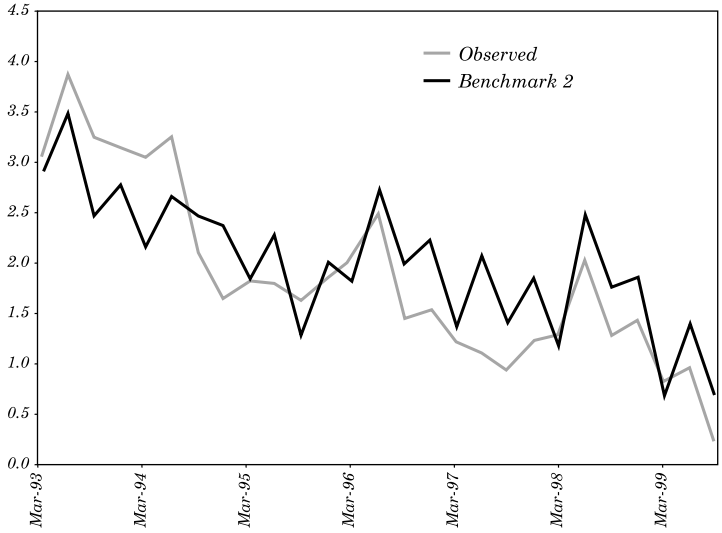
| *Date* | *Actual target* | *Cold-turkey target* | *Gradual target* |
|---|---|---|---|
| December 1991 | 17.5 | 17.5 | 17.5 |
| December 1992 | 15.0 | 15.0 | 15.0 |
| December 1993 | 11.0 | 11.0 | 11.0 |
| December 1994 | 10.0 | 8.0 | 10.5 |
| December 1995 | 9.0 | 5.0 | 10.0 |
| December 1996 | 6.5 | 3.0 | 9.5 |
| December 1997 | 5.5 | 3.0 | 9.0 |
| December 1998 | 4.5 | 3.0 | 8.5 |
| December 1999 | 4.3 | 3.0 | 8.0 |
| December 2000 | 3.5 | 3.0 | 7.5 |

Source: Central Bank of Chile and authors' assumptions.
a. December-to-December percent change in CPI.

path, termed a gradual target, and a more aggressive path, termed a cold-turkey target. The gradualist strategy considers a target reduction by only half of a percentage point (50 basis points) per year starting in 1994. The cold-turkey stabilization considers a quicker target reduction to attain a stationary inflation level of 3 percent in 1996 and beyond (see table 12).

**Figure 12. Core Inflation: Observed and Benchmark 2**

*Quarterly rate of change, in percent*




Source: Authors' calculations.

When altering the targets, the policy interest rate has to be changed accordingly. The structural model presented above is therefore extended to include the following policy reaction function for the Central Bank:[24]

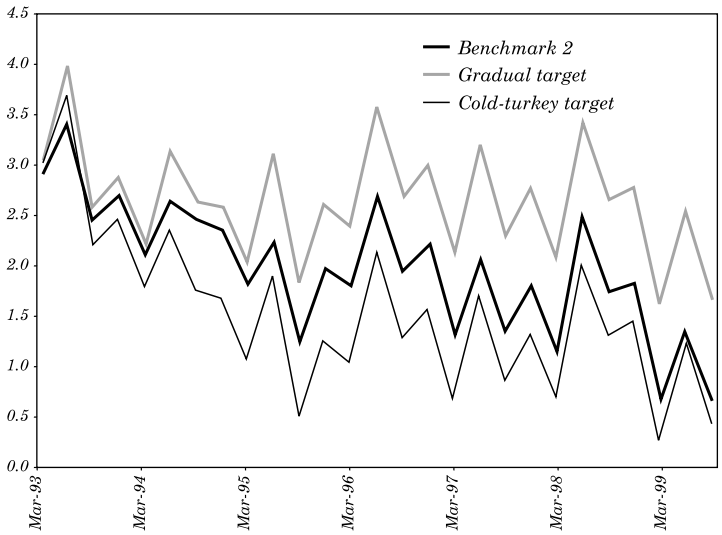
$$\mathrm{PRBC}_t = (1-\rho)\times\left[\psi_0 + \psi_1\left(\pi 4^S_{t+3} - \mathrm{TAR4}_{t+3}\right) + \psi_2 \mathrm{CAD}_{t+2}\right] + \rho\mathrm{PRBC}_{t-1} + \psi_3 \mathrm{D983}. \quad (12)$$

This policy reaction function is consistent with Corbo (2002), which extends previous work by Taylor (1993) and Clarida, Galí, and Gertler (1998) for countries that follow a policy aimed at achieving a gradual reduction in inflation. In this equation, the policy interest rate is specified as a function of the gap between expected inflation and target inflation, the gap between the ratio of the current account deficit to GDP

24. In this equation, $\pi 4^S_t$ is the four-quarter cumulative sum of quarterly core inflation rates, $\mathrm{TAR4}_t$ is the four-quarter cumulative sum of quarterly target inflation rates, and D983 is a dummy variable (equal to 1 in the third quarter of 1998).

**Figure 13. Core Inflation: Benchmark 2, Gradual Target, and Cold-Turkey Target Simulation**

*Quarterly rate of change, in percent*




Source: Authors' calculations.

and a target ratio (which is set at 4.5 percent of GDP), and the lagged value of the policy rate.[25]

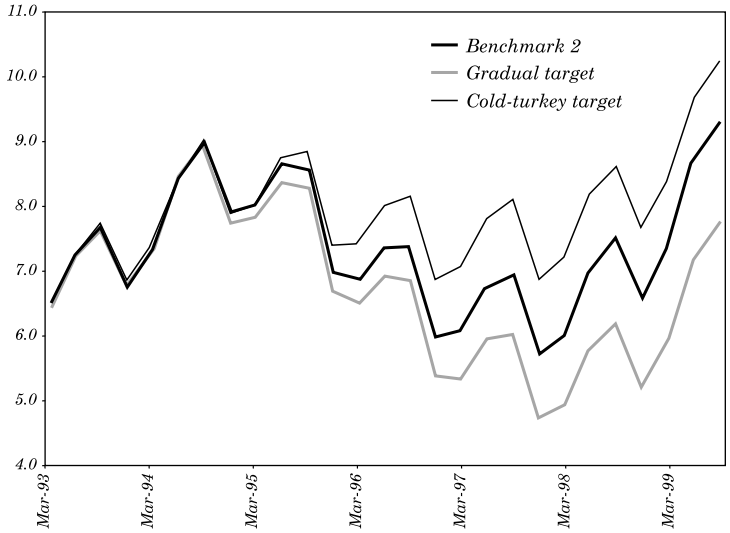
The amended model, which now includes the policy reaction function, is run to provide a new set of benchmark results for core inflation (benchmark 2). These are compared to actual core inflation in figure 12. The simulated benchmark 2 levels are closer to the actual values than was the case with benchmark 1. By endogenizing the policy interest rate, the latter is adjusted when the inflation forecast differs from the target level, helping to bring actual inflation closer to the target.

The counter-factual simulation results for core inflation under the gradualist strategy, the cold-turkey approach, and the benchmark 2 case are reported in figure 13. Unsurprisingly core inflation under the gradualist (cold-turkey) approach is well above (below) benchmark 2

25. The variables on the right-hand side of this equation are potentially endogenous. We therefore reestimate this equation using generalized method of moments (GMM) to obtain consistent and efficient coefficient estimates, reported in table 10.

**Figure 14. Unemployment: Benchmark 2, Gradual Target, and Cold-Turkey Target Simulation**

*Quarterly rate, in percent*




Source: Authors' calculations.

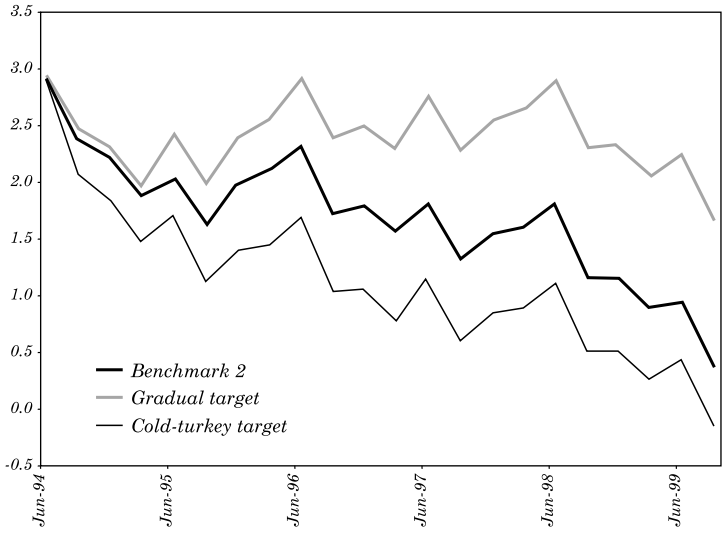
values. In the case of the cold-turkey target, the convergence of the simulated values toward target values is initially slow; this confirms that inflation exhibits substantial inertia and that the selection of a hard target could have resulted in higher unemployment and only a small gain in terms of lower inflation.

Figure 14 depicts the unemployment paths for both counter-factual strategies and the benchmark 2 case. The gradual (cold-turkey) strategy results in lower (higher) unemployment—a result of slow (quick) adjustment of inflation expectations toward target levels. To throw further light on the cost of disinflation, we also compute the sacrifice ratio for the reduction of inflation, comparing the cumulative sum of unemployment increases to the cumulative sum of the gains in inflation reduction. The sacrifice ratio corresponding to the cold-turkey approach is –1.26. Under a gradualist strategy, the sacrifice ratio is only –0.95. Alternative disinflation speeds thus entail asymmetric employment and output costs.

To check the robustness of our results, we use an alternative measure of inflation expectations, instead of the difference between nominal and

**Figure 15. Core Inflation: Benchmark 2, Gradual Target, and Cold-Turkey Target Simulation Using Consensus Forecast Expectations**

*Quarterly rate of change, in percent*




Source: Authors' calculations.

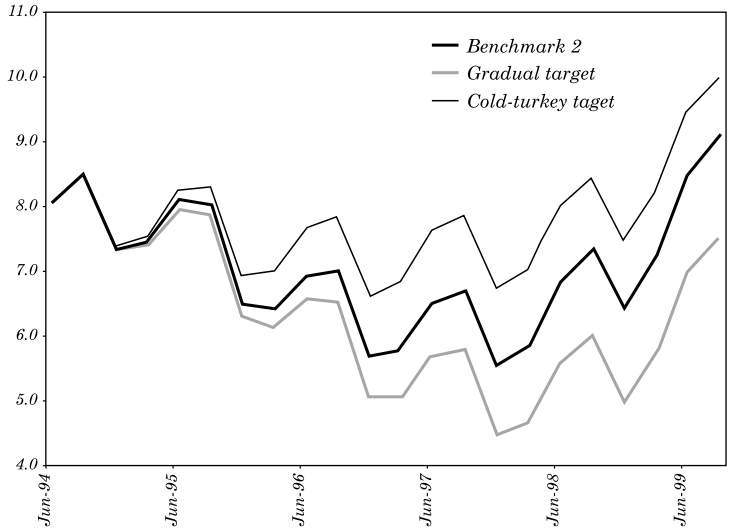
real interest rates. We reestimate equations 4, 5, and 10 using the Consensus Forecast measure of inflation expectations for Chile.[26] We then run the benchmark and the two counter-factual simulations again. The results, reported in figures 15 and 16, are fairly similar to those shown in figures 13 and 14. The sacrifice ratios are –1.26 for the cold-turkey strategy and –0.99 for the gradualist approach. This confirms the robustness of our results to alternative measures for inflation expectations.

Finally it could be claimed that our comparison between cold-turkey and gradualist strategies to disinflation does not properly represent the cold-turkey case because inflation expectations do not immediately adjust to target levels.[27] That is, inflation expectations do not embody full credibility of the inflation target because they are still determined by equation 10. To take into account a fully credible cold-turkey

26. We thank Consensus Economics for providing this data.
27. We thank Alejandro Werner for suggesting this exercise.

**Figure 16. Unemployment: Benchmark 2, Gradual Target, and Cold-Turkey Target Simulation Using Consensus Forecast Expectations**

*Quarterly rate, in percent*



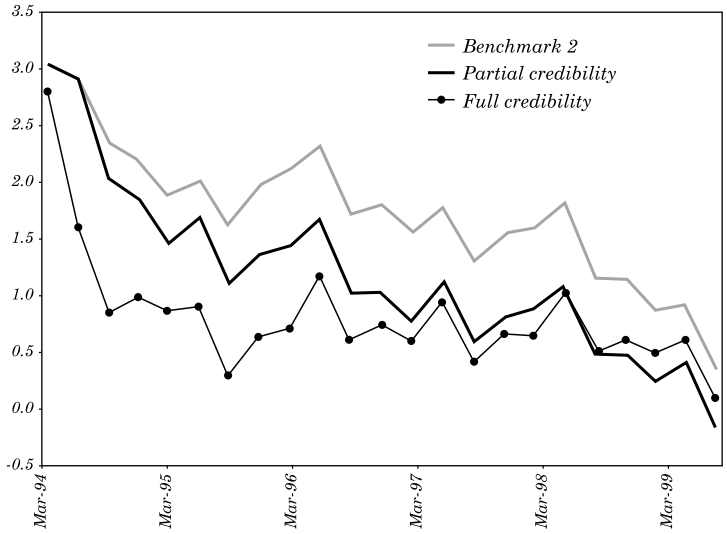

Source: Authors' calculations.

approach (using the Consensus Forecast measure of inflation expectations), we impose the restrictions $\mu_0 = \mu_2 = \mu_3 = 0$ and $\mu_1 = 1$ on equation 10. The simulation results for this amended model, based on the restricted version of equation 10 and run only for the cold-turkey case, are reported in figures 17 and 18. The reduction of inflation would have been somewhat quicker under full credibility than under partial credibility, while the unemployment cost is not too different under the two cases. The sacrifice ratio for full credibility is –0.53, as opposed to –1.26 under partial credibility; this is even lower than the –0.99 observed in the case of the gradualist approach under partial credibility. We therefore conclude that the actual sacrifice ratio of the cold-turkey approach is bounded between –1.26 and –0.53.[28]

28. In the price and wage equations, the actual values of the coefficients also depend on the degree of credibility of the inflation target. Therefore, with full credibility the coefficients of expected inflation in both equations could be higher, resulting in an even lower sacrifice ratio.

**Figure 17. Core Inflation: Benchmark 2 and Cold-Turkey Target Simulation Using Consensus Forecast Expectations with Partial and Full Credibility**

*Quarterly rate of change, in percent*




Source: Authors' calculations.

## 7. Conclusions

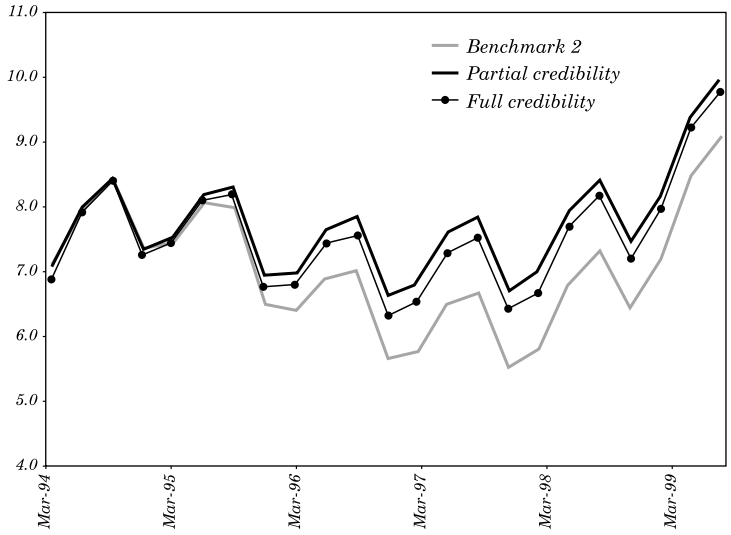
This paper has conducted a wide empirical search on the rationale and consequences of adopting inflation targeting. By comparing policies and outcomes in full-fledged inflation-targeting countries to two control groups of potential inflation targeters and nontargeters, we have identified how inflation targeting makes a difference.

Inflation targeters have been very successful in meeting their targets. In the 1990s, output sacrifice ratios measured by industrial production were lower among inflation targeters after they adopted inflation targeting than among potential inflation targeters and nontargeters. The volatility of industrial output fell in most inflation targeters after adoption to levels similar to those found among Nontargeters.

Inflation targeters have consistently reduced inflation forecast errors (based on country VAR models) toward the low levels prevalent in nontargeting industrial countries.

**Figure 18. Unemployment: Benchmark 2 and Cold-Turkey Target Simulation Using Consensus Forecast Expectations with Partial and Full Credibility**

*Quarterly rate, in percent*




Source: Authors' calculations.

Variance decomposition results from VARs show that the influence of price and output shocks on the behavior of inflation and output gaps changed much more strongly among inflation targeters than in nontargeting industrial countries in the course of the 1990s. Inflation persistence declined strongly among inflation targeters during the decade. This suggests that inflation targeting played a role in strengthening the effect of forward-looking expectations on inflation, thereby weakening the weight of past inflation inertia. The influence of inflation shocks on output declined in the 1990s, while output persistence increased significantly during the 1990s. The influence of price and output shocks on inflation and output gaps tended to converge among inflation targeters in the late 1990s to the pattern observed among nontargeting industrial countries. With regard to exchange rate innovations on inflation—evidence of reduced-form devaluation-inflation pass-throughs—no differences were identified between stationary industrialized inflation targeters and nontargeting industrial countries.

Cecchetti and Ehrmann find that central bankers' aversion to inflation does not differ, on average, between inflation targeters and nontargeters. They also find that inflation aversion increased significantly in most inflation targeters when they adopted inflation targeting (that is, during the 1990s), in comparison with nontargeters. We extended Cecchetti and Ehrmann's estimates and inflation-aversion measures in various ways and confirmed their first result: inflation aversion is not different, on average, among inflation targeters in comparison with nontargeters. However, we do not find evidence that stationary industrialized inflation targeters showed increasing inflation aversion in the 1990s. In contrast, inflation aversion increased in the emerging-country transition inflation targeters: Chile and Israel. Furthermore, we find a trend increase in inflation aversion among nontargeting industrial countries. Among potential inflation targeters, inflation aversion fell during the decade.

Does inflation targeting change central bankers' behavior in setting interest rates? We performed variance decomposition exercises from country VARs to test for changes in the response of interest rates to inflation and output innovations. The reaction of interest rates to both inflation and output shocks declined significantly among inflation targeters throughout the 1990s. Among nontargeting industrial countries, however, these reductions were either nil or much weaker in the 1990s. We then estimated Phillips curves that confirmed the latter result: the coefficients of inflation and output gaps have monotonically declined in both emerging and industrial inflation targeters during the 1990s, in comparison with unchanged parameters among nontargeters. This result suggests that inflation targeters gradually gained credibility, which allowed them to achieve their inflation targets with smaller changes in interest rates in the late 1990s than were necessary in the early 1990s.

Chile is the developing country with the longest inflation targeting experience, and inflation has already converged to the Central Bank's long-term target level. Three main lessons emerge from the Chilean experience. First, the initial progress in reducing inflation toward the target was slow as the public was learning about the Central Bank's true commitment to attaining the target. Second, the gradual phasing in of inflation targeting contributed to declining inflation by lowering inflation expectations and changing wage and price dynamics. Third, with respect to the speed of inflation reduction, a cold-turkey approach would have resulted in a larger sacrifice ratio stemming from higher unemployment during the early years of inflation targeting, when credibility was gradually being built up.

APPENDIX

## Data Definitions and Sources

### Inflation Targeting Periods

Countries are considered as inflation targeters in the following periods: Australia since the fourth quarter of 1994, Canada since the first quarter of 1991, Chile since the fourth quarter of 1990, Finland from the first quarter of 1993 to the fourth quarter of 1999, Israel since the first quarter of 1991, New Zealand since the second quarter of 1990, Spain from the third quarter of 1996 to the fourth quarter of 1998, Sweden since the first quarter of 1993, and the United Kingdom since the fourth quarter of 1992,

### Industrial Production

For all countries except those indicated below, we use the seasonally adjusted industrial production index, code 66.czf of the International Financial Statistics (IFS) published by the International Monetary Fund (IMF). For Chile, Colombia, and Mexico, we use the manufacturing production index, IFS code 66ey.czf; for New Zealand, the seasonally adjusted manufacturing production index, IFS code 66ey.czf; for Switzerland, the seasonally adjusted industrial production index (90 = 100), IFS code 66.izf; and for Turkey, the industrial production index, IFS code 66.zf.

### Money

For all countries except those indicated below, this variable is defined as the sum of money, IFS code 34.zf, and quasi-money, IFS code 35.zf. For Finland, Germany, Italy, and Spain, it is the sum of currency in circulation, IFS code 34a.nzf, and demand deposits, IFS code 34b.nzf.

### Inflation

For all counties, inflation is defined as the rate of change of the consumer price index, IFS code 60.zf.

### Interest Rate

For Austria, the interest rate variable is the new issue rate on three-month Treasury bills, IFS code 60 c.zf; for Canada, the overnight

money market rate, IFS code 60 b.zf; for Colombia, the lending rate, IFS code 60 b.zf; for Chile, the monthly average rate of ninety-day deposit certificates, obtained from Central Bank of Chile; for Denmark, Norway, Spain, and Sweden, the call money rate, IFS code 60 b.zf; for Finland, the average bank lending rate, IFS code 60 p.zf; for Israel, the overall cost of unindexed credit, IFS code 60 p.zf; for Italy, Japan, Korea, and Switzerland, the money market rate, IFS codes 60 b.zf and 60 p.zf; for Mexico, the Treasury bill rate, IFS code 60 b.zf; for New Zealand, the Comm. bill rate (ninety-day maximum), IFS code 60 b.zf; for the United Kingdom, the overnight interbank rate, IFS code 60 b.zf; for the United States, the federal funds rate, IFS code 60 b.zf; and for Turkey, the interbank money market rate, IFS code 60 b.zf;

## Nominal Exchange Rate

For all countries except those indicated below, the nominal exchange rate is defined as the market rate, IFS code ..rf..zf. For Chile and Mexico, it is the principal rate, IFS code ..rf..zf; and for Finland, Norway, Sweden, and Switzerland, it is the official rate, IFS code ..rf..zf,

## Relative Trend Deviations

For any variable $x$, we construct its relative trend deviation as $\log(x) - \log(hpx)$, where log is the natural logarithm and $hpx$ is a trend estimated by the Hodrick-Prescott filter of $x$. This measure represents the relative distance of the variable with respect to its trend, rather than the period change of the variable.

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# Targeting Inflation in an Economy with Staggered Price Setting

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After experiencing high and persistent inflation rates in the 1970s and early 1980s, most industrialized economies entered the new century with a sustained record of low, stable inflation rates. Many commentators attribute the new environment to good luck, in the form of no major supply shocks (at least until the recent hike in oil prices). Others invoke the magic powers of the new economy to explain why inflation has remained subdued despite robust economic growth. A growing body of research, however, points to a dramatic change in central banks' attitude toward inflation, which appears to have had a significant impact on the way monetary policy is conducted.[1]

Many authors consider the adoption of monetary policy strategies that aim, more or less explicitly, at targeting the inflation rate to be a critical factor behind the new era of macroeconomic stability that now seems to characterize the industrialized world.[2] The present paper inquires into the nature and workings of an inflation-targeting regime, using as a reference framework an optimizing monetary business cycle model with staggered price setting. Such a framework, which integrates Keynesian ingredients into a real-business-cycle-type dynamic general equilibrium apparatus, has in recent years become the workhorse for the analysis of the connection between money, inflation, and

I wish to thank Raimundo Soto for many insightful comments. Financial support from the National Science Foundation, the Bank of Spain, and the Centre de Recerca en Economia Internacional (CREI) are gratefully acknowledged.

1. See, for example, Clarida, Galí, and Gertler (2000) and Taylor (1999a) for formal econometric evidence of the new anti-inflationary stance of the Fed and other central banks in the 1980s and 1990s.

2. See Bernanke and others (1999) for a detailed account of the experience of several countries that adopted an explicit inflation-targeting regime.

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the business cycle, and the assessment of the desirability of alternative monetary policies.

Among other aspects, the novelty of its treatment of the sources and nature of inflation dynamics makes the new optimizing sticky price models a particularly interesting laboratory for the study of inflation-targeting policies. As discussed in section 1 below, inflation and its variations over time are, under the new paradigm, an immediate consequence of price revisions by profit-maximizing firms, in an environment in which the latter are subject to some constraints on the frequency with which they can adjust their prices. Those constraints may cause firms' markups to deviate from the optimal level, thus inducing periodic revisions in prices and, hence, inflation. Consequently, any policy that aims at targeting the aggregate price level will necessarily have to seek to stabilize firms' markups around their profit-maximizing level. This rather general result does not depend on details of the economy's structure.

On the other hand, the specific form of the rule that implements an inflation-targeting policy will generally depend on the structure of the model, the settings for the parameters describing the economic environment, and the properties of the underlying sources of fluctuations. Section 2 derives the interest rate rule that fully stabilizes the rate of inflation for an example economy. I refer to that rule as the optimal inflation-targeting rule. The section also discusses the conditions under which the equilibrium generated by that rule will be unique.

The nature and form of the optimal inflation-targeting rule suggest that its actual implementation would most likely face many difficulties. That consideration leads many authors to propose a variety of simple rules that approximate the outcome of the optimal one and that may be much easier to implement in practice. Sections 3 and 4 analyze the properties of one such rule in the context of the baseline model with staggered price setting developed in the previous section. The rule is a simplified version of the so-called Taylor rule, under which the monetary authority adjusts the interest rate in response to deviations of inflation from target. Section 3 examines the properties of that rule under the assumption that the monetary authority has access to accurate real-time inflation data. Section 4 analyzes the implications of the presence of measurement error in the inflation data used as the basis for interest rate decisions.

## 1. Sources of Inflation Dynamics

This section lays out a simple model of inflation dynamics in the presence of staggered price setting and discusses the role of markup variations as a source of those dynamics.

## 1.1 Price Dynamics

The very idea of price stickiness implies some form of dependence of current prices on lagged prices. The exact form of that dependence, and its mathematical representation, hinges on the precise way that sticky prices are modeled.

In an economy with staggered price setting, only a fraction of firms reset prices in any given period. Let me follow Calvo (1983) in assuming that each firm resets its price in any given period only with probability $1 - \theta$, independently of other firms and of the time elapsed since its last price adjustment.[3] By the law of large numbers, a measure $1 - \theta$ of producers reset their prices each period, while a fraction $\theta$ keep their prices unchanged. Let $p_t$ denote the log of the aggregate price level, and let $p_t^*$ denote the log of the price set by firms adjusting prices in period $t$.[4] The evolution of the price level over time can thus be approximated by the log-linear difference equation,

$$p_t = \theta p_{t-1} + (1-\theta) p_t^* . \tag{1}$$

It follows that the rate of price inflation $\pi_t = p_t - p_{t-1}$ will be given by

$$\pi_t = (1-\theta)\ \left( p_t^* - p_{t-1} \right). \tag{2}$$

Its simplicity notwithstanding, equation 2 turns out to be critical for understanding the source of inflation and its dynamics. Positive (negative) inflation will arise in such an environment if and only if firms adjusting their prices in the current period choose prices that are, on average, above (below) the average level of prices that prevailed in the economy in the previous period. Understanding aggregate inflation and its fluctuations thus requires a model of how and why firms may want to adjust their relative price periodically. I turn next to the optimal choice of that relative price.

## 1.2 Optimal Price Setting and Inflation Dynamics

In the context of the present model, a firm that is able to reset prices in period $t$ will choose its price to maximize expected discounted profits given technology, factor prices, and the constraint on price adjustment (defined by the reset probability $1 - \theta$). Log-linearization of

3. King and Wolman (1996), Yun (1996), and Woodford (1996) provide a detailed derivation of an optimal price setting rule under the Calvo formalism.

4. Notice that they will all set the same price, since they are assumed to face an identical problem.

the optimal price setting condition around a zero inflation steady state yields the approximate log-linear rule

$$p_t^* = \mu + (1-\beta\theta)\sum_{k=0}^{\infty}(\beta\theta)^k E_t\{mc_{t+k}^n\}. \quad (3)$$

In other words, prices are set as a markup over a weighted average of current and expected future (log) nominal marginal costs, $\{mc_{t+k}^n\}$, where $\mu$ is the optimal frictionless markup (that is, the markup they would choose were they able to adjust prices period by period), also expressed in logs. For simplicity I assume that all firms have access to an identical constant returns technology, such that they all face the same marginal cost, independently of the quantity produced.[5]

Let $\mu_t = p_t - mc_t^n$ denote the economy's average markup in period $t$. Equation 3 can be rewritten as follows:

$$p_t^* - p_{t-1} = \sum_{k=0}^{\infty}(\beta\theta)^k E_t\{\pi_{t+k}\} - (1-\beta\theta)\sum_{k=0}^{\infty}(\beta\theta)^k E_t\{\hat{\mu}_{t+k}\}, \quad (4)$$

where $\hat{\mu}_t = \mu_t - \mu$ denotes the deviation of the average markup from the frictionless markup (the markup gap, for short).

Equation 4 clearly points to the two factors that underlie the decision by firms currently adjusting prices to deviate from the average price level prevailing in the previous period. The first term captures the firm's willingness to keep up with the aggregate price level during the life of the price, at least in expected terms; in other words, it aims at maintaining the expected relative price unchanged. The second term reflects the wish to adjust that expected relative price, to avoid any anticipated gap between the expected and desired markups, were the firm not to adjust its relative price.

Equations 2 and 4 can be combined into a simple, first-order expectational difference equation for inflation:

$$\pi_t = \beta E_t\{\pi_{t+1}\} - \lambda\hat{\mu}_t, \quad (5)$$

5. To get some intuition for the form of that rule, let $\mu_{t,t+k} \equiv p_t^* - mc_{t+k}^n$ denote the markup in period $t + k$ of a firm that last set its price in period $t$. Equation 3 can be rewritten as

$$\mu = (1-\beta\theta)\sum_{k=0}^{\infty}(\beta\theta)^k E_t\{\mu_{t,t+k}\},$$

which yields a simple interpretation of the pricing rule: firms set prices at a level at which an appropriate weighted average of anticipated future markups matches the optimal frictionless markup, $\mu$.

where $\lambda \equiv \left[(1-\theta)(1-\beta\theta)\right]/\theta$.[6]

## 1.3 Inflation Targeting and Markup Stabilization

I now use $\pi*$ to denote the target level of inflation under an inflation-targeting regime and assume that such a target remains constant over time. Equation 5 can be rewritten as

$$\pi_t - \pi^* = -(1-\beta)\pi^* + \beta\left[E_t\{\pi_{t+1}\} - \pi^*\right] - \lambda\hat{\mu}_t .$$

A necessary and sufficient condition for attaining the inflation target every period (that is, $\pi_t = \pi^*$ for all $t$) is given by:

$$\mu_t = \mu - \left(\frac{1-\beta}{\lambda}\right)\pi^* \equiv \mu^* ,$$

where $\mu^*$ denotes the constant markup that is consistent with a constant inflation rate, $\pi^*$. Thus in the environment under consideration, positive (negative) levels of inflation are necessarily associated with average markups below (above) the desired markup, $\mu$.

To derive equation 5, I have not made use of any assumptions on the underlying sources of fluctuations, the properties and characteristics of monetary and fiscal policy, or any aspects of the economy's structure other than the form of staggered price setting and the associated optimal price setting decisions. A number of lessons can be drawn from this simple framework, however, which may inform the design of a monetary policy strategy that aims at targeting inflation. Three principles are worth emphasizing. First, current inflation is a function of current and expected future average markups. Stabilizing inflation necessarily requires that markups be stabilized. Second, a zero inflation target can be achieved by maintaining markups constant at their frictionless level. In that case, all firms will be maximizing profits at current prices and, accordingly, no firm will have an incentive to adjust its price. As a result, the aggregate price level will be stabilized. Third, attaining a positive inflation target requires holding the average markup below its frictionless level. Only in that case will firms adjusting prices in any given period choose to set a price above the average price in the previous period (the latter being a condition for positive inflation).

6. See Sbordone (1999), Galí and Gertler (1999), and Galí, Gertler, and López-Salido (2001) for econometric evidence supporting the empirical relevance of that inflation equation.

## 2. A Baseline Model with Staggered Price Setting

This section lays out a simple macroeconomic framework in which the model of inflation dynamics developed in the previous section is embedded. For simplicity, and to focus on the essential aspects, the baseline model abstracts from capital accumulation and the external sector. Next I briefly describe the main assumptions and derive the key equilibrium conditions.[7]

### 2.1 Households

The representative consumer is infinitely lived and seeks to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t \left( \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} \right), \tag{6}$$

subject to a standard sequence of budget constraints and a solvency condition. $N_t$ denotes hours of work, and $C_t$ is a CES aggregator of the quantities of the different goods consumed:

$$C_t = \left[ \int_0^1 C_t(i)^{(\varepsilon-1)/\varepsilon} di \right]^{\varepsilon/(\varepsilon-1)}.$$

The aggregate price index is represented by

$$P_t = \left[ \int_0^1 P_t(i)^{1-\varepsilon} di \right]^{1/(1-\varepsilon)},$$

where $P_t(i)$ denotes the price of good $i \in [0,1]$. The solution to the consumer's problem can be summarized by means of three optimality conditions (two static and one intertemporal), which I represent in log-linearized form, ignoring nonessential constants. Henceforth, lower case letters denote the logarithms of the original variables.

First, the optimal allocation of a given amount of expenditures among the different goods generates the set of demand schedules

$$c_t(i) = -\varepsilon [p_t(i) - p_t] + c_t, \tag{7}$$

for all $i \in [0,1]$.

7. See, for example, King and Wolman (1996), Yun (1996), and Woodford (1996, 2000) for a detailed derivation of the equilibrium conditions in a similar model. Galí and Monacelli (2000) extend the model to an open economy, and a version of the model with capital accumulation is discussed in Woodford (2000).

Second, under the assumption of a perfectly competitive labor market, the supply of hours must satisfy the condition

$$w_t - p_t = \sigma c_t + \varphi n_t, \tag{8}$$

where $w_t$ is the (log) nominal wage.

Finally, the intertemporal optimality condition is given by the Euler equation,

$$c_t = -\frac{1}{\sigma}\left[r_t - E_t\{\pi_{t+1}\} - \rho\right] + E_t\{c_{t+1}\}, \tag{9}$$

where $r_t$ is the yield on a nominally riskless one-period bond (the nominal interest rate, for short) and $\rho \equiv -\log \beta$ is the discount rate.

## 2.2 Firms

I assume a continuum of firms, each producing a differentiated good with a technology

$$y_t(i) = a_t + n_t(i),$$

where $a_t$ follows an exogenous, unspecified stochastic process.

Total demand for each good is given in levels by

$$Y_t(i) = C_t(i) + G_t(i),$$

where $G_t$ denotes government purchases. For simplicity, I assume that the government consumes a fraction $\tau_t$ of the output of each good. Government expenditures are financed through lump sum taxes. Letting $g_t = -\log(1-\tau_t)$, the demand for good $i$ in log-linear form can be rewritten as follows:[8]

$$y_t(i) = c_t(i) + g_t.$$

Given the previous demand schedule, a monopolistically competitive firm that faced no constraints on the frequency of price adjustment would choose a constant optimal gross markup (in logs) equal to $\mu \equiv \log[\varepsilon/(\varepsilon-1)]$.

Let aggregate output be denoted by

$$Y_t \equiv \left[\int_0^1 Y_t(i)^{(\varepsilon-1)/\varepsilon} di\right]^{\varepsilon/(\varepsilon-1)}$$

8. One can also reinterpret $g_t$ as a shock to preferences or, more broadly, as any other exogenous component of aggregate demand.

The clearing of all goods markets implies

$$y_t = c_t + g_t \,, \tag{10}$$

where $y_t \equiv \log Y_t$. Combining the previous market clearing condition with Euler equation 9 yields the equilibrium condition

$$y_t = -\frac{1}{\sigma}\left[r_t - E_t\{\pi_{t+1}\} - \rho\right] + E_t\{y_{t+1}\} - E_t\{\Delta g_{t+1}\}\,. \tag{11}$$

In addition, and letting $n_t = \log \int_0^1 N_t(i)\,di$, one can derive the following mapping between labor input and output aggregates:[9]

$$n_t = y_t - a_t\,. \tag{12}$$

The assumption of a constant returns technology implies that all firms face a common nominal marginal cost, given by $w_t$ - $a_t$. The economy's average markup will thus be given by

$$\mu_t = a_t - (w_t - p_t)\,. \tag{13}$$

Combining equations 8, 12, 10, and 13 generates an expression for the equilibrium average markup in terms of aggregate output, productivity, and government purchases:

$$\mu_t = -(\sigma + \varphi) y_t + (1 + \varphi) a_t + \sigma g_t\,. \tag{14}$$

In an equilibrium with fully flexible prices, the average markup remains constant at a level $\mu$. The equilibrium level of output is then given by

$$\bar{y}_t = \gamma + \psi_a\, a_t + \psi_g\, g_t\,, \tag{15}$$

where $\psi_a = (1+\varphi)/(\sigma+\varphi)$, $\psi_g = \sigma/(\sigma+\varphi)$, and $\gamma = -\mu/(\sigma+\varphi)$. Henceforth, I refer to the above equilibrium value as the natural level of output or, for short, potential output.

If firms do not adjust prices optimally each period, average markups will no longer be constant. Furthermore, firms' inability to adjust prices optimally every period generally implies the existence of a wedge between output and its natural level. I denote that wedge, or output gap, by $x_t \equiv y_t - \bar{y}_t$. The relationship between the markup gap and the output

9. For nondegenerate distributions of prices across firms, the previous equation holds up only to a first-order approximation. See Yun (1996) and King and Wolman (1996) for a detailed discussion.

gap can be derived from equation 14 and the exogeneity of $a_t$ and $g_t$:

$$\hat{\mu}_t = (\sigma + \varphi)\ x_t . \tag{16}$$

Combining equations 5 and 16 yields the familiar New Keynesian Phillips Curve:

$$\pi_t = \beta E_t \{\pi_{t+1}\} + \kappa x_t , \tag{17}$$

where $\kappa \equiv \lambda (\sigma + \varphi)$.

Finally, equilibrium condition 11 can be rewritten in terms of the output gap:

$$x_t = E_t\{x_{t+1}\} - \frac{1}{\sigma}\left[r_t - E_t\{\pi_{t+1}\} - \rho\right] + \psi_a E_t\{\Delta a_{t+1}\} - (1-\psi_g) E_t\{\Delta g_{t+1}\},$$

or, equivalently,

$$x_t = -\frac{1}{\sigma}\left[r_t - E_t\{\pi_{t+1}\} - \overline{rr_t}\right] + E_t\{x_{t+1}\}, \tag{18}$$

where

$$\overline{rr_t} = \rho + \sigma \psi_a E_t\{\Delta a_{t+1}\} - \sigma(1-\psi_g) E_t\{\Delta g_{t+1}\}. \tag{19}$$

This last equation represents the natural interest rate, that is, the expected real rate of return on a one-period bond that would prevail in an equilibrium under flexible prices.

## 3. The Optimal Inflation-targeting rule

In the baseline model developed above, a monetary authority seeking to stabilize inflation around a constant target, $\pi^*$, can fully attain its goal without facing any costs in terms of output gap instability. Achieving that goal requires that the economy's average markup be kept constant, at a level given by

$$\mu_t = \mu - \left(\frac{1-\beta}{\lambda}\right)\pi^* \equiv \mu^*,$$

for all $t$. That condition, in turn, corresponds to a constant output gap, as shown by equation 16. Formally, inflation targeting implies that

$$x^* = \left(\frac{1-\beta}{\kappa}\right)\pi^*,$$

for all $t$. Supporting a permanent non-zero inflation rate thus requires a proportional, permanent deviation of output from its natural level. In other words, the economy is characterized by a non-vertical long-run Phillips curve, at least for levels of inflation that are sufficiently close to zero for the linear approximation to be satisfactory.[10]

The next step is to derive the equilibrium path for the nominal rate that is consistent with a constant inflation $\pi^*$. Given equation 18, the implied nominal rate, denoted by $r_t^*$ is given by

$$r_t^* = \overline{rr}_t + \pi^*$$

$$= \rho + \pi^* + \sigma\psi_a E_t\{\Delta a_{t+1}\} - \sigma(1-\psi_g) E_t\{\Delta g_{t+1}\}, \quad (20)$$

where $\psi_a = (1+\varphi)/(\sigma+\varphi)$ and $\psi_g = \sigma/(\sigma+\varphi)$, as above.

The behavior of the equilibrium interest rate can be easily grasped by considering the response of consumption to both technology and fiscal shocks in the flexible price case. An anticipated fiscal expansion, corresponding to $E_t\{\Delta g_{t+1}\} > 0$, is associated, in the flexible price equilibrium, with an expected decline in consumption, which can only be supported with a lower real rate. On the other hand, the anticipation of higher productivity growth (that is, $E_t\{\Delta a_{t+1}\} > 0$) will bring about the expectation that consumption will gradually adjust to its new, higher plateau; supporting that response pattern requires a higher interest rate.

## 3.1 Implementation: Ruling Out Indeterminacy

Equation 20 cannot be interpreted as a monetary policy rule that the central bank could follow mechanically or that would guarantee the attainment of the optimal allocation. This can be demonstrated by plugging equation 20 into equation 18. The equilibrium dynamics for inflation and the output gap, expressed as deviations from their target levels, can then be represented by means of the stochastic difference equation,

$$\begin{bmatrix} \hat{x}_t \\ \hat{\pi}_t \end{bmatrix} = \mathbf{A_0} \begin{bmatrix} E_t\{\hat{x}_{t+1}\} \\ E_t\{\hat{\pi}_{t+1}\} \end{bmatrix}, \quad (21)$$

where $\hat{x}_t = x_t - x^*$ , $\hat{\pi}_t = \pi_t - \pi^*$, and

10. See King and Wolman (1996) for a careful analysis of the steady-state relationship between markups, inflation, and the output gap.

$$\mathbf{A_0} \equiv \frac{1}{\sigma} \begin{bmatrix} \sigma & 1 \\ \kappa\sigma & \kappa + \beta\sigma \end{bmatrix}.$$

Notice that $\hat{x}_t = \hat{\pi}_t = 0$, for all $t$, always constitutes a solution to equation 21. In other words, an allocation consistent with a rate of inflation that remains constant at its target level is always an equilibrium. However, a necessary and sufficient condition for the uniqueness of such a solution in a system with no predetermined variables like equation 21 is that the two eigenvalues of $\mathbf{A_0}$ lie inside the unit circle.[11] It is easy to check that such a condition is not satisfied in our case. More precisely, while both eigenvalues of $\mathbf{A_0}$ can be shown to be real and positive, only the smallest one lies in the (0,1) interval.[12] A continuum of solutions in the neighborhood of (0,0) thus satisfy the equilibrium conditions (local indeterminacy). Furthermore, one cannot rule out the possibility of equilibria displaying fluctuations driven by self-fulfilling revisions in expectations (stationary sunspot fluctuations).

The previous indeterminacy problem can be avoided—and the uniqueness of the equilibrium with constant inflation restored—by having the central bank follow a rule that would make the interest rate respond to inflation or the output gap (or both) should those variables deviate from their target values. Suppose that the central bank commits itself to following the rule:

$$r_t = \pi^* + \overline{rr_t} + \phi_\pi \, \hat{\pi}_t + \phi_x \, \hat{x}_t \, . \tag{22}$$

In that case, the equilibrium is described by a stochastic difference equation like equation 21, replacing $\mathbf{A_0}$ with

$$\mathbf{A_T} = \Omega \begin{bmatrix} \sigma & 1 - \beta\phi_\pi \\ \kappa\sigma & \kappa + \beta\left(\sigma + \phi_x\right) \end{bmatrix},$$

where $\Omega = 1/\left(\sigma + \phi_x + \kappa\phi_\pi\right)$. If $\phi_\pi$ and $\phi_x$ are restricted to nonnegative values, then a necessary and sufficient condition for $\mathbf{A_T}$ is to have both eigenvalues inside the unit circle, thus implying the uniqueness of the (0,0) solution to equation 21. This is given by[13]

$$\kappa\left(\phi_\pi - 1\right) + \left(1 - \beta\right) \phi_x \; > \; 0 \, . \tag{23}$$

11. See, for example, Blanchard and Kahn (1980).
12. Bullard and Mitra (2000) provide a formal proof.
13. Again, see Bullard and Mitra (2000) for a formal proof.

Henceforth, I refer to a rule of the form specified in equation 22, which satisfies the determinacy condition 23, as the optimal inflation-targeting rule.

Once uniqueness is restored, the term $\phi_\pi \hat{\pi}_t + \phi_x \hat{x}_t$ appended to the optimal rule vanishes, implying that $r_t = \pi^* + \overline{rr}_t$, for all $t$. Stabilization of the output gap and inflation thus requires a credible threat by the central bank to vary the interest rate sufficiently in response to any deviations of inflation or the output gap from target, yet the very existence of that threat makes its effective application unnecessary.

## 3.2 Implementation: Practical Difficulties

The above analysis suggests that the implementation of a successful inflation-targeting policy is not an easy task. Some of the difficulties can be illustrated in the context of the model.[14] To begin with, the specific form of the optimal inflation-targeting rule will not generally be robust to changes in some of the model characteristics; its correct application thus hinges on knowledge of both the true model and the values taken by all its parameters. Second, the implementation of the rule requires the use of unbiased forecasts of the future path of all underlying exogenous disturbances. It is in that sense that the optimal inflation-targeting rule is forward looking.

Neither condition is likely to be met in practice by any central bank, given the well-known problems associated with measuring variables like total factor productivity, not to mention the practical impossibility of detecting exogenous shifts in some parameters that may be unobservable by nature (for example, parameters describing preferences).[15] The practical difficulties of implementing rules of the sort considered here have led many authors to propose a variety of simple rules—namely, rules that make the policy instrument depend on observable variables and that do not require knowledge of any primitive parameters—and to evaluate their desirability in the context of alternative models.[16]

14. See Blinder (1998) for a general discussion of the practical complications facing central bankers in the design and implementation of monetary policy.

15. Given the likely difficulties in measuring the output gap, the previous argument would also seem to apply to the central bank's need to respond to that variable to avoid the indeterminacy problem. It is clear from equation 23, however, that the equilibrium is unique even if $\phi_x = 0$, so long as $\phi_\pi > 1$.

16. A large number of recent papers seek to analyze the properties and desirability of many such rules. See, for example, the contributions by several authors contained in the Taylor (1999b) volume.

The next section introduces and analyzes the properties of an alternative rule whose practical implementation is likely to be less demanding than the optimal inflation-targeting rule. The rule considered is a simplified version of the well-known Taylor rule. It is shown that the rule can approximate arbitrarily well the desired outcome of inflation stability, without generating any side effects.

## 4. A Simple, Inflation-Based Interest Rate Rule

This section analyzes the properties of an interest rate rule of the form

$$r_t = r + \phi_\pi \left( \pi_t - \pi^* \right), \tag{24}$$

where $r = \overline{rr} + \pi$ and $\overline{rr} = E\{\overline{rr}_t\}$ are, respectively, the steady-state nominal rate and the unconditional mean of the natural interest rate. I also assume that $\phi_\pi > 1$, that is, that the nominal rate responds to current inflation on a more than one-to-one basis. That condition guarantees the local uniqueness of a rational expectations equilibrium. The previous rule is just a simplified version of the rule put forward by John Taylor (1993) as a good characterization of recent U.S. monetary policy. The simplification consists in omitting an output-related term that is present in the original Taylor rule. The justification for that omission is twofold. First, in a model like the one considered here, an inflation-based rule is known to perform better than a more conventional Taylor rule that would have the central bank respond to detrended output as well.[17] Furthermore, it does not perform significantly worse than a rule in which the central bank responds to the true output gap $x_t$ (and which could hardly qualify as a simple rule, given the inherent difficulties in measuring the latter variable). Second, an inflation-based rule would seem to be more tightly connected with an inflation-targeting strategy. In what follows, I refer to the rule above as an inflation-based rule or, for short, a $\pi$-rule.

Relative to the optimal inflation-targeting rule derived in the previous section, a rule like that in equation 24 clearly offers practical advantages in terms of transparency, knowledge requirements, implementa-

17. See Rotemberg and Woodford (1999); Levin, Wieland, and Williams (1999); Galí (2000).

tion using real-time data, and so forth. This greater simplicity stems from the fact that under rule 24, the monetary authority does not need to know the contemporaneous value of the natural interest rate, $\overline{rr}_t$, when setting its instrument every period. It should also be clear that a π-rule will not generally succeed in stabilizing inflation fully. As discussed above, to keep inflation constant at its target level, the nominal interest rate would have to change one-for-one with the natural rate, $\overline{rr}_t$. The π-rule will not generate any change in the nominal rate, however, unless inflation deviates from target. Only in the particular case in which the natural interest rate is itself constant will the π-rule in equation 24 succeed in fully stabilizing inflation. In the baseline model developed above, that will be the case if and only if all changes in productivity or government purchases are fully unpredictable.

The previous result, as well as other interesting insights, can be shown more formally by deriving the stochastic difference equation satisfied by the economy's equilibrium when the monetary authority follows the rule given by equation 24. I assume, for simplicity, that the natural interest rate evolves over time according to an exogenous stationary AR(1) process:

$$\overline{rr}_t = (1-\rho_r)\overline{rr} + \rho_r \overline{rr}_{t-1} + \varepsilon_t,$$

where $\rho_r \in [0,1)$ and $\varepsilon_t$ is white noise with zero mean and variance $\sigma_\varepsilon^2$. The equilibrium dynamics can then be represented by means of the following system:

$$\begin{bmatrix} \hat{x}_t \\ \hat{\pi}_t \end{bmatrix} = \mathbf{A}_{\mathbf{\Pi}} \begin{bmatrix} E_t\{\hat{x}_{t+1}\} \\ E_t\{\hat{\pi}_{t+1}\} \end{bmatrix} + \mathbf{B}_{\mathbf{\Pi}} \left(\overline{rr}_t - \overline{rr}\right),$$

where $\hat{x}_t = x_t - x^*$, $\hat{\pi}_t = \pi_t - \pi^*$,

$$\mathbf{A}_{\mathbf{\Pi}} = \Theta \begin{bmatrix} \sigma & 1-\beta\phi_\pi \\ \sigma\kappa & \kappa+\beta\sigma \end{bmatrix}; \quad \mathbf{B}_{\mathbf{\Pi}} = \Theta \begin{bmatrix} 1 \\ \kappa \end{bmatrix},$$

and $\Theta = 1/(\sigma + \kappa\phi_\pi)$.

The maintained assumption that $\phi_\pi > 1$ guarantees that both eigenvalues of $\mathbf{A}_{\mathbf{\Pi}}$ lie within the unit circle, thus implying a unique rational expectations equilibrium.[18] Furthermore, it is clear that $\hat{x}_t = \hat{\pi}_t = 0$, for all *t,* will be a solution if and only if $\overline{rr}_t = \overline{rr}$, for all *t*, that is, if and only if the natural interest rate is constant.

18. Notice that $\mathbf{A}_{\mathbf{\Pi}}$ corresponds to $\mathbf{A}_{\mathbf{T}}$ when $\phi_x = 0$, implying that the condition for determinacy specified in equation 23 simplifies to $\phi_\pi > 1$.

How large are the size and persistence of the deviations from the inflation target implied by a simple $\pi$-rule, when the natural interest rate varies over time? A number of researchers have praised the performance of similar rules along different criteria and in a variety of models.[19] Here I carry out a simple quantitative exercise that focuses on the ability of the $\pi$-rule to stabilize inflation around the target. This involves analyzing the above model quantitatively under three alternative values for $\rho_r$, the parameter that controls the persistence of the natural interest rate: 0 (no persistence), 1/3 (low persistence), and 3/4 (high persistence). For any given choice of $\rho_r$, the parameter $\sigma_\varepsilon^2$ is then set at a level such that the annualized natural real rate has a standard deviation of 1 percent. That calibration is admittedly arbitrary, but it provides a useful benchmark against which to assess the nominal rate volatility implied by the $\pi$-rule.

For the remaining parameters, I assume a logarithmic utility for consumption, which corresponds to $\sigma = 1$. I also set $\varphi = 1$, which implies a unit wage elasticity of labor supply. The choice for $\theta$ is 0.75; this implies an average price duration of one year, a value in line with both econometric estimates of $\theta$ and survey evidence. Finally, I set $\beta = 0.995$.[20]

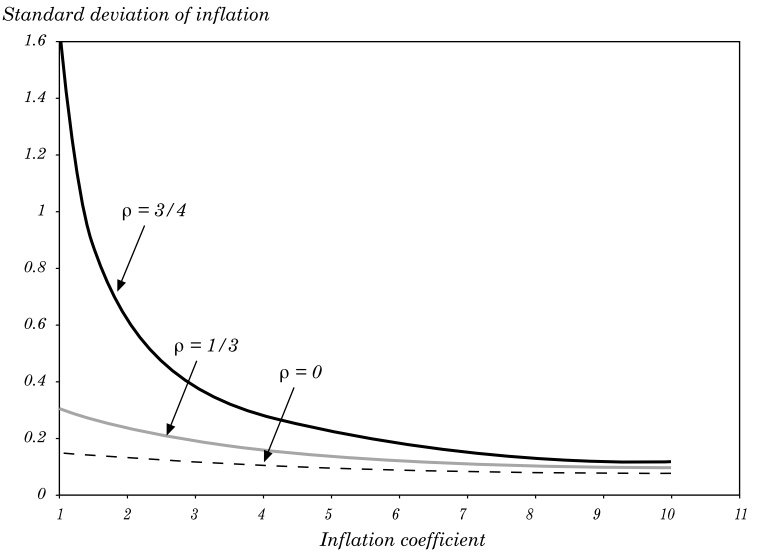
Figures 1 through 3 display a number of statistics that summarize the properties of the equilibrium under a $\pi$-rule, for the three configurations of $\rho_r$ and $\sigma_\varepsilon^2$ considered and a range of values greater than unity for $\phi_\pi$. A number of results are worth stressing. First, higher values for $\phi_\pi$—that is, a more aggressive response to inflation by the monetary authority—have clear stabilizing effects on inflation and the output gap. Thus the standard deviation of both (annualized) inflation and the output gap, shown respectively in figures 1 and 2, decreases monotonically as $\phi_\pi$ is raised, independently of $\rho_r$. The highest value of the inflation coefficient displayed ($\phi_\pi = 10$) causes the residual volatility in either variable to become almost negligible in all cases. In fact, the equilibrium allocation under a $\pi$-rule converges to that of the optimal inflation-targeting rule as $\phi_\pi$ approaches infinity. That property can be checked analytically by noticing that $\lim_{\phi_\pi \to \infty} \mathbf{B}_\Pi = 0$, while $\lim_{\phi_\pi \to \infty} \mathbf{A}_\Pi = \mathbf{C}_\Pi$ is well defined and bounded, with

$$\mathbf{C}_\Pi = \begin{bmatrix} 0 & -\beta\kappa^{-1} \\ 0 & 0 \end{bmatrix}.$$

19. See, for example, the introduction to the Taylor (1999b) volume for a discussion.

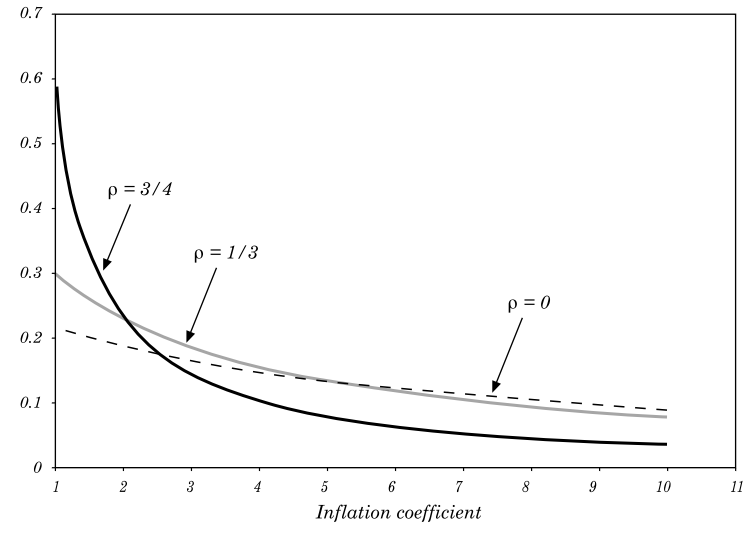
20. Notice that under the assumption of an average annual growth rate of 2 percent—which would correspond to $E\{\Delta a_t\} = 0.005$—the above settings for $\beta$ and $\sigma$ are consistent with an average annualized real interest rate, $\overline{rr}$, of 4 percent.

## Figure 1. Inflation Volatility under an Inflation-Based Rule



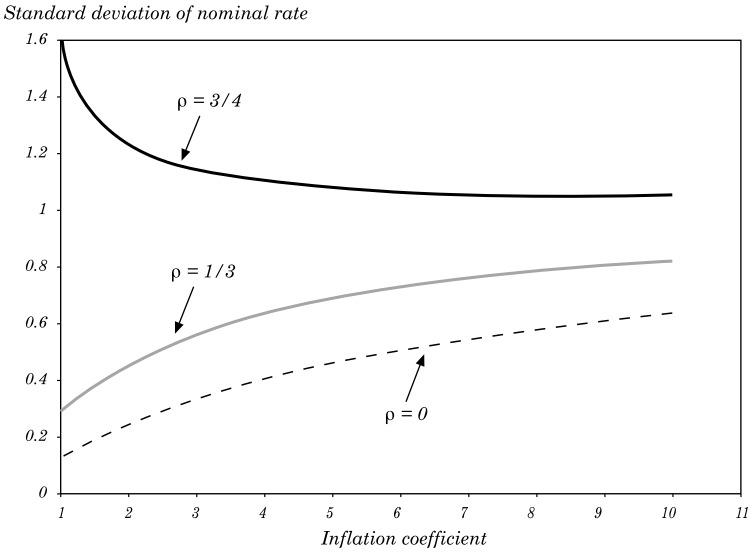

Source: Author's calculations.

## Figure 2. Output Gap Volatility under an Inflation-Based Rule




Source: Author's calculations.

**Figure 3. Nominal Rate Volatility under an Inflation-Based Rule**




Source: Author's calculations.

Second, for any given value of $\phi_\pi$, the volatility of inflation increases with the persistence of the natural interest rate, even though the standard deviation of the latter remains constant, by construction. Thus while the standard deviation of inflation remains very low (less than 15 basis points) and is little sensitive to changes in $\phi_\pi$ when $\rho_r = 0$ (no persistence), it behaves quite differently when the natural rate displays more persistence. For $\rho_r = 3/4$, the standard deviation of inflation is as high as 1 percent when $\phi_\pi = 1.5$ (Taylor's original inflation coefficient). Yet, as shown in figure 2, no such monotonic relationship exists between $\rho_r$ and output gap volatility; instead the sign of that relationship seems to depend on the value of the inflation coefficient $\phi_\pi$.

Third, a possible concern with a rule that requires a very strong response of the interest rate to deviations of inflation from target is that it may be a source of high interest rate volatility. This may be particularly worrisome in economies with low inflation targets, since it raises the possibility of hitting the zero bound constraint and perhaps plunging the economy into a liquidity trap. The analysis of the calibrated model helps dispel some of those worries, however. As shown

in figure 3, the two scenarios with little or no persistence in the natural rate process ($\rho_r = 0$ and $\rho_r = 1/3$) feature an equilibrium nominal rate that is less volatile than the natural rate itself, for all values of $\phi_\pi$ considered.[21] That result no longer holds when fluctuations in the natural real rate are highly persistent ($\rho_r = 3/4$)—the nominal rate is more volatile than its natural counterpart. Interestingly, in the latter case volatility is decreasing in $\phi_\pi$: the stronger the interest rate response to inflation, the lower the volatility of the interest rate. The reason for that seeming paradox is simple. For high values of $\rho_r$, the gains in inflation stabilization resulting from an increase in $\phi_\pi$ more than offset the potential instability resulting from the more aggressive response to a given change in inflation.

How does the nominal rate behave in the limit, as $\phi_\pi$ approaches infinity? By construction, its movements over time must match those of the natural rate; in particular its standard deviation must correspond to the latter's (here calibrated at 1 percent). The intuition behind that result is straightforward. Inflation converges to a constant ($\pi^*$) as $\phi_\pi$ approaches infinity, but as discussed in section 2, the only path for the nominal rate that can support that outcome is given by $r_t = \pi^* + \overline{rr}_t$, for all $t$. Accordingly, as $\phi_\pi \to +\infty$ the standard deviation of the nominal rate must converge to that of the natural rate. This common asymptotic behavior is also apparent in figure 3.

Under the maintained assumptions, the analysis points to a very simple policy recommendation for a central bank that seeks to stabilize inflation fluctuations around a target level (and that wishes to follow a simple rule): the outcome associated with the unfeasible optimal inflation-targeting rule can be approximated arbitrarily well by having the central bank commit to a sufficiently strong interest rate response to any deviation of inflation from target. In particular, following a $\pi$-rule with a relatively large inflation coefficient would succeed in stabilizing inflation as much as desired.

In practice, however, things are likely to be somewhat more complicated, and even a simple rule with the desirable properties considered here may not perform as well as indicated. The next section analyzes the complications that arise from the presence of error or noise in the real-time inflation measures on which the monetary authority would have to base its decisions if it were to follow a simple $\pi$-rule.

21. Recall that the standard deviation of the natural interest rate has been normalized to unity.

## 5. The Performance of a Simple Inflation-Based Rule in the Presence of Noisy Inflation Data

What would prevent a central bank from responding very strongly to inflation when, as in the model above, that rule leads to an outcome arbitrarily close to that generated by the optimal (but hard to implement) inflation-targeting rule? A frequent argument against the choice of such a policy strategy is that it carries the risk of potentially huge interest rate volatility should inflation deviate from its target. Yet the preceding discussion shows that interest rate volatility remains bounded largely as a result of the lower volatility of inflation resulting from the more aggressive policy. In the limit, as $\phi_\pi \to +\infty$ the standard deviation of the nominal rate must converge to that of the natural rate (1 percent in the calibration above). It is possible, however, that measured inflation could experience some residual variation in spite of the aggressive anti-inflation stance, perhaps due to the presence of measurement error. What, then, would be the consequences of an aggressive inflation-based rule on the volatility of true underlying inflation? Would it lead to excessive instrument instability?

To address that potential problem, I analyzed the equilibrium of the baseline model under the assumption that the monetary authority follows a noise-ridden Taylor rule of the form

$$r_t = r + \phi_\pi \left( \tilde{\pi}_t - \pi^* \right), \tag{25}$$

where $\tilde{\pi}_t$ denotes measured inflation at the time the interest rate decision is made and is given by $\tilde{\pi}_t = \pi_t + \xi_t$

where $\xi_t$ represents the measurement error. Notice that $\tilde{\pi}_t$ can be interpreted as the monetary authority's best estimate of current inflation when the interest rate is set; $\pi_t$ is then the actual (or revised) level of inflation. The latter is assumed to be known only with some delay, and not to be used as a policy input.

The equilibrium dynamics can now be represented by means of the system

$$\begin{bmatrix} \hat{x}_t \\ \hat{\pi}_t \end{bmatrix} = \mathbf{A}_{\mathbf{\Pi}} + \begin{bmatrix} E_t\{\hat{x}_{t+1}\} \\ E_t\{\hat{\pi}_{t+1}\} \end{bmatrix}, \tilde{B}_{\mathbf{\Pi}} \begin{bmatrix} \overline{rr}_t - \overline{rr} \\ \xi_t \end{bmatrix},$$

where

$$\tilde{B}_{\mathbf{\Pi}} = \Theta \begin{bmatrix} 1 & -\phi_\pi \\ \kappa & -\kappa\phi_\pi \end{bmatrix}.$$

In this system, deviations of inflation and the output gap from target are the result of both fluctuations in the natural interest rate and inflation noise. A close look at the system reveals that the coefficients associated with inflation noise (that is, the elements of the second column of $\tilde{B}_{\Pi}$) have an absolute value that is increasing in $\phi_{\pi}$. In and of itself, therefore, the presence of noise would call for a mild interest rate response to measured inflation, in order to minimize the volatility of true inflation and the output gap. That observation has to be balanced, however, with the previous finding of a negative relationship between those volatility measures and the strength of the interest rate response to the changes in inflation induced by fluctuations in the natural rate.

The tradeoff can be easily illustrated based on the assumption that both $\xi_t$ and $\overline{rr}_t$ follow independent white noise processes. In that case the variance of inflation is given by

$$\text{var}(\pi_t) = \left( \frac{\kappa}{\sigma + \kappa\phi_{\pi}} \right)^2 \left[ \text{var}(\overline{rr}_t) + \phi_{\pi}^2 \text{var}(\xi_t) \right]. \tag{26}$$

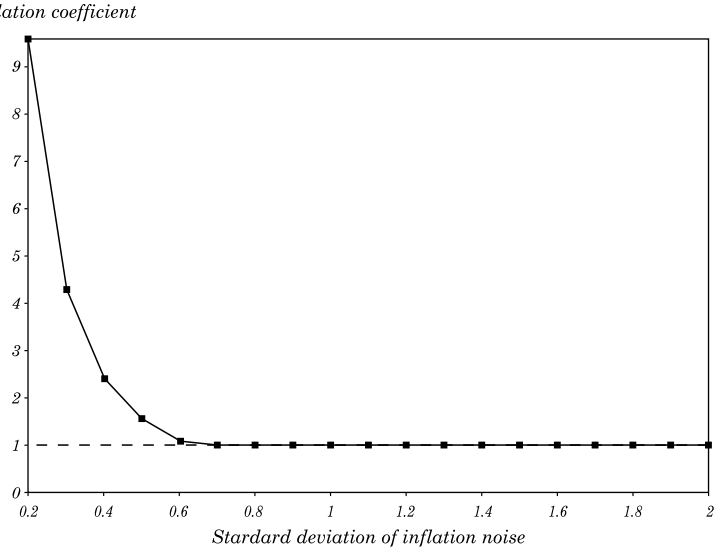
The value of the inflation coefficient, $\phi_{\pi}$, that minimizes the previous expression subject to the constraint $\phi_{\pi} \geq 1$ (which guarantees uniqueness) is given by

$$\phi_{\pi}^{*} = \max \left\{ \frac{\kappa \, \text{var}(\overline{rr}_t)}{\sigma \, \text{var}(\xi_t)}, 1 \right\}.$$

Hence, the strength of the interest rate response that minimizes inflation volatility is a function of the volatility of the noise term relative to that of the natural rate. Consistent with the findings of the previous section, the analysis shows that $\lim_{\text{var}(\xi) \to 0} \phi_{\pi}^{*} = +\infty$. In other words, as the magnitude of inflation noise vanishes, it is optimal for the central bank to respond more aggressively to deviations of inflation from target. As the importance of the noise term increases, however, the size of the optimal inflation coefficient and thus the strength of the optimal response to deviations of inflation from target decrease monotonically.

The results of several simulations under different values for $\rho_r$ suggest that the previous logic carries over to the case of a persistent natural rate process. Figure 4 illustrates this point by displaying the value of $\phi_{\pi}$ that minimizes the volatility of inflation as a function of the standard deviation of the noise term, under the assumption that $\rho_r = 1/3$. For reasonably low values of noise volatility, the optimal inflation coefficient rapidly attains values above those suggested by Taylor (1993) and others as empirically plausible.

**Figure 4. Inflation Stabilization with Noisy Inflation**




Source: Author's calculations.

What happens in the limiting case? First, as the inflation coefficient, $\phi_\pi$, approaches infinity,

$$\lim_{\phi_\pi \to \infty} \mathbf{B_\Pi} = \begin{bmatrix} 0 & -\kappa^{-1} \\ 0 & -1 \end{bmatrix}.$$

It then follows that, in the limiting case, the output gap and true inflation evolve according to

$$x_t = x^* - \frac{1}{\kappa}\xi_t \text{ and}$$

$$\pi_t = \pi^* - \xi_t,$$

whereas measured inflation, $\tilde{\pi}_t$, is fully stabilized at a level given by the inflation target, $\pi^*$. Furthermore, combining these results with equation 18 shows that the nominal interest rate will evolve in that case according to the process $r_t = \pi^* + \overline{rr}_t + (\sigma/\kappa)\ \xi_t$. Even if the monetary authority changes interest rates very aggressively in response to inflation measures that are partly ridden with error, the volatility of inflation, the output gap, and the nominal rate all remain bounded. Nevertheless, a central bank seeking to minimize the volatility of inflation will find it

optimal to choose a finite value for $\phi_\pi$ (that is, a more moderate response to inflation deviations from target).

## 6. Concluding Remarks

The present paper has analyzed the workings of an inflation-targeting regime in the context of an optimizing monetary business cycle model with staggered price setting. Under that paradigm, inflation and its variations over time are a consequence of deviations of markups from their flexible price level. Any policy that aims at stabilizing inflation around a constant target will require that the economy's average markup be stabilized.

While this result is quite general, the specific form of the rule that implements an inflation-targeting policy (the optimal inflation-targeting rule) will generally depend on the structure of the model, the settings for the parameters describing the economic environment, and the properties of the underlying sources of fluctuations. That observation suggests that the actual implementation of the optimal inflation-targeting rule would most likely face many difficulties, and it motivates the search for simple rules and the analysis of their properties. Sections 3 and 4 analyzed the properties of a simplified version of the so-called Taylor rule, which I referred to as the $\pi$-rule, under which the monetary authority adjusts the interest rate in response to deviations of inflation from target. Two results are worth emphasizing. First, in the absence of significant measurement error in the inflation data, a simple Taylor rule can approximate the outcome of the optimal inflation-targeting policy arbitrarily well, as long as the interest rate response to movements in inflation is sufficiently strong. Second, if the inflation data is ridden with error, choosing too large a value for the inflation coefficient, $\phi_\pi$, may cause the volatility of inflation to rise. The size of the coefficient that minimizes the volatility of inflation is shown to be finite and inversely related to the volatility of the noise term.

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# Alternative Monetary Rules in the Open-Economy: A Welfare-Based Approach

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How do central banks choose among alternative monetary policies? In this paper we analyze that question for an open economy following an interest rate rule. Many issues remain controversial in the design of such a rule. If inflation is targeted, as it presumably is, should the domestic interest rate also react to the output gap or to movements in other real variables? Should inflation targeting focus on the consumer price index (CPI), on home prices only, or on some other index? Should the interest rate respond to movements in the nominal exchange rate? Equivalently, should the exchange rate float cleanly?

All such questions can be addressed by considering a particular social loss function and quantitatively analyzing the response of a model economy to several shocks (domestic and foreign, real and nominal) under alternative monetary rules and exchange rate regimes. The best regime is the one that stabilizes the economy and consequently yields lower social losses. That is the approach we take here.

In the analysis that follows, we use a social loss function that includes the variability of the real exchange rate in addition to the variability of inflation and output, as is conventional in closed economy models. The three policy alternatives we consider and the corresponding results are as follows:

—Flexible versus managed exchange rate regimes. In the former, the currency floats freely, while in the latter the central bank adjusts its domestic interest rate in response to fluctuations in the nominal

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exchange rate, in addition to reacting to other variables such as inflation and output. We find that the social loss is much higher under managed exchange rates than under flexible rates in the presence of real shocks, while for nominal shocks the reverse is true. This result is consistent with conventional wisdom on the subject.

—CPI versus domestic inflation targeting. In the latter, the inflation target is defined exclusively in terms of the variation of the price index for domestically produced goods.[1] We find that domestic inflation targeting is preferable to CPI inflation targeting, since it minimizes volatility in output at the possible cost of some relatively small additional volatility in the real exchange rate.

—Strict versus flexible inflation targeting. In the former, interest rate policy reacts to inflation only, while in the latter it reacts to output (and possibly the exchange rate) in addition to the target inflation rate. We find that flexible inflation targeting is generally preferable to strict inflation targeting.

We carry out the analysis in a dynamic neo-Keynesian (DNK) model, modified to allow for inflation targeting in an open economy. This framework builds on previous research by Svensson (2000), Galí and Monacelli (2000), Parrado (2000), and Parrado and Velasco (2001), all of which focus on the performance of simple policy rules (whether optimal or not) in open economies. Our model contains three structural blocks: aggregate demand, aggregate supply, and a monetary sector. The aggregate demand block is derived from utility maximization. The same is true of aggregate supply, which also incorporates forward-looking sticky prices à la Calvo (1983).

Studying the welfare consequences of monetary rules has only lately become fashionable among academic economists. The issue was not tackled previously for lack of tools rather than lack of interest. The most recent generation of general equilibrium sticky-price models, based on utility maximization, naturally lends itself to welfare analysis, as evidenced by the number of recent papers on the subject.[2] Our model differs from much recent work in two dimensions. First, it focuses on a small open economy, while most pa-

1. Currently, some inflation targeters target the full CPI (for example, Germany, Israel, Spain, and Sweden). Others use the CPI but exclude volatile prices such as energy and food prices (for example, Australia and New Zealand). Canada, Chile, and the United Kingdom use both types of measure.

2. A partial list of recent papers incorporating an open economy, aside from works mentioned in the text, includes Benigno and Benigno (2001); Ghironi and Rebucci (2001); Monacelli (2000); Parrado (2000); Svensson (2000).

pers—with the important exception of Galí and Monacelli (2000)—focus on a world economy composed of two countries of comparable size. As Lane (2001) points out, much of the literature has been based on a two-country world, since this allows interest rates and asset prices to be endogenously determined. However, this benefit comes at the price of considerable model complexity and may not be of compelling importance for the analysis of issues relevant to a small open economy. Second, we focus on interest rate policies, while most other papers try to characterize the optimal behavior of the nominal quantity of money, starting with the seminal paper of Obstfeld and Rogoff (1995).

The paper is organized as follows. Section 1 outlines the model. Section 2 presents the solution of the model and its parameterization, while section 3 analyzes alternative policy experiments. Section 4 summarizes the results and their implications for models of monetary policy and discusses caveats and directions for future research.

## 1. A Sticky-Price Model

The model consists of an open economy that comprises a central bank, a fiscal authority (the government), a representative consumer, and monopolistically competitive firms. All goods are tradable. As is standard in the literature, domestic production requires a continuum of differentiated labor inputs that are supplied by home individuals. Time is discrete.

We proceed in three steps. First, we outline the main building blocks of the model and its microeconomic foundations. Second, we derive the main price relationship of the model, namely, inflation rates and exchange rates. Finally, we embed these relationships in an otherwise conventional DNK model.

### 1.1 Microeconomic Foundations of Demand and Supply

The economy has a continuum of measure 1 of consumer-producers indexed by $j \in (0,1)$. Each consumer-producer has the same intertemporal lifetime utility function,

$$E_t\left[U_{t+k}(j)\right] = E_t\left[\sum_{k=0}^{\infty}\beta^k\left\{u\left[C_{t+k}(j)\right] + h\left[\frac{M_{t+k}(j)}{P_{t+k}}\right] - \int_0^1 v\left[Y_{t+k}(j)dj\right]\right\}\right], \quad (1)$$

where $0 < \beta < 1$ is the discount factor and $C_t$ is a composite consumption index defined by

$$C_t = \left[ (1-\gamma)^{1/\eta} \left( C_{H,t} \right)^{(\eta-1)/\eta} + \gamma^{1/\eta} \left( C_{F,t} \right)^{(\eta-1)/\eta} \right]^{\eta/(\eta-1)}, \tag{2}$$

where $\eta > 0$ is the elasticity of substitution between domestic and foreign goods and $\gamma$ corresponds to the share of domestic consumption allocated to imported goods. The two consumption subindexes, $C_{H,t}$ and $C_{F,t}$, are symmetric, and they are defined, as in Dixit and Stiglitz (1977), by

$$C_{H,t} = \left[ \int_0^1 C_{H,t}(j)^{(\theta-1)/\theta} \, dj \right]^{\theta/(\theta-1)} \text{ and} \tag{3a}$$

$$C_{F,t} = \left[ \int_0^1 C_{F,t}(j)^{(\theta-1)/\theta} \, dj \right]^{\theta/(\theta-1)}, \tag{3b}$$

where $\theta > 1$ is the price elasticity of demand faced by each monopolist and $C_{H,t}(j)$ and $C_{F,t}(j)$ are the quantities purchased by home agents of home and foreign goods, respectively.

Consumers can store domestic non-interest-bearing money, and they can also hold state-contingent claims, as in Cole and Obstfeld (1991) and Galí and Monacelli (2000). The latter means that ex ante international financial markets are complete and thus there is no need for international portfolio diversification. In equilibrium, it also means that transitory shocks do not have permanent consequences, which sharply simplifies our analysis. The individual household constraint is given by

$$\int_0^1 \left[ P_{H,t}(j) C_{H,t}(j) + P_{F,t}(j) C_{F,t}(j) \right] + M_t(j) + E_t \left[ F_{t,t+1} B_{t+1} \right]$$
$$= (1-\tau) P_{H,t}(j) Y_{H,t}(j) + M_{t-1}(j) + B_t(j) + TR_t, \tag{4}$$

where $F_{t,t+1}$ is the stochastic discount factor, $B_{t+1}$ is the payoff in period $t + 1$ of the portfolio held at the end of period $t$, $TR_t$ are lump sum transfers, and $\tau$ is a proportional tax on nominal income.

The home commodity demand functions resulting from cost minimization are

$$C_{H,t}(j) = \left[\frac{P_{H,t}(j)}{P_{H,t}}\right]^{-\theta} C_{H,t} \text{ and}$$

$$C_{F,t}(j) = \left[\frac{P_{F,t}(j)}{P_{F,t}}\right]^{-\theta} C_{F,t},$$

where $P_{H,t}$ and $P_{F,t}$ are the price indexes for domestic and foreign goods, both expressed in the domestic currency:

$$P_{H,t} \equiv \left[\int_0^1 P_{H,t}(j)^{1-\theta} dj\right]^{1/(1-\theta)} \text{ and}$$

$$P_{F,t} \equiv \left[\int_0^1 P_{F,t}(j)^{1-\theta} dj\right]^{1/(1-\theta)}.$$

Using the definition of total consumption in equation 2, we can derive the demand allocation for home and foreign goods:

$$C_{H,t} = (1-\gamma)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t \text{ and}$$

$$C_{F,t} = \gamma\left(\frac{P_{F,t}}{P_t}\right)^{-\eta} C_t, \tag{5}$$

where $P_t \equiv \left[(1-\gamma)\left(P_{H,t}\right)^{1-\eta} + \gamma\left(P_{F,t}\right)^{1-\eta}\right]^{1/(1-\eta)}$ is the consumer price index (CPI).

Plugging equation 5 into budget constraint 4, we can obtain a new expression for the latter in terms of the composite good:

$$P_t C_t + M_t(j) + E_t\left[F_{t,t+1} B_{t+1}\right] = (1-\tau) P_{H,t}(j) Y_{H,t}(j) + B_t(j) + M_{t-1}(j) + TR_t. \tag{6}$$

The home agent's problem is to choose paths for consumption, money, and the output of good $j$. Therefore, the representative consumer chooses his optimal holdings of contingent bonds, $B(j)$, and money, $M(j)$, to maximize his expected utility (equation 1) subject to the budget constraint (equation 6). It follows that the first-order necessary conditions (FONCs) are

$$\beta E_t\left[\frac{u_c(C_{t+1})}{u_c(C_t)}\frac{P_t}{P_{t+1}}\right] = E_t\left[F_{t,t+1}\right] \text{ and} \tag{7}$$

$$u_c(C_t) = h_m\left(\frac{M_t}{P_t}\right)\frac{1}{P_t} + \beta E_t\left[u_c(C_{t+1})\frac{P_t}{P_{t+1}}\right]. \tag{8}$$

Equation 7 represents the traditional intertemporal Euler equation for total real consumption, while equation 8 corresponds to the intertemporal Euler equation for money.

The problem is analogous for the rest of the world, although the crucial assumption here is that the share of goods that are not produced within the economy is insignificant. The Euler equation for the rest of the world would thus be

$$\beta E_t\left[\frac{u_c^*(C_{t+1})}{u_c^*(C_t^*)}\frac{P_t^*}{P_{t+1}^*}\frac{S_t}{S_{t+1}}\right] = E_t\left[F_{t,t+1}\right]. \tag{9}$$

Combining and iterating equations 7 and 9 yields

$$u_c(C_t) = \kappa u_c^*(C_t^*)Q_t, \tag{10}$$

where $Q_t = \left(S_t P_t^*\right)/P_t$ is the real exchange rate and $\kappa$ is a constant that depends on initial wealth differences. The assumption of complete markets thus leads to equation 10, which associates home consumption with the consumption of the rest of the world and with a switching factor given by the real exchange rate.[3]

The model employs a price-setting process that follows Calvo (1983), in which firms are able to change their prices only with some probability, independently of other firms and the time elapsed since the last adjustment. We assume that producers behave as monopolistic competitors. Each firm faces the following demand function:

$$y_{H,t}^d(j) = \left[\frac{p_{H,t}(j)}{P_{H,t}}\right]^{-\theta} C_{H,t}^A, \tag{11}$$

3. The assumption of complete markets has the additional advantage of eliminating foreign asset movements from the dynamics of the economy. As a result, the steady state is unique, in that consumption is independent of the past history of shocks. We can thus linearize around that unique steady state. This is not possible in standard models of small open economies.

where $C^{A}_{H,t} = C_{H,t} + C^{*}_{H,t}$.

Recall that the economy has a continuum of measure 1 of consumer-producers indexed by $j \in (0,1)$, where each consumer-producer has the same expected profit function. It follows that the objective function can be written as

$$E_{t-1}\left[\sum_{k=0}^{\infty}\alpha^{k}\beta^{k}\Lambda_{t+j}\left\{\frac{p_{H,t}(j)}{P_{H,t+k}}\left[\frac{p_{H,t}(j)}{P_{H,t+k}}\right]^{-\theta}C^{A}_{H,t+k} - \frac{W_{t+k}V\left\{\left[p_{H,t}(j)/P_{H,t+k}\right]^{-\theta}C^{A}_{H,t+k}\right\}}{P_{H,t+k}\tilde{Z}_{t+k}}\right\}\right], \quad (12)$$

where $\alpha$ is the probability that consumer-producers maintain the same price of the previous period, $\Lambda_{t+j}$ is the marginal utility of home goods, $V\left(y^{d}_{H,t}\right)/\tilde{Z}_{t}$ is the input requirement function, $\tilde{Z}_{t}$ is an exogenous economywide productivity parameter, and $W_t$ is the price of the composite input.

The problem of the producers, which is solved in appendix A, is to choose $p_{H,t}(j)$ to maximize equation 12.

## 1.2 Government

We assume the government balances its budget each period. The government budget constraint is thus given by

$$\tau P_{H,t}Y_{H,t} - TR_t + M_t - M_{t-1} = 0 .$$

We restrict our analysis to the case in which $\tau = 1/(1-\theta)$. In this case, the government offsets the market power distortion created by monopolistic competition in the market for differentiated goods. This means that the only distortion in the economy is price rigidity, and offsetting the effects of that distortion is the object of monetary policy.

## 1.3 Price Relationships

Before moving on to the complete log-linearized model, we define the price relationships involved in the model, in log terms. Let $p_{H,t}$ and $p_{F,t}$ be the stochastic components of (log) levels of domestic and foreign good prices, respectively, in period $t$. Thus the (log) consumer price index (CPI) can be defined as

$$p_t = (1-\gamma)p_{H,t} + \gamma p_{F,t}, \quad (13)$$

where γ, a parameter of the utility function, is the share of home goods in the CPI, with $0 < \gamma < 1$. Therefore, the (log) CPI inflation can also be defined as

$$\pi_t = (1-\gamma)\pi_{H,t} + \gamma\pi_{F,t}\,, \tag{14}$$

where $\pi_{H,t} = p_{H,t} - p_{H,t-1}$ is domestic inflation and $\pi_{F,t} = p_{F,t} - p_{F,t-1}$ denotes foreign inflation. Depending on the choice of the inflation target (CPI versus domestic inflation), $\pi_t$ and $\pi_{H,t}$ will be measured as deviations from a constant mean, which equals the constant inflation target.

The (log) real exchange rate can similarly be defined as

$$q_t \equiv s_t + p_t^* - p_t \Rightarrow q_t = (1-\gamma)\left(s_t + p_t^* - p_{H,t}\right), \tag{15}$$

where $s_t$ represents the (log) nominal exchange rate and where we have included the key assumption that the rest of the world behaves as a closed economy, that is, $p_t^* = p_{F,t}^*$. In other words, we assume that the rest of the world's consumption of foreign goods (that is, of the goods produced by the home economy) is negligible.[4]

## 1.4 The Log-Linearized Model

This section presents the complete log-linearized model of this open economy. Additional details are presented in the appendix. Lower case variables denote percent deviations from the steady state, and ratios of capital letters without time subscript denote steady-state values of the respective ratios. We express the complete log-linearized model in terms of three blocks of equations: aggregate demand, aggregate supply, and monetary policy rules and stochastic processes.

### Aggregate Demand

Aggregate demand in this economy is given by

$$x_t = E_t\left[x_{t+1}\right] + \phi_\pi E_t\left[\pi_{H,t+1}\right] - \phi_s\left(E_t\left[s_{t+1}\right] - s_t\right) - \frac{1}{\sigma} i_t - (1-\rho_z) z_t + \gamma\left(1-\rho_{y^*}\right) y_t^*\,, \tag{16}$$

4. Galí and Monacelli (2000) use the same approximation.

where $\phi_\pi = \left[(1-\gamma)/\sigma + \gamma\eta(2-\gamma)\right]$, $\phi_s = \gamma\left[\eta(2-\gamma) - 1/\sigma\right]$, $0 \le \rho_z \le 1$, and $0 \le \rho_{y^*} \le 1$. Note that $i_t = (P_{t+1}/P_t)E_t\left[F_{t,t+1}\right]$ is the nominal interest rate, while $y_t^* = c_t^*$ is foreign output, which follows a stationary univariate AR(1) process.

Equation 16 represents a nontraditional IS curve that relates the output gap not only to the interest rate, but also to the expected future output gap and current and expected future nominal exchange rates. A nominal depreciation, and consequently a real depreciation, raises aggregate demand, because it shifts demand from foreign goods to domestic output (foreign prices are given, and any repercussion effects from the home economy to the rest of the world are neglected).

## Aggregate Supply

Aggregate supply is obtained by log-linearizing the first-order condition of the price setting problem. It follows that

$$\pi_{H,t} = \beta E_t\left[\pi_{H,t+1}\right] + \lambda_x x_t + \lambda_q\left(s_t + p_t^* - p_{H,t}\right) \text{ and} \tag{17}$$

$$\pi_t = \gamma\pi_{H,t} + (1-\gamma)(s_t - s_{t-1}), \tag{18}$$

where $\lambda_x = \left\{\left[(1-\alpha)(1-\alpha\beta)\right]/\alpha(1+\varepsilon\theta)\right\}\xi$, $\lambda_q = \lambda_x\gamma$, and $z_t$ is an economywide productivity shock.

Equation 17 embeds the staggered price setting formulation of Calvo (1983) described earlier, giving rise to the dynamic version of the aggregate supply schedule for domestic goods. Current domestic inflation depends on expected future domestic inflation, current domestic output, and the terms of trade. This reflects the forward-looking nature of price setting, stemming from the implicit costs of changing prices.

Equation 18 defines CPI inflation in terms of domestic inflation and accumulated nominal exchange rate depreciation. Derivation of this equation assumes that foreign prices are constant.

## Uncovered Interest Parity Condition

The uncovered interest parity condition is given by

$$i_t = i_t^* + E_t\left[s_{t+1}\right] - s_t, \tag{19}$$

which relates the movements of the interest rate differentials to the expected variations in the nominal exchange rate.

## Monetary Policy Rules and Stochastic Processes

We assume that the central bank manages a short-term nominal interest rate according to an open economy variant of the Taylor rule. Specifically, we consider a rule in which the central bank adjusts the current nominal interest rate in response to expected inflation, the current output gap, the current exchange rate, and the lagged interest rate. In general, this kind of rule describes the variation of short-term interest rates relatively well.[5]

As Clarida, Galí, and Gertler (1998) show, the current interest rate typically depends on the interest rate target and the lagged interest rate, that is, there is a degree of interest rate smoothing given by $\rho_i$. The assumption behind this point is that monetary authorities are concerned about interest rate volatility, because it is presumably costly in terms of financial market health and also investment and growth. Thus we have

$$i_t = (1-\rho_i)\bar{i}_t + \rho_i i_{t-1}, \tag{20}$$

where $\bar{i}_t$ is the nominal interest target toward which the central bank gradually adjusts the interest rate, given by

$$\bar{i}_t = \chi_\pi E_t\left[\tilde{\pi}_{t+k} - \bar{\pi}\right] + \chi_x x_t + \chi_s s_t, \tag{21}$$

where $\chi_\pi > 1$, $\chi_x \geq 0$, and $\chi_s \geq 0$ and where $\pi_{t+k} = \tilde{\pi}_{t+k} - \bar{\pi}, \tilde{\pi}_{t+k}$ denotes the percent change in the price level between periods $t$ and $t + k$ and $\bar{\pi}$ is the inflation target. The policy rule used by the monetary authority depends on expected future inflation. Higher expected future inflation raises the current nominal interest rate target. Batini and Haldane (1998) also consider this kind of policy rule. They conclude that policy rules based on inflation forecasts embody all information that is useful for predicting future inflation, and such rules can achieve a high degree of output smoothing.

Including the term $\chi_s$ in the policy rule helps to reproduce the behavior of nominal exchange rates. This rule implies the type of exchange regime chosen by the country, depending on the degree of control that the central bank exercises over the nominal exchange rate

5. See Clarida, Galí, and Gertler (1998, 1999); Rotemberg and Woodford (1998a).

(the value of $\chi_s$). If $\chi_s = 0$, the central bank does not care about deviations of the nominal exchange rate, that is, the economy reproduces a flexible exchange rate behavior. On the other hand, if $\chi_s \in (0,\infty)$, the central bank acts in response to the deviation of the nominal exchange rate from its current target or steady-state value. This case corresponds to a managed exchange rate and, in the limit as $\chi_s$ goes to infinity, to a fixed exchange rate.

By plugging equation 21 into equation 20, we determine that the monetary policy rule is given by[6]

$$i_t = \rho_i i_{t-1} + \upsilon_\pi E_t\left[\pi_{t+k}\right] + \upsilon_x x_t + \upsilon_s s_t + \in_t , \tag{22}$$

where $\upsilon_\pi = (1 - \rho_i)\chi_\pi$, $\upsilon_x = (1 - \rho_i)\chi_x$, $\upsilon_s = (1 - \rho_i)\chi_s$, and $\in_t$ is an interest rate shock. This shock has two interpretations: it may capture deliberate decisions to deviate temporarily from its systematic rule, or it may represent erratic monetary policy (if there is another monetary policy instrument, for example).

Finally, equations 23, 24, 25, and 26 describe the evolution of foreign interest rate, foreign output, technology, and domestic interest rate shocks, respectively.

$$r_t^* = \rho_{r^*} r_{t-1}^* + \varepsilon_t^{r^*} , \tag{23}$$

$$y_t^* = \rho_{y^*} y_{t-1}^* + \varepsilon_t^{y^*} , \tag{24}$$

$$z_t = \rho_z z_{t-1} + \varepsilon_t^z , \text{ and} \tag{25}$$

$$\in_t = \rho_\in \in_{t-1} + \varepsilon_t^\in , \tag{26}$$

where $\varepsilon_t^{r^*}$, $\varepsilon_t^{y^*}$, $\varepsilon_t^z$ and $\varepsilon_t^\in$ are independent and identically distributed (i.i.d.) shocks with zero mean and variance $\sigma_{r^*}^2 = 0.25$, $\sigma_{y^*}^2 = 1$, $\sigma_z^2 = 1$, and $\sigma_\in^2 = 0.25$.

6. An important consideration is in order with regard to the definition of inflation targeting. Some authors argue, based on McCallum and Nelson (1999) and Batini and Haldane (1998), that inflation targeting is the case in which monetary policy responds to inflation in addition to other variables such as output and real exchange rates. Alternatively, Svensson (2000) defines inflation targeting as the minimization of a loss function that is increasing in the deviation between the target variable(s) and the target level(s). He points out that "the best way to minimize such a loss function is then to respond optimally with the instrument to the determinants of the target variables, that is, the state variables of the economy." These two definitions are equivalent only if there is a one-to-one relation between the variables in the reaction function and the loss function.

## 1.5 Welfare Criterion

To evaluate the welfare implications of alternative monetary policy rules and exchange rate regimes, we need a welfare criterion. This welfare criterion is based on expected social loss. Social loss is, in turn, assumed to depend on the deviations of output and inflation from their steady-state values, and possibly on other variables. Our assumptions on social loss may be seen as an approximation of some aggregate of the welfare of consumer-producers.

Therefore, the welfare criterion of the home country, disregarding liquidity effects, is defined broadly as[7]

$$L_t = \psi_\pi \pi_{H,t}^2 + \psi_x x_t^2 + \psi_q q_t^2 . \tag{27}$$

After taking unconditional expectations, the loss function becomes

$$E\left[L_t\right] = \psi_\pi \operatorname{Var}\left[\pi_{H,t}\right] + \psi_x \operatorname{Var}\left[x_t\right] + \psi_q \operatorname{Var}\left[q_t\right],$$

where $\operatorname{Var}[\pi_{H,t}]$, $\operatorname{Var}[x_t]$, and $\operatorname{Var}[q_t]$ are the unconditional variances of domestic inflation, the output gap, and the real exchange rate, respectively.

The fact that we attribute social costs to domestic inflation can be justified in the context of the Calvo (1983) staggered setup. As Woodford (1996, 1999, 2001), Rotemberg and Woodford (1998a, 1998b), and Benigno (2000) show in detail, staggering inflation causes the dispersion of relative prices, which is costly for output and welfare. Since domestic prices are sticky in our model, ongoing domestic inflation causes such relative price distortions.

Designing the optimal monetary policy involves minimizing equation 27.[8] The strategy of this paper is to compare alternative (nonoptimal) policy rules using this benchmark criterion. We assume that the welfare criterion for the small open economy includes not only variations in output and inflation, as is standard in the closed economy case, but also changes in the real exchange rate. In particular, we analyze the broad case in which the loss function considers the following weights: $\psi_\pi = 1.5$; $\psi_x = 0.5$; and $\psi_q = 0.5$.

7. The instrument of the monetary authority is the short nominal interest rate. This implies that the behavior of monetary aggregates plays no essential role in the analysis.

8. See Svensson (2000) for a detailed derivation of an optimal reaction function under the Calvo (1983) scheme. See also Parrado and Velasco (2001) for solution methods similar to those based on Obstfeld and Rogoff (1995).

To make sure that our results do not depend on the particular specification of the loss function, we experimented with different weights for inflation, output gap, and the real exchange rate. In general, the main conclusions do not differ with alternative reasonable parameter values.

## 2. Model Simulations

We now turn to some quantitative experiments indicating how inflation targeting can influence business cycle dynamics within the DNK framework. Specifically, we consider three types of exercises. First, we compare flexible versus managed exchange rates, considering both CPI and domestic inflation targeting. Second, we study how the choice between the CPI and domestic inflation indexes influences the behavior of output, inflation, interest rates, and exchange rates. Finally, we contrast differences between strict and flexible inflation targeting.

### 2.1 Model Parameterization

For parameter values, we choose standard values that appear in the traditional related literature. These values are in line with Chilean estimations. The first subsection presents estimates of the Central Bank of Chile's feedback rule found in Parrado (2000), while the second subsection considers the choice of parameter values from the traditional literature.

#### Monetary Policy Rule

Empirical research suggests that many countries have used anticipated future inflation rather than current or lagged inflation. Parrado (2000) employs generalized method of moments (GMM) to show that the Central Bank of Chile's actions during the 1990s were driven mainly by an inflation-forecast-based policy rule. Table 1 reports GMM estimates of coefficients $\chi_\pi$, $\chi_x$, $\chi_s$, and $\rho$ using monthly time series from 1990:12 to 1999:02. These estimates yield several results. First, the coefficient associated with expected inflation is greater than one; this indicates that whenever expected inflation rose, the Central Bank reacted by increasing real interest rates aggressively. Second, the coefficient that captures interest inertia is low ($\rho \cong 0.5$), which suggests that the monetary authority reacted independently of the level of past interest rates. Third, the coefficient associated with output does not have the expected sign, but it is not significant. We therefore cannot reject the hypothesis that $\chi_x$ is 0. Finally,

**Table 1. GMM Estimations of the Central Bank of Chile's Reaction Function[a]**

| *Reaction to inflation* | $\upsilon_\pi$ | $\upsilon_x$ | $\upsilon_s$ | $\rho$ | $p$ |
|---|---|---|---|---|---|
| Expected inflation (6 periods ahead) | 1.98 (0.61) | –0.18 (2.16) | 3.34 (1.92) | 0.50 (0.15) | 0.06 |
| Expected inflation (3 periods ahead) | 2.03 (0.63) | –0.22 (1.97) | 3.33 (1.90) | 0.50 (0.15) | 0.06 |
| Current inflation | 3.50 (2.77) | 3.01 (5.02) | 1.45 (4.06) | 0.73 (0.18) | 0.07 |

Source: Parrado (2000).

a. The set of instruments includes one to six, nine, and twelve lags of inflation, output, the interest rate, commodity price inflation, and money growth. Standard deviations are in parentheses.

estimates of $\chi_s$ (the coefficient that measures the sensitivity to the exchange rate) are high and significant. This indicates that the Central Bank was trying to stabilize exchange rates during the 1990s.

In sum, we can infer from the estimates that during the sample period the Chilean Central Bank tried to stabilize only inflation (ignoring output), directly through the inflation target and indirectly through the nominal exchange rate and current account.[9]

## Other Parameter Values

The following parameter values are selected both from traditional related literature and from current Chilean data. The quarterly discount factor is set at $\beta = 0.99$. We take the share of home goods in total home consumption to be $\gamma = 0.29$, which is equivalent to the average share of Chilean imports in its GDP over the period 1998–2000. We let the probability that a firm does not change its price within a given period, $\alpha$, equal 0.75, which implies that the frequency of price adjustment is four quarters. The price demand elasticity or the degree of monopolistic competition, $\theta$, is set at 4.33. We set $\sigma = 1$, which corresponds to log utility, and we assume that the elasticity of substitution between domestic and foreign goods, $\eta$, equals 1.5.

In the policy rule (equation 22), the degree of interest rate smoothing, $\rho_i$, is equal to 0.7 and the coefficient of inflation, $\chi_\pi$, is 1.5. In the

9. The estimates in Parrado (2000) do not differ significantly between CPI and domestic inflation.

simulations, we compare rules with $\chi_x = 0.5$ against $\chi_x = 0.0$ and rules with $\chi_s = 0$ against $\chi_s = 3.34$.

Finally, the serial correlation parameters for foreign interest rate, foreign output, productivity, and domestic interest rate shocks, $\rho_{r^*}$, $\rho_{y^*}$, $\rho_z$, and $\rho_\in$, respectively, are set equal to 0.8.

## 2.2 Model Solution

The dynamic system is given by equations 16, 17, 19, and 22 and by the definition of domestic inflation, $\pi_{H,t} = p_{H,t} - p_{H,t-1}$. In matrix form, the system is the following:

$$E_t\left[\mathbf{k}_{t+1}\right] = \mathbf{A}\mathbf{k}_t + \mathbf{B}\mathbf{v}_t, \tag{28}$$

where $\mathbf{k}_t$ is a vector of endogenous variables, $\mathbf{k}_t = \left(y_t, \pi_{H,t}, s_t, i_{t-1}, p_{H,t-1}\right)'$, **A** is a five-by-five matrix of coefficients, **B** is a five-by-four matrix of coefficients, and $\mathbf{v}_t = \left(r_t^*, y_t^*, z_t, \in_t\right)'$.

The dynamic system has two predetermined variables, $i_{t-1}$ and $p_{H,t-1}$, and three nonpredetermined variables, $y_t$, $\pi_{H,t}$, and $s_t$. As shown in Blanchard and Kahn (1980), if the number of eigenvalues of **A** outside the unit circle is equal to the number of nonpredetermined variables —in our case three— then there exists a unique rational expectations solution to system 28.

The strategy is to transform the model into canonical form. Let $\mathbf{A} = \mathbf{QJQ}^{-1}$, where **J** is the Jordan matrix associated with **A**, and **Q** is the corresponding matrix of eigenvectors. We can define the vector of canonical variables as $\mathbf{w}_t = \mathbf{Q}^{-1}\mathbf{k} = (a_t, b_t)$, where $a_t$ and $b_t$ are associated with the unstable and stable eigenvalues, respectively. Let **J** and **Q** be the corresponding partition of the Jordan matrix and matrix of eigenvectors, respectively, with

$$\mathbf{J} = \begin{bmatrix} J_a & 0 \\ 0 & J_b \end{bmatrix} \text{and } \mathbf{Q} = \left(Q_a, Q_b\right).$$

Thus we can rewrite system 28 as

$$E_t\begin{bmatrix} a_{t+1} \\ b_{t+1} \end{bmatrix} = \begin{bmatrix} J_a & 0 \\ 0 & J_b \end{bmatrix}\begin{bmatrix} a_t \\ b_t \end{bmatrix}. \tag{29}$$

The canonical system requires that we set $a_t = 0, \forall_t$, to rule out explosive solutions. If the number of eigenvalues outside the unit circle

is equal to the number of nonpredetermined variables, the appropriate normalization choice is

$$b_t = \begin{bmatrix} i_{t-1} \\ p_{H,t-1} \end{bmatrix}$$

We know that $i_{t-1}$ and $p_{H,t-1}$ are predetermined, and therefore $b_{t+1} = E_t[b_{t+1}]$. This implies that $b_t = \varphi_b b_{t+1}$, where $\varphi_b$ is a two-by-two matrix with the two stable eigenvalues in the diagonal. This type of equilibrium implies that output, inflation, the real exchange rate, and the interest rate converge monotonically toward their steady states.

## 3. Results and Numerical Comparisons

We consider four types of aggregate shocks: foreign interest rate shocks, foreign output shocks, technology shocks, and domestic interest rate shocks. Each shock is a first-order process, as described above. As Rotemberg and Woodford (1998a) stress, one has to present unconditional standard deviations to obtain a policy evaluation criterion that is not subject to any problem of time consistency. In other words, we do not want to condition on the current state of the economy at the particular date at which the policy action is to be taken. Selected unconditional standard deviations for each shock are reported in appendix B for all exercises.

The foreign interest rate shock has effects on both regions: our open economy and the rest of the world. Therefore, whenever we experience an unanticipated increase of 25 basis points in the foreign nominal interest rate, we also include a negative shock in foreign output with variance 3.76.[10]

Finally, each subsection presents the impulse response functions of key variables to different stochastic disturbances for different exchange rate regimes and inflation targeting regimes.

### 3.1 Flexible versus Managed Exchange Rates

Figures 1 and 2 display the responses of our economy to different types of shocks under two different scenarios: a floating exchange rate regime

10. To obtain the variance of the rest of the world's variables, we compute the dynamic behavior of the rest of the world assuming that the consumption of domestic goods is negligible. We also assume that the foreign monetary authority follows a traditional Taylor rule with parameters $\chi_{\pi^*} = 1.5$ and $\chi_{y^*} = 0.5$.

**Figure 1. Flexible versus Managed Exchange Rate: Domestic Inflation Targeting[a]**

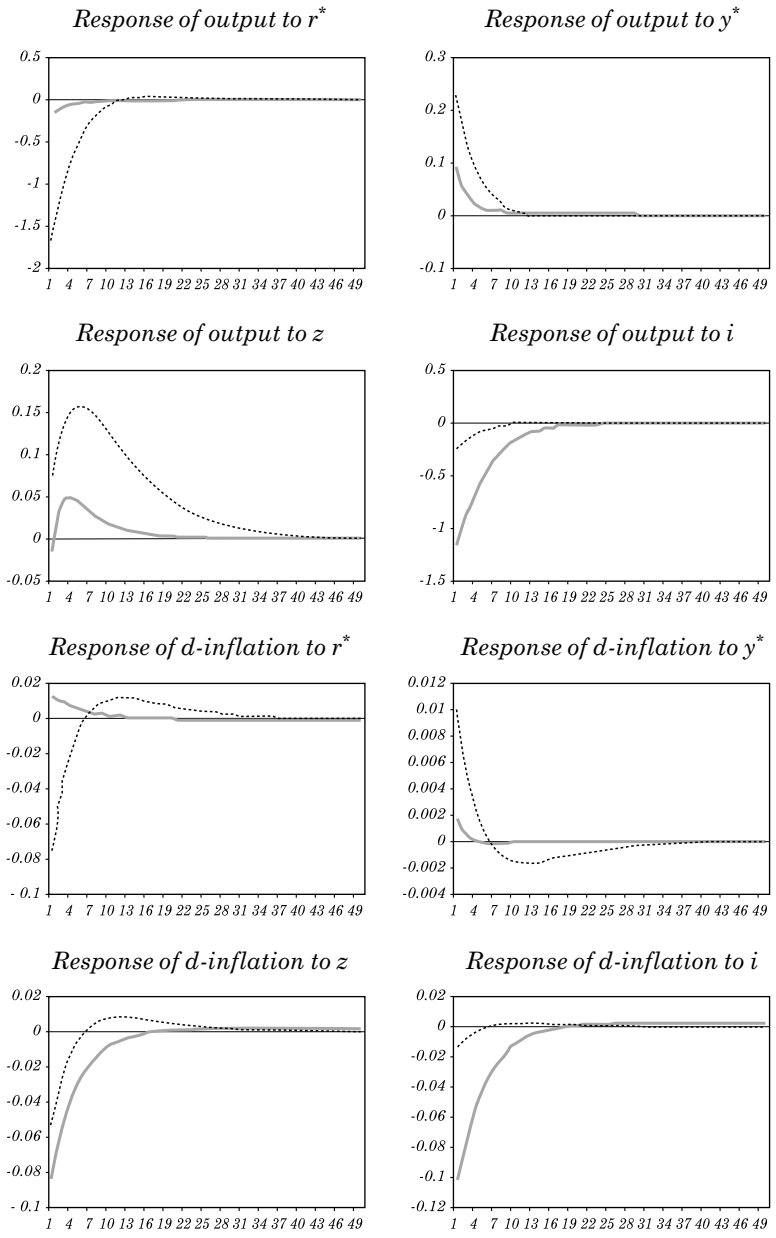


**Figure 1. (continued)**

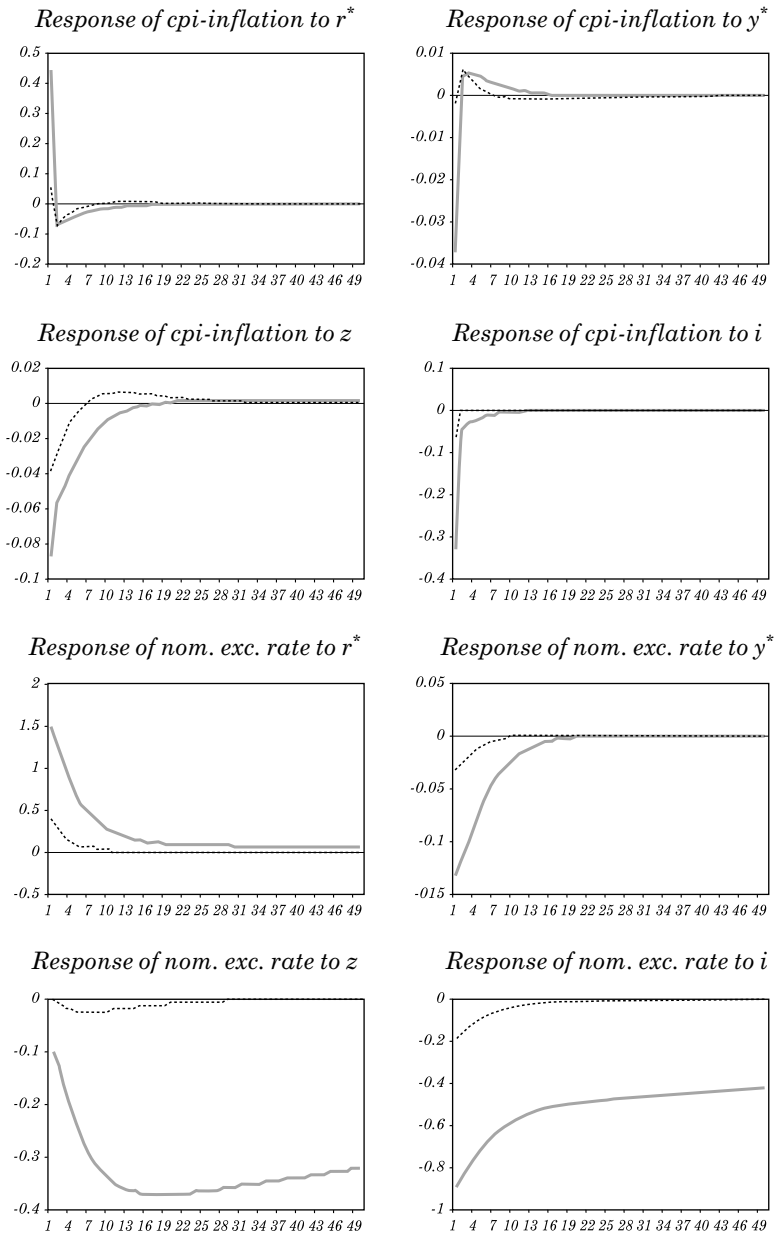


**Figure 1. (continued)**

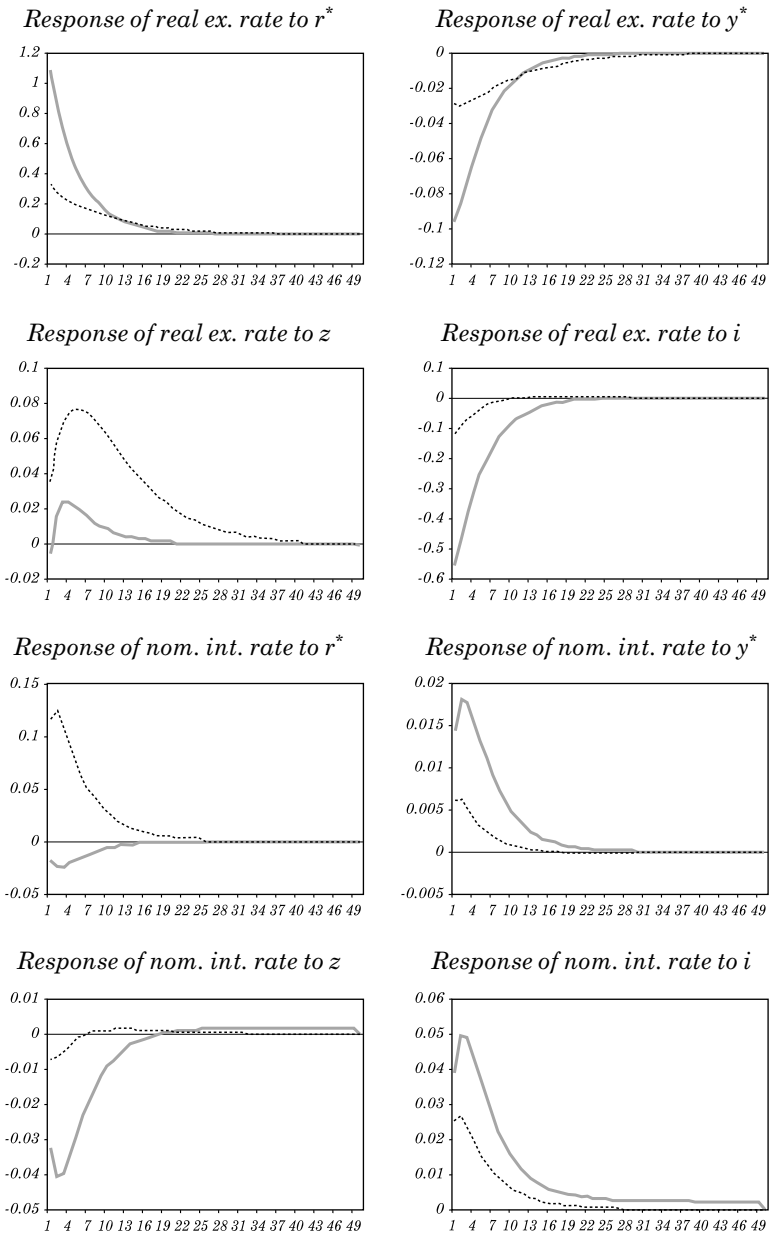
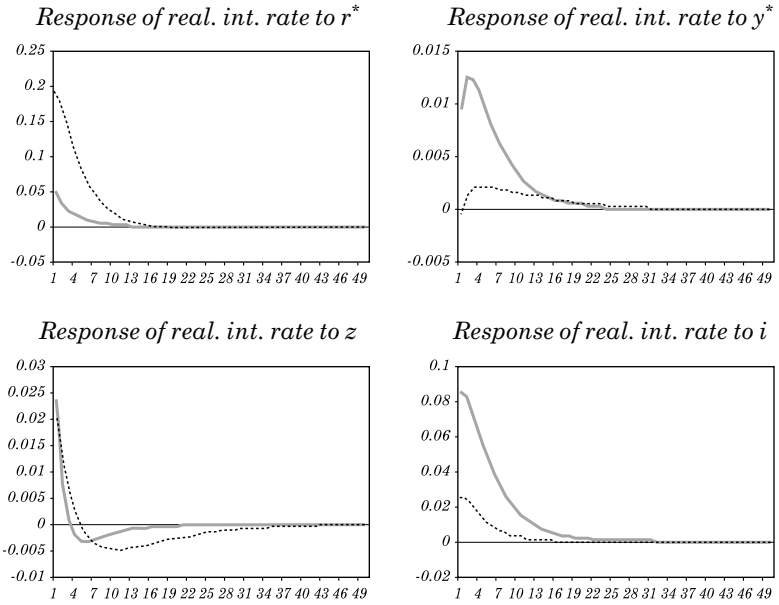


**Figure 1. (continued)**




a. The first graph for each variable presents impulse responses to a twenty-five-basis-point temporary innovation in the foreign interest rate; the second to a 1 percent foreign output shock; the third to a 1 percent total factor productivity shock; and the fourth to a twenty-five-basis-point temporary innovation in the domestic interest rate. The solid line corresponds to a flexible exchange rate and the dashed line to a managed exchange rate.

and a managed exchange rate regime. In addition, figure 1 presents the impulse response functions in the presence of domestic inflation targeting, whereas figure 2 takes into consideration CPI inflation targeting.

Recall that under the managed exchange rate, the monetary authority gives some weight to exchange rate stabilization in its policy rule, that is, $\chi_s \in (0,\infty)$. Since we are not allowing for a pure fixed exchange rate, the policy instrument is still the nominal interest rate. In the flexible exchange rate case, the central bank adopts a feedback rule that adjusts the nominal rate to variations in output and inflation only, that is, $\chi_s = 0$.

To demonstrate the dynamic properties of the model, we use the example of a foreign disturbance that hits the economy. Our results are consistent with previous studies and conventional wisdom. Under managed exchange rates, the domestic interest rate rises to match the

**Figure 2. Flexible versus Managed Exchange Rate: CPI Inflation Targeting[a]**

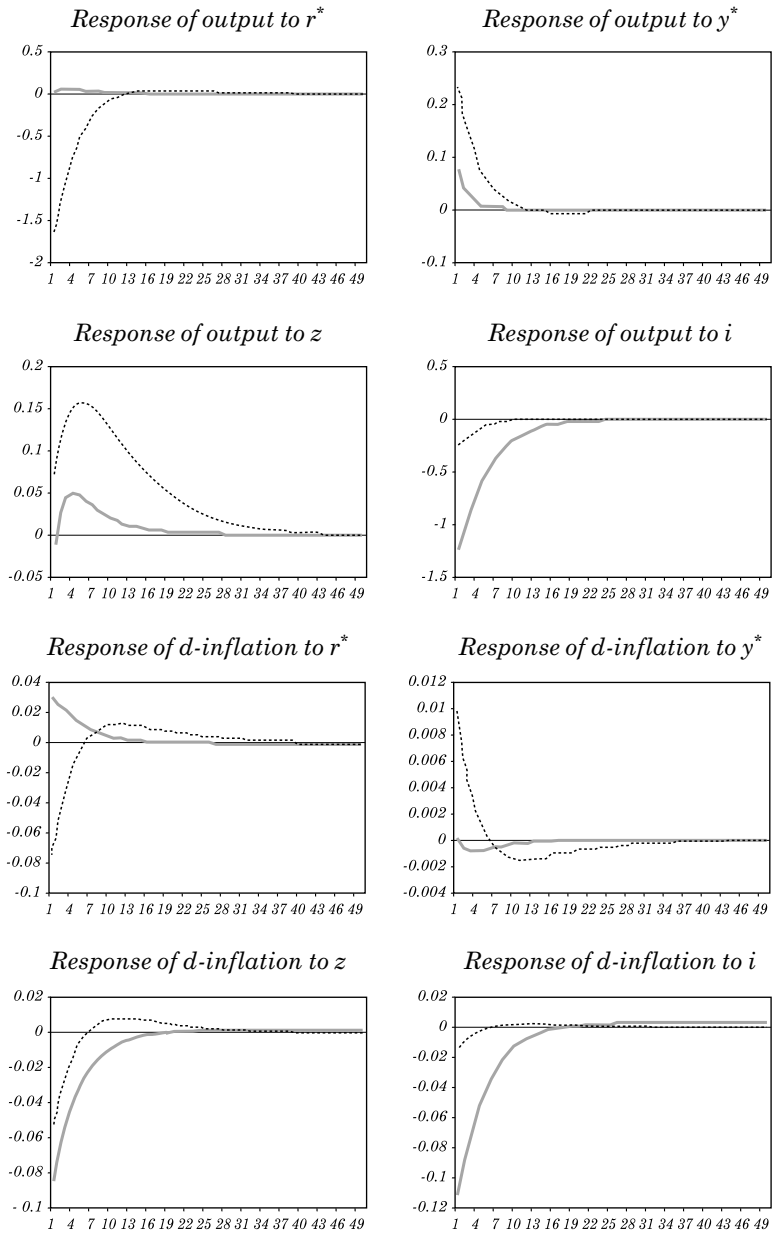


**Figure 2. (continued)**

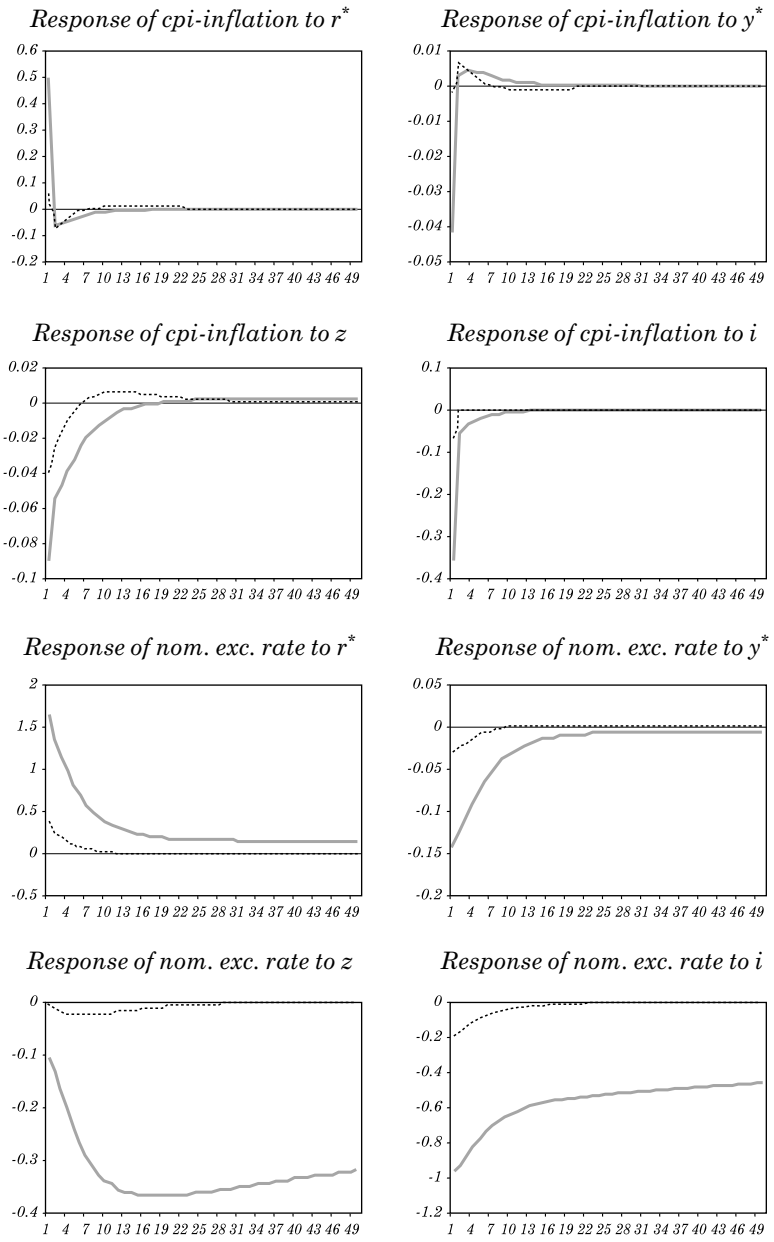


**Figure 2. (continued)**

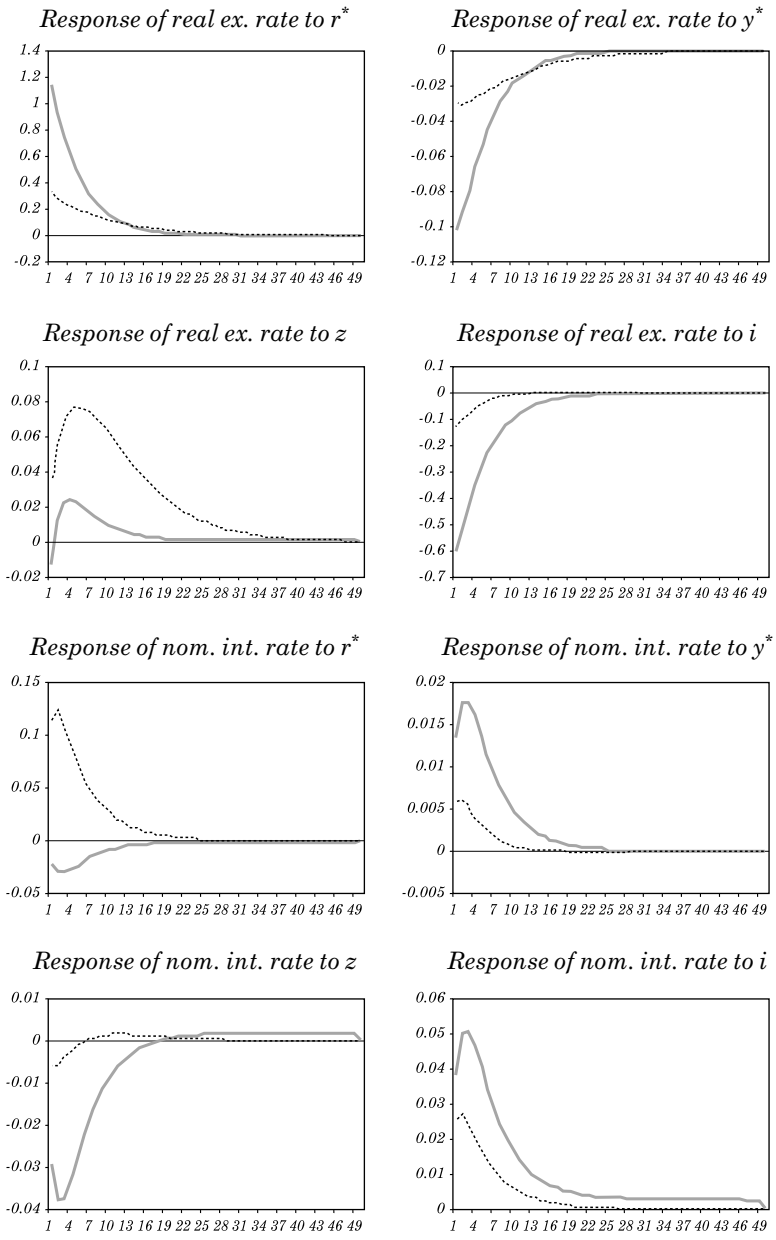
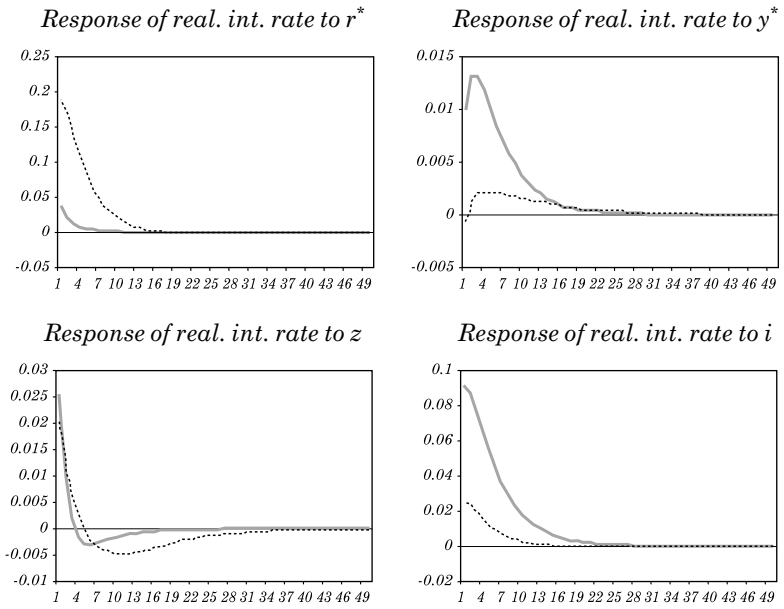


**Figure 2. (continued)**




a. The first graph for each variable presents impulse responses to a twenty-five-basis-point temporary innovation in the foreign interest rate; the second to a 1 percent foreign output shock; the third to a 1 percent total factor productivity shock; and the fourth to a twenty-five-basis-point temporary innovation in the domestic interest rate. The solid line corresponds to a flexible exchange rate and the dashed line to a managed exchange rate.

foreign rate movement, at least partially. Nominal rigidities further cause a significant rise in the real interest rate, which, in turn, induces a contraction in output.

Under flexible exchange rates, the domestic nominal interest rate is no longer tied to the foreign interest rate. The foreign interest rate shock thus produces a considerable nominal depreciation, which has a significant impact on CPI inflation. Output volatility is lower in the flexible case than in the managed case because adjustment is immediately reached through changes in the nominal exchange rate and not through changes in the price level. CPI inflation also differs across exchange rate regimes. If this economy has pegged exchange rates, inflation volatility is consistently lower than in an economy with flexible exchange rates.

**Table 2. Welfare Loss**

| | *Type of shock* | | | |
|---|---|---|---|---|
| *Targeting case* | *Foreign interest rate* ($r_t^*$) | *Foreign output* ($y_t^*$) | *Technology* ($z_t$) | *Nominal interest rate* ($\in_t$) |
| *Flexible CPI inflation targeting* | | | | |
| Flexible exchange rate | 1.8722 | 0.0229 | 0.0347 | 2.9785 |
| Managed exchange rate | 3.4804 | 0.0601 | 0.1578 | 0.0920 |
| *Strict CPI inflation targeting* | | | | |
| Flexible exchange rate | 2.9837 | 0.0642 | 0.0964 | 96.6302 |
| Managed exchange rate | 4.5803 | 0.0800 | 0.1857 | 0.1263 |
| *Flexible domestic inflation targeting* | | | | |
| Flexible exchange rate | 1.5876 | 0.0229 | 0.0345 | 2.5242 |
| Managed exchange rate | 3.5089 | 0.0602 | 0.1581 | 0.0884 |
| *Strict domestic inflation targeting* | | | | |
| Flexible exchange rate | 1.4537 | 0.0745 | 0.0718 | 45.5737 |
| Managed exchange rate | 4.5890 | 0.0796 | 0.1861 | 0.1203 |

## Welfare Comparisons

Table 2 compares the welfare loss associated with alternative monetary policies and different unanticipated innovations. The main result is that flexible exchange rates dominate managed exchange rates if the economy is hit by foreign interest, foreign output, and productivity innovations, while the reverse is true for nominal interest rate shocks. This confirms the conventional wisdom that flexibility is better in the case of foreign and real shocks, while pegging is preferable in the case of nominal shocks.

## 3.2 CPI versus Domestic Inflation Targeting

Figures 3 and 4 present impulse response functions comparing CPI and domestic inflation targeting. Figure 3 considers the responses in the presence of flexible exchange rates, while figure 4 covers the managed exchange rate case.

If the economy has a managed exchange rate, the distinction between CPI and domestic inflation targeting is not relevant, since volatility in all variables is equivalent. This result is obvious, because targeting the CPI is equivalent to targeting both domestic inflation and the nominal exchange rate; it is also equivalent to targeting domestic inflation with managed exchange rates.

**Figure 3. CPI versus Domestic Inflation Targeting: Flexible Exchange Rate[a]**

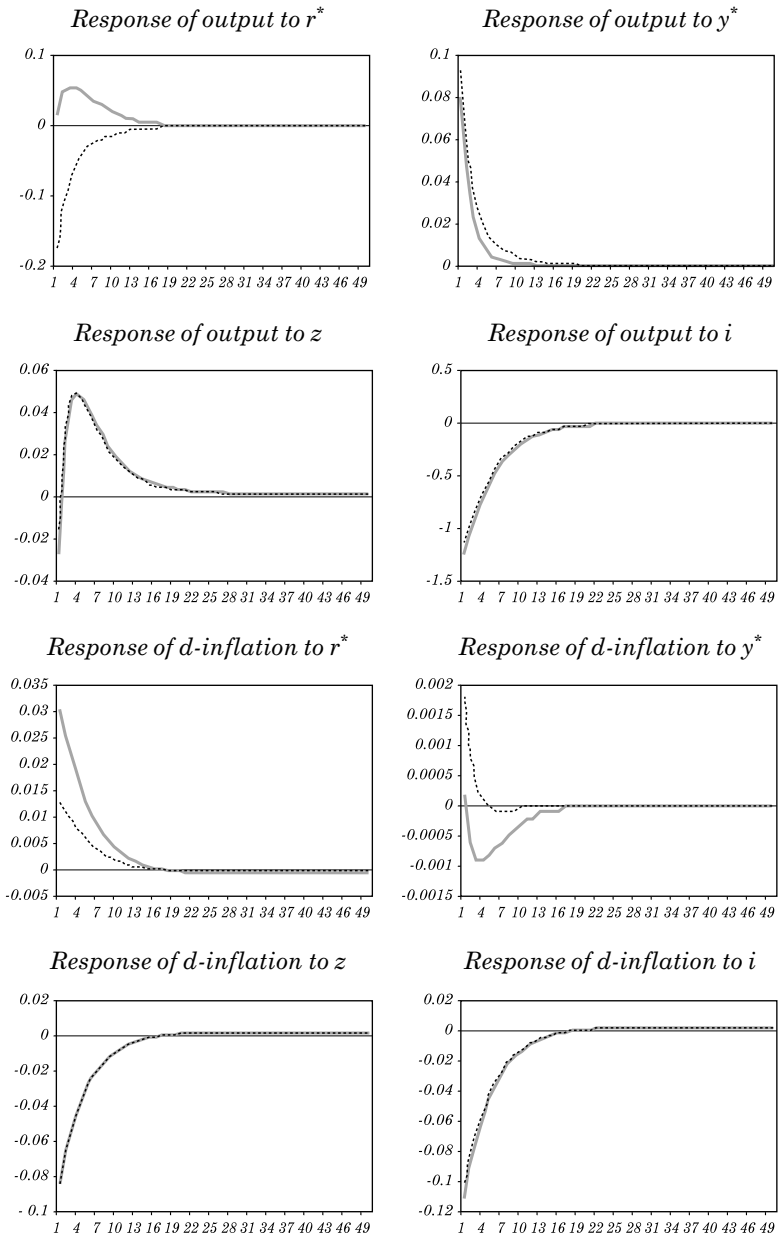


**Figure 3. (continued)**

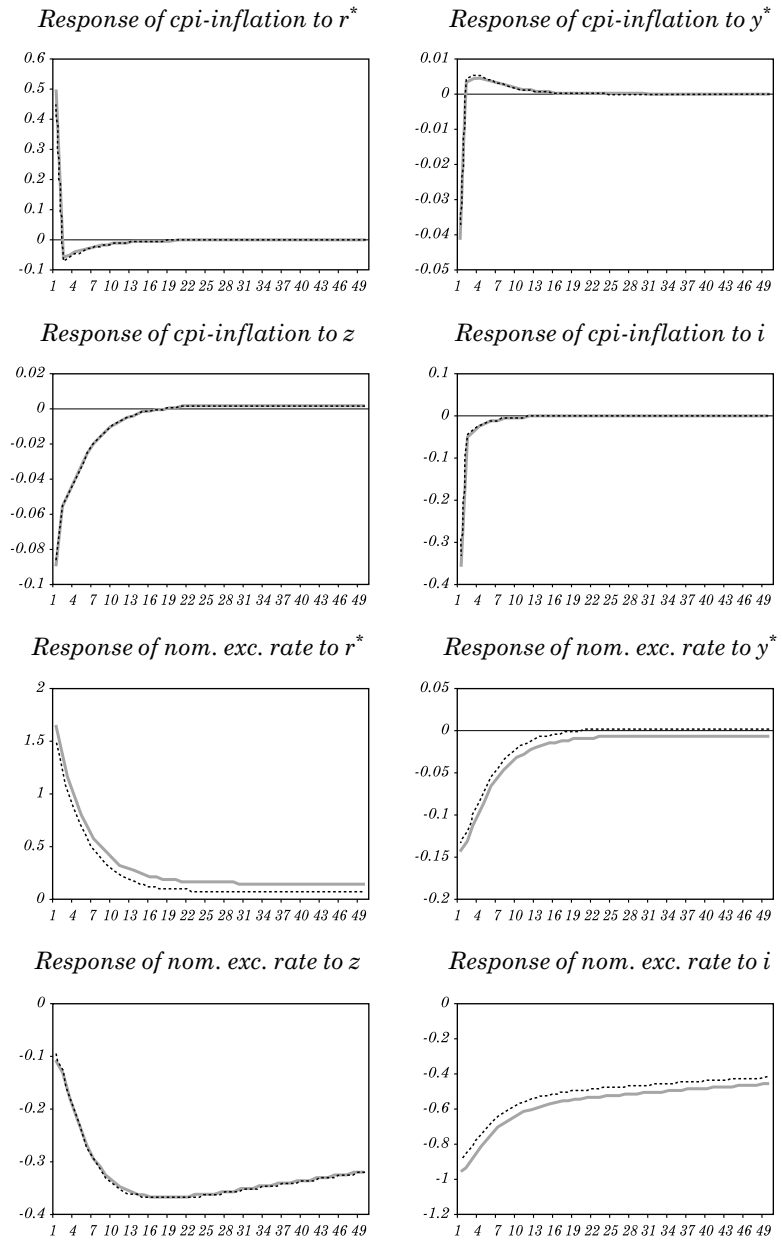


**Figure 3. (continued)**

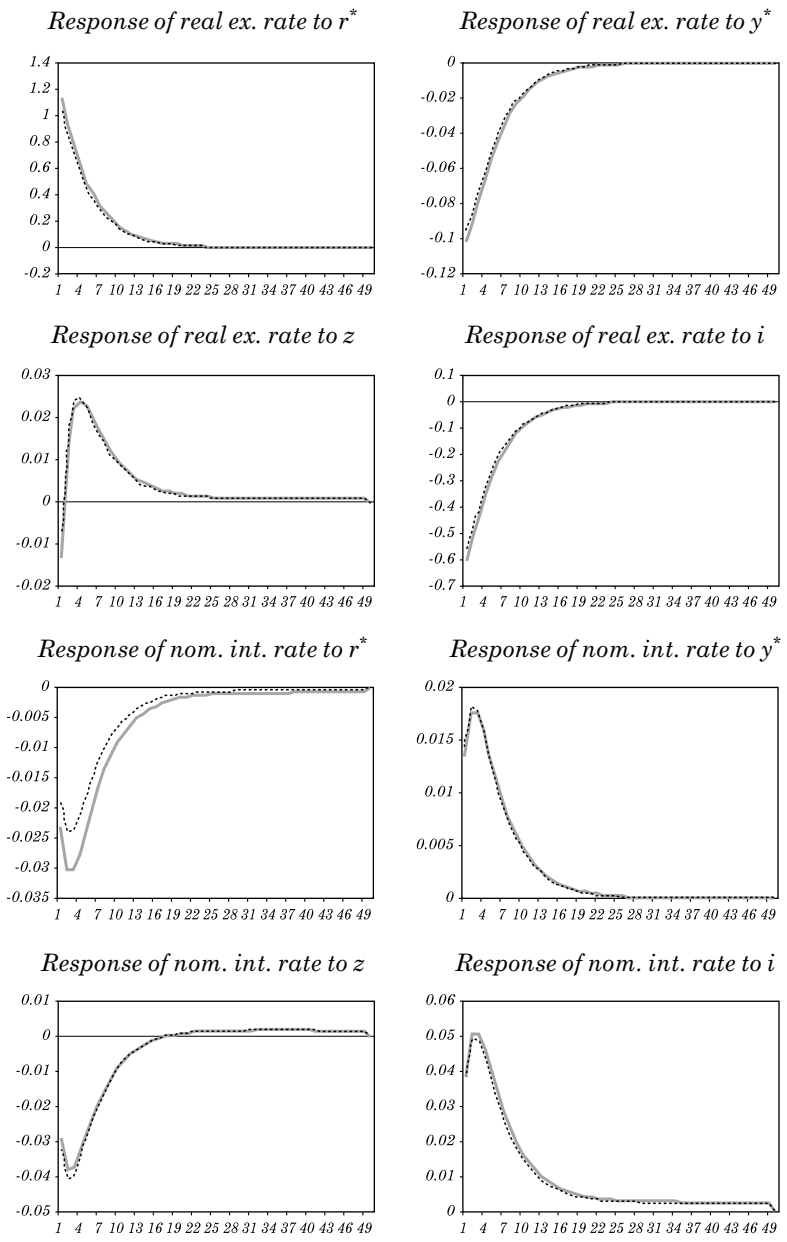
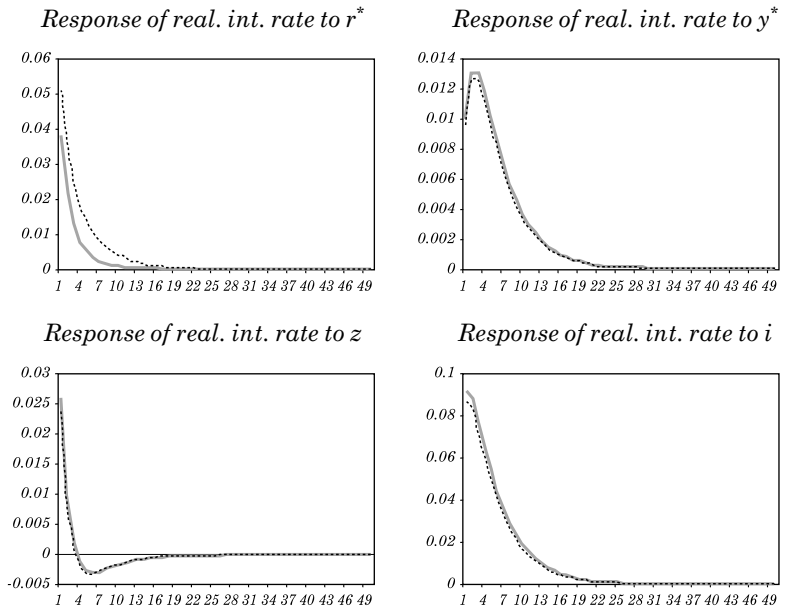


**Figure 3. (continued)**




a. The first graph for each variable presents impulse responses to a twenty-five-basis-point temporary innovation in the foreign interest rate; the second to a 1 percent foreign output shock; the third to a 1 percent total factor productivity shock; and the fourth to a twenty-five-basis-point temporary innovation in the domestic interest rate. The solid line corresponds to CPI inflation targeting and the dashed line to domestic inflation targeting.

Focus, then, on the flexible exchange rate case, considering the effects of a foreign interest rate innovation. (The same conclusions hold across different shocks.) Dynamic responses are similar to those in the previous subsection. The key result in this comparison is that for all shocks, targeting domestic inflation is preferable to targeting CPI inflation. The intuition is that the domestic inflation target allows the exchange rate to move more in response to disturbances, thereby stabilizing output to a greater degree. The variability of domestic inflation (obviously) and output is therefore lower under domestic inflation targeting, while the variability of the real exchange rate can be higher, though it need not be. The beneficial welfare impact of the former two always outweighs the welfare costs of higher real exchange rate volatility (when it exists), so that welfare losses are lower under domestic inflation targeting than under the CPI targeting regime.

**Figure 4. CPI versus Domestic Inflation Targeting: Managed Exchange Rate[a]**

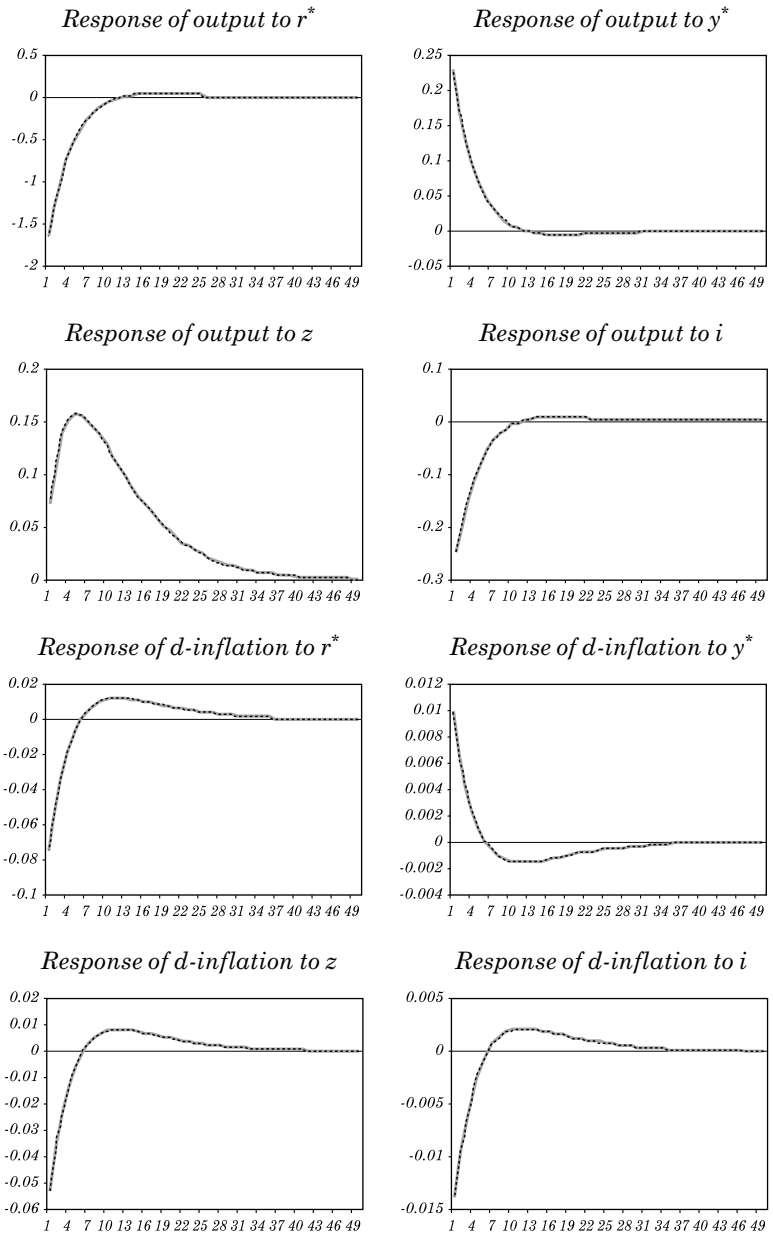


**Figure 4. (continued)**

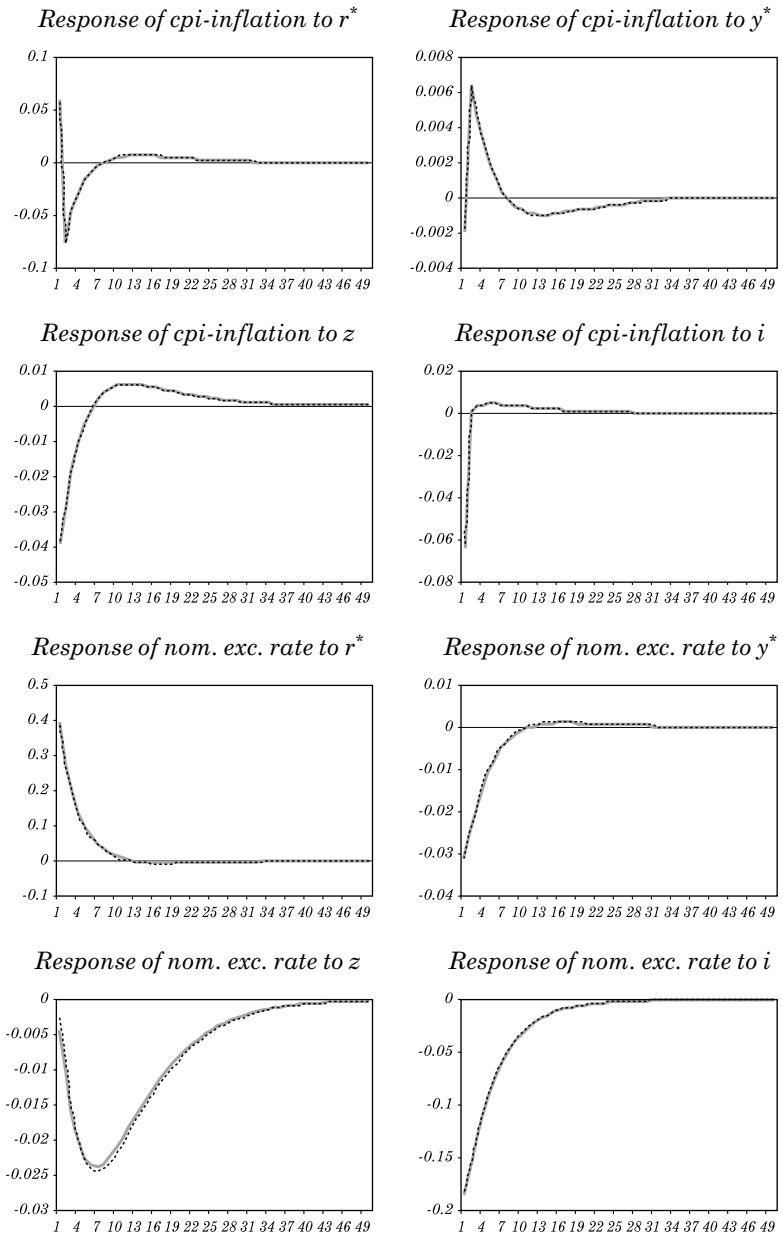


**Figure 4. (continued)**

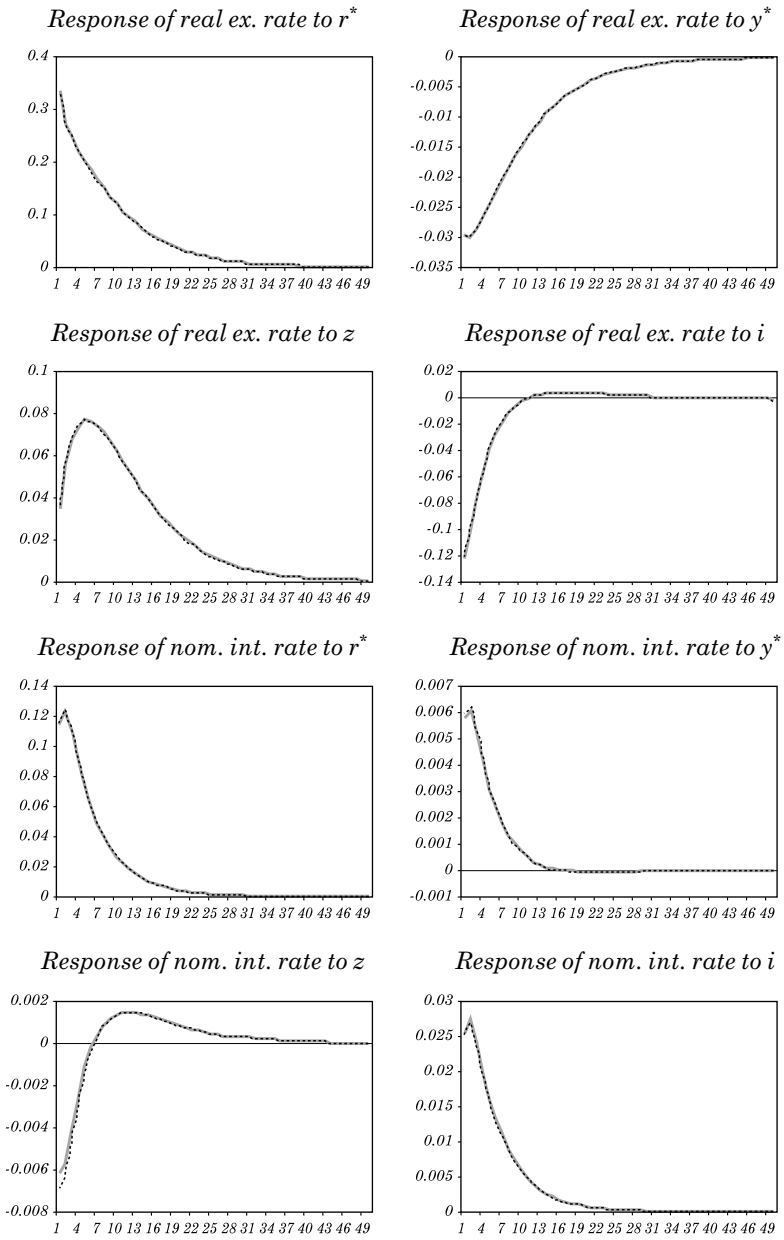
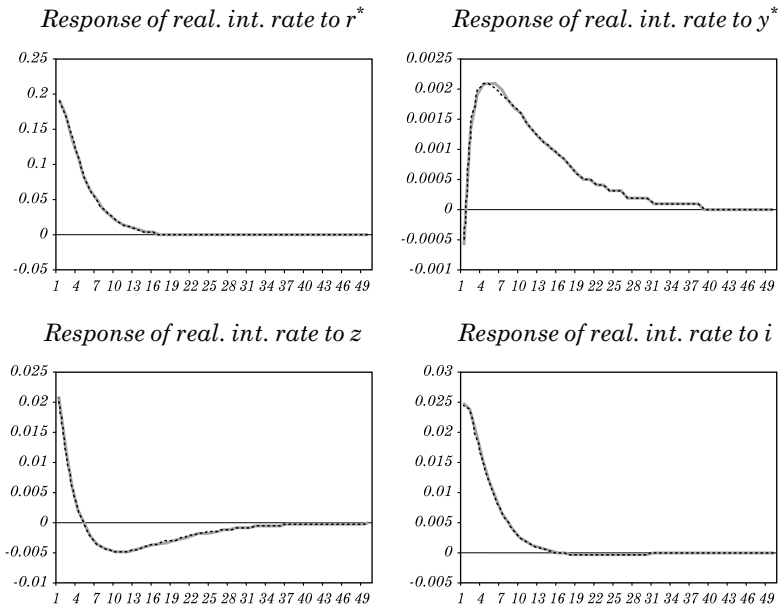


**Figure 4. (continued)**




a. The first graph for each variable presents impulse responses to a twenty-five-basis-point temporary innovation in the foreign interest rate; the second to a 1 percent foreign output shock; the third to a 1 percent total factor productivity shock; and the fourth to a twenty-five-basis-point temporary innovation in the domestic interest rate. The solid line corresponds to CPI inflation targeting and the dashed line to domestic inflation targeting.

## Welfare Comparisons

Social loss is larger under CPI inflation targeting than under domestic inflation targeting (see table 2). In the flexible exchange rate case, which is the relevant regime for comparing CPI and domestic inflation targeting, the same conclusion holds, irrespective of the targeting case and source of the shock.[11] A monetary policy that considers domestic inflation is far more stabilizing compared with one that takes CPI inflation into account in the inflation targeting regime.

11. The only exception is in the case of strict inflation targeting in the presence of productivity shocks. In this case, however, the difference between the CPI and domestic inflation targeting is negligible.

### 3.3 Flexible versus Strict Inflation Targeting

Flexible inflation targeting, in the nomenclature of Svensson (2000), occurs when a central bank seeks to stabilize output, inflation, and the exchange rate. By contrast, strict inflation targeting occurs when the monetary authority only attempts to stabilize inflation and the exchange rate without considering the effects on output. Figures 5 and 6 compare the impulse response functions of flexible and strict inflation targeting under flexible and managed exchange rates, respectively.

A number of interesting results emerge from these figures. First, independently of the source of disturbance, output volatility is higher in the strict case than in the flexible case. Second, the results are ambiguous in terms of inflation stability and depend on the type of shock. For instance, if the source of disturbance is the domestic interest rate, flexible inflation targeting dominates strict inflation targeting. If there is a productivity shock, however, the impact on CPI and domestic inflation is higher under flexible inflation targeting. As Svensson (2000) points out, strict CPI inflation targeting relies on the use of the exchange rate channel to stabilize CPI inflation. The real exchange rate thus exhibits lower volatility under strict targeting than under the flexible case, and this results in higher volatility of output and domestic inflation. These differences decrease under managed exchange rates, since in this case the monetary authority seeks to stabilize the nominal exchange rate as well and hence introduces less adjustment to nominal interest rates and, in turn, less volatility in output and inflation.

### Welfare Comparisons

As mentioned above, we found mixed evidence regarding inflation volatility in the two cases. The conclusion is quite clear, however, with regard to the social loss, which combines inflation, domestic inflation, and real exchange rate volatility: social loss is lower under flexible inflation targeting than under strict inflation targeting (see table 2).

## 4. Conclusions

In this paper we have developed a simple dynamic neo-Keynesian model of a small open economy and used it to examine the effects of different exchange rate regimes and inflation target indicators, in the context of simple forecast-based monetary policy rules. The main findings of the paper are that the effects of inflation targeting on output

**Figure 5. Flexible versus Strict CPI Inflation Targeting: Flexible Exchange Rate[a]**

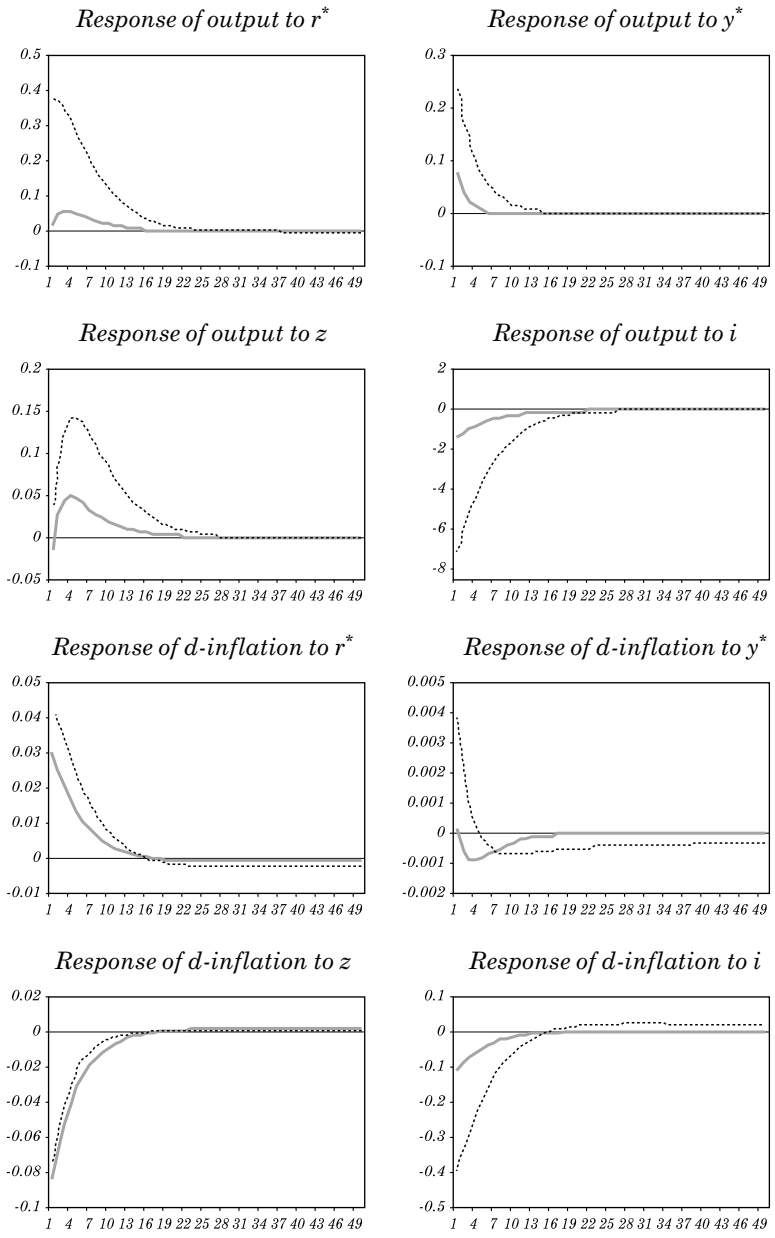


**Figure 5. (continued)**

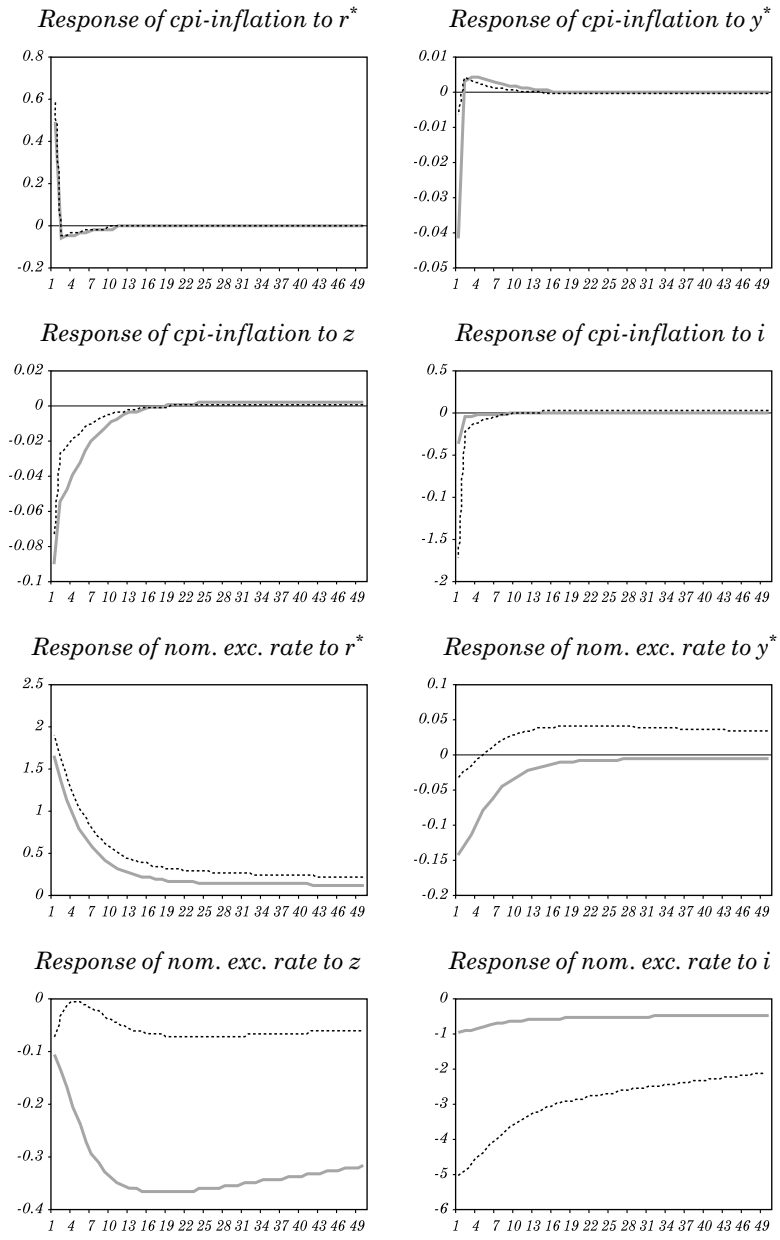


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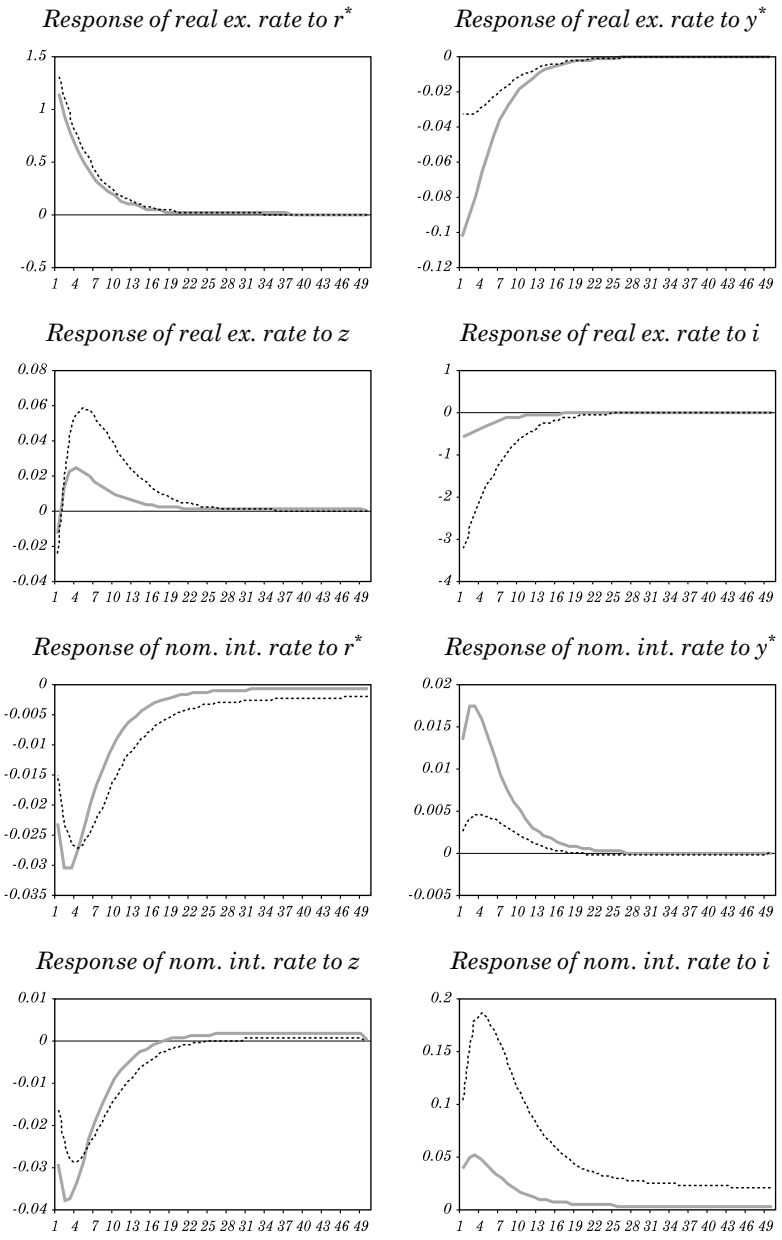
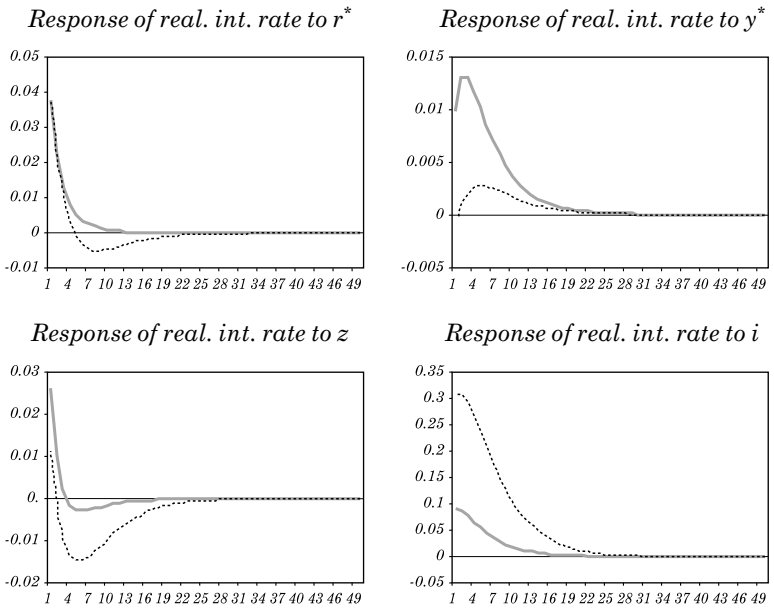


**Figure 5. (continued)**




a. The first graph for each variable presents impulse responses to a twenty-five-basis-point temporary innovation in the foreign interest rate; the second to a 1 percent foreign output shock; the third to a 1 percent total factor productivity shock; and the fourth to a twenty-five-basis-point temporary innovation in the domestic interest rate. The solid line corresponds to flexible CPI inflation targeting and the dashed line to strict CPI inflation targeting.

and inflation volatility depend crucially on the exchange rate regime and the inflation index being targeted, as well as on the type of shocks affecting this economy. With regard to the exchange rate, we find that the social loss is much higher under managed exchange rates than under flexible rates if there are foreign and real shocks, while for nominal shocks, the reverse is true. As far as the definition of the inflation targeting index is concerned, domestic inflation appears to outperform the CPI. Finally, and somewhat predictably, flexible inflation targeting is superior to strict inflation targeting.

These results, while suggestive, are subject to many caveats. Here we highlight three. First, we are dealing with simulation results. Conclusions about policy dominance and welfare consequences depend on a specific parameterization, and they should not be taken as general propositions. We chose parameters that conform to the Chilean economy, so

**Figure 6. Flexible vs. Strict Domestic Inflation Targeting: Flexible Exchange Rate[a]**

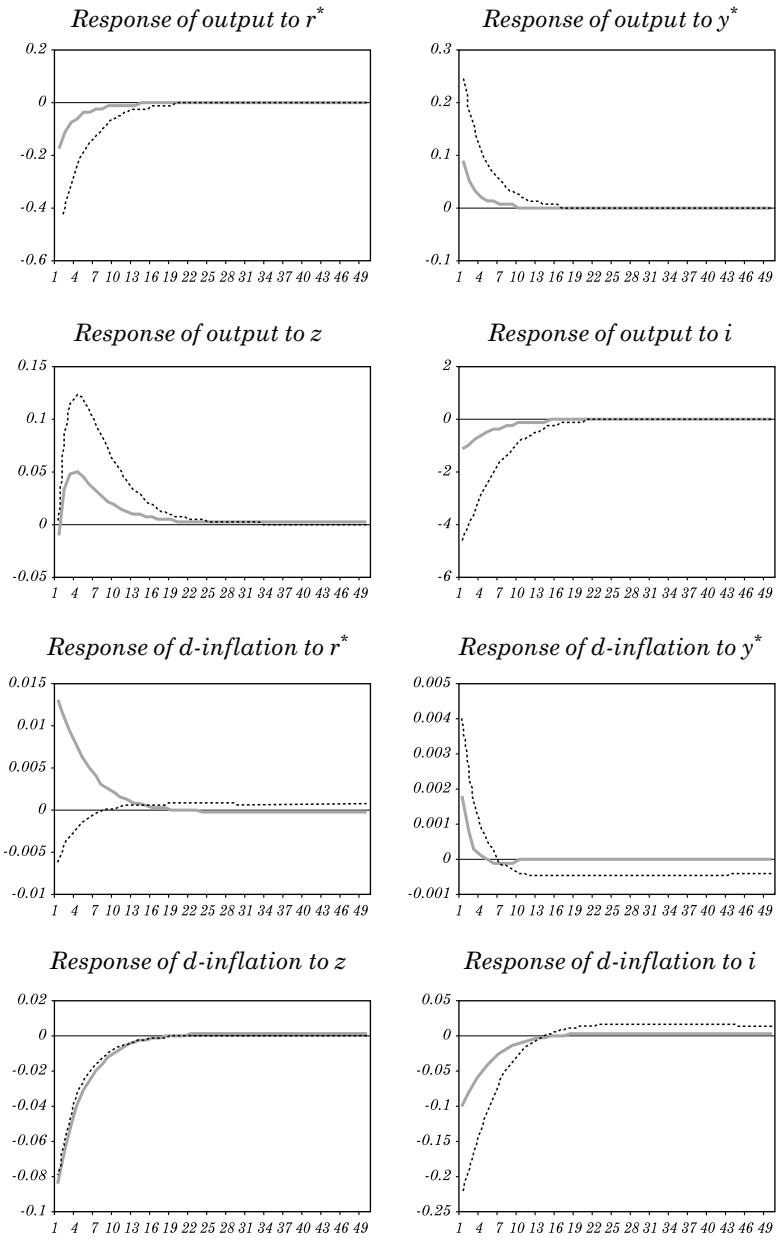


**Figure 6. (continued)**

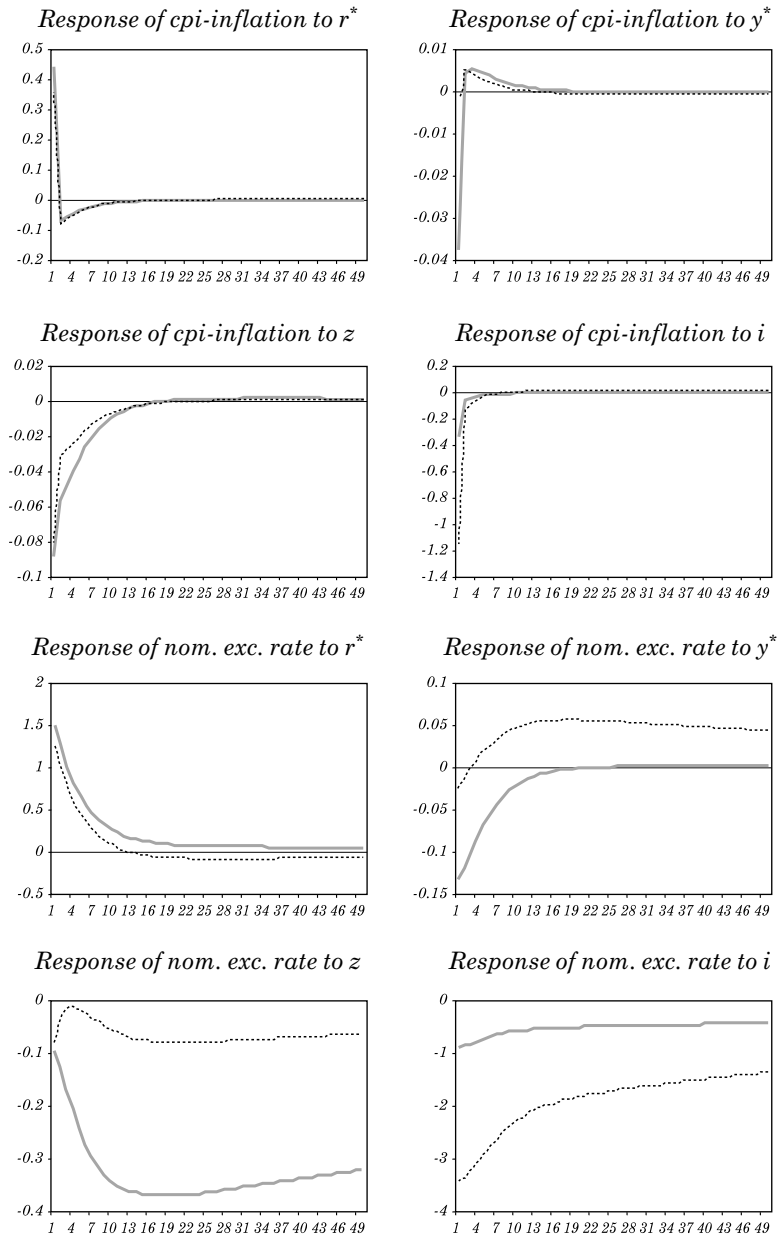


**Figure 6. (continued)**

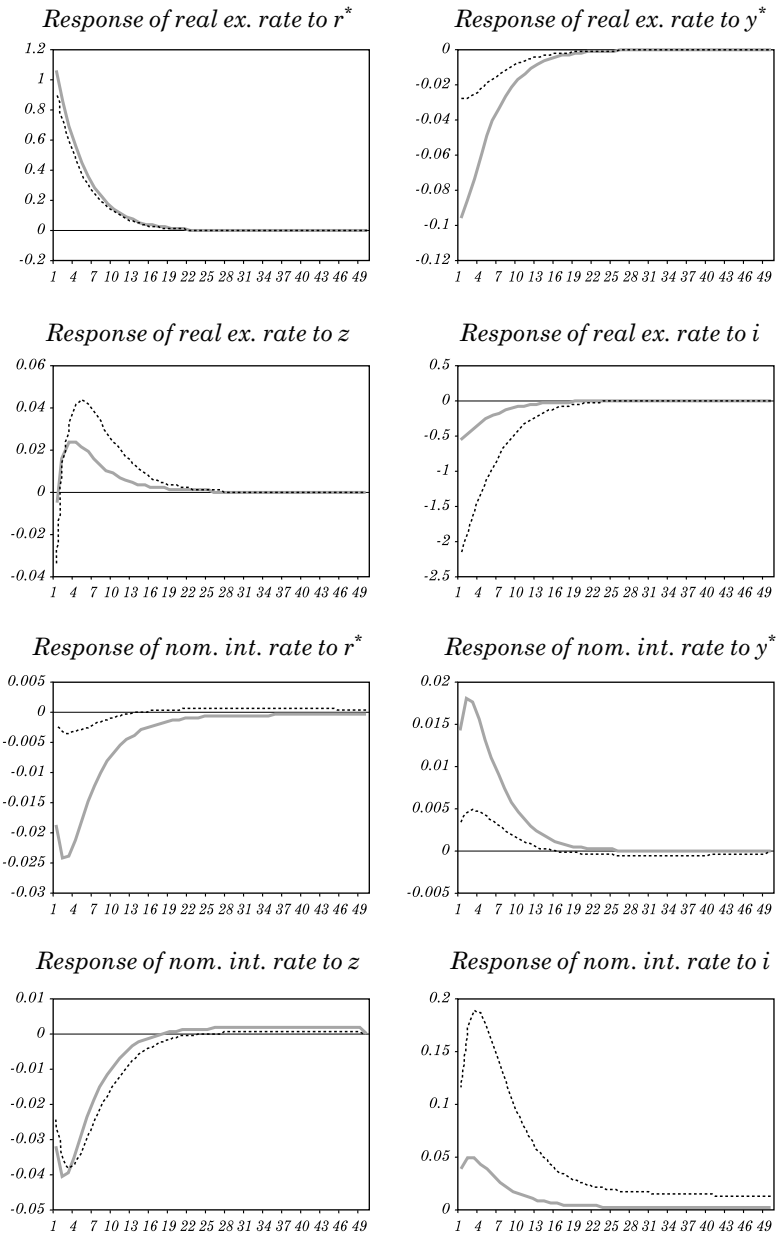
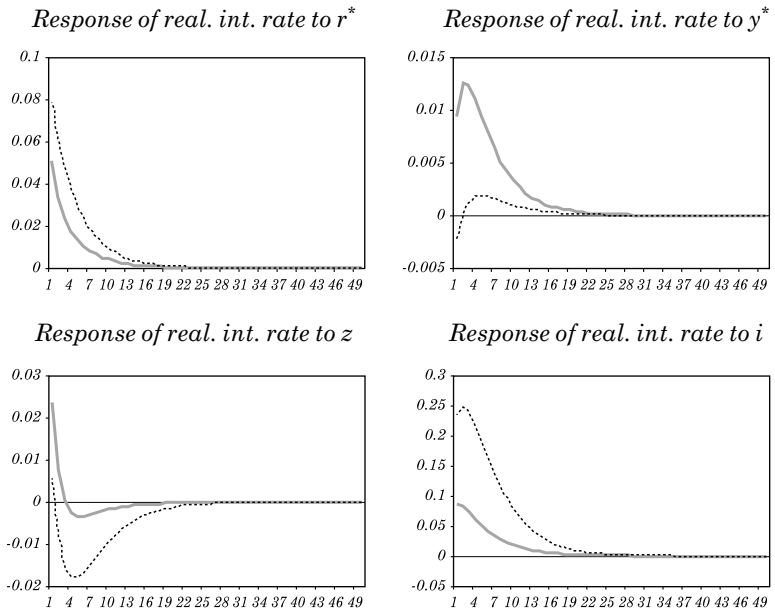


**Figure 6. (continued)**




a. The first graph for each variable presents impulse responses to a twenty-five-basis-point temporary innovation in the foreign interest rate; the second to a 1 percent foreign output shock; the third to a 1 percent total factor productivity shock; and the fourth to a twenty-five-basis-point temporary innovation in the domestic interest rate. The solid line corresponds to flexible domestic inflation targeting and the dashed line to strict domestic inflation targeting.

the conclusions should have some empirical relevance. In addition, we experimented sufficiently with alternative parameterization to be confident that the results presented here are robust to relatively minor changes in assumptions. More work is clearly warranted, however, before we can come to confident policy recommendations. The second caveat has to do with those aspects the model omits. Much of the recent discussion of exchange rate policy in developing countries is concerned with the impact of exchange rate changes on financial variables: balance sheets, creditworthiness, risk premiums, and so forth. These effects become important when there are imperfections in financial markets; borrowing constraints and dollarization of liabilities are two that have received much recent attention. By contrast, the model here assumes not just well-functioning financial markets, but a full set of state-contingent assets. We have two justifications for this omission: it

makes sense to analyze the performance of alternative rules in a more-or-less standard model before moving on to add financial imperfections, and work including financial imperfections in simpler macroeconomic models (see, for instance, Céspedes, Chang, and Velasco, 2000; Chang and Velasco, 2000) shows that in spite of the presence of balance sheet effects and liability dollarization, the qualitative ranking of alternative monetary policies may be quite similar to that found in more standard sticky price models, such as the one studied here.

Finally, a natural next step is to base the analysis on the consumer's utility and not on ad hoc welfare criteria. This important step implies not only aggregating the behavior of individuals, but also finding a tractable way to do so. This extension is not straightforward for a small open economy, since an additional variable—the terms of trade—makes it difficult to arrive at the quadratic formulation based on Taylor approximations developed by Woodford (1996, 2000) and Rotemberg and Woodford (1998a, 1998b).

## APPENDIX A

### 1. Aggregate Demand

For all differentiated goods, market clearing implies

$$Y_t(j) = C_{H,t}(j) + C^*_{H,t}(j).$$

Log-linearization around a steady state with balanced trade implies

$$y_t(j) = (1-\gamma)c_{H,t}(j) + \gamma c^*_{H,t}(j).$$

Define $Y_t(j) \equiv \int_0^1 Y_t(j)dj$ as the aggregate domestic output. Then, log-linearizing this expression around the steady state, we get

$$y_t = \int_0^1 y_t(j)dj.$$

An analogous expression for $c_{H,t}(j)$ and $c^*_{H,t}(j)$ can be obtained to get the following expression: $y_t = (1-\gamma)c_{H,t} + \gamma c^*_{H,t}$. Combining this expression with a log-linearized version of equation 2, namely, $c_t = (1-\gamma)c_{H,t} + \gamma c_{F,t}$, we obtain

$$\begin{aligned} y_t &= (1-\gamma)c_t + \gamma c^*_t + \gamma\eta(2-\gamma)q_t \\ &= (1-\gamma)c_t + \gamma c^*_t + \gamma\eta(2-\gamma)\left(s_t + p^*_t - p_{H,t}\right). \end{aligned}$$

Finally, assuming that $u(C) = C^{1-\sigma}/(1-\sigma)$ and using the log-linearization version of the Euler equation 7, we obtain an expression for the domestic output gap (equation 16 in the main text):

$$\begin{aligned} x_t = {} & E_t[x_{t+1}] + \phi_\pi E_t[\pi_{H,t+1}] - \phi_s\left(E_t[s_{t+1}] - s_t\right) \\ & - \frac{1}{\sigma} i_t - (1-\rho_z)z_t + \gamma\left(1-\rho_{y^*}\right)y^*_t, \end{aligned}$$

where $x_t$ is the domestic output gap, $\phi_\pi = \left[(1-\gamma)/\sigma + \gamma\eta(2-\gamma)\right]$, $\phi_s = \gamma\left[\eta(2-\gamma) - 1/\sigma\right]$, $0 \le \rho_z \le 1$ and $0 \le \rho_{y^*} \le 1$.

## 2. Aggregate Supply

The FONC of the firm is:

$$E_t\left[\sum_{k=0}^{\infty}\alpha^k\beta^k\Lambda_{t+k}\left\langle\frac{p_{H,t}(j)}{P_{H,t+k}}-\frac{\theta W_{t+k}V'\left\{\left[p_{H,t}(j)/P_{H,t+k}\right]^{-\theta}C^A_{H,t+k}\right\}}{\theta-1P_{H,t+k}\tilde{Z}_{t+k}}\right\rangle\left[\frac{p_{H,t}(j)}{P_{H,t+k}}\right]^{-\theta}C^A_{H,t+k}\right]=0.$$

Define $G_t\equiv p_{H,t}(j)/P_{H,t}$, $\Pi_{H,t}\equiv P_{H,t}/P_{H,t-1}$ and $\zeta\equiv\theta/(\theta-1)$, then

$$E_t\left[\sum_{k=0}^{\infty}\alpha^k\beta^k\Lambda_{t+k}\left\{\frac{G_t}{\prod_{s=1}^{k}\Pi_{H,t+s}}-\zeta\frac{W_{t+k}V'\left[\left(G_t/\prod_{s=1}^{k}\Pi_{H,t+s}\right)^{-\theta}C^A_{H,t+k}\right]}{P_{H,t+k}\tilde{Z}_{t+k}}\right\}\left(\frac{G_t}{\prod_{s=1}^{k}\Pi_{H,t+s}}\right)^{-\theta}C^A_{H,t+k}\right]=0.$$

In equilibrium, each consumer-producer that chooses a new price in period $t$ will choose the same new price and the same level of output. Then the (aggregate) price of domestic goods will obey

$$p_{H,t}=\left[\alpha p_{H,t-1}+(1-\alpha)p_{H,t}(j)\right]^{1/(1-\theta)}.$$

Therefore,

$$\Pi_{H,t}=\alpha^{1/(1-\theta)}\left[1-(1-\alpha)G_t^{1-\theta}\right]^{1/(\theta-1)},$$

log-linearizing around the steady state. We allow bounded fluctuations in $C^A_{H,t}$, $\Pi_{H,t}$, $G_t$, $\Lambda_t$, and $W_t/P_{H,t}$ around a steady state ($y^d$, 1, 1, Λ, and 1). Thus,

$$v'_t=\xi y_t^d,$$

$$w_t=(1-\delta)p_{H,t}+\delta p_t^*, \text{ and}$$

$$\pi_{H,t}=\frac{1}{(\theta-1)}\frac{-(1-\alpha)}{\left[1-(1-\alpha)\right]}(1-\theta)g_t=\frac{1-\alpha}{\alpha}g_t,$$

where $\xi>0$ is the elasticity of $V'$ with respect to $Y_t^d$ and $1\geq\delta\geq 0$ is the

share of tradable goods in the composite input.

$$E_t\left[\sum_{k=0}^{\infty}\alpha^k\beta^k\left\{g_t-\sum_{s=1}^{k}\pi_{H,t+s}-w_{t+k}+p_{H,t+k}-\xi\left[y_{t+k}^d-\theta\left(g_t-\sum_{s=1}^{k}\pi_{H,t+s}\right)\right]+\tilde{z}_{t+k}\right\}\right]=0\,.$$

$$E_t\left[\sum_{k=0}^{\infty}\alpha^k\beta^k\left[(1+\xi\theta)\left(g_t-\sum_{s=1}^{\infty}\pi_{H,t+s}\right)-\xi y_{t+k}^d-\gamma q_{t+k}+\tilde{z}_{t+k}\right]\right]=0\,.$$

However, $\sum_{k=0}^{\infty}\alpha^k\beta^k\sum_{\tau=1}^{k}\pi_{H,t+s}=\sum_{\tau=1}^{\infty}\pi_{H,t+s}\sum_{k=\tau}^{\infty}\alpha^k\beta^k=\sum_{\tau=1}^{\infty}\pi_{H,t+\tau}\frac{\alpha^\tau\beta^\tau}{1-\alpha\beta}$, and this is equal to

$$\frac{1}{1-\alpha\beta}\sum_{k=1}^{\infty}\alpha^k\beta^k\pi_{H,t+k}\,.$$

Then we can rewrite

$$E_t\left[\frac{1+\xi\theta}{1-\alpha\beta}g_t-\frac{1+\xi\theta}{1-\alpha\beta}\sum_{k=1}^{\infty}\alpha^k\beta^k\pi_{H,t+k}-\sum_{k=0}^{\infty}\alpha^k\beta^k\left(\xi y_{t+k}^d+\gamma q_{t+k}-\tilde{z}_{t+k}\right)\right]=0\,.$$

Thus,

$$g_t=\mathrm{E}_t\left\{\alpha\beta\pi_{H,t+1}+\frac{1-\alpha\ \ \beta}{1+\xi\ \ \theta}\left[\xi y_{t+k}^d+\gamma s_{t+k}-z_{t+k}\right]+\alpha\beta\,\mathrm{E}_t\left[x_{t+1}\right]\right\},$$

$$g_t=E_t\left[\sum_{k=1}^{\infty}\alpha^k\beta^k\pi_{H,t+s}+\frac{1-\alpha\beta}{1+\xi\theta}\sum_{k=0}^{\infty}\alpha^k\beta^k\left(\xi y_{t+k}^d+\gamma q_{t+k}-\tilde{z}_{t+k}\right)\right],$$

but $\pi_{H,t}=\frac{1-\alpha}{\alpha}g_t$. Hence,,

$$\frac{\alpha}{1-\alpha}\pi_{H,t}=E_t\left[\alpha\beta\pi_{H,t+1}+\frac{1-\alpha\beta}{1+\xi\theta}\left(\xi y_{t+k}^d+\gamma q_{t+k}-\tilde{z}_{t+k}\right)+\alpha\beta\frac{\alpha}{1-\alpha}E_t\left[\pi_{H,t+1}\right]\right],$$

and finally

$$\pi_{H,t}=\beta E_t\left[\,\pi_{H,t+1}\,\right]+\lambda_x x_t+\lambda_q q_t\,,$$

where we let $z_t=\xi\tilde{z}_t$, and hence the output gap is defined as $x_t=y_t^d-z_t$. Recalling that $q_t=s_t+p_t^*-p_{H,t}$, we get an expression for

the aggregate supply (equation 17 in the main text):

$$\pi_{H,t} = \beta E_t\left[\pi_{H,t+1}\right] + \lambda_x x_t + \lambda_q\left(s_t + p_t^* - p_{H,t}\right),$$

where $\lambda_x = \dfrac{(1-\alpha)(1-\alpha\beta)}{\alpha(1+\xi\theta)}\xi$ and $\lambda_q = \lambda_x \gamma$.

# APPENDIX B

## Supplemental Tables

### Table B1. Unconditional Standard Deviations: Foreign Interest Rate Shock

| *Targeting case* | *Output* | *Domestic inflation* | *CPI inflation* | *Real exchange rate* | *Nominal interest rate* | *Real interest rate* |
|---|---|---|---|---|---|---|
| *Flexible CPI inflation targeting* | | | | | | |
| Flexible exchange rate | 0.8466 | 0.0957 | 0.6972 | 2.4209 | 0.1419 | 0.7433 |
| Managed exchange rate | 2.4270 | 0.1236 | 0.1651 | 0.8473 | 0.5965 | 0.7073 |
| *Strict CPI inflation targeting* | | | | | | |
| Flexible exchange rate | 4.2840 | 0.2026 | 1.1340 | 4.0510 | 0.0863 | 1.1273 |
| Managed exchange rate | 2.9132 | 0.1248 | 0.1254 | 0.6447 | 0.6698 | 0.7534 |
| *Flexible domestic inflation targeting* | | | | | | |
| Flexible exchange rate | 0.3504 | 0.0712 | 0.6314 | 2.1916 | 0.1866 | 0.7019 |
| Managed exchange rate | 2.4483 | 0.1248 | 0.1615 | 0.8383 | 0.6013 | 0.7107 |
| *Strict domestic inflation targeting* | | | | | | |
| Flexible exchange rate | 0.9913 | 0.0314 | 0.7161 | 2.5534 | 0.0794 | 0.7402 |
| Managed exchange rate | 2.9289 | 0.1254 | 0.1227 | 0.6387 | 0.6744 | 0.7572 |

## Table B2. Unconditional Standard Deviations: Foreign Output Shock

| *Targeting case* | *Output* | *Domestic inflation* | *CPI inflation* | *Real exchange rate* | *Nominal interest rate* | *Real interest rate* |
|---|---|---|---|---|---|---|
| *Flexible CPI inflation targeting* | | | | | | |
| Flexible exchange rate | 0.0950 | 0.0021 | 0.0429 | 0.1957 | 0.0402 | 0.0513 |
| Managed exchange rate | 0.3337 | 0.0163 | 0.0104 | 0.0853 | 0.0116 | 0.0070 |
| *Strict CPI inflation targeting* | | | | | | |
| Flexible exchange rate | 0.3536 | 0.0060 | 0.0102 | 0.0794 | 0.0123 | 0.0099 |
| Managed exchange rate | 0.3988 | 0.0163 | 0.0113 | 0.0633 | 0.0011 | 0.0108 |
| *Flexible domestic inflation targeting* | | | | | | |
| Flexible exchange rate | 0.1327 | 0.0036 | 0.0367 | 0.1745 | 0.0394 | 0.0439 |
| Managed exchange rate | 0.3329 | 0.0163 | 0.0105 | 0.0854 | 0.0120 | 0.0071 |
| *Strict domestic inflation targeting* | | | | | | |
| Flexible exchange rate | 0.3751 | 0.0078 | 0.0120 | 0.0700 | 0.0140 | 0.0073 |
| Managed exchange rate | 0.3976 | 0.0163 | 0.0113 | 0.0634 | 0.0015 | 0.0105 |

**Table B3. Unconditional Standard Deviations: Productivity Shock**

| *Targeting case* | *Output* | *Domestic inflation* | *CPI inflation* | *Real exchange rate* | *Nominal interest rate* | *Real interest rate* |
|---|---|---|---|---|---|---|
| *Flexible CPI inflation targeting* | | | | | | |
| Flexible exchange rate | 0.1181 | 0.1361 | 0.1341 | 0.0577 | 0.0860 | 0.0944 |
| Managed exchange rate | 0.4529 | 0.0697 | 0.0523 | 0.2212 | 0.0098 | 0.0462 |
| *Strict CPI inflation targeting* | | | | | | |
| Flexible exchange rate | 0.3792 | 0.1095 | 0.0879 | 0.1571 | 0.0746 | 0.0841 |
| Managed exchange rate | 0.5585 | 0.0705 | 0.0490 | 0.2727 | 0.0046 | 0.0466 |
| *Flexible domestic inflation targeting* | | | | | | |
| Flexible exchange rate | 0.1600 | 0.1153 | 0.1108 | 0.0781 | 0.0699 | 0.0781 |
| Managed exchange rate | 0.4526 | 0.0698 | 0.0522 | 0.2210 | 0.0111 | 0.0453 |
| *Strict domestic inflation targeting* | | | | | | |
| Flexible exchange rate | 0.2836 | 0.1173 | 0.0948 | 0.1055 | 0.0877 | 0.0876 |
| Managed exchange rate | 0.5590 | 0.0704 | 0.0486 | 0.2730 | 0.0063 | 0.0453 |

**Table B4. Unconditional Standard Deviations: Domestic Interest Rate Shock**

| *Targeting case* | *Output* | *Domestic inflation* | *CPI inflation* | *Real exchange rate* | *Nominal interest rate* | *Real interest rate* |
|---|---|---|---|---|---|---|
| *Flexible CPI inflation targeting* | | | | | | |
| Flexible exchange rate | 4.4134 | 0.3791 | 0.7371 | 2.1553 | 0.2455 | 0.8113 |
| Managed exchange rate | 0.7382 | 0.0452 | 0.1323 | 0.3605 | 0.1102 | 0.1581 |
| *Strict CPI inflation targeting* | | | | | | |
| Flexible exchange rate | 25.4384 | 1.4824 | 3.5524 | 12.0738 | 1.1190 | 3.7836 |
| Managed exchange rate | 0.9111 | 0.0453 | 0.1540 | 0.4449 | 0.1361 | 0.1861 |
| *Flexible domestic inflation targeting* | | | | | | |
| Flexible exchange rate | 3.7255 | 0.3441 | 0.6634 | 1.8194 | 0.2724 | 0.7268 |
| Managed exchange rate | 0.7368 | 0.0452 | 0.1321 | 0.3598 | 0.1098 | 0.1579 |
| *Strict domestic inflation targeting* | | | | | | |
| Flexible exchange rate | 16.6473 | 0.9681 | 2.3801 | 7.7738 | 0.8745 | 2.5862 |
| Managed exchange rate | 0.8890 | 0.0442 | 0.1505 | 0.4342 | 0.1330 | 0.1820 |

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# A Critical View of Inflation Targeting: Crises, Limited Sustainability, and Aggregate Shocks

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Inflation targeting has recently been adopted by the central banks of several advanced economies, including Australia, Canada, Finland, New Zealand, Spain, Sweden, and the United Kingdom. The policy is widely perceived as having been successful (see the discussions in Leiderman and Svensson, 1995; McCallum, 1996; Bernanke and others, 1999), and it is now increasingly being implemented by emerging economies. In response to recent currency crises, several emerging economies have had to let their currencies float. A view has emerged that for these economies, the option of simply fixing the exchange rate is no longer viable and that in the design of a new, permanent monetary policy framework, the choice is between a fixed exchange rate with an extremely strong form of commitment (such as a currency board or full dollarization) and flexible exchange rates.[1] Several important emerging economies, such as Brazil and Mexico, have chosen the latter. Given the well-known problems associated with choosing a monetary aggregate as the nominal anchor, they have opted for an inflation target.

This transplants inflation targeting to a new and quite different economic environment. It also assigns it a new task, namely, the attainment and maintenance of low inflation rates in a historically highly inflationary environment, starting from double digit inflation rates. The suitability of inflation targeting for such environments was first discussed in Masson, Savastano, and Sharma (1997). They find that the policy is unsuitable for most emerging markets, based on two objections. The main criticism is that for emerging markets the exchange

1. This view is not unanimous. See, for example, Frankel (1999).

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rate remains an important additional objective of monetary policy, which is bound to lead to conflicts with the inflation target. Strong empirical support for this view can be found in Calvo and Reinhart (2000a, 2000b) and Levy-Yeyati and Sturzenegger (1999), who find that the actual behavior of many emerging economies' exchange rate regimes, while officially classified as floating, in fact resembles that of noncredible pegs. The second objection to inflation targeting, which may no longer be applicable to all emerging markets but certainly is to a majority of them, is fiscal dominance. In such economies the government budget remains a source of instability, and seigniorage often continues to be an important source of government financing. The reasons include a weak fiscal revenue base, a rudimentary tax collection system, the contingent bailout liabilities associated with weak banking systems, and simple overspending at the federal or regional level. There is often no political consensus that low inflation should be the overriding objective of monetary policy. For example, the Brazilian crisis of 1999 was by most accounts caused by unsustainable fiscal policies.

As I show in section 1 of this paper, inflation targets are vulnerable to speculative attacks under conditions of fiscal inconsistencies. Fiscal policy is one reason why the sustainability of inflation targets in emerging markets cannot be taken for granted in the same way as in the industrialized economies that have used this policy. Section 2 explores the consequences of limited sustainability in a full-fledged sticky price small open economy model. The section concludes that the defense of an inflation target against the inflationary bias resulting from a perceived lack of sustainability (modeled as policy temporariness) requires a more volatile and distortionary monetary policy, and it leads to lower welfare. These results should be of great importance for policymakers in emerging markets as they evaluate the suitability of different monetary regimes, a point that is also stressed by Mendoza (2001). As is well known to every student of open economy macroeconomics, however, flexible exchange rates allow for a more effective countercyclical monetary policy when an economy is subject to real shocks. This is the basis of a number of recent papers, including Schmitt-Grohé and Uribe (2001), Céspedes, Chang, and Velasco (2000), Parrado and Velasco (2001), and Galí and Monacelli (2000), which argue that inflation targeting is superior to exchange rate targeting. This question is addressed in section 3. Using the analytical apparatus developed for the previous exercise, I analyze the dynamic response of the economy to real and money demand shocks. I find that the superiority of one or the other regime in terms of welfare depends on a number of factors, including not only the

nature of shocks but also their direction. Furthermore, the analysis discredits the logic that is often implied in the policy debate, namely, that the flexibility of exchange rates under inflation targeting allows the nominal exchange rate to quickly bring the real exchange rate to a new equilibrium. This is one of the fallacies of the popular debate on this subject, which bases conclusions for the supposedly flexible exchange rates under inflation targeting on the results of an earlier literature on flexible rates under money targeting. In fact, the attainment of a new equilibrium real exchange rate happens at a very similar speed under exchange rate and inflation targeting when the latter is understood as a strict target for the level of inflation as opposed to a flexible interest rate rule. This assumption, which is critical for the results of section 3, seems appropriate for many emerging markets because they have to demonstrate credibility through the at least initially strict adherence to a target (see, for example, the discussion in Morande and Schmidt-Hebbel, 1999).[2] The conclusion from this exercise is that the performance of inflation targeting and exchange rate targeting under perfect policy sustainability and exogenous shocks is not very different.

This discussion, however, may miss the real point behind the attractiveness of inflation targeting. The theoretical results derived in this paper are based on the assumption that when a central bank targets the inflation rate, its commitment to that target is just as serious as the commitment to an equivalent exchange rate target. As documented in more detail in Kumhof, Li, and Yan (2000), many emerging market central bankers who are pursuing inflation targets apparently do not consider themselves to be vulnerable to currency crises, and they are willing to accept much larger short-run nominal exchange rate movements than is consistent with a strict inflation target. There is talk of constrained discretion, and of letting bygones be bygones. If one is willing to simply assume that, despite discretion, the perceived sustainability of the monetary regime in the eyes of the public is unaffected, it is really no wonder that inflation targeting would outperform exchange rate targeting. But in that case, the comparison of inflation targeting with a rigidly fixed exchange rate is really not fair and it should more properly be compared with a dirty peg. That regime, how-

2. An additional problem with flexible interest rate rules, on which I do not dwell further in this paper, is that many popular versions of such rules are subject to nonuniqueness problems. The discussion in section 2 on pure forward-looking inflation targeting versus price level rules is related to this point.

ever, has long since ceased to be respectable in emerging markets, especially in Latin America, precisely because its lack of commitment to a nominal anchor was frequently found to give rise to credibility and time inconsistency problems. Given the long history of monetary mismanagement in emerging markets, the debate about rules versus discretion was at some point decided in favor of rules. It now looks as though discretion has made a comeback, albeit under the more respectable and fashionable name of inflation targeting. Fashion aside, this trend is a mystery, except perhaps in the case of the strongest of the emerging markets, such as Chile.

The paper presents a set of theoretical models of a monetary small open economy. The emphasis is on the economic intuition, which is discussed with the help of computations of dynamic time paths. Rigorous definitions of equilibria, as well as computational and mathematical details, are omitted except where they are relevant to the intuition. Where appropriate, the reader is referred to the original papers (Kumhof, Li, and Yan, 2000; Kumhof, 2000a, 2000b) for technical details.

## 1. Currency Crises

In the policy debate about inflation targeting, it is often claimed that a major advantage of this monetary regime is that it does not leave an economy vulnerable to a speculative attack. The logic is that a run on reserves can be averted because the central bank can simply let the exchange rate go. This is not at all obvious, however, if the policymaker is strictly committed to the inflation target. The reason is that in a small open economy the exchange rate is a very important component of the price index, and exchange rate management becomes necessary to achieve the inflation target. This commitment to intervene in the foreign exchange market makes a speculative attack possible. This section explores that point and further investigates whether inflation targeting and exchange rate targeting are quantitatively very different with respect to the behavior of economic variables under conditions that must ultimately lead to a speculative attack.

The key ideas can be presented with a simple microfounded balance-of-payments crisis model along the lines of Calvo (1987). The additional element needed is nontradable goods; this allows a natural specification of the consumer price index, the variable targeted in all current inflation targeting regimes. It is shown that once reserves are sufficiently low, exchange rate depreciation starts to exceed the inflation target in anticipation of the crisis. The central bank then has to

permit a contraction of the money supply to continue to meet the inflation target. This generates domestic deflation and sharply accelerating reserve losses in the final phase of the program. In calibrated experiments this final phase is very short but not instantaneous, unlike under a collapsing exchange rate target. Nothing in this logic depends on the inevitability of the crisis displayed by our model, and the principle can therefore easily be extended to second-generation balance-of-payments crisis models (see the arguments in Krugman, 1996). In fact, as described by Carstens and Werner (1999) and Morandé and Schmidt-Hebbel (1999), contagion-driven speculative pressure on inflation targets did occur in Mexico, Chile, and Israel in the second half of 1998.

This theory has important consequences for monetary policy in small open economies. The only way to completely rule out speculative attacks is to choose a target that does not involve any commitment to central bank intervention in the foreign exchange markets. One possibility is a target growth rate for the quantity of nominal money balances, which is the traditional definition of a floating exchange rate regime. Generally, the greater the weight of the exchange rate in the nominal target variable, the greater is the vulnerability to a speculative attack. For an open economy that targets the inflation rate, this weight is far greater than zero.

The rest of this section is organized as follows. Subsection 1.1 develops the model. Subsection 1.2 calibrates it and discusses computed solution paths, and subsection 1.3 concludes. Computational aspects of the model solution can be found in the original paper (Kumhof, Li, and Yan, 2000).

## 1.1 The Model

Consider a small open economy that consists of a government and representative price-taking, infinitely lived consumers. For tradable goods, purchasing power parity holds and their international price is constant and normalized to one. Nontradable goods prices are flexible. Time is continuous. Lower and upper case letters represent real and nominal quantities, respectively.

### Consumers

Consumers maximize lifetime utility derived from the consumption of tradable and nontradable goods, $c_t^*$ and $c_t$. Their personal discount rate equals the constant real international interest rate, $r$, to

ensure the existence of a steady state. The objective function is

$$\text{Max} \int_0^{\infty} \left[ \gamma \ln(c_t^*) + (1-\gamma) \ln(c_t) \right] e^{-rt}\, dt \,. \tag{1}$$

Consumers receive fixed endowments of tradable and nontradable goods, $y^*$ and $y$, and government lump-sum transfers, $g_t$. The nominal exchange rate and the price level of nontradable goods are denoted by $E_t$ and $P_{N_t}$, respectively, and the real exchange rate by $e_t = E_t / P_{N_t}$. Consumers hold two types of assets, real international bonds, $b_t$, and real money balances, $m_t = M_t / P_{N_t}$, with total asset holdings of $a_t = b_t + m_t$. Real money balances in terms of nontradable goods are $n_t = M_t / P_{N_t}$. The rate of currency depreciation is denoted by $\varepsilon_t = \dot{E}_t / E_t$, and uncovered interest parity is assumed to hold, $i_t = r + \varepsilon_t$, where $i_t$ is the nominal interest rate on international bonds. Consumers face a cash-in-advance constraint on consumption, $m_t \geq \alpha\left( c_t^* + c_t / \varepsilon_t \right)$, which will be shown to hold with equality in equilibrium. Their lifetime budget constraint, incorporating the cash-in-advance constraint, is

$$a_0 + \int_0^{\infty} \left( y^* + \frac{y}{e_t} + g_t \right) e^{-rt}\, dt = \int_0^{\infty} \left( c_t^* + \frac{c_t}{e_t} \right) (1 + \alpha i_t)\, e^{-rt}\, dt \,. \tag{2}$$

First-order conditions are

$$\frac{c_t}{c_t^*} = e_t \frac{1-\gamma}{\gamma} \text{ and} \tag{3}$$

$$\frac{\gamma}{c_t^*} = \lambda\left(1 + \alpha i_t\right). \tag{4}$$

This implies real money demands $n_t = \alpha c_t \left(1-\gamma\right)^{-1}$ and $m_t = \alpha c_t^* \gamma^{-1}$. If $\mu_t = \dot{M}_t / M_t$, then the latter means that $\dot{m}_t / m_t = \left( \mu_t - \varepsilon_t \right) = \dot{c}_t^* / c_t$.

## Definition of the Inflation Rate

A paper on inflation targeting in an open economy has to consider the appropriate definition of the aggregate inflation rate. For example, if all goods were tradable and purchasing power parity prevailed, there would be no difference between inflation targeting and exchange rate targeting. All countries that have implemented inflation targeting have chosen as their target a version of the consumer price index (CPI),

which is based on a goods basket of both tradable goods with price level $E_t P_t^*$ and nontradable goods with price level $P_{N_t}$. Given the normalization $P_t^* = 1$, a natural definition of the CPI $P_t$ is therefore the consumption-based price index:

$$P_t = \left(E_t\right)^{\gamma}\left(P_{N_t}\right)^{1-\gamma} \gamma^{-\gamma}\left(1-\gamma\right)^{-(1-\gamma)}. \tag{5}$$

In rate-of-change form, this is

$$p_t = \gamma \varepsilon_t + \left(1-\gamma\right)\pi_t, \tag{6}$$

where $p_t = \dot{P}_t / P_t$ and $\pi_t = \dot{P}_{N_t} / P_{N_t}$.

## Government and Aggregate Budget Constraint

The government's policy consists of a specification of the path of lump-sum transfers, $\{g_t\}_{t=0}^{\infty}$, of an initial condition, $P_0$, for the CPI and of the initial (unsustainable) target rate of CPI inflation, $\bar{p}$, with the post-crisis steady-state rate of CPI inflation being determined by a balanced-budget requirement. I assume full central bank monetary accommodation at time 0, which implies a constant $E$ and jumps in $P_N$ and $P$ on impact.[3]

The case in which $P_t$ is the only target variable in a perfect foresight environment corresponds to what King and Wolman (1996) call perfect inflation targeting. They show that in a closed economy setting, the target can be achieved either by manipulation of the money supply (as in this model) or by an interest rate feedback rule with a very strong interest rate response to deviations of $P_t$ from its target path. The economy described in the present model has an equivalent interest rate policy, but given uncovered interest parity, interest rate policy is indistinguishable from exchange rate policy. Taylor (2000) suggests that a money instrument may, in fact, be more appropriate for emerging markets.

Let $h_t$ be the government's foreign exchange reserves. Then the government's lifetime budget constraint is

$$h_0 + \int_0^{\infty}\left(\dot{m}_t + \varepsilon_t m_t - g_t\right)e^{-rt}dt = 0. \tag{7}$$

3. This appears to be the most reasonable assumption. Calvo and Reinhart (2000a) and Reinhart (2000) show that central banks in emerging economies continue to resist large swings in nominal exchange rates.

There is a minimum level of net foreign assets, which for simplicity is assumed to be equal to zero: $h_t \geq 0 \quad \forall t$ .[4]
In equilibrium the nontradable goods market must clear: $c_t = y \quad \forall t$ , which implies $\mu_t = \pi_t \quad \forall t$ . The economy's overall resource constraint can now be derived as

$$f_0 + \frac{y^*}{r} = \int_0^\infty c_t^* \, e^{-rt} \, dt \, , \tag{8}$$

with current account $\dot{f}_t = r f_t + y^* - c_t^*$ .

## 1.2 Crisis Dynamics

Assume that the economy is in an initial steady state (subscript *I*) with, for simplicity, zero net foreign assets ($f_I = 0$), zero inflation, a constant level of foreign exchange reserves, $h_I$ , and a balanced budget. In this steady state, $p_I = \varepsilon_I = \pi_I = 0$ and $r h_I = g_I$. Now assume that the government starts to pursue an inconsistent fiscal policy at $t = 0$, with the inflation target kept at $\bar{p} = 0$ and $g$ permanently increased to $\bar{g} = 10\%$ of output. The time $T$ at which the final steady state (subscript *T*) is reached is endogenous. The same is true for final steady-state inflation, $p_T = \varepsilon_T = \pi_T$, which is a function of $c_T^* = y^* + r f_T$ by $p_T = \gamma \bar{g} / \alpha \left( y^* + r f_T \right) > p_I$ .

The mathematical and computational aspects of solving the model are discussed in Kumhof, Li, and Yan (2000). Parameter values are assigned according to table 1. Some parameters are calibrated using Brazilian data, since Brazil was one of the first emerging economies to adopt inflation targeting. For an emerging market, the real marginal cost of borrowing in international capital markets, *r,* is assumed to be given by the real Brady bond yield. In Brazil the nominal Brady yield has mostly fluctuated between 10 and 15 percent, which after adjusting for U.S. inflation suggests using $r = 10$ percent. The inverse velocity, $\alpha$, is set equal to the ratio of the real monetary base to quarterly absorption in Brazil in 1996.[5] A 50 percent share of tradables in consumption is empirically reasonable (see De Gregorio, Giovannini, and Wolf, 1994). The nontradables and tradables endowments are normalized to 1. The parameters $\alpha$ and $\gamma$ imply $m_I = 0.6$. Central bank foreign

4. See Obstfeld (1986) for a discussion of this condition. It is highly relevant for emerging economies, which lose access to international capital markets during balance-of-payments crises, as documented by Calvo and Reinhart (2000b).

5. Brazilian absorption data are only available with a long lag.

**Table 1. Parameter Values for Dynamic Equilibrium**

| *Parameter* | *Value* | *Description* |
|---|---|---|
| $p_I$ | 0% p.a. | Initial inflation target |
| $\bar{p}$ | 0% p.a. | New inflation target |
| $g_I$ | 0.02 | Initial primary deficit |
| $\bar{g}$ | 0.20 | New permanent primary deficit |
| $r$ | 10% p.a. | Real international interest rate |
| $\beta$ | 10% p.a. | Subjective discount rate |
| $\alpha$ | 0.3 | Inverse velocity |
| $\gamma$ | 0.5 | Share of tradable goods |
| $y$ | 1 | Nontradables endowment |
| $y^*$ | 1 | Tradables endowment |
| $f_I$ | 0 | Initial net foreing assets |
| $h_I$ | 0.8 | Initial reserves |

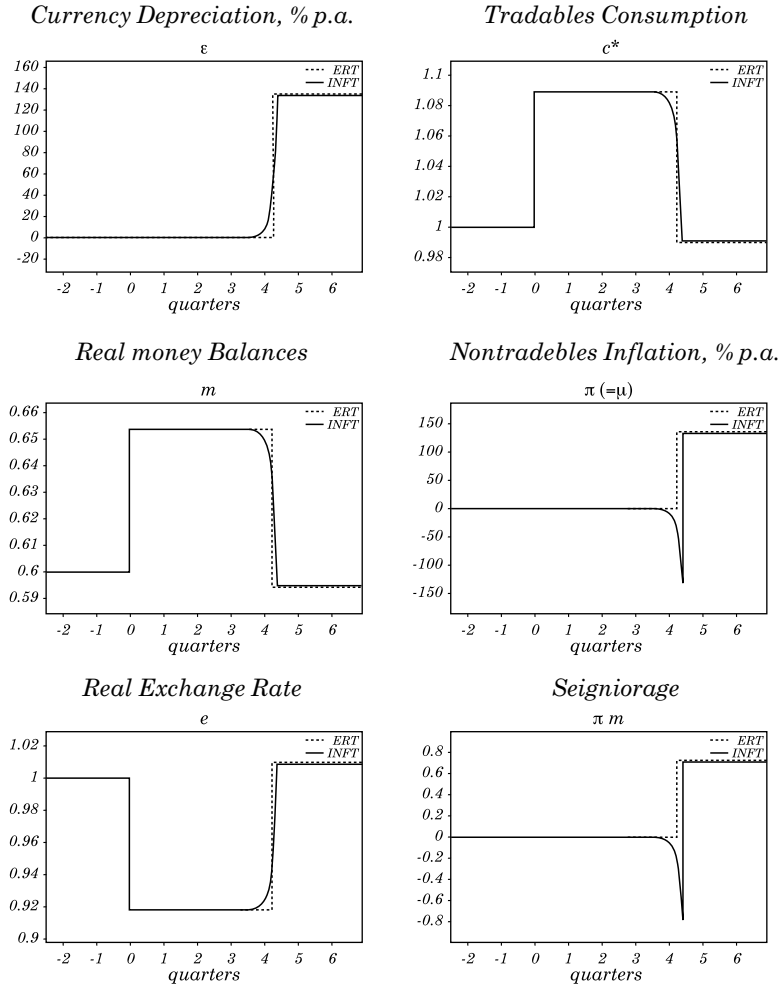
exchange reserves, $h_I$, are set at 0.8, based on the $h/m$ ratio in Brazil in 1996. The logarithmic specification of the utility index is somewhat restrictive, as it implies an intertemporal elasticity of substitution of one. Empirical estimates of this elasticity are typically below one, as in Reinhart and Végh (1995), but Ogaki and Reinhart (1998) and Eckstein and Leiderman (1992) provide examples of estimates closer to one.

Figure 1 presents solution paths for inflation targeting $\bar{p} = 0$ (the solid lines) and compares these to balance-of-payments crises under exchange rate targeting $\bar{\varepsilon} = 0$ (broken lines). The figure shows that the dynamics generated by collapsing exchange rates and inflation targets are quite similar. The collapse of the exchange rate target in a continuous time model happens instantaneously, while under inflation targeting reserve losses occur as flows. But for practical purposes this is not very different, because almost all reserve losses are concentrated in about one month before the end of the program. During that period the beginning exchange rate depreciation tends to drive the CPI inflation rate up. If the central bank is fully committed to defending the inflation target, it is then forced to allow a monetary contraction which generates an offsetting domestic deflation. The key to understanding the associated flow reserve losses is the seigniorage term in the government's budget constraint, which is shown as the final panel of figure 1:

$$\dot{m}_t + \varepsilon_t m_t = \mu_t m_t = \pi_t m_t .$$

Although in the final stages of the program the inflation tax compo-

**Figure 1. Crisis Dynamics under Inflation and Exchange Rate Targeting**




Source: Author's calculations.

nent of seigniorage, $\varepsilon_t m_t$, may increase, money demand falls so fast that overall seigniorage declines steeply, thereby accelerating reserve losses above those caused by the primary deficit, $\bar{g}$. This rapid reserve loss owing to a steep drop in private sector asset demands is the speculative attack. Figure 1 can also be used to infer a more general result regarding the vulnerability of different monetary regimes to specula-

tive attacks. The figure shows that the inflation target, $\bar{p} = 0$, collapses later than the exchange rate target, $\bar{\varepsilon} = 0$. This must be due to smaller reserve losses attributable to the speculative attack, given that reserve losses related to the government deficit per period are assumed to be equal. Under the money-targeting rule $\bar{\mu} = 0$, an attack would be completely impossible, meaning that reserve losses attributable to a speculative attack would be zero.[6] The crisis would therefore happen even later. The conclusion is that within the class of monetary policy rules that target the growth rate of a single nominal variable, vulnerability to a speculative attack increases with the weight of the exchange rate in the target. That weight is lower under inflation targeting than under exchange rate targeting, but it is far greater than zero.

## 1.3 Summary

Inflation targeting is a commitment to achieve a certain path of the consumer price index. Given that in a small open economy this index is strongly influenced by the exchange rate, foreign exchange market intervention becomes a necessary part of monetary policy. That makes balance-of-payments crises possible. Such crises have quite similar dynamics to the collapse of a fixed exchange rate regime, with two important exceptions: the attack takes place over a short time period as opposed to instantaneously, and reserve losses attributable to the attack are smaller and increasing in the share of tradable goods in total consumption.

Policymakers in some, but by no means all, emerging economies that are currently implementing inflation targeting recognize the possibility of speculative attacks under this policy. For Chile, Morandé and Schmidt-Hebbel (1999) explicitly acknowledge the necessity of potentially heavy foreign exchange market intervention to defend the inflation target. Carstens and Werner (1999) state that Mexico's transition to full inflation targeting is slow precisely because policymakers find that they must allow frequent large shocks to the exchange rate to lead to deviations from the inflation target. On the other hand, this problem is not explicitly acknowledged by Tombini and Bogdanski (2000) for Brazil or by Uribe, Gomez, and Vargas (2000) for Colombia. Unless a country pursues the Chilean hard line, however, it is difficult to see how the credibility of the target can be established, given that otherwise the commitment to the target is contingent on the absence of specu-

6. The money-targeting rule is equivalent to targeting the nontradable goods price in the present model.

lative pressure. This should be a point of concern, because credibility of the nominal anchor continues to be a much more critical issue for monetary policy in emerging economies than it is in advanced economies. This lack of credibility, or more specifically the public's belief that monetary policy is not sustainable and is therefore temporary, is the subject of the next section.

## 2. Limited Sustainability

This section assesses the theoretical implications of using what the public perceives to be an unsustainable and therefore temporary inflation target to maintain a low rate of inflation in a small open economy with open capital account and sticky nontradable goods prices. Results can be compared with those of the well-established literature on exchange rate targeting and policy temporariness.[7]

The model builds on that of the last section, the main difference being that nontradables prices are now assumed to be sticky. A discrete time set-up is used to apply a convenient new computable general equilibrium method to the computation of equilibrium paths. This method has wide applicability to small open economy models, which are typically characterized by a personal discount rate equal to an exogenous world real interest rate, and consequently a nonhyperbolic steady state.[8]

The analysis shows that forward-looking inflation targeting alone results in indeterminacy of equilibrium paths (nonuniqueness). This problem does not arise if inflation targeting is defined as fixing the path of the price level. The main results of the section are driven by the fact that the consumer price index, which is the target variable in all current inflation-targeting regimes, is an average of relatively sticky domestic nontradable goods prices and more flexible, exchange-rate-driven tradable goods prices.

Limited sustainability of an inflation target is represented as public expectations that a low inflation period will be of limited duration, expectations which are assumed to be validated by the policymaker in equilibrium. As a result, nontradable goods inflation stays above the target at all times. In order to meet the target, the monetary authority is forced to reduce the rate of currency depreciation through a tight monetary policy. Especially toward the end of the program, this leads

7. See, for example, Calvo and Végh (1993, 1999).
8. See Kumhof (2000a, 2000b) for details.

to very large current account deficits, real appreciations, and domestic recessions in excess of those observed under exchange rate targeting. In addition, tradables consumption temporarily contracts after the collapse. The welfare losses of unsustainable inflation targeting exceed those of exchange rate targeting, the more so the higher is the degree of price stickiness.

These conclusions are closely related to the arguments of Masson, Savastano, and Sharma (1997). The seigniorage-driven negative fiscal effect of a lower inflation target is even worse than under exchange rate targeting as a result of the need for an especially tight monetary policy. The need to use the exchange rate in this way leads to an exacerbated real appreciation, clashing with the competing exchange rate or competitiveness objective.

The rest of the section is organized as follows. Subsection 2.1 develops the model. Subsection 2.2 discusses the uniqueness of equlibrium paths. Subsection 2.3 calibrates the model and computes the effects of unsustainable exchange rate targeting and inflation targeting programs on the paths of economic variables. Subsection 2.4 evaluates the welfare consequences of these policies. Subsection 2.5 concludes.

## 2.1 The Model

Consider a small open economy that consists of a government, a representative price-taking, infinitely lived household, and a continuum, indexed by $j \in (0, 1)$, of monopolistically competitive, infinitely lived firms that produce nontradable goods.

### Households

Households maximize lifetime utility, which depends on their consumption of homogeneous tradable goods, $c_t^*$, heterogeneous nontradable goods, $c_t(j), j \in (0, 1)$, and utility from leisure aggregated over heterogeneous occupations $[1 - l_t(j)], j \in (0, 1)$, where 1 is the fixed endowment of time per occupation and $l_t(j)$ is heterogeneous labor. Their personal discount rate equals the constant real international interest rate, $r > 0$, as in section 1.

Aggregate nontradables consumption is given by

$$c_t = \left[ \int_0^1 c_t(j)^{\theta-1/\theta} \right]^{\theta/\theta-1}, \tag{9}$$

with elasticity of substitution $\theta > 1$. Let $P_{N_t}(j)$ be the price of individual good $c_t(j)$. Then cost minimization implies

$$c_t(j) = c_t\left[\frac{P_{N_t}(j)}{P_{N_t}}\right]^{-\theta}, \tag{10}$$

where the price index of nontradables $P_{N_t}$ is

$$P_{N_t} = \left[\int_0^1 P_{N_t}(j)^{1-\theta}\right]^{1/1-\theta}. \tag{11}$$

Households' objective function is

$$\text{Max}\sum_{t=0}^{\infty}\left(\frac{1}{1+r}\right)^t\left\{\gamma\ln\left(c_t^*\right)+(1-\gamma)\ln\left(c_t\right)+\kappa\int_0^1\ln\left[1-l_t(j)\right]dj\right\}. \tag{12}$$

Log consumption utility is a standard assumption in this literature.[9] Leisure utility is aggregated over all occupations. This means that the objective function 12 is that of the overall household sector, where households perfectly share through a set of contingent securities their idiosyncratic labor income risk. For every occupation, *j*, there is then a single household facing a single firm, which gives rise to a bilateral monopoly (whereas a continuum of households per occupation would give rise to a monopsony). It is well known that the allocation under a bilateral monopoly is indeterminate unless additional assumptions are made. I impose the competitive outcome, which makes the solution of this model identical to one in which firms are operated by yeoman farmers, as in Woodford (1996).

The nominal and real exchange rates are denoted by $E_t$ and $e_t = E_t / P_{N_t}$. The rate of currency depreciation is $\varepsilon_t = \left(E_t - E_{t-1}\right) / E_{t-1}$ and nontradables inflation is $\pi_t = \left(P_{N_t} - P_{N_{t-1}}\right) / P_{N_{t-1}}$. The real exchange rate evolution is governed by

$$\frac{e_t}{e_{t-1}} = \frac{1+\varepsilon_t}{1+\pi_t}. \tag{13}$$

9. See Bergin and Feenstra (2000); King and Wolman (1996).

Households receive a constant endowment of tradable goods, $y^*$, and government lump-sum transfers in terms of tradables, $g_t$. From firms they receive nominal wages, $\int_0^1 W_t(j)\, l_t(j)\, dj$, and nominal lump-sum profit distributions, $\int_0^1 \Pi(j)\, dj$. They hold two kinds of assets, real international bonds, $b_t$, and real money balances, $m_t = M_t / E_t$, with total assets of $a_t = b_t + m_t$. Uncovered interest parity is assumed to hold: $(1+i_t) = (1+r)(1+\varepsilon_{t+1})$. Households face a cash-in-advance constraint on consumption $m_t \geq \alpha(c_t^* + c_t / e_t)$. It can be verified that this constraint holds with equality in equilibrium. When this is incorporated into their lifetime budget constraint, one obtains

$$(1+r)b_{-1} + \frac{m_{-1}}{1+\varepsilon_0} + \sum_{t=0}^{\infty}\left(\frac{1}{1+r}\right)^t \left[ g_t + y^* + \frac{\int_0^1 W_t(j) l_t(j)\, dj}{E_t} + \frac{\int_0^1 \Pi_t(j)\, dj}{E_t} \right]$$
$$= \sum_{t=0}^{\infty}\left(\frac{1}{1+r}\right)^t \left\{ \left[ c_t^* + \frac{\int_0^1 P_{N_t}(j) c_t(j)\, dj}{E_t} \right] \left( 1 + \alpha \frac{i_t}{1+i_t} \right) \right\}. \tag{14}$$

The household's problem is to maximize 12 subject to 14. The first-order conditions are 14 and

$$\frac{\gamma}{c_t^*} = \lambda \left( 1 + \alpha \frac{i_t}{1+i_t} \right), \tag{15}$$

$$\frac{c_t}{c_t^*} = e_t \frac{1-\gamma}{\gamma}, \text{ and} \tag{16}$$

$$w_t(j) = \frac{\kappa c_t \left\{ 1 + \alpha \left[ i_t / (1+i_t) \right] \right\}}{(1-\gamma)\left[ 1 - l_t(j) \right]}, \tag{17}$$

where $\lambda$ is the constant multiplier of the lifetime budget constraint, equation 14, equal to the shadow value of lifetime wealth, and

$w_t(j) = W_t(j)/P_{N_t}$ is the real wage in terms of nontradables in occupation j. Equation 15 shows that the current account is driven by intertemporal substitution owing to variations in the effective price of consumption, via either changes in nominal interest rates or in inverse velocity, $\alpha$. Equation 16 equates the marginal rate of substitution between tradables and nontradables to their relative price, the real exchange rate. Equation 17 equates the marginal consumption utility of extra nontradables earnings to the marginal disutility of additional labor supply, adjusted for the monetary distortion to the consumption-leisure choice.

## Definition of the Inflation Rate

The consumption-based price index is defined as in section 1. Foreign inflation is still set equal to zero in this section, but in section 3 below, I allow for it to be other than zero. The general formula for the index is therefore

$$P_t = \left(E_t P_t^*\right)^{\gamma} \left(P_{N_t}\right)^{1-\gamma} \gamma^{-\gamma} (1-\gamma)^{-(1-\gamma)}. \tag{18}$$

In rate of change form this is

$$(1+p_t) = (1+\varepsilon_t)^{\gamma} \left(1+\pi_t^*\right)^{\gamma} (1+\pi_t)^{1-\gamma}, \tag{19}$$

where $p_t = (P_t - P_{t-1})/P_{t-1}$ and $\pi_t^* = \left(P_t^* - P_{t-1}^*\right)/P_{t-1}^*$.

Inflation targeting is defined as a target path for $P_t$. Several recent papers advocate targeting nontradable goods prices, because under sticky prices, such a policy replicates the flexible price equilibrium. While theoretically very interesting, I consider this line of argument to be practically not very relevant for emerging markets for two reasons. First, constructing such an index is obviously difficult both because he availability of data in emerging markets is limited and, more fundamentally, because the model's clean separation of tradable goods with flexible prices and nontradable goods with sticky prices has no easily identifiable counterpart in the real world. The second—and more serious—difficulty with nontradable goods price targeting is policy credibility. Several Latin American countries have manipulated price indexes to meet policy targets in the past. That danger will be perceived to be far more serious with a new and badly understood index. The simple consumer price index, $P_t$, has a clear advantage in this respect.

## Technology and Pricing

Purchasing power parity is assumed to hold for tradable goods, and their international price level is normalized to one. This seems justified on the basis of the empirical evidence on tradables pass-through for emerging markets. Kumhof, Li, and Yan (2000) survey the limited evidence currently available, which finds far higher pass-through coefficients in emerging markets than in industrialized countries.

Firms producing nontradable goods have linear production functions, $y_t(j) = l_t(j)$, where $j \in (0, 1)$. They are price takers in the labor market and monopolistically competitive in the goods market, taking into account the goods demand defined in equation 10. Firms distribute all nominal profits $\Pi_t(j)$ to households in a lump-sum fashion.

Following Calvo (1983), it is assumed that firms have infrequent opportunities to change their prices and that these opportunities arrive as exogenous processes, are independent across firms, and for each firm are independent of their last occurrence. Specifically, it is assumed that in each period the probability that any firm will be able to change its price is $1 - \delta$. The interval between price changes for an individual firm is therefore a random variable. With a continuum of firms, however, $1 - \delta$ also represents the fraction of firms that can change prices in any period. Together with the assumptions of lump-sum profit distributions to households and perfect sharing of labor income risk among households, this implies that firm-specific uncertainty does not translate into aggregate income uncertainty for households. The model can therefore be solved under perfect foresight.

When the model is calibrated for a typical emerging market, it will display nonzero steady-state inflation. This possibility does not affect the original Calvo (1983) specification, but the fully microfounded version needs to be modified. I therefore allow today's price setters to both choose today's price level and change their price by the steady-state inflation rate, $\pi_{ss}$, every period thereafter, as in Yun (1996). Without this assumption, steady-state nontradables output would depend on steady-state inflation because of relative price dispersion effects. This would create an undesirable long-run monetary nonneutrality.

Following Rotemberg (1982) and Walsh (1998), it is further assumed that each firm, *j,* that does get an opportunity to change its price sets it to minimize a quadratic loss function that depends on the discounted sum of expected percentage differences between its prices in future periods, *t*, namely, $P_{N_t}(j)$, and its optimal prices in those periods, $P^+_{N_t}$. Let

$(1+r_t^n)=(1+r_t)(1+\varepsilon_{t+1})/(1+\pi_{t+1})$, and let $R_{0,i}=\prod_{s=0}^{i-1}(1+r_s^n)^{-1}$ for $i\geq 1$, ($R_{0,0}=1$) be the period $i$ discount factor for nontradables. Then firms' problem is

$$\text{Min}\ \frac{1}{2}E(t)\left\{\sum_{i=0}^{\infty}R_{0,i}\left[\ln P_{N_{t+i}}(j)-\ln P_{N_{t+i}}^{+}\right]^2\right\}. \tag{20}$$

Here $E(t)$ denotes the expectations operator, conditional on information available at time $t$. The optimal price, $P_{N_t}^{+}$, is the period t flexible price profit-maximizing price taking as given the current aggregate price level $P_{N_t}$ and labor supply equation 17. It does not have a firm-specific index because all firms determining this price will choose identically. I define the markup $\mu=\theta/(\theta-1)$ and let the optimal choice of relative price be $Q_t\equiv P_{N_t}^{+}/P_{N_t}$.

Equation 20 implies $P_{N_t}^{+}=Q_t P_{N_t}$. When this is combined with the exogenous arrival rate of price changing opportunities $(1-\delta)$, the firm's objective function becomes

$$\underset{P_{N_t}(j)}{\text{Min}}\ \frac{1}{2}\left\langle\sum_{i=0}^{\infty}\delta^i R_{0,i}\left\{\ln\left[P_{N_t}(j)(1+\pi_{ss})^i\right]-\ln Q_{t+i}P_{N_{t+i}}\right\}^2\right\rangle \tag{21}$$

The first-order condition of this problem can be combined with the aggregate price index $P_{N_t}^{1-\theta}=\delta P_{N_{t-1}}^{1-\theta}+(1-\delta)X_t^{1-\theta}$, where $X_t$ is the optimal choice of $P_{N_t}(j)$, and log-linearized to obtain the familiar new-Keynesian Phillips curve. Let log deviations be denoted by a hat above the relevant variable. For rates of price change, $x$, $\hat{x}_t=\ln(1+x_t)-\ln(1+x_{ss})$, while for all other variables, $y$, $\hat{y}_t=\ln(y_t)-\ln(y_{ss})$. Again after some algebra, this yields

$$\beta_1\hat{\pi}_{t+1}-\hat{\pi}_t=-3\beta_2\hat{c}_t-2A\beta_2\hat{\varepsilon}_{t+1}, \tag{22}$$

where $\beta_1=1/(1+r)$; $\beta_2=[(1-\delta)/\delta(2+\theta)]$; and $A=\alpha/(1+i_{ss}+\alpha i_{ss})$.

Equations 13, 15, and 22, plus an equation for determining $\lambda$ through first-order condition 15 and the aggregate budget constraint (see below), constitute the system of equations that governs the dynamic behavior of this economy. Starting from an initial steady state, this system will be subjected to a shock in the form of a change in the exog-

enous monetary policy target. Under exchange rate targeting, this target is $\varepsilon_t$, while the inflation rate, $p_t$, is endogenous. Under inflation targeting, $\varepsilon_t$ becomes endogenous and must be replaced in all equations, according to equation 19, by $(1+\varepsilon_t) = (1+p_t)^{1/\gamma} \Big/ (1+\pi_t)^{(1-\gamma)/\gamma}$, with $p_t$ as the new target.

Finally, it can be shown that $Q_{ss} = 1$, which means that steady-state nontradables output and consumption are given by

$$c_{ss} = l_{ss} = \frac{1}{1+\left[(\kappa\mu)/(1-\gamma)\right]\left\{1+\alpha\left[i_{ss}/(1+i_{ss})\right]\right\}} \quad . \tag{23}$$

This depends negatively on the steady-state nominal interest rate, because of the distortion in the consumption-leisure choice introduced by the presence of money. Realistic calibrations of emerging economies must take this rate to be far above zero, which implies that steady-state nontradables output is far below the Friedman rule optimum.

## Government and Aggregate Budget Constraint

It is assumed that the government redistributes to households, over their lifetime, the proceeds from money creation and its initial net wealth:

$$(1+r)h_{-1} - \frac{m_{-1}}{1+\varepsilon_0} + \sum_{t=0}^{\infty}\left(\frac{1}{1+r}\right)^t m_t \frac{i_t}{1+i_t} = \sum_{t=0}^{\infty}\left(\frac{1}{1+r}\right)^t g_t \quad . \tag{24}$$

This implies that monetary policy has no wealth effects. The economy's overall budget constraint is then obtained as

$$(1+r)f_{-1} + y^*\left(\frac{1+r}{r}\right) = \sum_{t=0}^{\infty}\left(\frac{1}{1+r}\right)^t c_t^* \quad , \tag{25}$$

with current account $f_t - f_{t-1} = r\, f_{t-1} + y^* - c_t^*$.

## 2.2 Uniqueness of Equilibrium Paths

The existence of unique convergent equilibrium paths is of more than academic interest. A monetary policy rule or nominal anchor is only useful if it makes (rational) expectations converge on a unique equilibrium path, given the sequence of shocks to which the economy is subjected. This is a nontrivial exercise for the present case, as the small

open economy contains one unit root and is therefore situated at a nonhyperbolic steady state.[10] It can be shown that the dynamic system can be represented by the laws of motion for three variables, $c_t^*$, $e_t$, and $\pi_t$, characterized by one unit root, one root inside the unit circle, and one outside. Under both inflation targeting and exchange rate targeting, $\pi_t$ is a free variable. The unit root is attributable to net foreign assets and thus to $c_t^*$, which is a free variable but can be tied down by the lifetime budget constraint. The requirement for saddle path convergence is therefore that the real exchange rate be a predetermined variable. Remember that

$$e_t = e_{t-1}\left(\frac{1+\varepsilon_t}{1+\pi_t}\right) = e_{t-1}\left(\frac{1+p_t}{1+\pi_t}\right)^{1/\gamma}. \tag{26}$$

For $e_t$ to be predetermined, $\varepsilon_t$ must be determined by monetary policy at all times under exchange rate targeting, while $p_t$ must be determined at all times under inflation targeting. Because exchange rate rules generally do specify a path for levels of the exchange rate, $\{E_\tau\}_{\tau=t}^{\infty}$, such targets are consistent with a unique convergent equilibrium path. The same is not evident from the policy debate about inflation targeting, however, given that policy rules are often implied to be pure forward-looking rules for the rate of change of the price level, $\{p_\tau\}_{\tau=t+1}^{\infty}$, and price level surprises are dealt with by the rule of letting bygones be bygones. This implies indifference about $p_t$, meaning that any real exchange rate is possible today; and, of course, the story repeats itself at any future time. This is not consistent with a unique convergent equilibrium path. What is required is a target path for price levels, $\{P_\tau\}_{\tau=t}^{\infty}$, and this is how inflation targeting is defined in the remainder of the paper.

## 2.3 Policy Experiments, Calibration, and Discussion of Solution Paths

Under the assumptions of the model, particularly full lump-sum redistribution of seigniorage, a permanent, sustainable reduction in an exchange rate target or inflation target results in an instantaneous downward jump in nontradable goods inflation at an unchanged real exchange rate. In the absence of sustainability problems, the choice of

10. See Kumhof (2000a, 2000b) for the technical details.

nominal anchor is immaterial for the outcome. This section therefore focuses on programs that are characterized by a perceived lack of sustainability. The public simply may not believe, and cannot be forced to believe, that the government will permanently maintain the lower level of public spending required by lower seigniorage revenue. Following the literature on exchange rate targeting, this is modeled as policy temporariness, and the public's expectations are taken to be exogenous. It is not conceptually difficult to endogenize expectations for the case of fiscal problems, along the lines of section 1. In the present case of sticky prices, however, this would greatly complicate the model and computations without adding much insight.

It is assumed that the economy starts with and is expected by the public to eventually revert to a high exchange rate target, $\varepsilon^H$, or inflation target, $p^H$. The public expects a new lower target $\varepsilon^L < \varepsilon^H$ or $p^L < p^H$ to be temporary, where $\varepsilon^H = p^H$ and $\varepsilon^L = p^L$.[11] The experiments discussed below maintain $\varepsilon^L$ or $p^L$, without loss of generality, for a fixed period $t \in [0, T_\varepsilon)$ or $t \in [0, T_p)$, where $T_\varepsilon = T_p = T$ equals four or twelve quarters.

Monetary policy under CPI inflation targeting differs from money or exchange rate targeting in one very important respect. While a central bank can directly control either the growth rate of nominal money balances or the rate of change of the exchange rate, the CPI must be controlled indirectly. As set out in equation 19, the exchange rate has to be consistent with the CPI inflation target given the behavior of nontradables inflation, which precludes an independent exchange rate target. The nominal money supply must be set so as to achieve this exchange rate. There can therefore be no announced target rate for the direct instruments of monetary policy, as both are subordinated to the CPI target. Their dynamic time paths will be endogenously determined.

Table 2 summarizes the parameter values chosen for the calibration exercise. The time unit is one quarter. The benchmark case is specified as a policy duration of $T = 12$ quarters and firms' probability of not being able to change their price of $\delta = 0.75$, corresponding to an average contract length of one year. In other dimensions, the calibration reflects the likely magnitude of an inflation targeting program in today's emerging economies. The final steady-state inflation rate is 40 percent, with a target inflation rate of 10 percent, which is very close to the current Brazilian and Mexican targets. I set $r = 10$ percent, $\alpha = 0.3$,

11. Assumptions about the public's expectations are restricted by the requirement that nonnegative nominal interest rate paths must obtain in equilibrium. For the inflation targeting case, this rules out certain extreme beliefs.

**Table 2. Parameter Values for Calibration Exercise**

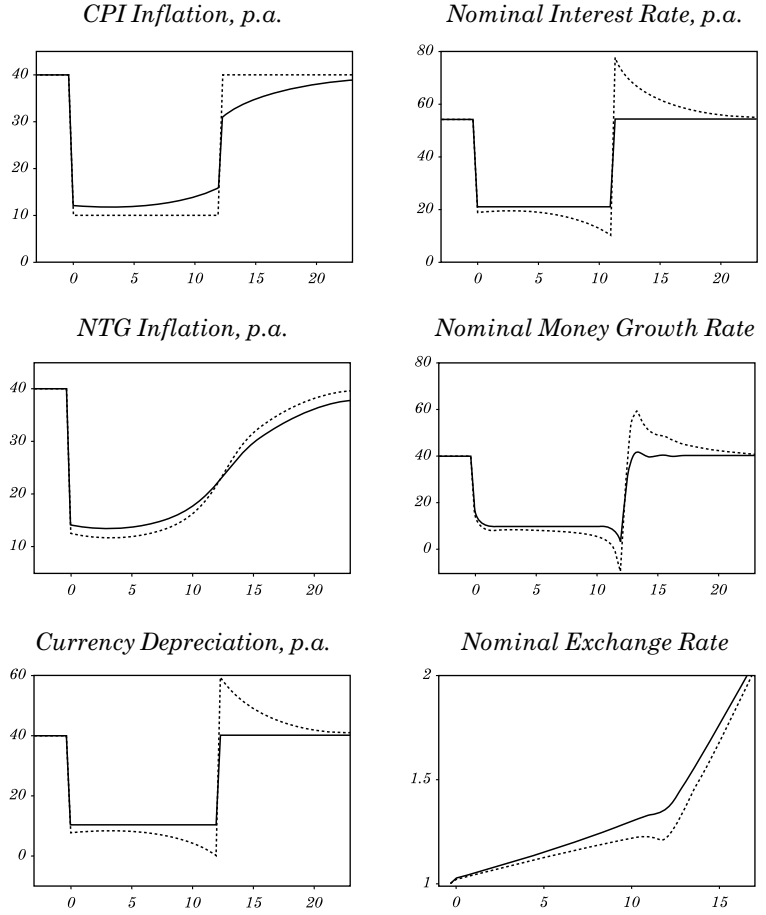
| *Parameter* | *Value* | *Description* |
|---|---|---|
| $T$ | 4 /12 quarters | Duration of temporary programs |
| $\varepsilon^H = p^H$ | 40% p.a. | Steady state exchange rate / inflation targets |
| $\varepsilon^L = p^L$ | 10% p.a. | Transitional exchange rate / inflation targets |
| $r$ | 10% p.a. | International real interest rate |
| $\theta$ | 4.33 | Own price demand elasticity |
| $\delta$ | 0.75 | Probability of not being able to change price |
| $\alpha$ | 0.3 | Monetary base to consumption ratio (Brazil) |
| $\gamma$ | 0.5 | Share of tradables in consumption |
| $c_{ss}$ | 1/3 | Proportion of time working in steady state |
| $f_0$ | 0 | Initial net foreign assets |

and $\gamma = 0.5$, as in the previous section. The functional form of the utility function is close to King and Wolman (1996), except that aggregate consumption is here split into tradables and nontradables components and labor is heterogeneous. Initial net foreign assets are assumed to be zero.

In figure 2 the solid line represents exchange rate targeting (ET) and the dashed line inflation targeting (IT). The unit along the horizontal axis is quarters, with 0 representing the time of announcement of the program. Because this is a forward-looking model, the value of the exchange rate or inflation target before time 0 is, in fact, immaterial.

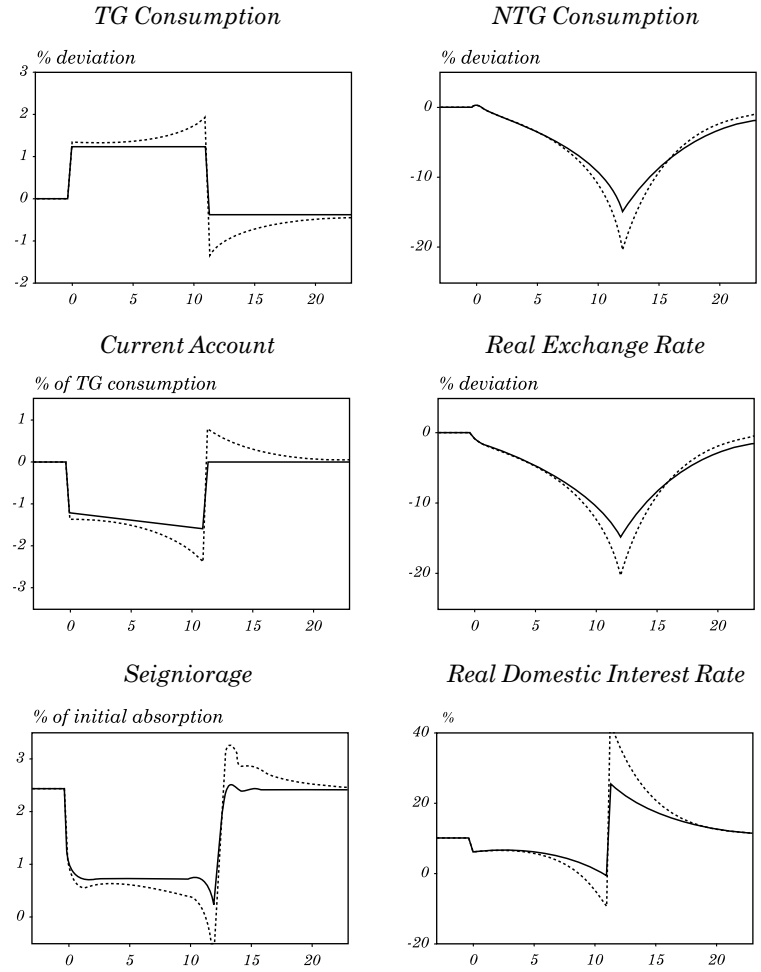
The performance of the two policies is generally very similar in the initial phase of the program, but strong differences emerge around the time of collapse. Limited sustainability in both cases implies that in anticipation of a future collapse of the program, nontradable goods inflation never drops to the new lower target. However, maintaining CPI inflation at its target requires that the average of nontradable goods inflation and currency depreciation equals the lower target. The exchange rate therefore has to compensate by depreciating more slowly than the CPI inflation rate. In some cases this effect may be so extreme that the currency actually has to appreciate for much of the transition. This significantly exacerbates the real effects observed under noncredible exchange rate targeting. The very much lower nominal interest rate drives up tradables consumption and causes a larger current account deficit. Furthermore, the combination of relatively high nontradables inflation and low currency depreciation appreciates the real exchange rate very rapidly, by ultimately around 20 percent. This is accompanied by a very deep nontradables recession, in which output falls by over 20 percent.

**Figure 2. Solutions for Benchmark Case**




All of these effects become particularly severe just before the collapse of the program, when nontradables inflation rises more quickly in anticipation of the imminent reversion to a high-inflation regime. On the collapse of the program, however, the higher steady-state inflation rate is not immediately attained in that sector, where inflation now approaches the higher target from below. This requires a large upward jump in the rate of currency depreciation and nominal interest rate at that time, after which they approach the new higher target from above. A temporary tradables recession and a positive current account therefore follow the collapse.

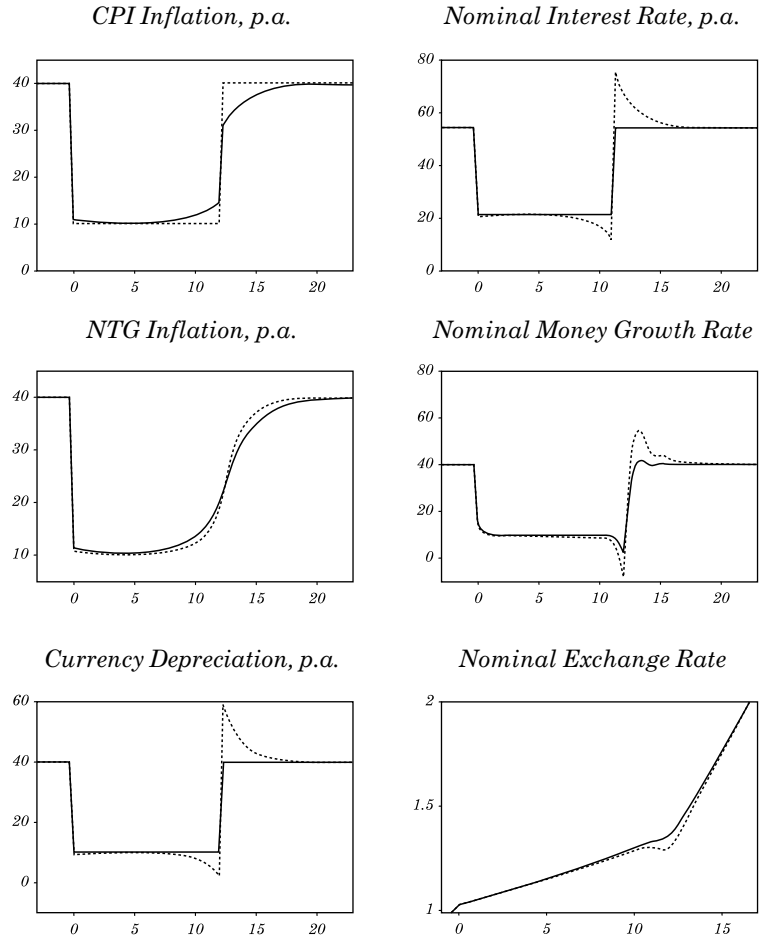
**Figure 2. (continued)**




Source: Author's calculations.

These distortions are the result of the monetary policy required to sustain a low CPI inflation rate in the face of a public perception of limited sustainability. When nontradables inflation fails to drop to the lower target, monetary tightening to reduce exchange rate depreciation is the endogenous policy response. This is reflected in a far slower and mostly negative money growth rate during the transition, which results

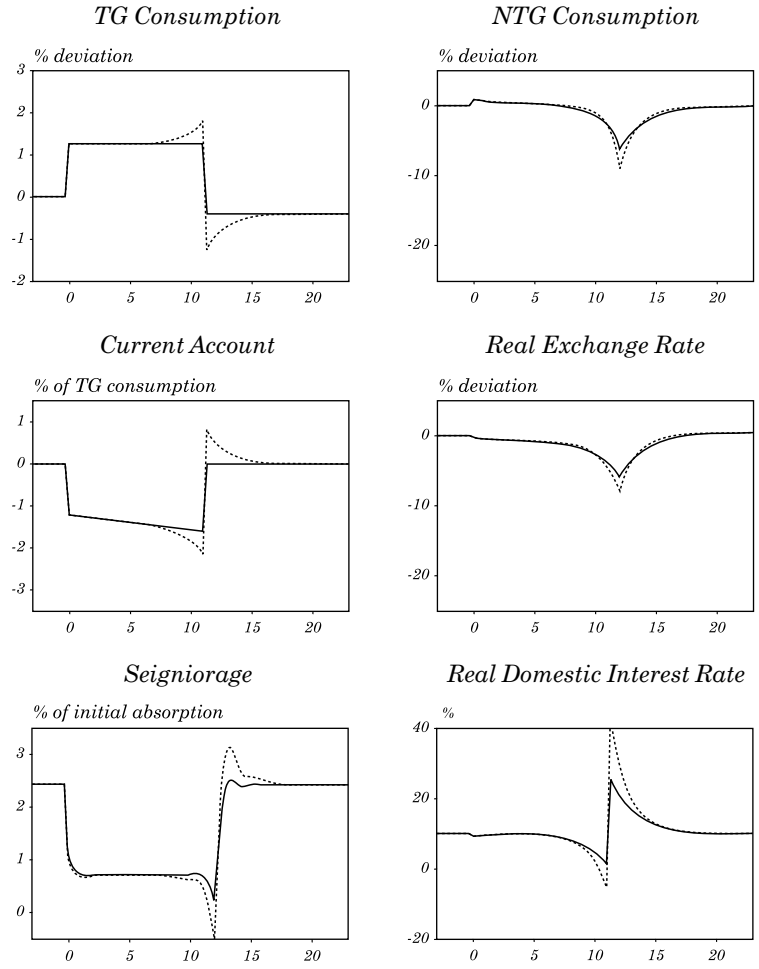
**Figure 3. Solutions for More Flexible Prices**




in a more appreciated path of the nominal exchange rate. Monetary policy under inflation targeting therefore requires much larger swings in money growth and therefore also in seigniorage income. Both cases feature a severe contraction in this source of government revenue, from around 2.5 percent of initial real absorption to less than 1 percent. In the case of inflation targeting, the necessary monetary contraction is so severe that seigniorage actually turns negative during the transition.

Figures 3 and 4 analyze different degrees of price stickiness and policy duration. When price adjustment is faster than in the bench-

**Figure 3. (continued)**

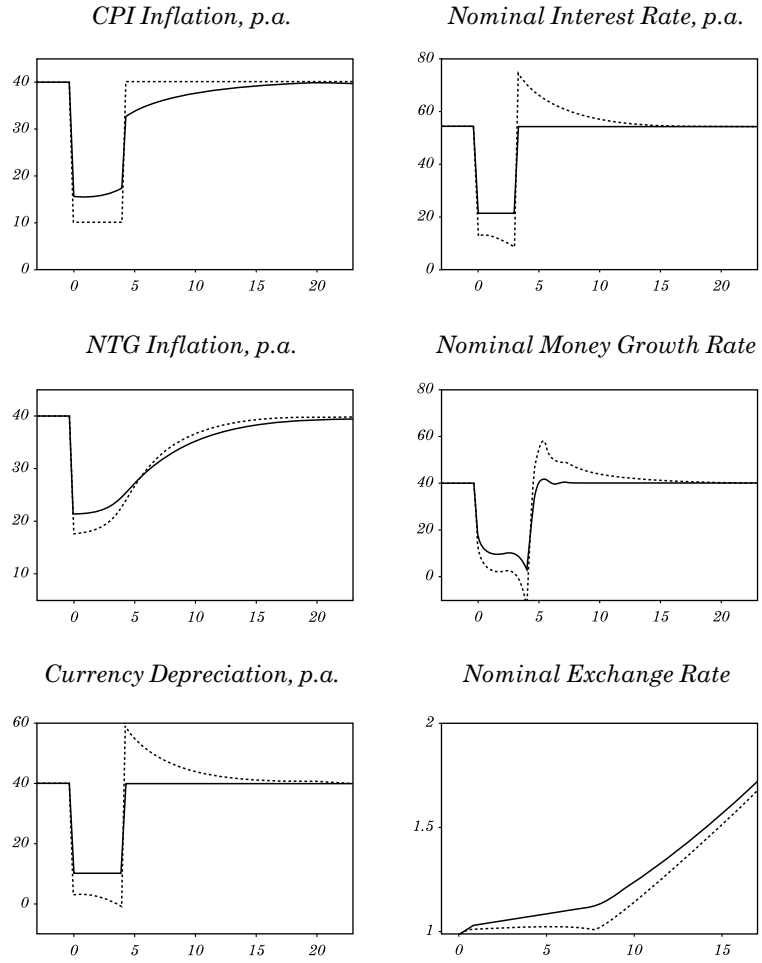



Source: Author's calculations.

mark case ($\delta = 0.5$) but policy duration is the same, the policy based on an inflation target looks very similar to that based on the exchange rate during much of the program, except again for a few months before and after the collapse.

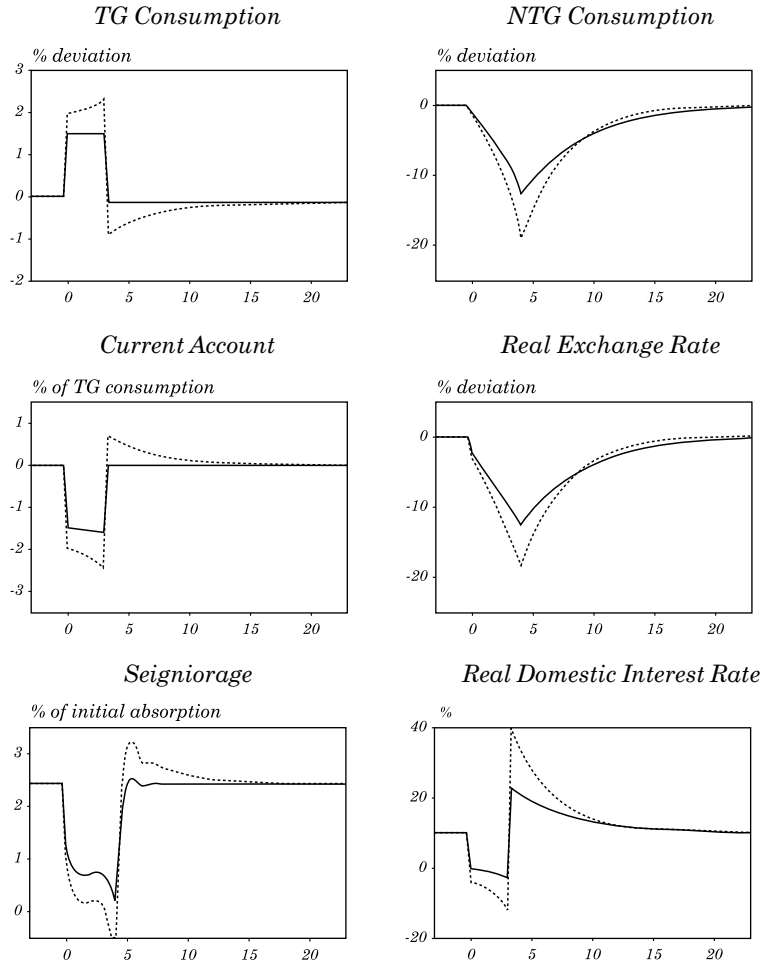
I conclude this subsection with some supporting evidence, using Mexican data for 1997–2000. Figure 5 below shows that Mexican inflation rates and real exchange rate data are consistent with the above story. It shows

**Figure 4. Solutions for Shorter Policy Duration**




the Mexican annual inflation target plotted against currency depreciation (three-month moving average) and CPI inflation. During the Russian crisis, the exchange rate was allowed to depreciate far faster than what was consistent with the inflation target, and high pass-through ensured that the inflation target was not met in the following months. Ever since then, exchange rate depreciation has almost continuously been below the inflation target to ensure that it was met. The result was, as the second panel shows, a very pronounced real appreciation.

**Figure 4. (continued)**

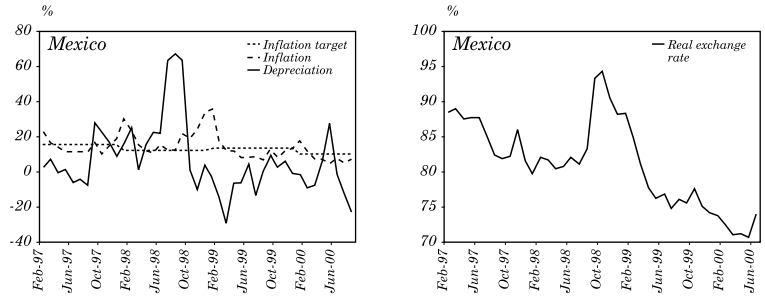



Source: Author's calculations.

## 2.4 Welfare

The welfare loss of an unsustainable program is defined, following Lucas (1987), as the percentage reduction, $\eta$, in the prestabilization steady-state streams of tradables and nontradables consumption, $\bar{c}^{*}_{ss}$ and $\bar{c}_{ss}$, that makes households indifferent between the reduced constant streams of consumption, with leisure unchanged, and the streams of consump-

**Figure 5. Mexico - Inflation and Real Exchange Rate**



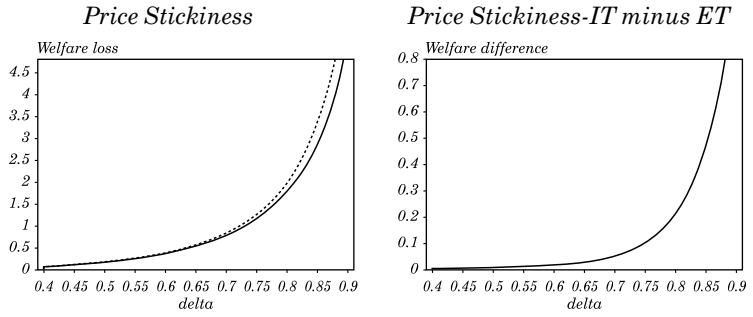

tion and leisure obtained as a result of the stabilization program $\left\{c_t^*, c_t, \left[1-l_t(j)\right], j \in (0,1)\right\}_{t=0}^{\infty}$. This computation is complex for the above economy, as at any time there is a large number of cohorts of firms and workers characterized by different relative prices and equilibrium labor supply. The solution is therefore approximated by evaluating utility for the thirty most recent cohorts, which account for more than 99.99 percent of the overall distribution of relative prices. Figures 6 and 7 present the results. Figure 6 holds policy duration at its benchmark value of $T = 12$ quarters and varies $\delta$ between 0.4 and 0.8. Figure 7 holds $\delta$ at its benchmark value and varies policy duration between 1 and 20 quarters. The main result is that unsustainable inflation-targeting programs always involve slightly larger welfare losses than unsustainable exchange-rate-targeting programs. The difference is largest for high price stickiness. Overall losses become very small as $\delta$ falls below 0.5. Programs suffering from very low sustainability involve smaller losses, as distortions are limited to a very short period.

## 2.5 Summary

The analysis presented in this section indicates that the performance of inflation targeting is slightly inferior to that of exchange rate targeting when fiscal sustainability is limited. Nominal and real variables display larger and more persistent deviations from their steady-state values under inflation targeting, and welfare is lower.

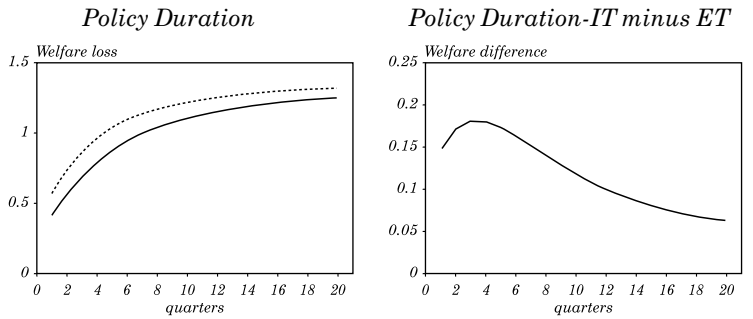
Perhaps one should stress the similarities more than the differences. The performance of two target price indexes that are heavily driven by the exchange rate turns out to be very similar. The only differences are due to differences in the extent of exchange rate dependence, which are not that large in a small and very open economy.

**Figure 6. Welfare Losses and Price Stickiness**




Source: Author's calculations.

**Figure 7. Welfare Losses and Policy Duration**




Source: Author's calculations.

Nevertheless, the inferior performance of inflation targeting carries an important lesson. Lack of policy sustainability is rarely studied in evaluations of different monetary policy rules, although it produces different rankings among policies than the more conventional analysis of monetary policy performance under exogenous shocks. The latter is, of course, the relevant concern for industrialized countries, where inflation targeting originated. But that is precisely the problem with the current debate, in which lessons learned in the industrialized world are applied to emerging markets while important characteristics that distinguish the latter are potentially overlooked. In many of the successful cases in industrialized economies, either sustainability was not a big issue to start with, or monetary policy changes were combined with fiscal improvements that improved sustainability. Whether lasting improvements are likely to be observed in emerging economies must at this point re-

main open to question. Even if such improvements are ultimately achieved, a perceived lack of sustainability in the transition period, until the public is finally convinced of the program's feasibility, may give rise to the above described dynamics for a prolonged period. Caution is therefore in order when applying the lessons learned from existing inflation targeting programs to a new and very different economic environment.

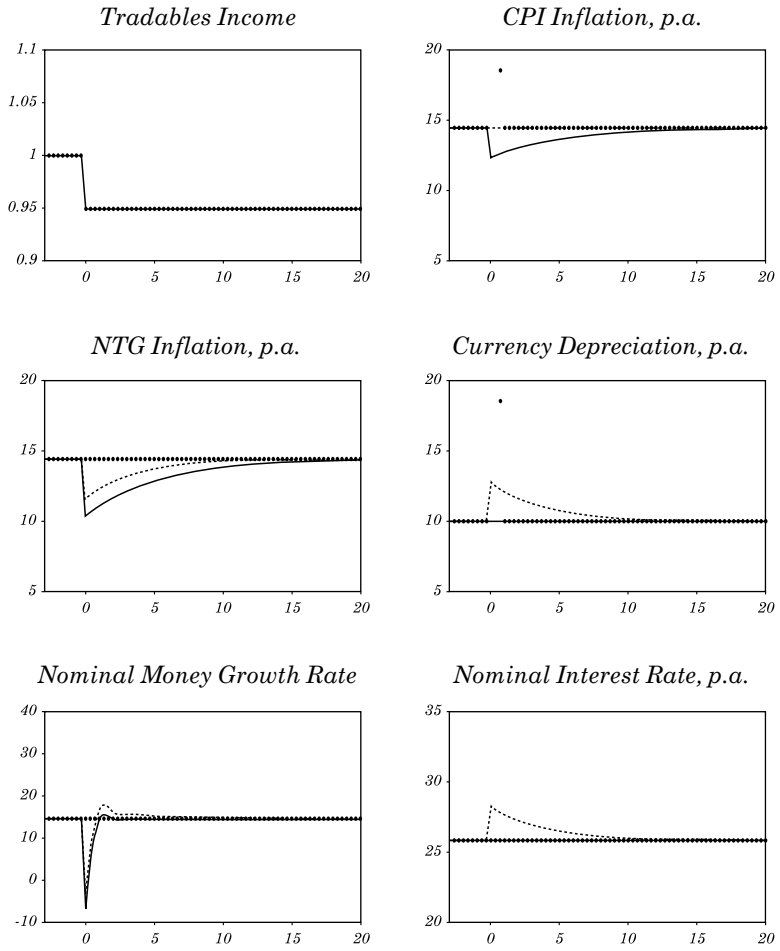
## 3. Exogenous Shocks

This section assumes perfect sustainability of monetary policy and evaluates the performance of different monetary regimes under exogenous shocks. The framework used is identical to that of section 2, except that I now allow for time-varying real international interest rates, $r_t$, international inflation, $\pi_t^*$, inverse velocity, $\alpha_t$, and tradables income, $y_t^*$, where the latter can be interpreted as a simplified representation of terms-of-trade shocks. In addition, a third monetary policy, which targets the money growth rate, is analyzed. This permits another contribution to the policy debate, given that much of the economic intuition about flexible exchange rates derives from this case and not from inflation targeting. I conclude that the behavior of strict inflation targets is much closer to exchange rate targets than to this original notion of flexible exchange rates. The flexibility of exchange rates is largely an illusion if an inflation target is rigidly pursued, since that target tightly constrains exchange rate flexibility. Of course, this is not the case if what is really meant by inflation targeting is discretionary monetary policy.

Emerging economies, much more than industrialized countries, frequently face the problem of adjusting to very large exogenous shocks, and it is in these situations that the choice of exchange rate regime is deemed especially critical. The methodology employed here lends itself to studying the adjustment mechanism to large exogenous shocks, with the help of impulse responses as in section 2. A full stochastic analysis requires a different methodology. Schmitt-Grohé and Uribe (2001) conduct such an analysis for the case of Mexico.

Four shocks are analyzed in detail. Figure 8 presents a 5 percent permanent decrease in tradables endowment, $y_t^*$, which can be interpreted as a negative terms-of-trade shock. Figure 9 analyzes a jump of the real international interest rate from 10 percent to 15 percent, followed by a gradual return to 10 percent, and figure 10 shows a jump in international inflation from 4 percent to 8 percent, again followed by a gradual return to its original value. Figure 11 illustrates the consequences of a permanent 10 percent increase in money demand via an increase in

**Figure 8. Tradables Endowment Shock: 5% Drop in TG Endowment**

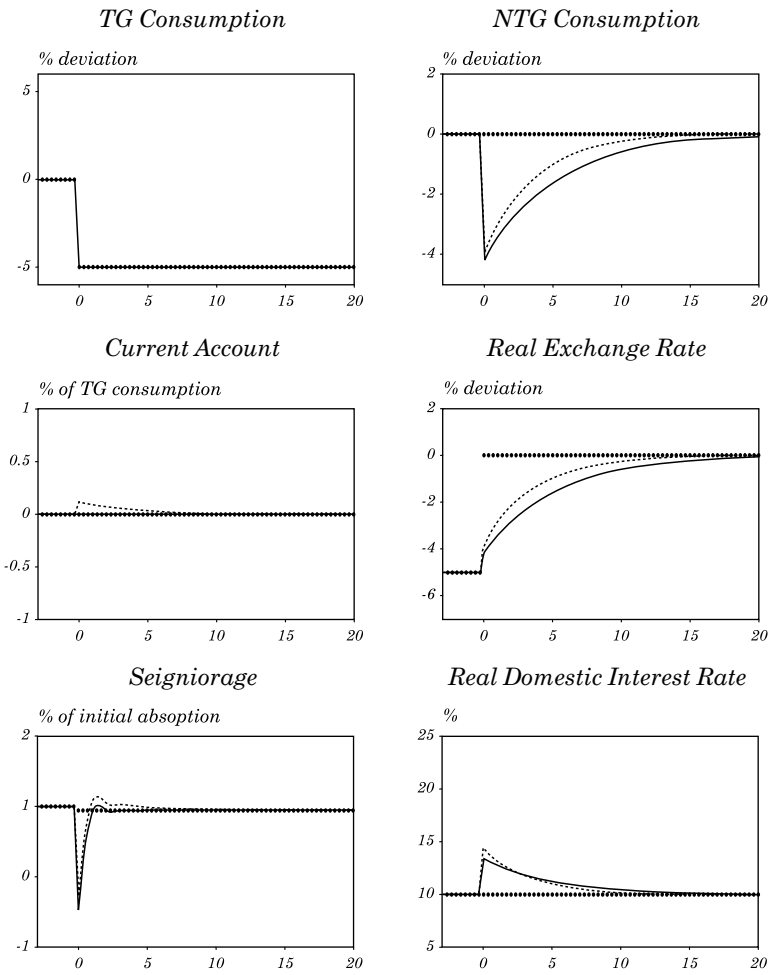



the parameter α. In the figures, the first panel shows the exogenous shock and the remaining panels show the induced response of the economy.

## 3.1 Discussion of Solutions

What is most striking about these results is just how similarly inflation targets and exchange rate targets perform under foreign real shocks. Negative shocks to tradables income (terms-of-trade shocks) and real

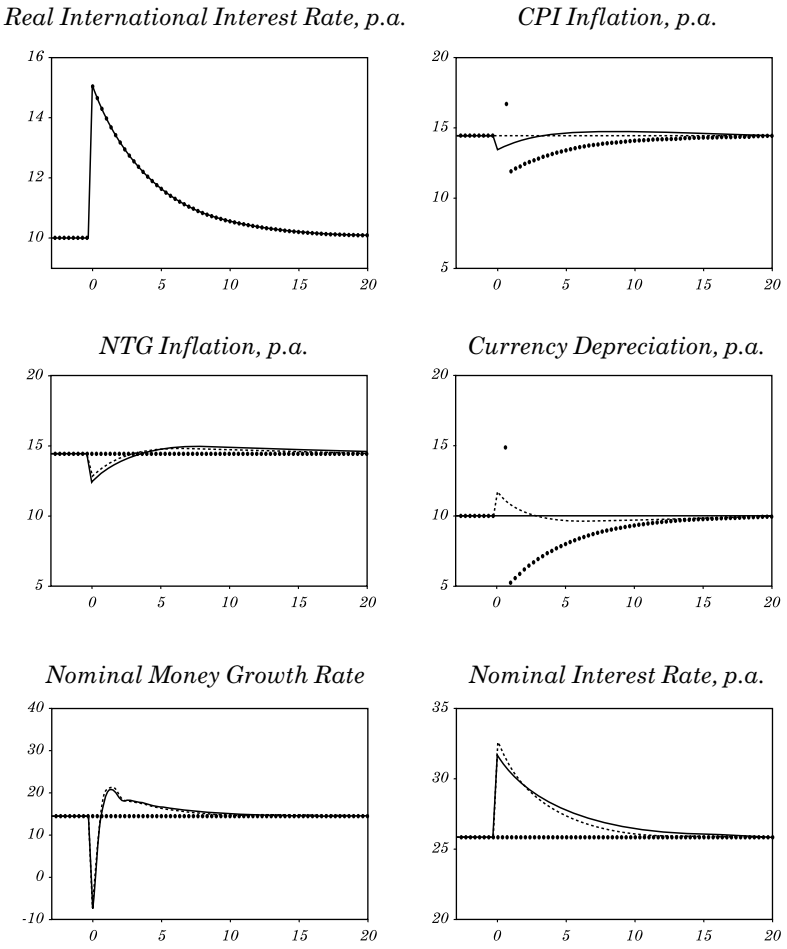
**Figure 8. (continued)**




Source: Author's calculations.

interest rate shocks require large initial downward jumps in tradables consumption. Under fixed exchange rates this requires an accompanying deep nontradables recession, because the real exchange rate is predetermined. The recession eventually leads to the required real exchange rate depreciation through a slowdown in nontradables inflation. More nominal—and therefore real—exchange rate flexibility would ensure that the nontradables sector remained closer to steady-state output at all times.

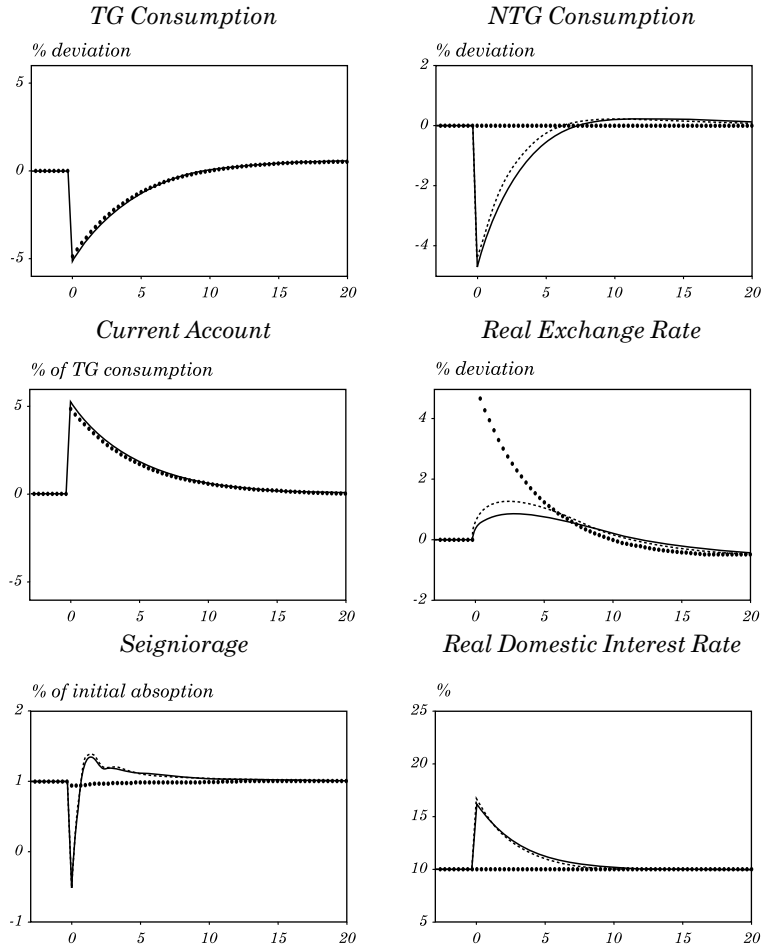
**Figure 9. Real International Interest Rate Shock: 5% Increase in Real Interest Rate**




However, strict inflation targeting does not give the economy much greater real exchange rate flexibility, most importantly because exchange rate depreciation is constrained by the requirement of meeting the inflation target. The real counterpart of this is that there is also a nontradables recession under inflation targeting.

In contrast, the money growth rate targeting case corresponds exactly to our intuition about flexible exchange rates. The real exchange rate can instantaneously jump to a new level, leaving the nontradables

**Figure 9. (continued)**

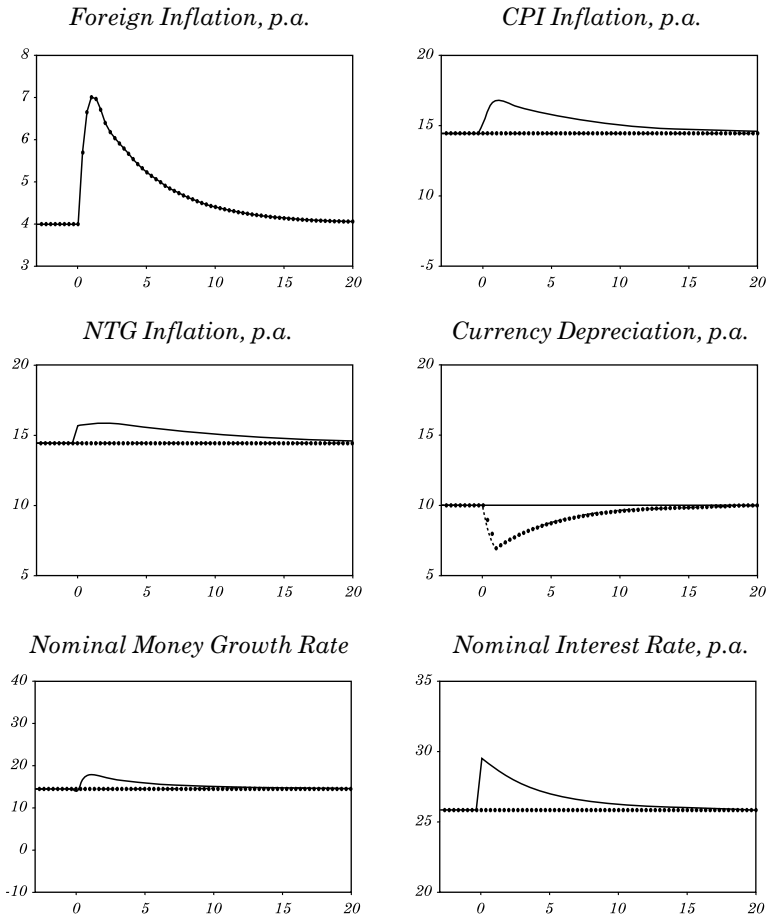



Source: Author's calculations.

sector at its steady-state level at all times. Under a real interest rate shock, overshooting of the exchange rate permits a subsequently low rate of depreciation that exactly offsets the higher real interest rate, leaving the nominal interest rate constant at all times.

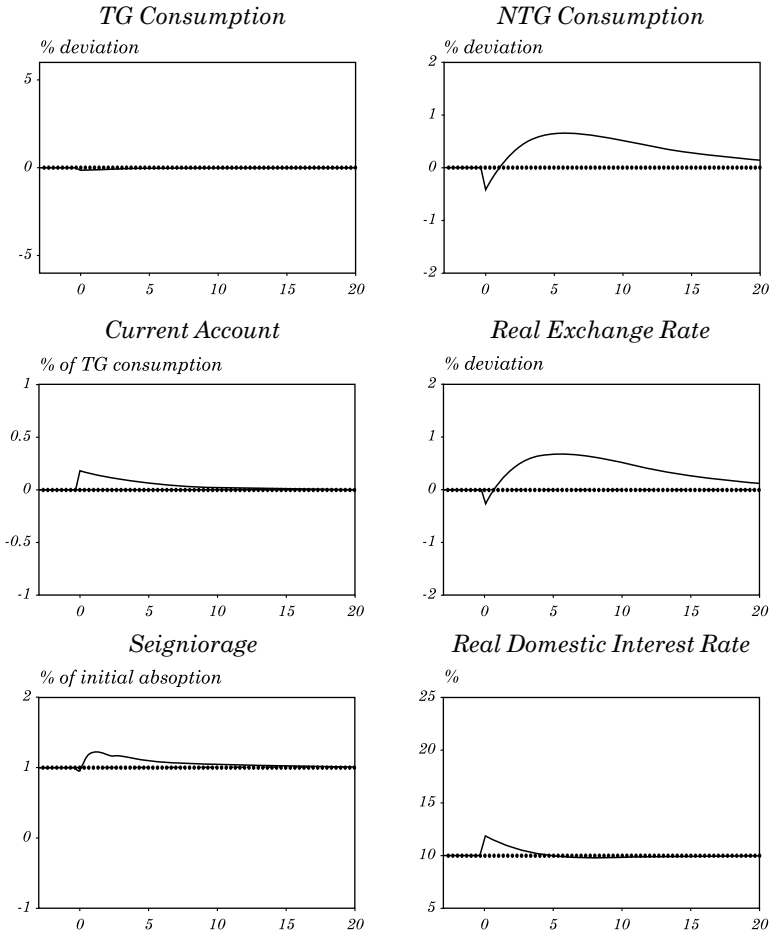
The one case in which inflation targeting is just as effective as money targeting and clearly superior to exchange rate targeting is a foreign inflation shock. Both inflation-targeting and money-targeting regimes respond with a downward and exactly offsetting jump in

**Figure 10. International Inflation Shock: 3% Increase in Foreign Inflation, p.a.**




exchange rate depreciation, leaving the nominal interest rate and all real variables unchanged. The response of an exchange rate target is quite complex. On impact the higher nominal interest rate depresses nontradables output through the consumption-leisure distortion. This leads to slower nontradables than foreign inflation, so that the real exchange rate starts to depreciate and the nontradables recession quickly turns into a prolonged expansion. The real effects, however, are small compared to those of a real interest rate change.

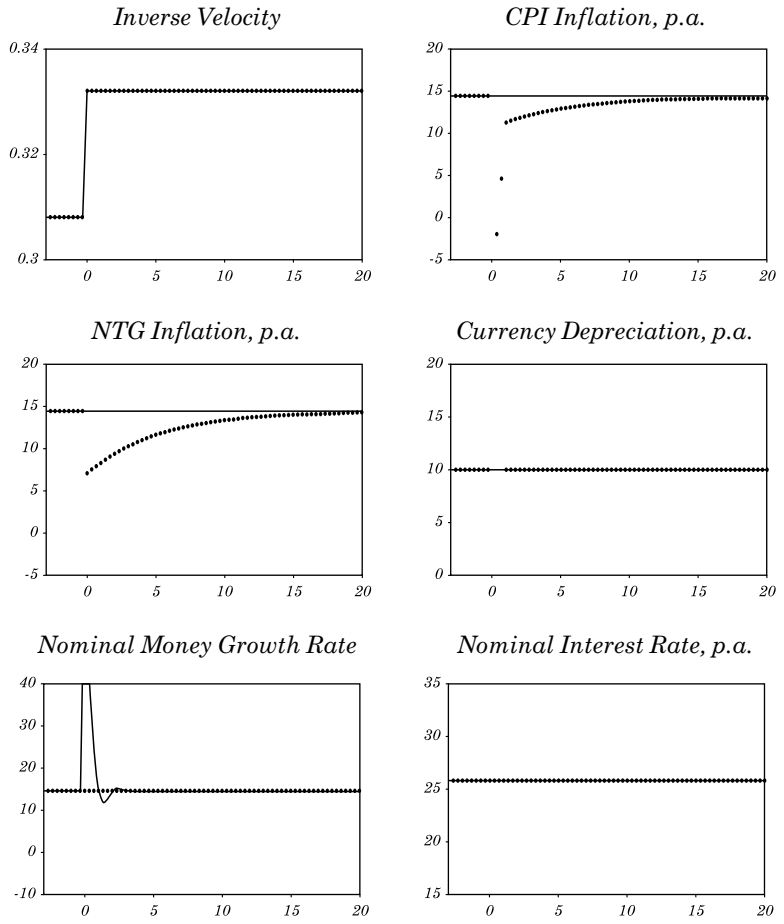
**Figure 10. (continued)**




Source: Author's calculations.

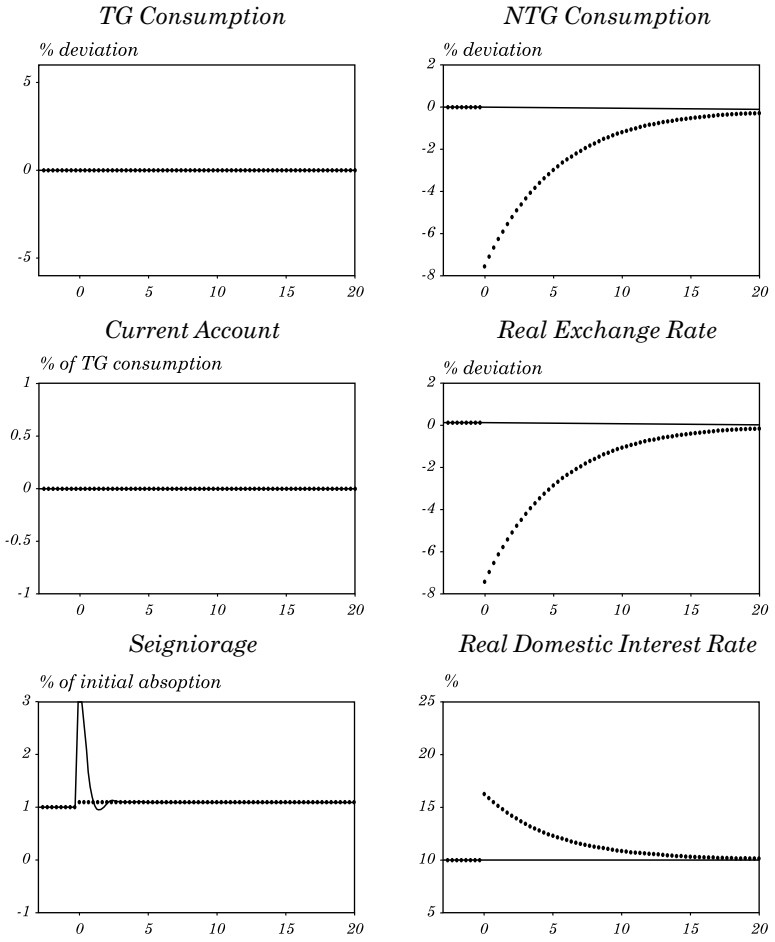
Conventional wisdom in open economy macroeconomics holds that flexible exchange rates perform badly under money demand shocks. Figure 11 shows that this is indeed true for money targeting, in that an increase in money demand leads to a deep nontradables recession. Because monetary accommodation is ruled out, the recession is necessary to generate the slowdown in nontradables inflation that brings real money balances in terms of nontradables into line with higher steady-state demand. The vulnerability of money tar-

**Figure 11. Increase in Inverse Velocity: 10% Increase in Money Demand**




gets to volatility in the velocity of money, which is very common empirically, is the main reason why this monetary regime is no longer practiced in all but a handful of countries. The same is not at all true, however, when flexible exchange rates stand for inflation targeting. An inflation target performs almost identically to an exchange rate target, this time to its advantage. Under both regimes, the monetary authority is not prevented from satisfying the increase in money demand by injecting extra money.

**Figure 11. (continued)**




Source: Author's calculations.

To summarize, purely in terms of the adjustment to exogenous shocks, the differences between inflation targeting and exchange rate targeting appear small. The one exception is a foreign inflation shock. To further quantify the differences, I now turn to welfare analysis.

## 3.2 Welfare

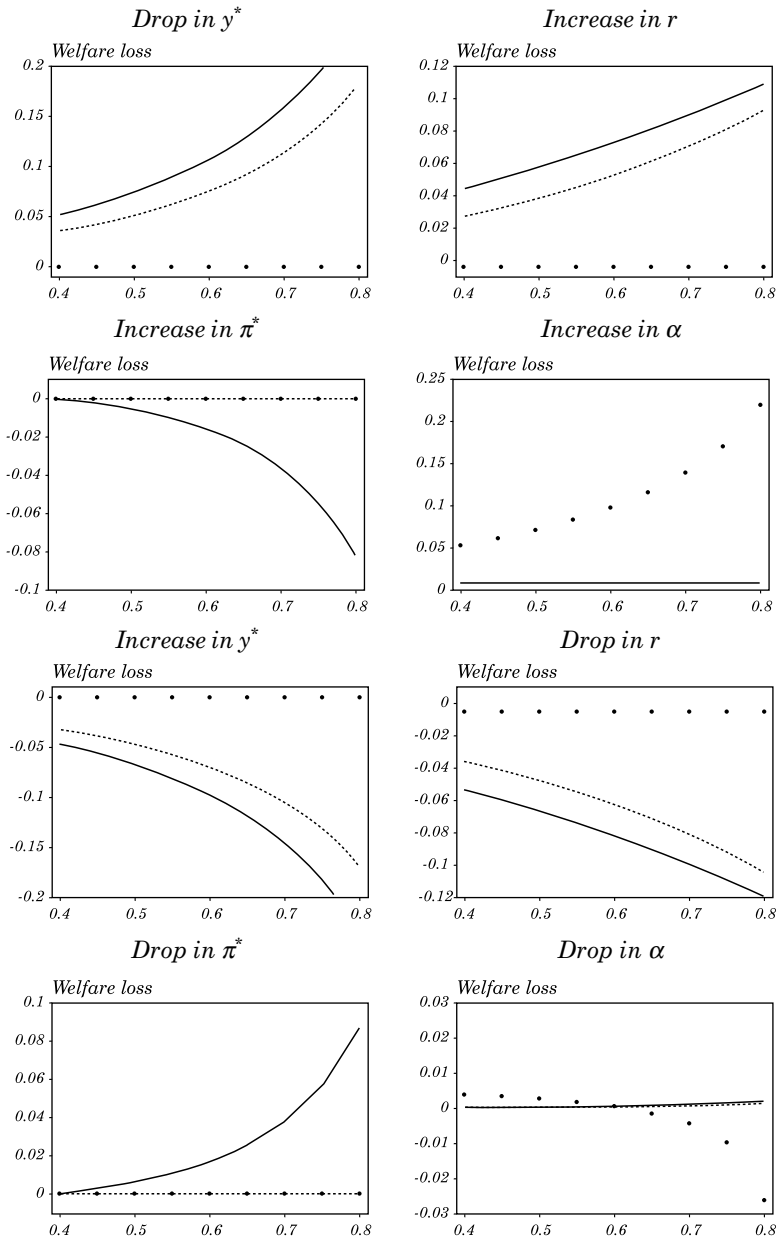
Figure 12 summarizes the welfare results, which were computed

by the same method as in section 2. The benchmark against which welfare is evaluated assumes either that the economy stays at its initial steady state if the shock has no effect on the steady state except through the unit root in tradables consumption or that it immediately jumps to a new long-run steady state if the shock does have such an effect. The latter case applies to the tradables endowment shock, where for the purpose of computing a long-run steady-state tradables consumption is assumed to immediately and permanently drop by 5 percent, and to the money demand shock, where nontradables consumption is assumed to immediately drop to the lower level consistent with a 10 percent increase in inverse velocity.

The first four panels of figure 12 show the welfare results for the four exogenous shocks studied in the previous subsection, for different degrees of price stickiness. The Mundell-Fleming logic appears to be strongly confirmed when one compares money targeting and exchange rate targeting. Inflation targeting, as indicated before, performs much like exchange rate targeting except under foreign inflation shocks. Money targets are superior to exchange rate targets under negative real shocks such as the tradables endowment shock and the real interest rate shock because they permit an instantaneous adjustment of the real exchange rate. They are inferior under an increase in money demand because they do not permit central bank accommodation of higher money demand. An ambiguity arises under foreign inflation shocks, in which case exchange rate targeting involves lower welfare losses and even welfare gains at higher degrees of price stickiness. This points to an important qualification of the Mundell-Fleming logic.

The key point is that a sticky price cash-in-advance monetary economy is subject to preexisting distortions, namely markups and deviations from the Friedman rule. The latter is very significant in an emerging economy with high steady-state inflation. The above model economy, which features 14.4 percent steady-state inflation, has a steady-state nontradables output more than 5 percent below what would be possible at the Friedman rule. This means that exogenous shocks that require an increase in nontradables output in the transition can actually lead to welfare gains. The only example of this in the four scenarios studied so far is the foreign inflation shock under exchange rate targeting, but as shown in the final four panels of the figure, generating other examples is straightforward. These panels illustrate the same four shocks with opposite signs. Exchange rate targeting now performs best of all the regimes under foreign real shocks, as a result of the greater boom in nontradables output needed to generate domestic infla-

**Figure 12. Welfare Losses for Four Exogenous Shocks**




Source: Author's calculations.

tion and a real appreciation. The magnitude of welfare losses under negative shocks exceeds that of welfare gains under equal-sized positive shocks by a small amount. Consequently, Schmitt-Grohé and Uribe (2001), who analyze expected utility based on stochastic shock processes estimated from Mexican data, find some advantage of inflation targeting over exchange rate targeting. The above discussion demonstrates why this difference is found to be quite small except under extreme degrees of price stickiness.

### 3.3 Summary

This section has analyzed the performance of three different monetary regimes—exchange rate targeting, inflation targeting, and money targeting—in the presence of four exogenous shocks—shocks to tradables endowment (terms of trade), real international interest rates, foreign inflation, and money demand. Both the dynamic response of real and nominal variables and the welfare consequences of shocks were discussed.

The most important results concern the Mundell-Fleming logic regarding the relative performance of fixed and flexible exchange rates under real and money demand shocks. First, except for a foreign inflation shock (in which case the results are ambiguous), the logic is confirmed insofar as money targets are superior to exchange rate targets under negative real shocks because they permit instantaneous real exchange rate adjustment, and they are inferior under an increase in money demand because they do not allow monetary accommodation. Second, the argument misses the fact that shocks that require a temporary nontradables consumption boom are beneficial in a welfare sense, because preexisting distortions in a sticky-price monetary economy make steady-state nontradables output suboptimal. Third, and most importantly for this paper, the most appropriate label for strict inflation targeting is not flexible exchange rates. Except for a foreign inflation shock, strict inflation targeting behaves much more like an exchange rate target than a money target, with the inflation target imposing a very tight limit on exchange rate flexibility.

## 4. Conclusion

This paper compares inflation targeting with other monetary regimes, especially exchange rate targeting, along various dimensions. The emphasis is on the environment facing emerging markets. The conclusions of the analysis are ambiguous, much more so than the

current tide of opinion against exchange rate targeting would lead one to believe. Both exchange rate targets and inflation targets are vulnerable to speculative attacks. While this vulnerability is somewhat smaller for inflation targeting, the monetary policy required to defend a vulnerable inflation target leads to somewhat greater distortions and welfare losses. In addition, an inflation target behaves very similarly to an exchange rate target under many exogenous shocks.

I restate here the conjecture made in the introduction. It may be provocative, but that is the point. An honest debate about the advantages of inflation targeting for emerging markets should probably be the old debate about rules versus discretion. With at most a few years of a reasonably successful track record in most of the countries concerned, are we really at a point at which we can be comfortable with discretion?

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# Inflation Targeting and the Liquidity Trap

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This paper considers whether issues regarding liquidity trap or zero lower bound phenomena substantially affect the case for inflation targeting, in comparison with other possible strategies for conducting monetary policy. It examines both theoretical and empirical issues and, in the latter case, emphasizes the importance of an economy's openness to foreign trade in goods and securities.

The first theoretical topic to be investigated is prompted by recent papers by Benhabib, Schmitt-Grohé, and Uribe (2001), Dupor (1999), and Schmitt-Grohé and Uribe (2000), among others, which argue that recognition of the existence of a zero lower bound (ZLB) on nominal interest rates leads to the conclusion that inflation targeting rules—as well as more general Taylor-type rules (see Taylor, 1993a)—are likely to fail. The alleged reason is that the existence of a zero lower bound implies that rational expectations solutions to standard optimizing models with Taylor rules are not unique, and one solution that is likely to be attained involves a deflationary liquidity trap. The present paper contends that the alleged danger should not be considered to be of substantial practical importance. This argument is developed in section 1.

Section 2 takes up a closely related topic concerning the danger of solution indeterminacy, which, according to Woodford (1994) and several other analysts, is generated by the practice of basing policy actions on expected future inflation rates rather than on currently observed values. Again, and for similar reasons, I argue that the danger is probably illusory.

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The foregoing points are of a theoretical and general nature, so they can be discussed within a highly stylized and extremely simplified theoretical framework. When one turns to empirically oriented issues, however, it becomes important to work with a model that more closely reflects the properties of actual economies. Section 3 therefore specifies an open economy model with slow price-level adjustments and inertia in consumption demand. Quantitative calibration is undertaken in section 4, which also presents aspects of the model's properties.

In section 5, the model is used to examine the frequency, under alternative policy rules, with which zero or negative interest rates are encountered in stochastic simulations designed to mimic realistic conditions. This exercise provides some indication of the relative frequency with which liquidity trap situations may arise under inflation targeting, in comparison with other policy rules.

Then in section 6, it is assumed that the economy is in a liquidity trap, such that the usual interest rate instrument is immobilized. The possibility of using monetary policy for stabilizing purposes, nevertheless, is provided by the existence of a transmission channel involving foreign exchange. The section quantitatively examines the relative potency of this channel with an inflation targeting objective. Some authors contend that this exchange rate channel is not available because of uncovered interest parity; the paper analyzes and strongly disputes such contentions. Finally, section 7 provides a brief concluding summary.

Before beginning with these various topics, it is necessary to mention the way in which the term inflation targeting is used in this paper. An inflation targeting regime is taken to be one in which monetary policy is conducted according to a rule that specifies adjustments of an instrument variable in response to deviations of inflation, or expected future inflation, from a policy-specified target value.[1] Given this definition, are responses to other variables, such as the output gap term in Taylor-style rules, permitted? Here no particular position is taken on that terminological issue; I simply refer to such cases as reflecting departures from pure inflation targeting. Also, responses to previous-period values of the instrument variable are permitted so as

1. Of course, it is not supposed that any actual central bank would ever literally follow the instructions of any simple formula. For analytical purposes, however, the systematic aspects of monetary policy can be clearly expressed in terms of a rule. I do not attempt to find an "optimal" rule, for any such finding would be highly model specific, so I do not need to discuss commitment issues. With regard to the question of rules versus discretion, note that it is implausible that any actual central bank would ever literally follow the instructions of an optimal control exercise repeated anew each decision period.

to reflect the type of smoothing behavior that seems to be widely practiced by central banks.

I am, of course, fully aware that Svensson (1997, 1999) has argued for a different terminological convention, one that would use the word target only to refer to variables that appear in explicitly specified loss functions. It is often useful, however, to proceed without adoption of any explicit loss function. Furthermore, I believe that my terminology is more consistent with actual practice, in part because actual central banks have thus far not adopted explicit loss functions. In any event, the issue is of little importance, since it is always possible to write instrument rules that approximate as closely as desired the instrument settings of a policy regime involving targeting in Svensson's sense.

## 1. An Expectational Liquidity Trap?

As mentioned above, Benhabib, Schmitt-Grohé, and Uribe (2001) suggest that Taylor-style rules, of which inflation targeting rules provide a special case, are perilous in the sense that they may induce the economy to enter a deflationary liquidity trap.[2] In a previous paper (2000), I briefly argue that this outcome is highly unlikely; that the danger is a theoretical curiosity that should not be considered relevant for practical policy analysis. This section develops that argument more fully.

For the purpose of this purely analytical investigation, it is sufficient to use a closed economy model with full price flexibility. An extremely simple but adequate framework is provided by the following two-equation system:[3]

$$y_t = \mathrm{b}_0 + \mathrm{b}_1 \left( R_t - \mathrm{E}_t \Delta p_{t+1} \right) + \mathrm{E}_t \, y_{t+1} + \mathrm{v}_t \text{, and} \tag{1}$$

$$R_t = \mu_0 - \mu_1 \pi^* + \left(1 + \mu_1\right) \Delta p_t + \mu_2 \mathrm{y}_t \text{.} \tag{2}$$

Here $y_t$ and $p_t$ denote the logs of output and the price level, so $\Delta p_t$ is inflation and $R_t$ is the one-period nominal interest rate. Equation 1 represents a log-linearized expectational IS function, which describes aggregate demand behavior in a fashion that can be rationalized by dynamic optimizing analysis, as explained by Woodford (1995, 2000),

2. The trap discussed by Reifschneider and Williams (2000) and Krugman (1998) is similar in some respects, but it involves a different mechanism, as the models used are entirely backward-looking.

3. This is essentially a linearized version of the first model used by Benhabib, Schmitt-Grohé, and Uribe (2001).

McCallum and Nelson (1999), and many others. The term $v_t$ represents a taste shock that is generated by an exogenous stochastic process, which is assumed to be AR(1), that is, autoregressive of order one, with parameter $\rho$. Equation 2 is a Taylor rule in which the central bank is depicted as setting an interest rate instrument, $R_t$, each period so as to tighten policy when inflation exceeds its target value $\pi^*$ and/or when output is high. In equation 2, $y_t$ should be interpreted as the output gap, $y_t - \bar{y}_t$, with $\bar{y}_t$ for simplicity assumed constant at the value zero. For present purposes, furthermore, I am treating prices as fully flexible, so that $y_t = 0$ in each period. The system thus contains only two endogenous variables, $R_t$ and $\Delta p_t$. The model also includes the requirement that $\Delta p_t$ must not approach $-\infty$ as $t \to \infty$, which represents a transversality condition that obtains in the underlying optimizing model.[4]

To obtain a rational expectations solution, I first substitute out $R_t$ and, using $y_t = 0$, obtain

$$0 = b_0 + b_1\left[\mu_0 - \mu_1\pi^* + (1+\mu_1)\Delta p_t - E_t\,\Delta p_{t+1}\right] + v_t\,. \tag{3}$$

The minimum state variable (MSV) solution is of the form

$$\Delta p_t = \phi_0 + \phi_1 v_t\,, \tag{4}$$

which implies that $E_t\Delta p_{t+1} = \phi_0 + \phi_1\rho v_t$. Substitution into equation 3 and application of the undetermined coefficient procedure then yields the requirement that

$$0 = b_0 + b_1\left[\mu_0 - \mu_1\pi^* + (1+\mu_1)(\phi_0 + \phi_1 v_t) - \phi_0 - \phi_1\rho v_t\right] + v_t\,, \tag{5}$$

holds identically for all realizations of $v_t$. That implies unique values for $\phi_0$ and $\phi_1$ and gives the MSV solution

$$\Delta p_t = \pi^* - \frac{b_0 + b_1\mu_0}{\mu_1} - \left[b_1(1-\rho+\mu_1)\right]^{-1} v_t\,. \tag{6}$$

Of course, Taylor (1993a) and many others prescribe that the central bank set $\mu_0 = r$, the long-run average real rate of interest, which equation 1 defines as $-b_0/b_1$. Adherence to this recommendation there-

4. See, for example, Woodford (2000, chap. 2).

fore implies that the second term on the right-hand side of equation 6 vanishes, yielding

$$\Delta p_t = \pi^* - \left[b_1 \left(1 - \rho + \mu_1\right)\right]^{-1} \mathrm{v}_t ,$$

as the MSV solution for inflation. Since the unconditional expectation is $\mathrm{E}(\mathrm{v}_t) = 0$, it is clear that $\mathrm{E}\Delta p_t = \pi^*$, that is, the long-run average rate of inflation is equal to the target value specified by the central bank's policy rule.

There is, however, another solution that satisfies the usually stated conditions for a rational expectations equilibrium. Consider the candidate solution

$$\Delta p_t = \phi_0 + \phi_1 \mathrm{v}_t + \phi_2 \Delta p_{t-1} , \tag{7}$$

which implies that

$$\mathrm{E}_t \Delta p_{t+1} = \phi_0 + \phi_1 \rho \mathrm{v}_t + \phi_2 \left(\phi_0 + \phi_1 \mathrm{v}_t + \phi_2 \Delta p_{t-1}\right).$$

Then, presuming $\mu_0 = -\mathrm{b}_0/\mathrm{b}_1$, the undetermined coefficient conditions are

$$\mathrm{b}_1 \left[-\mu_1 \pi^* + \left(1+\mu_1\right)\phi_0 - \phi_0 \left(1 + \phi_2\right)\right] = 0 , \tag{8a}$$

$$\mathrm{b}_1 \left[\left(1 + \mu_1\right)\phi_1 - \phi_1 \rho - \phi_2 \phi_1\right] + 1 = 0 , \text{ and} \tag{8b}$$

$$\phi_2^2 = \phi_2 \left(1 + \mu_1\right). \tag{8c}$$

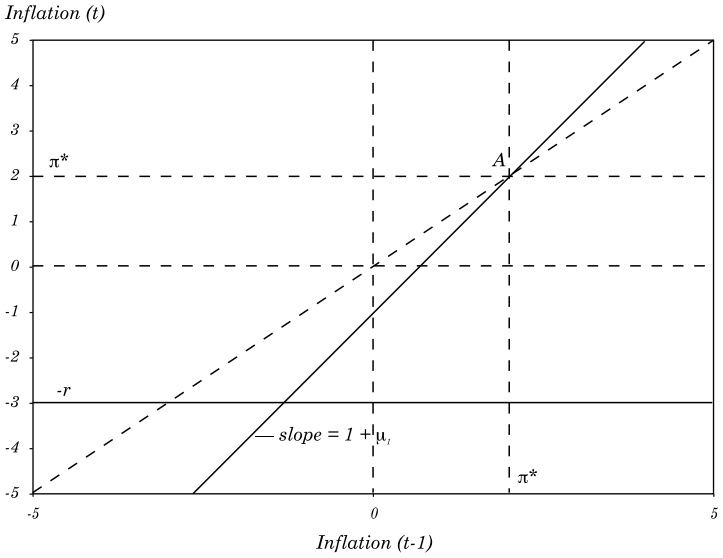
Thus there are two possibilities for $\phi_2$, 0 and $1 + \mu_1$. Selecting the former generates the same MSV solution as in equation 6, but if $\phi_2 = 1 + \mu_1$ is designated as relevant, the solution becomes

$$\Delta p_t = -\mu_1 \pi^* + \left(1 + \mu_1\right)\Delta p_{t-1} + \left(\mathrm{b}_1 \rho\right)^{-1} \mathrm{v}_t . \tag{9}$$

Clearly, with $\mu_1 > 0$ the latter is explosive. If the system begins with $\Delta p_{t-1} > \pi^*$, then inflation will increase explosively, and if the startup value is below $\pi^*$, then $\Delta p_t$ will tend to approach $-\infty$, according to equation 9 and as illustrated in figure 1.

The last statement, however, ignores the existence of a zero lower bound on the nominal interest rate. In the flexible price system at hand, the latter translates into a lower bound on $\Delta p_t$, generating the restriction $\Delta p_t \geq -r$. Thus if the system begins with $\Delta p_{t-1} < \pi^*$, inflation cannot behave as specified by equation 9. Instead, the alleged outcome is that $\Delta p_t \to -r$, which corresponds to $R_t \to 0$. In this case, therefore, the policy rule given by equation 2 fails to stabilize inflation around its target

**Figure 1. Inflation Dynamics, System Defined in Equations 1 and 2**




value, π*. This is the failure of the Taylor rule proposed and emphasized by the writers mentioned above.

In McCallum (2000), I argue that the foregoing is a pseudo problem, in that the solution just described most likely is not economically relevant. The argument there is that equation 6 provides the MSV or fundamentals solution, whereas equation 9 represents a rational expectations bubble, and that it is doubtful that bubble solutions are of empirical relevance, at least from a macroeconomic perspective. Here I extend that argument with another reason to ignore the non-MSV solution, a reason based on the closely related concepts of E-stability and least squares learnability.

Iterative E-stability was developed in the 1980s, principally by Evans (1985, 1986), and then modified in response to work by Marcet and Sargent (1989). Iterative E-stability involves a thought experiment in which one conceives of expectational behavior with anticipated variables such as $\Delta p^e_{t+1}$ being described by an expression of a form that would be appropriate under rational expectations, but with parameter values that are initially incorrect.[5] When substituted into the model of the economy, this so-called expectations function implies a law of mo-

5. Here $\Delta p^e_{t+1}$ denotes the subjective expectation of $\Delta p_{t+1}$ formed at time $t$, not necessarily according to rational expectations.

tion that entails systematic expectational errors. One can then conceive of revised values of the parameters of the expectations function that are suggested by the law of motion. These, too, will imply incorrect forecasts, but one can imagine continuing with a series of iterations and consider whether they will converge to a specific rational expectations solution, either the MSV or a non-MSV solution.[6] If such a process converges to a particular solution, then the latter is said to be iteratively E-stable.

By considering ever-smaller time periods for these iterations, one can develop a process that is continuous in notional time (meta-time). Evans and Honkapohja (1999, 2001) emphasize this refined notion of E-stability because it is, under fairly general conditions, equivalent to learnability by means of a least-squares-based adaptive process. For a useful introduction to E-stability and learnability, see Bullard and Mitra (2000).

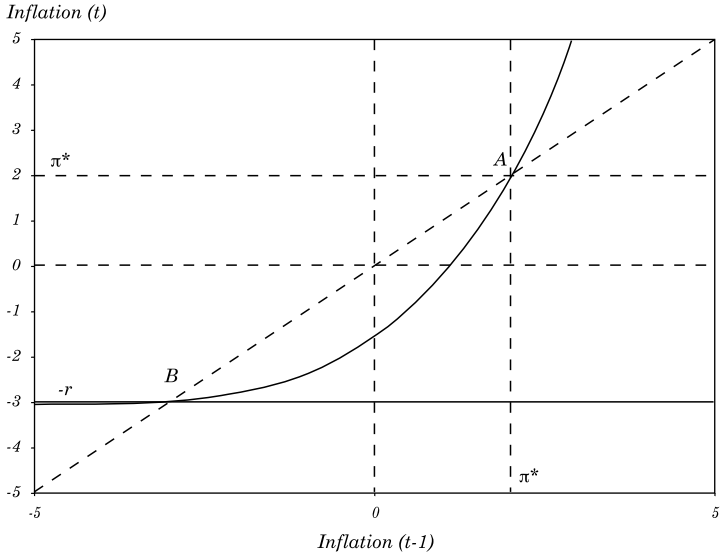
Evans (1986) analyzes the model at hand, as summarized in equation 3, and finds the MSV solution to be E-stable and the bubble solution to be E-unstable. These results extend to the refined definition of E-stability and therefore imply that the MSV solution is least squares learnable and the non-MSV is not (see Evans and Honkapohja, 2001, section 9.7). This statement applies literally to the model without the ZLB constraint, but the constraint does not affect the analysis, which is local in nature, of the MSV solution. For the non-MSV solution, equation 3 must be replaced with the ZLB constraint, which can be done by rewriting equation 3 so as to pass through the point $(-r, -r)$ and inserting a parameter that controls its slope. The constraint would then be imposed by letting the slope approach zero. Thus the analysis would be as before, but with a slope of less than 1.0 at the non-MSV point, which would not yield E-stability.

A more satisfying approach might be to recognize that the lower bound on the nominal interest rate is actually the consequence of a decreasing net marginal benefit, via facilitation of transactions, provided by holdings of money.[7] Figure 2 illustrates the relevant functional form, in which the MSV solution is at point A and the liquidity trap at point B. For this continuous nonlinear case, Evans and Honkapohja (2001, section 11.5) establish that the MSV solution is E-stable and the trap solution is not.

In sum, there are several reasons to believe that MSV solutions generally prevail in actual economies. Thus there is no compelling rea-

6. If there is convergence, it will be to some rational expectations solution.
7. See McCallum (2000).

**Figure 2. Inflation Dynamics, Nonlinear System**




son to believe that a liquidity trap would be generated, in the manner under discussion, by the adoption of a Taylor rule or the special case of pure inflation targeting.

## 2. Is Indeterminacy a Problem for Inflation Forecast Targeting?

A closely related issue pertains to policymaking that follows a rule for inflation forecast targeting, that is, a rule of the form

$$R_t = \mu_0 + \mathrm{E}_t \, \Delta p_{t+1} + \mu_1 \left( \mathrm{E}_t \, \Delta p_{t+j} - \pi^* \right) + \mu_2 y_t \,, \tag{10}$$

with $j \geq 1$. This is evidently how actual inflation targeting regimes have been operated in practice, because of the perceived need for central banks to behave preemptively—that is, adjusting policy instruments to combat inflationary (or deflationary) pressures before measured inflation (or deflation) begins to show up strongly in measured data.[8] However, several analysts, beginning with Woodford (1994), argue that when

8. On the need for preemptive policymaking, see Goodfriend (1997). For descriptions of practices of the Bank of England, the Reserve Bank of New Zealand, and the Bank of Canada, see King (1999); Archer (2000); Freedman (2000).

$j \geq 1$ in equation 10, a danger of indeterminacy is induced, which is not present if the policy rule is of the form given by equation 2.[9] Note that for very large values of $\mu_1$, in a policy rule like equation 10, the implied policy is virtually the same as exact targeting of an expected inflation rate, as promoted by Svensson (1997) and others. The argument thus seems to deserve scrutiny. As in the previous section, however, the danger identified by this line of analysis represents a theoretical curiosity that is probably not of practical relevance.

It is important to keep in mind that the term indeterminacy first became prominent in monetary economics through a series of writings by Patinkin—beginning with Patinkin (1949) and culminating with (1961) and (1965)—that grew out of observations made by Lange (1942) about a putative logical inconsistency in classical monetary theory. Some of Patinkin's conclusions were disputed in a notable book by Gurley and Shaw (1960), and the resulting controversy was prominently reviewed in an influential survey article by Johnson (1962). In all of this early literature, the form of indeterminacy under discussion is price-level indeterminacy, such that the models in question fail to determine the value of any nominal variable, including the money supply. That type of failure occurs basically because of postulated policy behavior that is entirely devoid of any nominal anchor—that is, there is no concern on the part of the central bank for nominal variables.[10] Since rational private households and firms care only about real variables, according to standard neoclassical analysis, the absence of any money illusion by both them and the central bank must imply that no agent (in the model) has any concern for any nominal variable. Thus no nominal variable appears anywhere in the model, so naturally the model cannot determine the value of such variables.

The type of indeterminacy under discussion in the literature cited at the beginning of this section is very different. Instead of a failure to determine any nominal variable, without any implied problematic behavior for real variables, the recent Woodford-warning literature (as termed by Lars Svensson) is concerned with a multiplicity of stable equilibria in terms of real variables.[11] This type of aberrational behavior

9. Other papers that either promote this idea or discuss it with apparent approval include Bernanke and Woodford (1997); Kerr and King (1996); Clarida, Gali, and Gertler (1997); Svensson (1997); Christiano and Gust (1999); Carlstrom and Fuerst (2000); Isard, Laxton, and Eliasson (1999); Bullard and Mitra (2000); King (2000).

10. See Patinkin (1965, p. 309).

11. Dynamically stable equilibria are the relevant issue, because explosive paths of real variables are normally ruled out by transversality conditions that show them to be suboptimal for individual private agents.

stems not from the absence of any nominal anchor (a static concept), but from the essentially dynamic fact that various paths of real money balances can be consistent with rational expectations under some circumstances.[12] As an example of the sort of confusion that can arise if the foregoing distinction is not recognized, consider the analysis of price-level indeterminacy under an interest rate rule developed by Sargent and Wallace (1975). It has long been my belief that this paper is concerned with nominal indeterminacy (see McCallum, 1981, 1986). Woodford (2000, chap. 2), by contrast, interprets this particular Sargent and Wallace discussion as pertaining to solution multiplicity. My position is strengthened by the fact that the only substantive reference cited by Sargent and Wallace is Olivera (1970), which is clearly concerned with nominal indeterminacy. In any event, Sargent and Wallace (1975) and subsequent writings clearly illustrate the importance of observing the distinction.

Consider now the substance of the Woodford warning of multiple solutions when policy is based on rational forecasts of future inflation. It can be illustrated in a model similar to the prototype given by equations 1 and 2 presented above.[13] For convenience, the model is rewritten here, but adding a gradual price adjustment relation and ignoring constant terms that are tedious and for present purposes uninteresting. Finally, suppose that $E_t \Delta p_{t+1}$ is the inflation-forecast variable to which the policy rule pertains. The system can then be written as

$$y_t = b_1 (R_t - E_t \Delta p_{t+1}) + E_t y_{t+1} + v_t, \tag{11}$$

$$\Delta p_t = \beta E_t \Delta p_{t+1} + \alpha y_t, \text{ and} \tag{12}$$

$$R_t = (1 + \mu_1) E_t \Delta p_{t+1} + \mu_2 y_t + e_t, \tag{13}$$

where $e_t$ in equation 13 is white noise and $v_t$ in equation 11 is, as before, generated by a first-order autoregressive process with parameter $\rho$.

In this model the unique MSV rational expectations solution is of the form[14]

12. McCallum (1986) proposes that different terms be used for the two types of aberrational behavior to avoid possible semantic confusions, but this proposal has not met with widespread acceptance.

13. I am not disputing the point that central banks need to base policy on their own information and structural models, which is also discussed by Woodford (1994) and Bernanke and Woodford (1997).

14.The minimum state variable (MSV) concept is discussed at length in McCallum (1983, 1999), where it is interpreted as the unique solution that includes no bubble or sunspot components. In those papers, I propose a solution procedure that generates a unique solution by construction in a very wide class of linear rational expectations models.

$$y_t = \phi_{11}\, v_t + \phi_{12}\, e_t, \text{ and} \tag{14}$$

$$\Delta p_t = \phi_{21}\, v_t + \phi_{22}\, e_t. \tag{15}$$

Thus $E_t y_{t+1} = \phi_{11}\rho_1 v_t$ and $E_t \Delta p_{t+1} = \phi_{21} p_1 v_t$, such that standard undetermined coefficient calculations yield

$$\phi_{11} = \frac{1}{1-\rho_1 - b_1\mu_2 - (\alpha b_1 \mu_1 \rho_1)/(1-\beta\rho_1)}, \tag{16a}$$

$$\phi_{12} = \frac{b_1}{1 - b_1\mu_2}, \tag{16b}$$

$$\phi_{21} = \frac{\alpha}{(1-\beta\rho_1)(1-\rho_1 - b_1\mu_2) - \alpha b_1 \mu_1 \rho_1}, \tag{16c}$$

$$\phi_{22} = \frac{\alpha b_1}{1 - b_1\mu_2}. \tag{16d}$$

This implies unique values for $\phi_{11} > 0$, $\phi_{12} < 0$, $\phi_{21} > 0$, and $\phi_{22} < 0$, so the MSV solution suggests that there is no problem with the inflation-forecast targeting rule in equation 13.

Suppose, however, that a researcher looks for non-MSV solutions of the form

$$y_t = \phi_{11}\, v_t + \phi_{12}\, e_t + \phi_{13}\Delta p_{t-1}, \text{ and} \tag{17}$$

$$\Delta p_t = \phi_{21}\, v_t + \phi_{22}\, e_t + \phi_{23}\Delta p_{t-1}, \tag{18}$$

where the extraneous state variable $\Delta p_{t-1}$ is included. These expressions imply that

$$E_t\, y_{t+1} = \phi_{11}\rho_1\, v_t + \phi_{13}\left(\phi_{21}\, v_t + \phi_{22}\, e_t + \phi_{23}\Delta p_{t-1}\right), \text{ and}$$

$$E_t\, \Delta p_{t+1} = \phi_{21}\rho_1\, v_t + \phi_{23}\left(\phi_{21}\, v_t + \phi_{22}\, e_t + \phi_{23}\Delta p_{t-1}\right).$$

Undetermined coefficient reasoning implies that the values for $\phi_{ij}$ are given by six relations analogous to equation 16, among which are

$$\phi_{13} = b_1\mu_1\,\phi_{23}^2 + b_1\mu_2\phi_{13} + \phi_{13}\,\phi_{23}, \text{ and} \tag{19}$$

$$\phi_{23} = \beta\phi_{23}^2 + \alpha\phi_{13}. \tag{20}$$

These equations can be used to solve for $\phi_{23}$, yielding the cubic equation

$$\phi_{23} = \beta\phi_{23}^2 + \frac{\alpha b_1 \mu_1 \phi_{23}^2}{1 - b_1 \mu_2 - \phi_{23}}. \tag{21}$$

Inspection of the latter indicates that one solution is provided by $\phi_{23} = 0$, which implies that $\phi_{13} = 0$. This, of course, gives the MSV solution obtained previously, but equation 21 is also satisfied by roots of the quadratic

$$\beta\phi_{23}^2 - \left(1 + \beta + \alpha b_1 \mu_1 - b_1 \mu_2 \beta\right)\phi_{23} + \left(1 - b_1 \mu_2\right) = 0, \tag{22}$$

that is, by

$$\phi_{23} = \frac{d \pm \left[d^2 - 4\beta\left(1 - b_1 \mu_2\right)\right]^{0.5}}{2\beta}, \tag{23}$$

where $d$ is the first bracketed term in equation 22. Therefore, for some values of the parameters $\alpha$, $\beta$, $b_1$, $\mu_1$, and $\mu_2$, there may be other real solutions in addition to the MSV solution.

To keep matters relatively simple, let $\mu_2 = 0$, so that the policy rule responds only to expected inflation. Then $d$ becomes $1 + \beta + \alpha b_1 \mu_1$, and equation 22 will have two real roots if $\mu_1 < 0$ or if

$$\mu_1 > \mu_1^c \equiv \frac{2\beta^{0.5} + 1 + \beta}{-b_1 \alpha}.$$

Furthermore, while one of the $\phi_{23}$ values in equation 22 will exceed 1.0 in absolute value when $\mu_1 > \mu_1^c$, the other will not—it will be a negative stable root. Consequently, there will be no transversality condition to rule out that root's implied trajectory as a rational expectations equilibrium. Thus with $\mu_1 > \mu_1^c$, there is an infinite multiplicity of stable rational expectations solutions indexed by the initial start-up value of $\Delta p_{t-1}$. In such cases, moreover, so-called sunspot solutions are also possible in the sense of not being ruled out by the conditions of rational expectations equilibria.[15] This is the danger pointed out by the Woodford warning. Furthermore, it is made less likely when values of $\mu_2$ exceed zero, thereby providing an additional reason to avoid pure inflation forecast targeting.[16]

The postulated danger may not be of any practical significance, however, for it is entirely possible that non-MSV solutions—namely, bubbles and sunspots—are empirically irrelevant.[17] This is a cogent and plau-

15. By a sunspot solution I mean one that includes random variables (of a martingale difference variety) that have no connection with other elements of the model.

16. See, for example, Bullard and Mitra (2000).

17. At least in macroeconomic contexts.

sible hypothesis that has not been convincingly contradicted by any empirical tests, despite the enormous amount of interest shown by researchers over the past twenty-five years. The main line of argument in favor of the proposition that only MSV solutions are of empirical relevance again concerns the E-stability and learnability of the alternative solutions. For the model at hand, Bullard and Mitra (2000, figure 3) show that when $\mu_1$ or $\mu_2$ values are large, the MSV solutions are E-stable and, therefore, learnable by a real-time least squares learning procedure.[18] Bullard and Mitra do not analyze the E-stability and learnability properties of the non-MSV solutions, but very closely related cases have been analyzed by Evans (1986, pp. 150–53) and Evans and Honkapohja (1999, pp. 487–506; 2001, chap. 10). Their results indicate that the non-MSV solutions do not possess E-stability in the case at hand.

A second line of argument is developed in McCallum (2001), from which this section is adapted. That paper emphasizes that the unique MSV solution is available in the high-$\mu_1$ cases indicated by the Woodford warning and that this solution is well behaved in the sense of experiencing no discontinuity when $\mu_1$ passes through the critical value that delineates the region of multiple stable solutions. Specifically, impulse response functions for the MSV solution are plotted and shown to be virtually indistinguishable for $\mu_1$ values just above and just below the $\mu_1^c$ critical value at which solution multiplicity sets in. Also, the MSV impulse response functions change continuously with $\mu_1$ more generally (McCallum, 2001, figures 3–5). By contrast, the non-MSV solutions are not continuous at $\mu_1^c$, and they feature additional peculiarities. Those results illustrate the well-behaved nature of the MSV solution for the example considered, as well as the erratic nature of the non-MSV (bubble) solutions. Such results also obtain for other parameter values and clearly suggest the desirability of considering the MSV solution as the sole economically relevant solution.

If the MSV solution is taken to represent implied behavior for the model at hand, then there is no compelling reason to believe that strong responses to forecast inflation values will generate undesirable behavior. In that case, preemptive inflation forecast targeting could be an attractive policy regime, despite warnings of the type under discussion.[19]

18. As mentioned above, E-stability pertains to the convergence of meta-time iterations that may or may not drive nonrational expectations functions to their rational expectations values, and it governs least squares learnability.

19. This argument does not apply to the case with $\mu_1 < 0$, in which the Taylor principle does not hold and there is a genuine problem. For analysis and more discussion, see McCallum (2001).

## 3. A Framework for Quantitative Open Economy Analysis

Whereas the points addressed in the previous two sections could be discussed in the context of extremely simple models with only qualitative specifications, the topics considered below require a more realistic specification of the relations governing the dynamics of both consumption and price adjustment behavior. The foreign trade of goods, services, and financial assets also plays an important role, and postulating alternative monetary policy rules similarly requires a degree of realism. The present section, accordingly, is devoted to describing the open economy model used in sections 4, 5, and 6.

The basic structure of the model is derived from McCallum and Nelson (1999), but with a few adjustments that are intended to improve its match with actual data. The McCallum-Nelson model was designed in the spirit of what has been called the new open economy macroeconomics.[20] In other words, it was intended to be a dynamic open economy macroeconomic model that features rational expectations, optimizing agents, and slowly adjusting prices of goods. It differs from other contributions in the area, however, in the manner in which imported goods are treated. In particular, the McCallum-Nelson model treats imports not as finished goods, as is usual, but rather as raw material inputs to the home economy's production process. This alternative treatment leads to a cleaner and simpler theoretical structure, relative to the standard treatment, and it is empirically attractive in ways that are outlined below. Since the optimizing, general equilibrium analysis (from the perspective of a small economy) is presented in McCallum and Nelson (1999), here I take an informal expository approach designed to facilitate understanding of the model's basic structure.

In a wide variety of infinite-horizon models involving imperfect competition, optimizing analysis leads to a consumption Euler equation that can be expressed or approximated in the form,

$$c_t = \mathrm{E}_t\, c_{t+1} + \mathrm{b}_0 + \mathrm{b}_1\, r_t + \mathrm{v}_t\,, \tag{24}$$

where $c_t$ is the log of a Dixit-Stiglitz consumption-bundle aggregate of the many distinct goods that a typical household consumes in

20. For references to this line of work, see Lane (1999). Also see Brian Doyle's "New Open Economy Macroeconomics Homepage," at www.geocities.com/brian_m_doyle/open.html.

period $t$.[21] In equation 24, $r_t$ is the real interest rate on home-country one-period bonds (private or government) and $v_t$ is a stochastic shock term that pertains to household preferences regarding present versus future consumption. In the analysis of a closed economy, relation 24 is often combined with a log-linearized, per-household, overall resource constraint to yield an "expectational IS function," to use the term of Kerr and King (1996). This step presumes that investment and capital are treated as exogenous. The simplest version of that assumption is that the capital stock is fixed; since that assumption is rather common in the new open economy macroeconomics literature, I adopt it here.

For the current open economy application, one might be tempted to write the resource constraint as

$$y_t = \omega_1 c_t + \omega_2 g_t + \omega_3 x_t - \omega_4 im_t, \tag{25}$$

where $y_t$, $g_t$, $x_t$, and $im_t$ are logarithms of real output, government consumption, exports, and imports, respectively, while $\omega_1$, $\omega_2$, $\omega_3$, and $\omega_4$ are steady-state ratios of consumption, government purchases, exports, and imports to output. If imports are exclusively material inputs to the production of home-country goods, however, and if $Y_t = \ln^{-1} y_t$ is interpreted as units of output, then the relevant identity is

$$y_t = \omega_1 c_t + \omega_2 g_t + \omega_3 x_t. \tag{25′}$$

This is, of course, the same as equation 25 with $\omega_4 = 0$. Either of these versions can be thought of as the resource constraint for the model.

It is desirable that import demand be modeled in an optimizing fashion. Toward that end, assume that production of all consumer goods is effected by households that are constrained by a production function of the constant elasticity of substitution (CES) form, with labor and material imports being the two variable inputs. The cost-minimizing demand for imports then equals

$$im_t = y_t - \sigma q_t + \text{const.}, \tag{26}$$

where $\sigma$ is the elasticity of substitution between materials and labor in production and where "const." denotes some constant.[22] Also, $q_t$ is the

21. Thus $c_t = \ln C_t$, with $C_t = \left[\int C_t(z)^{(\theta-1)/\theta}\, dz\right]^{\theta/(\theta-1)}$, where $\theta > 1$, $z$ indexes distinct goods, and the integral is over (0,1), while the corresponding price index is $P_t = \left[\int P_t(z)^{1-\theta}\, dz\right]^{1/(1-\theta)}$.

22. That is, the expression "const." in different equations appearing below typically refers to different constant magnitudes.

log price of imports in terms of consumption goods. In other words, $Q_t = \ln^{-1} q_t$ is the real exchange rate. Let $P_t$ and $S_t$ be the home-country money price of goods and foreign exchange, with $P_t^*$ the foreign-money price of home-country imports. If $p_t$, $s_t$, and $p_t^*$ are logs of these variables, then

$$q_t = s_t - p_t + p_t^* . \tag{27}$$

Symmetrically, export demand is assumed to be given as

$$x_t = y_t^* + \sigma^* q_t + \text{const.}, \tag{28}$$

where $y_t^*$ denotes production abroad and $\sigma^*$ is the price elasticity of demand from abroad for home-country goods.

Now consider output determination in a flexible-price version of the model. A log-linear approximation to the home-country production function yields

$$y_t = (1 - \alpha)a_t + (1 - \alpha)n_t + \alpha im_t + \text{const.},$$

where $n_t$ and $a_t$ are logs of labor input and a labor-augmenting technology shock term, respectively. Suppose for simplicity that labor supply is inelastic, with 1.0 units supplied per period by each household. Thus with price flexibility, $n_t = 0$ and the flexible-price, natural-rate (or potential) value of $y_t$ is

$$\bar{y}_t = (1 - \alpha)a_t + \alpha(\bar{y}_t - \sigma q_t) + \text{const.}, \text{ or}$$

$$\bar{y}_t = a_t - \left(\frac{\sigma\alpha}{1 - \alpha}\right) q_t + \text{const.}. \tag{29}$$

But while $\bar{y}_t$ would be the economy's output in period $t$ if prices could adjust promptly in response to any shock, the model assumes that prices adjust only sluggishly. If the economy's demand quantity as determined by the rest of the system ($y_t$) differs from $\bar{y}_t$, then the former quantity prevails—and workers depart from their inelastic supply schedules so as to provide whatever quantity is needed to produce the demanded output, with $im_t$ given by equation 26.

In such a setting, the precise way in which prices adjust has a direct impact on demand and, consequently, on production. The recent literature uses various models of gradual price adjustment that are intended to represent optimizing behavior. The analysis below explores two candidates, one of which is presented here. Because it is the one used in previous work (McCallum and Nelson, 1999), I begin with the

*P*-bar model, here expressed in the form

$$p_t - p_{t-1} = (1 - \phi_1)(\bar{p}_{t-1} - p_{t-1}) + \mathrm{E}_{t-1}(\bar{p}_t - \bar{p}_{t-1}). \tag{30}$$

Thus prices adjust in response to prior departures of $p_t$ from its market-clearing value ($\bar{p}_t$) and to expected changes in the latter. In the tabulation of endogenous variables, however, neither $p_t$ nor $\bar{p}_t$ needs to be included in addition to $\Delta p_t$, since equation 30 is logically equivalent to

$$\mathrm{E}_{t-1}(p_t - \bar{p}_t) = \phi_1(p_{t-1} - \bar{p}_{t-1}), \text{ and thus to}$$

$$\mathrm{E}_{t-1}(y_t - \bar{y}_t) = \phi_1(y_{t-1} - \bar{y}_{t-1}), \tag{30′}$$

as is shown in McCallum and Nelson (1999). The same conclusion regarding endogenous variables holds in the second model of price adjustment considered below. The adjustment relation in that case is

$$\Delta p_t = 0.5(\mathrm{E}_t \Delta p_{t+1} + \Delta p_{t-1}) + \phi_2(y_t - \bar{y}_t) + \mathrm{u}_t, \tag{30″}$$

where $\mathrm{u}_t$ is a behavioral disturbance. This form of equation has been fairly prominent in recent work, primarily because it tends to impart a more realistic degree of persistence to inflation than does the more theoretically attractive Calvo-Rotemberg model.[23]

A standard feature of most current open economy models is a relation implying uncovered interest parity (UIP). One is therefore adopted here, despite the prominent empirical weaknesses of such relations:

$$R_t - R_t^* = \mathrm{E}_t \Delta s_{t+1} + \xi_t. \tag{31}$$

The equation includes a time-varying risk premium term, $\xi_t$, however, which may have a sizeable variance and could be autocorrelated.

It remains to describe how monetary policy is conducted. In the spirit of most recent research in monetary economics, I presume that the monetary authority conducts policy in a manner suggested by the Taylor (1993a) rule, that is, by adjusting a one-period nominal interest rate in response to prevailing (or forecasted future) values of inflation and the output gap, $\tilde{y}_t = y_t - \bar{y}_t$:

$$R_t = (1 - \mu_3)[\mu_0 + \Delta p_t + \mu_1(\Delta p_t - \pi^*) + \mu_2 \tilde{y}_t] + \mu_3 R_{t-1} + \mathrm{e}_t \tag{32}$$

The quantitative results presented below are based on estimated or calibrated versions of this rule, in most cases with $\mathrm{E}_{t-1}$ applied to $\tilde{y}_t$ and $\Delta p_t$.

23. See Fuhrer and Moore (1995); Clarida, Gali, and Gertler (1999).

To complete the model, we need only to include the Fisher identity,

$$1 + r_t = \frac{1 + R_t}{1 + \mathrm{E}_t \, \Delta p_{t+1}},$$

which we approximate in the familiar fashion:

$$r_t = R_t - \mathrm{E}_t \, \Delta p_{t+1} . \tag{33}$$

The model is thus a simple log-linear system in which the ten structural relations presented in equations 24 through 33 determine values for the endogenous variables $y_t$, $\bar{y}_t$, $\Delta p_t$, $r_t$, $R_t$, $q_t$, $s_t$, $c_t$, $x_t$, and $im_t$. Government spending, $g_t$, and the foreign variables $p_t^*$, $y_t^*$, and $R_t^*$ are taken as exogenous—as are the shock processes for $v_t$, $a_t$, $e_t$, and $\xi_t$. This is probably the simplest and cleanest model extant that includes the essential features of the new open economy macroeconomics literature.

Of course, it is possible to append a money demand function such as

$$m_t - p_t = \gamma_0 + \gamma_1 y_t + \gamma_2 R_t + \eta_t , \tag{34}$$

and one of this general form—perhaps with $c_t$ replacing $y_t$—would be consistent with optimizing behavior.[24] As many writers have noted, however, that equation would serve only to determine the values of $m_t$ that are needed to implement the $R_t$ policy rule.

With the structure given above, it is possible to calculate the log of the balance on goods and services account—that is, net log exports—as

$$net_t = x_t - \left( im_t + q_t \right), \tag{35}$$

where it is assumed that $\omega_3 = \omega_4$. Also, the log of the GDP deflator can be calculated as

$$p_t^{DEF} = \frac{p_t - \omega_3 \left( s_t + p_t^* \right)}{1 - \omega_3}. \tag{36}$$

These represent extra features, however, that need not be included with the basic model (equations 24 through 33).

An advantage of this strategy of modeling imports as material inputs to the production process is that the relevant price index for produced goods is the same as the consumer price index, which implies that the same gradual price adjustment behavior is relevant for all domestic consumption. It also avoids the unattractive assumption,

24. See McCallum and Nelson (1999); Woodford (1995, 2000).

implied by the tradable vs. nontradable goods dichotomization, that export and import goods are perfectly substitutable in production. Theoretical advantages would not constitute a satisfactory justification, of course, if most imports were, in fact, consumption goods. Such is not the case, however, at least for the United States. Instead, the data suggest that under conservative assumptions, productive inputs actually comprise a larger fraction of U.S. imports than do consumer goods (including services).[25]

## 4. Calibration and Model Properties

There is one way in which the model developed in McCallum and Nelson (1999) differs significantly from the ten-equation formulation just presented. Specifically, it includes a somewhat more complex form of consumption versus saving behavior, featuring habit formation. Thus in place of the time-separable utility function that leads to equation 24, the model assumes that each period-$t$ utility term includes $c_t/(c_{t-1})^h$, with $0 \leq h < 1$, rather than $c_t$ alone. This specification gives rise to the following replacement for equation 24:

$$c_t = \mathrm{h}_0 + \mathrm{h}_1 c_{t-1} + \mathrm{h}_2 \mathrm{E}_t c_{t+1} + \mathrm{h}_3 \mathrm{E}_t c_{t+2} + \mathrm{h}_4 \left(\log \lambda_t\right) + \mathrm{v}_t . \tag{24′}$$

Here $\lambda_t$ is the Lagrangian multiplier on the household's budget constraint, which obeys

$$\log \lambda_t = \text{const.} + \mathrm{E}_t \lambda_{t+1} + r_t , \tag{37}$$

and there are constraints relating the $h_j$ parameters to others in the system. For details and additional discussion, see McCallum and Nelson (1999) and the recent study by Fuhrer (2000).

Calibration of the model draws on McCallum and Nelson (1999), but it differs in a few ways that, in retrospect, seem appropriate. For the parameters governing spending behavior, I retain here the $h = 0.8$ value taken from an early version of Fuhrer (2000), but for the counterpart of

25. In 1998, imported consumer goods amounted to US$453 billion while imports of business inputs came to US$624 billion, approximately. These figures are based on an examination of categories reported in the August 1999 issue of the *Survey of Current Business*. Several categories are clearly composed predominantly of either consumer or business goods. For other groups, judgmental assignments were required. Those assignments are as follows, with the reported figure being the fraction of the category classified as business inputs: automotive vehicles, engines, and parts, 25 percent; travel, 25 percent; passenger fares, 25 percent; foods, feed, and beverages, 50 percent; and other private services, 75 percent.

$b_1$ I now use –0.4 rather than –1/6 to reflect the greater responsiveness of investment spending, which is not included explicitly in the model.[26] I again use 1/3 for both $\sigma$ (the elasticity of substitution in production and, therefore, the elasticity of import demand with respect to $Q_t$) and the elasticity of export demand with respect to $Q_t$. In equation 29, the labor-share parameter $1 - \alpha$ equals 0.64. The steady-state ratio of imports (and exports) to domestic production is taken to be 0.25, which is a higher value than in McCallum and Nelson (1999) so as to reflect an economy that is more open than the United States. Unlike McCallum and Nelson (1999), I include government consumption, setting $\omega_2 = 0.25$.

In the two price adjustment specifications, the parameter values are $\phi_1 = 0.89$ (estimated by McCallum and Nelson) and $\phi_2 = 0.02$ (based on my reading of a wide variety of studies, plus conversion into nonannualized fractional terms for a quarterly model). Policy rule parameters vary in the experiments, but they should be thought of in relation to realistic values close to $\mu_1 = 0.5$, $\mu_2 = 0.4$, and $\mu_3 = 0.8$, with the latter reflecting considerable interest rate smoothing.[27] In most cases, expectations based on $t - 1$ data are used for the $\Delta p_t$ and $\tilde{y}_t$ variables appearing in the policy rule, to make our version of the rule operational.

The stochastic processes driving the model's shocks must also be calibrated, of course. For both foreign output and the technology shock, I have specified AR(1) processes with AR parameters of 0.95, rather than the 1.0 values used in McCallum and Nelson (1999). The innovation standard deviations are 0.03 and 0.0035, as before. The latter value might appear smaller than is usual, but it is appropriate to generate a realistic degree of variability in $\bar{y}_t$ when the latter is not exogenous but is dependent on $q_t$. The UIP risk premium term, $\xi_{t,}$ is generated by an AR(1) process with AR parameter 0.5 and innovation 0.04; these values are based on work reported in Taylor (1993b). Government consumption (ln logs) follows an AR(1) process, with an AR parameter of 0.99 and an innovation standard deviation of 0.02. Finally, the $v_t$, $u_t$, and $e_t$ shock processes are taken to be white noise with standard deviation values of 0.011, 0.002, and 0.0017, respectively.

One way to represent a model's properties is in terms of its variances and autocovariances. Unconditional variances for some of the

26. The parameter in question is the intertemporal elasticity of substitution in consumption when $h = 0$.

27. The coefficient attached to the output gap actually equals 0.1 in the simulations, as they include results based on quarterly fractional units. The literature on Taylor rules usually works with annualized percentages, however, so I here describe the number as 0.4.

**Table 1. Standard Deviations of $\Delta p_t$, $y_t$, $\tilde{y}_t$, and $R_t$**

| | *0.1 trade share* | | *0.25 trade share* | |
|---|---|---|---|---|
| *Variable* | $\mu_3$=*0.0* | $\mu_3$=*0.8* | $\mu_3$=*0.0* | $\mu_3$=*0.8* |
| *P-bar variant* | | | | |
| $\Delta p_t$ | 4.41 | 4.42 | 10.20 | 7.94 |
| $y_t$ | 2.22 | 1.98 | 4.41 | 3.91 |
| $\tilde{y}_t$ | 2.56 | 2.25 | 6.31 | 4.81 |
| $R_t$ | 5.78 | 2.80 | 13.12 | 5.48 |
| *Equation 30″ variant* | | | | |
| $\Delta p_t$ | 2.38 | 2.18 | 2.58 | 2.39 |
| $y_t$ | 1.19 | 1.19 | 1.46 | 1.59 |
| $\tilde{y}_t$ | 1.02 | 1.02 | 1.91 | 2.11 |
| $R_t$ | 2.97 | 2.97 | 3.40 | 2.22 |

Source: Author's calculations.

model's crucial variables are shown in table 1 for various specifications. The first segment of the table pertains to the variant with the *P*-bar price adjustment (equation 30), whereas the second is based on the alternative adjustment relation (equation 30″). Two assumptions are considered for the share of exports to total production, namely, that this share is 0.10 or 0.25. The former represents a large economy that is relatively closed to foreign trade, whereas the latter figure is for a more typical economy. Finally, policy rule 32 is used both with and without interest smoothing, that is, with $\mu_3 = 0.8$ (the more realistic case) and with $\mu_3 = 0$ (as in the original version of Taylor's rule). In both cases the other coefficients are given the values mentioned above.

Table 1 clearly demonstrates that the *P*-bar variant of the model generates more variability in all principal variables than does the equation 30″ variant. The simulations do not aim to match the moments of any specific economy, but knowledge of values for the United States gives one the impression that that the equation 30″ values are the more realistic of the two sets, though they are slightly too small. The model also generates much more variability when the economy is more open to foreign trade. This is not surprising, since more trade leads to a bigger effect of exchange rate movements on the natural-rate value of output. The remainder of the paper uses the more open of the two specifications, that is, the one with an export-to-output (or import-to-output) ratio of 0.25. Finally, table 1 also indicates that in most cases interest rate smoothing (that is, $\mu_3 = 0.8$) helps to reduce the variability of inflation and the output gap.

Another way to represent the model's properties is in terms of its impulse response functions. The responses to a unit shock to the policy rule (that is, a 1.0 realization of the shock $e_t$) are shown in figure 3 for $\mu_3 = 0.8$. This temporary tightening of monetary policy induces temporary but lasting drops in output, inflation, and both the real and nominal exchange rate, together with a temporary increase in net exports. The dynamic patterns are somewhat different for the two price adjustment specifications, with much more inflation persistence apparent in the second case. Since this persistence is more consistent with observed behavior of inflation in most developed economies, this difference in outcomes favors the specification of equation 30″. Consequently, this specification is emphasized in what follows and is henceforth considered the standard price adjustment specification. A questionable feature of both models is that the exchange rates and net exports respond promptly to shocks, rather than with a lagged or gradual pattern. Overall, however, the nature of the models' responses are encouraging. The magnitude of the output response to a policy shock is somewhat larger than in McCallum and Nelson (1999), but this is due to the larger share of foreign trade.

## 5. Frequency of a Zero Lower Bound with Inflation Targeting

This section now examines the effects of inflation targeting, as compared with other monetary policy regimes, on the frequency of liquidity trap problems. The general strategy is to conduct simulations and determine how often a liquidity trap or zero lower bound (ZLB) constraint is encountered with various policy rules, including inflation targeting. For a given model, the frequency of ZLB constraints being encountered depends on $R^*$, which is the sum of the target inflation rate, $\pi^*$, and the average real interest rate, $r$. The smaller is $\pi^*$, the more frequently will the constraint be encountered. This frequency could be quite low, however, even with a reasonably small value of $\pi^*$, say, 2.0 percent per year (that is, 0.005 in quarterly fractional terms).

The simulations reported in this section do not actually impose a ZLB constraint. Instead, they permit negative rates of interest, in order to maintain a linear computational framework. The number of periods with such rates thus overestimates how frequently ZLB constraints would be binding, since in some periods the previous period's rate will have been negative. To more accurately estimate how often ZLB constraints would be encountered, I examine the frequency of periods (quarters)

**Figure 3. Responses to Unit Shock to Policy Rule**

*P-Bar Model*

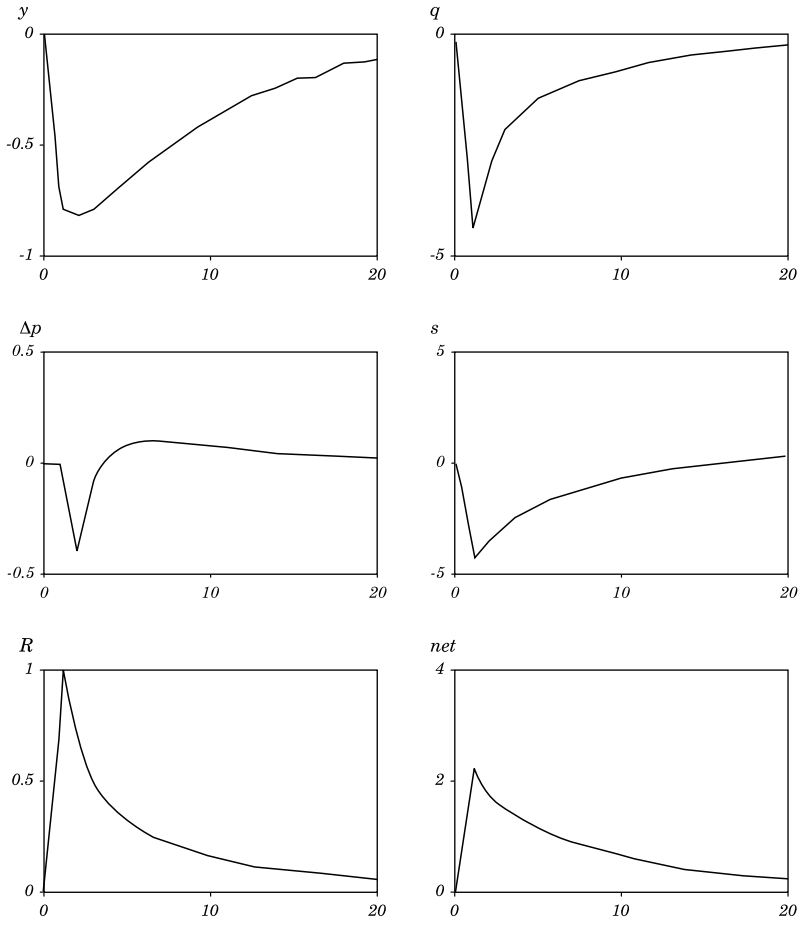


**Figure 3. (continued)**

*Standard Model*

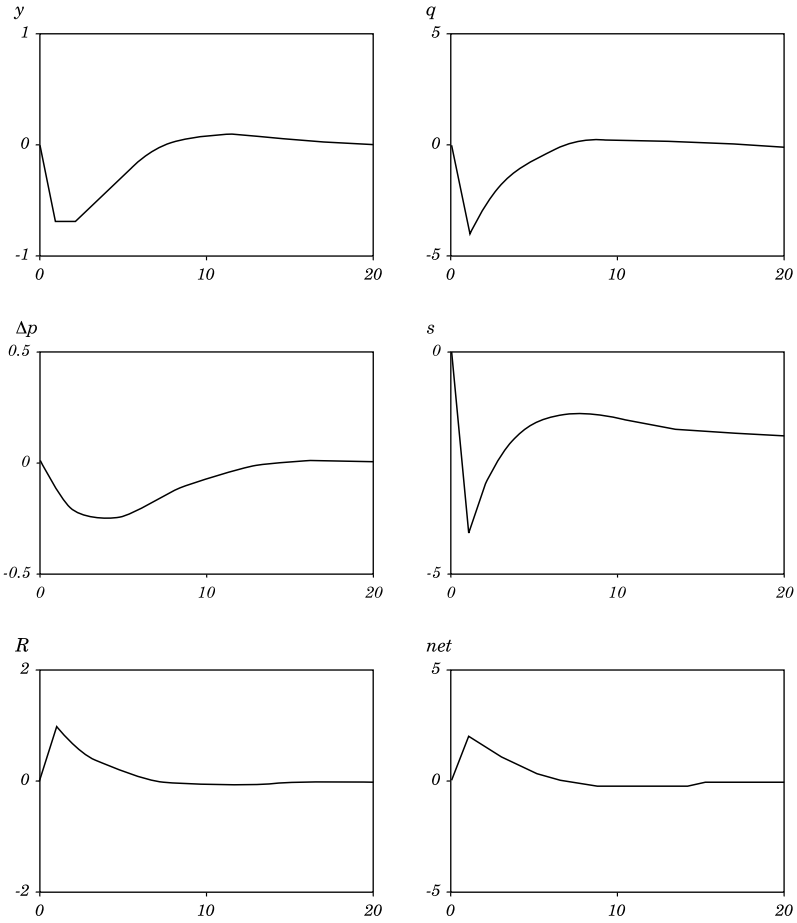


**Table 2. Relative Frequency of Zero Lower Bound Statistics**

| *R* (percent per year)* | *Statistic 1* | *Statistic 2* | *Statistic 3* |
|---|---|---|---|
| 8.0 | 0.0001 | 0.0001 | 0.0001 |
| 7.0 | 0.0006 | 0.0004 | 0.0003 |
| 6.0 | 0.0088 | 0.0060 | 0.0034 |
| 5.0 | 0.0158 | 0.0108 | 0.0061 |
| 4.0 | 0.0408 | 0.0269 | 0.0126 |
| 3.0 | 0.0882 | 0.0565 | 0.0243 |
| 2.0 | 0.1990 | 0.1232 | 0.0423 |

Source: Author's calculations.

in which the recorded interest rate is both negative and lower than in the previous period. (If a value is negative but higher than in the previous period, the presumption is that $R_t$ movement would also be upward in the model with a ZLB constraint, so the bound would not be encountered.) To illustrate, table 2 reports relative frequencies of three statistics pertaining to the zero lower bound: the fraction of periods in which negative rates are realized;[28] the fraction of periods in which negative rates are realized and the realized value is lower than in the previous period (this is the preferred measure); and the fraction of periods in which negative rates are realized and the value in the previous period was positive. This latter statistic is designed to indicate how many episodes of zero or negative rates occur, with each string of zero or negative values counted only once.

Several assumptions regarding $R^*$ are investigated in table 2, that is, values ranging from 2 to 8 percent per year (0.005 to 0.02 in quarterly fractional units). If one believed that an economy's average real interest rate was about 3 percent and its inflation target was set at 2 percent, then the relevant figure for $R^*$ would be 5 percent. For the calculations in table 2, the standard version of the model is used and the policy rule parameters $\mu_1$, $\mu_2$, and $\mu_3$ are set at 0.5, 0.4, and 0.8, respectively. With $R^* = 5$ percent, negative interest rates are encountered in 1.58 percent of the quarterly time periods, but the preferred measure, for the reasons just explained, is given by the second statistic, which equals 1.08 percent of the time periods. Finally, the third statistic takes on a still smaller value, of 0.61 percent, for the relative frequency of episodes in which interest rate constraints are encountered. Of course, the frequencies

28. The simulations are carried out with all constant terms set equal to zero. Thus the observations described as negative are those in which the simulated value is less than $-R^*$. This way of proceeding is standard and innocuous.

**Table 3. Performance Measures with Standard Model and $R^* = 5.0$ Percent**

Standard deviations of inflation and output gap; percent of ZLB periods

| $\mu_1$, $\mu_2$ | $\mu_3 = 0.0$ | $\mu_3 = 0.5$ | $\mu_3 = 0.8$ | $\mu_3 = 0.9$ | $\mu_3 = 0.99$ |
|---|---|---|---|---|---|
| 0.1, 0.4 | | | | | |
| Inflation | 4.91 | 4.10 | 3.32 | 3.23 | 20.18 |
| Output gap | 2.04 | 2.13 | 2.31 | 2.49 | 10.88 |
| ZLB | 12.18 | 9.03 | 3.36 | 0.71 | 0.00 |
| 0.5, 0.4 | | | | | |
| Inflation | 2.63 | 2.52 | 2.36 | 2.60 | 17.33 |
| Output gap | 1.94 | 1.98 | 2.11 | 2.31 | 8.40 |
| ZLB | 5.93 | 4.07 | 1.23 | 0.34 | 0.00 |
| 1.0, 0.4 | | | | | |
| Inflation | 2.16 | 2.07 | 2.06 | 2.26 | 11.79 |
| Output gap | 1.91 | 1.93 | 2.04 | 2.19 | 6.65 |
| ZLB | 6.39 | 3.30 | 0.81 | 0.15 | 0.00 |
| 10.0, 0.4 | | | | | |
| Inflation | 1.28 | 1.29 | 1.36 | 1.50 | 2.95 |
| Output gap | 2.09 | 2.09 | 2.07 | 2.09 | 2.55 |
| ZLB | 20.31 | 13.80 | 6.66 | 2.96 | 0.03 |
| 0.1, 0.0 | | | | | |
| Inflation | 4.85 | 4.11 | 3.25 | 3.29 | 22.31 |
| Output gap | 2.12 | 2.17 | 2.35 | 2.59 | 12.03 |
| ZLB | 11.64 | 8.32 | 3.49 | 0.57 | 0.00 |
| 0.5, 0.0 | | | | | |
| Inflation | 2.60 | 2.42 | 2.32 | 2.55 | 16.59 |
| Output gap | 1.98 | 2.06 | 2.16 | 2.35 | 9.05 |
| ZLB | 6.34 | 3.32 | 0.61 | 0.18 | 0.00 |
| 1.0, 0.0 | | | | | |
| Inflation | 2.15 | 2.03 | 2.05 | 2.22 | 12.36 |
| Output gap | 1.95 | 2.00 | 2.12 | 2.24 | 6.98 |
| ZLB | 5.89 | 3.17 | 0.92 | 0.16 | 0.01 |
| 10.0, 0.0 | | | | | |
| Inflation | 1.29 | 1.26 | 1.35 | 1.50 | 3.01 |
| Output gap | 2.14 | 2.13 | 2.12 | 2.09 | 2.56 |
| ZLB | 19.60 | 13.37 | 7.30 | 2.88 | 0.01 |

Source: Author's calculations.

are all higher for lower values of $R^*$, with, for example, the ZLB constraint binding quite rarely at $R^* = 7.0$ but with a disturbingly high frequency for an $R^*$ of 2.0 or 3.0. The main point here is that the regular and intuitive behavior of the three different statistics gives confidence that the second statistic does indeed provide a reasonable measure of the frequency of periods in which the zero lower bound would be encountered if one were to use nonlinear methods. In what follows, consequently, only that statistic is reported, and it is described simply

as the fraction or percentage of periods in which the ZLB constraint is binding (see footnote 30 below).

The first set of basic substantive results is premised on the assumption that a value of 5 percent per year is appropriate for $R^*$. A hundred simulations were run for each case, and their average results are reported in table 3. The object is to consider alternative values for the policy rule parameters $\mu_1$, $\mu_2$, and $\mu_3$ to determine the relative desirability of different rules. In each cell of table 3, the three numbers represent the standard deviation of inflation, the standard deviation of the output gap, and the frequency of ZLB occurrences. All of these are reported in percent (not fractional units), with the inflation figures annualized. The inflation and output gap figures should be interpreted as root-mean-square deviations from their target values.

Table 3 considers a wide range of values for $\mu_1$ (from 0.1 to 10.0), which represents the strength of reaction to the inflation variable. The degree of interest rate smoothing, measured by $\mu_3$, is also varied over a wide range, from 0 to 0.99. Only two values are reported, however, for $\mu_2$, the response coefficient on the output gap. First, a value of 0.4 is considered, as it is close to the original Taylor-rule value of 0.5. Larger magnitudes are not explored since it is very dangerous, I believe, to respond strongly to perceptions of the output gap, because of the difficulty of measuring or even conceptualizing an operational measure of potential output.[29] Second, a value of $\mu_2$ equal to zero is included to approximate a rule that is representative of pure inflation targeting.

In table 3 it can be seen that ZLB cases appear with excessive frequency for all cases with no interest smoothing or only a small degree (namely, $\mu_3 = 0.5$). At the value 0.8, which is close to those estimated empirically by Clarida, Gali, and Gertler (1997, 1999) and McCallum and Nelson (1999), most of the cases still show ZLB problems arising in over 1 percent of the quarterly time periods. With $\mu_3 = 0.9$, however, the frequency of ZLB periods becomes acceptably small.[30] Next, larger values of the inflation coefficient, $\mu_1$, consistently lead to reduced variability of inflation around its target value.

29. For some discussion and results pertaining to this danger, see McCallum and Nelson (2000).

30. Reifschneider and Williams (2000) use the FRB/US econometric model and actually impose a proper zero lower bound. In their table 1, they report results for a case based on a Taylor rule with coefficients $\mu_1 = 0.5$, $\mu_2 = 0.5$, and $\mu_3 = 0$. They assume $r = 2.5$ percent per year, so their case with an inflation target of 2 percent implies an $R^*$ value of 4.5 percent, which leads to a frequency of ZLB periods of 5 percent. When I use these settings, I get 8 percent, which is close and on the conservative side.

Increasing $\mu_1$ from 0.1 to 1.0, moreover, tends to reduce both the variability of the output gap and the frequency of ZLB occurrences. Higher values, however, seem not to be helpful on balance. Finally, a comparison of the bottom and top halves of the table indicates that there is little difference between the pure inflation targeting case (with $\mu_2 = 0$) and the case with moderate, Taylor-style responses to the output gap (with $\mu_2 = 0.4$).

Next I turn to other, non-Taylor rules that use target variables other than inflation. From the perspective of actual practice, the most important are those that use the exchange rate, or its rate of change, as the principal target variable. I therefore consider policy rules of the form

$$R_t = (1 - \mu_3)\left[\mu_0 + \Delta p_t + \mu_1 (z_t - z^*)\right] + \mu_3 R_{t-1} + e_t, \tag{38}$$

where $z_t$ is the target variable. Letting $s_t$ denote the log of the home-country price of foreign exchange, I experiment with $s_t$ and $\Delta s_t$ as examples of $z_t$. In addition, since several analysts have promoted nominal income, or its growth rate, as a target variable, I also use $x_t = y_t + p_t$ and $\Delta x_t$ for $z_t$. As before, I actually use $E_{t-1}\Delta p_t$ rather than $\Delta p_t$ in equation 38 and also use the $t - 1$ expectation of $x_t$ and $\Delta x_t$. For the exchange rate, however, it is assumed that the current-period value is observable and so appears in the rule. In addition, I want to consider price level targeting, that is, the use of $E_{t-1}p_t$ rather than $E_{t-1}\Delta p_t$ as the rule's target variable. This choice does not necessarily imply that the target for the price level is constant over time, but if it grows at a constant rate then target misses for the price level will subsequently have to be reversed.

Results are shown in table 4. In all cases considerable interest smoothing is assumed, with a realistic value of 0.8 for $\mu_3$. The first column repeats figures from table 3 for reference. The second and third columns give results for $s_t$ and $\Delta s_t$. With $\mu_1 = 0.1$, the performance of the $s_t$ target is about as good as for $\Delta p_t$ with $\mu_1 = 0.5$, but in all other cases both of the exchange rate targets give quite poor results with very high frequencies of ZLB occurrences. The high degree of variability of the exchange rate evidently leads to a great deal of interest variability and thus to a high frequency of ZLB constraints. The nominal income level target performs rather well for values of $\mu_1$ up to 1.0, but it induces many ZLB periods when $\mu_1 = 10$. The nominal income growth target performs less well, although its performance is not too bad when $\mu_1$ equals 0.5 or 1.0. Finally, the price level target yields very good results when $\mu_1$ equals 0.1 or 0.5, but it induces a high frequency of ZLB constraints with stronger feedback parameters.

**Table 4. Performance Measures with Alternative Targets and $R^* = 5$ Percent**

Standard deviations of inflation and output gap; percent of ZLB periods[a]

| $\mu_1$ | $E_{t-1}\Delta p_t$ | $s_t$ | $\Delta s_t$ | $E_{t-1}x_t$ | $E_{t-1}\Delta x_t$ | $E_{t-1}p_t$ |
|---|---|---|---|---|---|---|
| 0.1 | | | | | | |
| Inflation | 3.25 | 2.51 | 3.25 | 1.98 | 3.39 | 1.97 |
| Output gap | 2.35 | 2.05 | 2.40 | 2.16 | 2.44 | 2.18 |
| ZLB | 3.49 | 0.56 | 3.25 | 0.02 | 3.67 | 0.03 |
| 0.5 | | | | | | |
| Inflation | 2.32 | 2.66 | 2.58 | 1.79 | 2.47 | 1.63 |
| Output gap | 2.16 | 1.91 | 2.34 | 2.12 | 2.34 | 2.21 |
| ZLB | 0.61 | 8.60 | 7.37 | 0.10 | 0.72 | 0.50 |
| 1.0 | | | | | | |
| Inflation | 2.05 | 2.79 | 2.73 | 1.70 | 2.26 | 1.50 |
| Output gap | 2.12 | 1.90 | 2.26 | 2.12 | 2.40 | 2.29 |
| ZLB | 0.92 | 13.99 | 16.57 | 0.27 | 0.63 | 1.81 |
| 10.0 | | | | | | |
| Inflation | 1.35 | 2.93 | 2.81 | 1.60 | 2.44 | 1.09 |
| Output gap | 2.12 | 2.01 | 1.81 | 2.04 | 3.10 | 2.87 |
| ZLB | 7.30 | 24.60 | 26.60 | 5.89 | 2.72 | 15.21 |

Source: Author's calculations.

a. Based on the policy rule defined in equation 38 and $\mu_1 = 0.8$

With regard to the basic policy issue at hand, inflation targeting performs somewhat better than other growth rate targets ($\Delta s_t$ and $\Delta x_t$) in certain respects and about the same with regard to the ZLB problem. In comparison with a price level target, inflation targeting appears to be less effective for stabilizing inflation and output, but less open to serious ZLB problems. Exchange rate level targeting is the most sensitive to the ZLB problem of any of the targets considered. Finally, nominal income level targeting seems to perform quite well, but not so well as to dominate inflation targeting.

## 6. Monetary Stabilization despite a Liquidity Trap

Even if an economy has its interest rate instrument immobilized because of a liquidity trap or zero lower bound, there is nevertheless scope for monetary stabilization policy provided that the economy is open—as all are—to foreign trade. The argument presented here follows that outlined in McCallum (2000), but the model is improved and more open, as described above.[31] Specifically, suppose that the model

31. This proposal does not represent the only way of combating ZLB problems. Other possibilities are promoted by Goodfriend (2000) and Meltzer (2001). For Svensson (2000), see below.

economy's interest rate is fixed rigidly at $R_t = 0$ (or some other constant value), but that the monetary authority adopts a policy rule with an exchange rate instrument—not a target—of the following specification:

$$s_t - s_{t-1} = \nu_0 - \nu_1 \left( \mathrm{E}_{t-1} \Delta p_t - \pi^* \right) - \nu_2 \, \mathrm{E}_{t-1} \left( y_t - \bar{y}_t \right) + \zeta_t , \tag{39}$$

where $\nu_1 > 0$ and $\nu_2 \geq 0$. Here the rate of depreciation of the foreign exchange rate is lowered if inflation or output exceeds its target value. The exchange rate is being used as an instrument or indicator variable in much the same way as is normally the case (in industrialized economies) with a short-term interest rate. Thus the central bank uses open market operations or standing facilities to set the asset price at the desired value—the value specified by the policy rule—so as to promote the achievement of macroeconomic targets (inflation and output).

To represent such a policy process, equation 39 is included in the model in place of equation 32. Then, since $R_t$ is no longer a variable, one of the model's equations must be deleted or else modified so as to introduce another endogenous variable. For the moment this step can be understood as involving the deletion of uncovered interest parity, as expressed in equation 31. This is only a shorthand method of describing the actual alteration involved, however, which is explained and defended below. My purpose now is to demonstrate that with policy rule 39 in place, stabilizing monetary policy can be conducted even though the nominal interest rate is held fixed at a constant value.

The main simulation results are given in table 5.[32] As $\nu_1$, the coefficient attached to the inflation target, is increased, the variability of inflation drops sharply—that is, inflation is stabilized. Also, larger values of $\nu_2$, the coefficient on the output gap target, lead to reduced variability of the output gap.

Another way of demonstrating the effectiveness of monetary policy stabilization with the policy rule 39 is via impulse response functions. In figure 4, the top panels present the responses of key endogenous variables to a policy rule shock (that is, an upward blip in $\Delta s_t$) when the rule parameter values are $\nu_1 = 1.0$ and $\nu_2 = 1.0$. This loosening of policy brings about an increase in both inflation and output, as would be expected. Then in the bottom panels the rule parameter $\nu_2$ is set at the larger value of 10. Thus the rule is designed to exert stronger stabilizing tendencies for inflation. Indeed, the response of inflation and output to the

32. The disturbance $\zeta_t$ is assumed to possess the same stochastic properties as $\xi_t$ in equation 31.

**Table 5. Performance Measures with Policy Rule 39 and Fixed *R***

Standard deviations of $\Delta p_t$, $\tilde{y}_t$, and $\Delta s_t$

| $\nu_1$ | $\nu_2 = 0$ | $\nu_2 = 1$ | $\nu_2 = 10$ | $\nu_2 = 50$ |
|---|---|---|---|---|
| 0 | | | | |
| $\Delta p_t$ | 11.66 | 8.86 | 4.00 | 4.12 |
| $\tilde{y}_t$ | 5.73 | 4.56 | 2.14 | 1.52 |
| $\Delta s_t$ | 18.61 | 17.22 | 18.47 | 26.24 |
| 1 | | | | |
| $\Delta p_t$ | 6.46 | 5.54 | 3.27 | 3.55 |
| $\tilde{y}_t$ | 3.91 | 3.49 | 2.02 | 1.49 |
| $\Delta s_t$ | 17.74 | 17.46 | 18.49 | 25.32 |
| 10 | | | | |
| $\Delta p_t$ | 2.14 | 2.05 | 1.93 | 2.51 |
| $\tilde{y}_t$ | 2.52 | 2.40 | 1.88 | 1.47 |
| $\Delta s_t$ | 21.23 | 20.66 | 20.84 | 24.34 |
| 50 | | | | |
| $\Delta p_t$ | 1.23 | 1.23 | 1.30 | 1.64 |
| $\tilde{y}_t$ | 2.63 | 2.57 | 2.21 | 1.68 |
| $\Delta s_t$ | 33.35 | 32.78 | 30.11 | 27.43 |

Source: Author's calculations.

shock are muted in comparison with the top panels. A similar comparison is provided in figure 5 for the case of a technology shock, which tends to increase output and decrease inflation. Again the bottom panels feature the higher value for $\nu_2$, and again the inflation and output responses are muted by this stronger attempt at stabilization. The cost, of course, is that the nominal and real exchange rates both respond more strongly, since the former is the policy instrument variable. These responses induce larger fluctuations in net exports, as well. From the results shown in table 5 and figures 4 and 5, it seems clear that the policy rule 39 does exert stabilizing influence on the economy despite the liquidity trap immobilization of the nominal interest rate.

Let me now take up some issues regarding this way of modeling this phenomenon. In his comment on McCallum (2000), Christiano (2000) objects to the elimination of the uncovered interest parity (UIP) relation from the model.[33] That this objection would be made is surprising,

33. Christiano's lengthy comment largely consists of variously expressed assertions to the effect that a model should include the UIP relation.

**Figure 4. Responses to Unit Shock to Policy Rule in Equation 39**

$\nu_1 = 1, \nu_2 = 1$

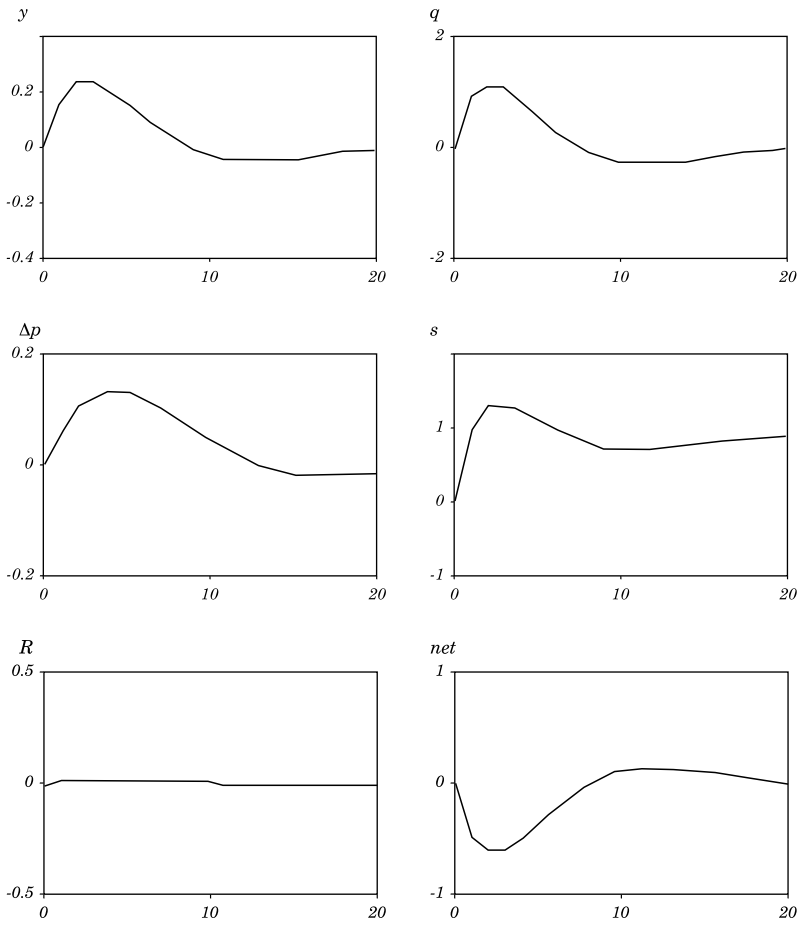


**Figure 4. (continued)**

$\nu_1 = 10, \nu_2 = 1$

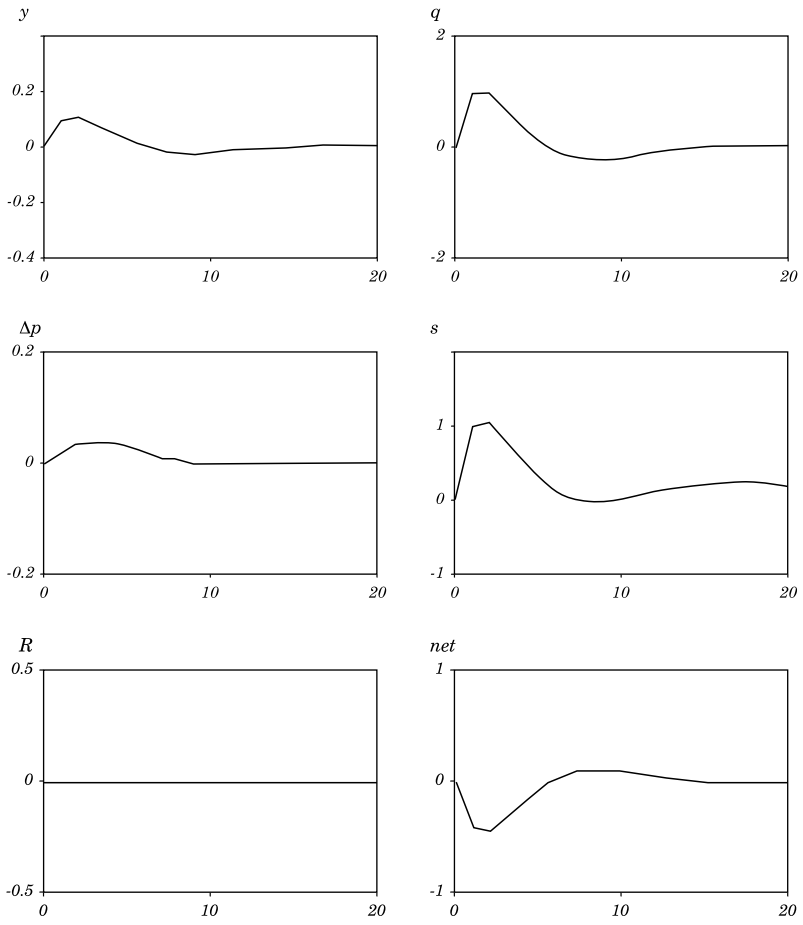


**Figure 5. Responses to Unit Technology Shock to Policy Rule in Equation 39**

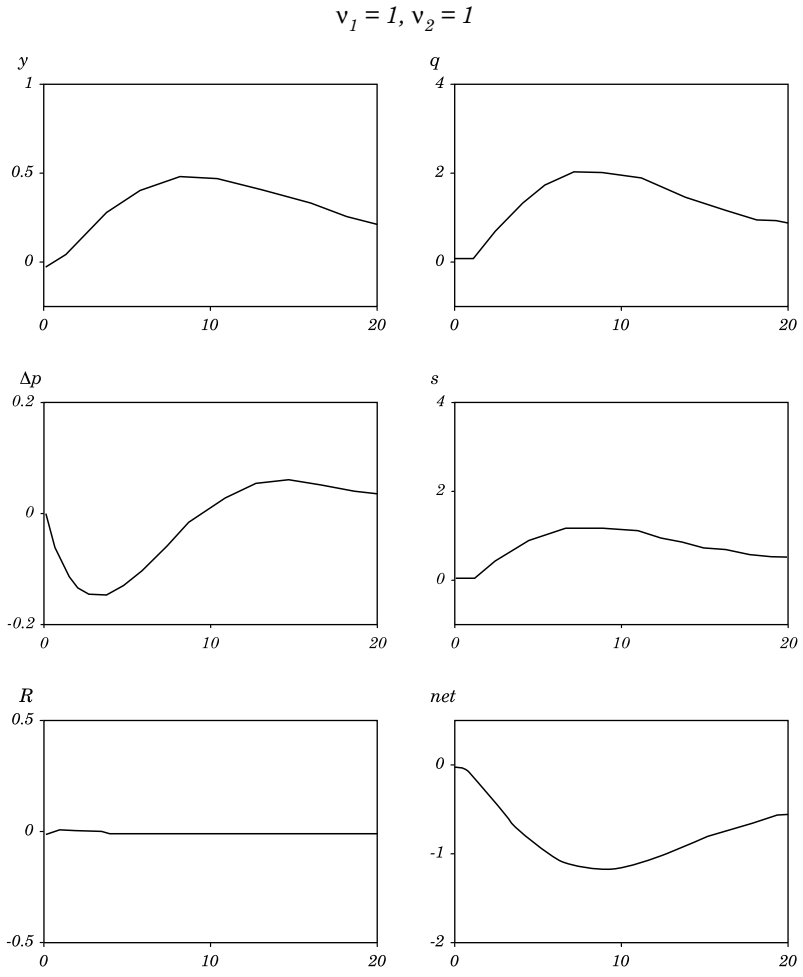
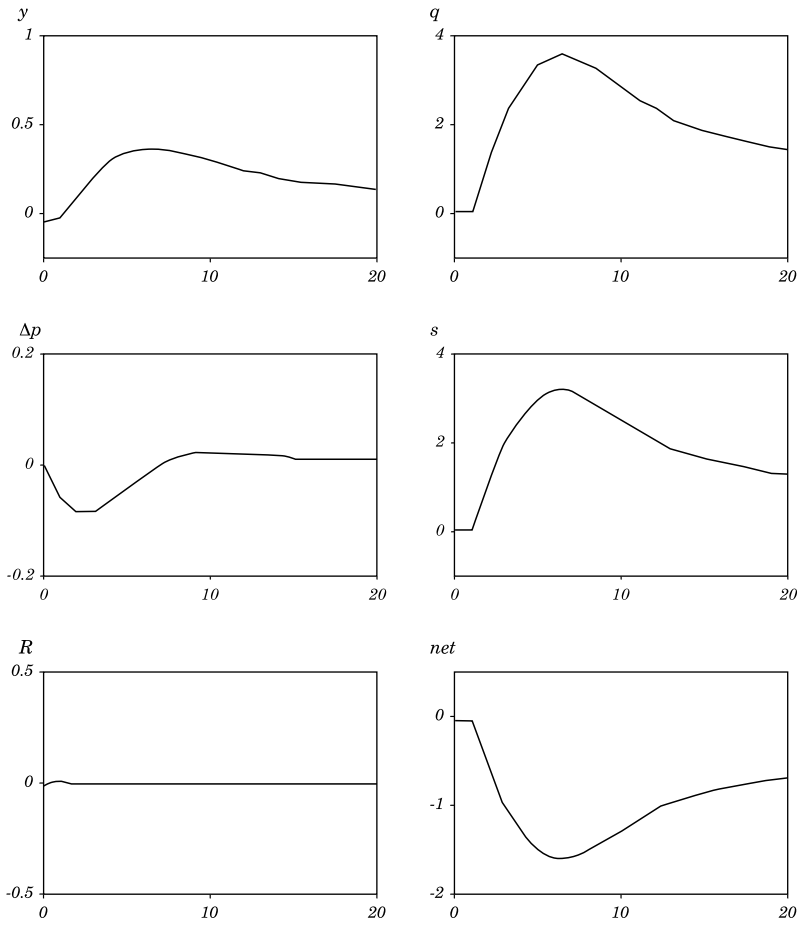


**Figure 5. (continued)**

$\nu_1 = 10, \nu_2 = 1$



given the enormous volume of empirical evidence that finds major departures from UIP. In the most standard empirical test, the slope coefficient that should equal 1.0 if UIP holds usually turns out to be negative—often significantly so.[34] It thus seems peculiar to insist on including the relation, since its drastic empirical failure is well documented. Despite this evidence, UIP is retained in many models, of course, but that is partly because it is unclear how to complete the model in its absence.[35] That is not a problem, however, if the exchange rate is used as the instrument variable; the relation can simply be omitted. This strategy is entirely analogous to omitting a base money demand function from models in which an interest rate is used as the instrument. The point is that in such cases it is not necessary to know how much base money must be supplied to set $R_t$ at its desired value, since its current value is immediately observable in the asset markets. Thus a poor understanding of the demand function for base money does not preclude the use of an interest rate instrument in standard models because the only role of the base money demand function is to specify how much base money must be supplied to implement the interest rate rule. In the case of the exchange rate instrument, it again is not necessary to know the magnitude of the exchange market purchases (increases in base money) needed to implement the rule, because the value of the exchange rate can be immediately observed from the relevant asset market (the foreign exchange market).

In McCallum (2000), it is recognized that the foregoing argument implies that there is some effect on the home country's exchange rate of purchases of foreign exchange with domestic base money. In other words, it is assumed that domestic and foreign currency assets are not perfect substitutes. In that paper, the lack of perfect substitutability is described in terms of the portfolio balance model of exchange rate determination that has been out of favor since the late 1970s.[36] That particular description is not necessary; it was adopted primarily in the belief that it would make the general argument more transparent. The fundamental point is merely that assets denominated in domestic and foreign currencies are not perfect substitutes, so there is scope for departure from exact UIP to be affected by unsterilized purchases of for-

34. Well-known references include Lewis (1995) and Froot and Thaler (1990).

35. For many purposes, using the UIP assumption is entirely sensible. The application under discussion here, however, is an extreme, special case.

36. Specialists in exchange rate analysis have recently shown a renewed attraction to the basic aspects of this approach. See Flood and Marion (2000); Jeanne and Rose (1999).

eign exchange, possibly in very large quantities.[37]

Svensson (2000) puts forth a proposal that, although different in detail, is in essence closely related to the use of a policy rule such as that described by equation 39. Svensson's "foolproof" way of providing monetary stimulus, when a country cannot reduce $R_t$ because of a zero lower bound, is, first, to announce an upward sloping $p_t$ path with the initial value above the current price level; second, to announce that the currency will be devalued immediately and will depreciate henceforth at the rate of increase planned for the price level; third, to announce that the scheme will be converted into a normal price-level or inflation targeting arrangement once the target price path has been achieved; and fourth, to implement the second step by offering to buy and sell foreign exchange at the specified value. The first, second, and fourth parts of this scheme are clearly similar to the adoption of an inflation target and the use of exchange rate depreciation as implied by equation 39. Svensson understandably emphasizes the differences between his scheme and the one presented in McCallum (2000). He exaggerates the differences, however, in stating that his argument "does not depend on any portfolio-balance effect of foreign-exchange interventions, in contrast to the argument of Meltzer (2001) and McCallum (2000), and thus, it is more general.… As long as the central bank supplies an unlimited amount of domestic currency at the target exchange rate,… arbitrage in the foreign-exchange market will ensure that this exchange rate is the equilibrium exchange rate" (Svensson, 2000, p. 24). My point is that exactly the same can be said for equation 39; the central bank is by assumption willing to make whatever unsterilized exchange market purchases (or sales) are needed to make $s_t$ take on the value that the rule specifies. That Svensson's path for $s_t$ is not contingent on other variables does not alter this aspect of the situation. To put the matter differently, if domestic and foreign assets were perfect substitutes, which they are not, then the central bank would not be able to achieve the initial exchange rate specified by his scheme.[38]

37. Notable recent evidence that dollar and deutsche mark assets are not perfect substitutes, based on market-microstructure analysis, is provided by Evans and Lyons (2000).

38. Both Svensson's scheme and mine, incidentally, are feasible only under the proviso that the situation is one in which the central bank must raise the inflation rate and depreciate the currency to escape the liquidity trap. In this case the central bank will not run out of reserves, because it is supplying domestic currency that it can print in unlimited amounts. A major reason why it is widely believed that central banks have no control over exchange rates is that in practice, most have attempted to keep the value of the domestic currency higher than the equilibrium rate, not to lower it to a non-ZLB rate. This requires supplying large amounts of foreign exchange, which cannot be printed by the economy in question.

## 7. Conclusion

The paper has argued, first, that the danger of a liquidity trap induced solely by self-confirming expectations, due to the existence of two rational expectations equilibria when there is a zero floor on interest rates, is probably minimal. Such a situation implies that the trap equilibrium, which is of a bubble nature, prevails despite the existence of a well-behaved MSV or fundamental equilibrium that yields the target rate of inflation. Crucially, the MSV solution possesses the property of E-stability, which implies that it is achievable by an adaptive least squares learning process, while the trap equilibrium is not. The paper's suggestion is that this form of a liquidity trap represents a theoretical curiosity that is not of practical importance.[39]

Second, a similar analysis applies to the issue of indeterminacy induced by a policy rule that responds strongly to expected future inflation, rather than to currently observed or recent inflation. This situation again appears to be more of a theoretical curiosity than a genuine problem. In considering this issue, it is important to be clear about the nature of two very different concepts of indeterminacy that have been prominent at different times in the monetary policy literature.

Third, the paper quantitatively examines the likelihood of encountering a liquidity trap or zero lower bound, in which the central bank is powerless to combat a recession by reduction of short-term nominal interest rates. This exercise requires a carefully calibrated numerical model of an open economy; the one used here is adapted from McCallum and Nelson (1999). The paper's findings are that the chances of a ZLB constraint are strongly dependent on the sum of the inflation target and the long-run average real interest rate. If that sum is 5 percent per year, the chances of encountering the ZLB constraint can be kept well below 1 percent per quarter by an interest rate policy rule that targets inflation and incorporates a fairly high degree of interest rate smoothing. Adopting the inflation rate as the target variable, instead of other candidate macroeconomic measures, does not exacerbate the difficulty of avoiding the ZLB problem.

Finally, the paper describes a policy rule for escaping a zero lower bound if the economy does fall into a liquidity trap. The proposed rule is one that (temporarily) makes the foreign exchange rate the instrument

39. The recent experience of Japan is quite different. Because the target inflation rate is too low, the economy can fall into a trap of the fundamental type, as in the examples of section 5.

variable, rather than the immobilized interest rate. Macroeconomic stimulus is generated by the purchase (with base money) of foreign exchange so as to satisfy the rule, which includes inflation as a principal target variable. Simulation exercises and impulse response functions indicate that macroeconomic stabilization can in fact be exerted by monetary policy in this manner, despite ZLB immobilization of the usual interest rate instrument.

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# Inflation Targeting in the Context of IMF-Supported Adjustment Programs

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For the last few years, the staff of the International Monetary Fund (IMF) has been engaged in assessing the functioning and effectiveness of inflation targeting in IMF member countries that have adopted this scheme as their monetary policy anchor. This involvement was restricted to the IMF's surveillance function, however, because the first countries to embrace inflation targets were industrialized economies. The assessments therefore constituted part of the macroeconomic analysis performed during the regular annual consultations between the IMF and its member countries, and they were not associated with IMF lending operations.

A number of emerging market economies have recently abandoned their fixed exchange rate regimes and moved toward a flexible exchange rate system with an explicit inflation-targeting framework for monetary policy. This made it increasingly likely that the IMF would be

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called on to provide financial assistance to a country that is using, or has decided to adopt, explicit inflation targets as the key component of its monetary policy framework. Indeed, the IMF faced just this situation in mid-January 1999, when the Brazilian authorities announced their intention of implementing a formal inflation-targeting framework shortly after adopting a floating exchange rate regime. In the months that followed, the framework was implemented in the context of the ongoing IMF-supported adjustment program.

These developments posed particular analytical and practical challenges in terms of the operational procedures of the IMF in its financial relations with its member countries. The challenge resulted from the need to reconcile the inflation-targeting framework with the conceptual and practical aspects of conditionality. Conditionality is the device used by the IMF in its financial programs to establish safeguards that increase the certainty that its resources are used only temporarily. This, in turn, implies the adoption of so-called performance criteria, that is, formal quantitative targets on a number of variables defined jointly by the member country and the IMF. The evolution of these variables is subject to verification, and the fulfillment of these criteria is the condition for disbursement. In the monetary policy area, performance criteria in Fund programs have traditionally been set in terms of specific quantitative limits on the evolution of certain monetary variables. Typically, a floor is set for the level of net international reserves (NIR) and a ceiling is established on the net domestic assets (NDA) of the central bank.

At first glance, therefore, the inflation-targeting framework, by the very nature of its operating procedures, appears to be incompatible with the traditional monetary conditionality framework usually embodied in Fund-supported adjustment programs. This is so because the actual implementation of inflation targeting is largely based on the premise that an independent central bank can use its various instruments at its own discretion, in the proportions considered appropriate in each particular circumstance, to ensure the attainment of its inflation goal. This clashes with a scheme that sets an explicit and somewhat rigorous quantitative objective for key monetary variables.

Because each member country has the prerogative to adopt the monetary policy framework of its choice, the IMF faced the question of whether and how to adapt monetary conditionality to the specific features of monetary policy under inflation targeting. In principle, inflation targeting can be accommodated within the traditional structure of monetary conditionality in Fund-supported adjustment programs, given that this conditionality focuses primarily on a program's balance-of-payments objective. At the same time, it may be desirable to modify and supplement

traditional monetary conditionality by introducing features that reflect the specific functioning of the inflation-targeting framework.[1]

This paper considers the issues that arise from the implementation of inflation targeting in the context of the conditionality embodied in Fund-supported adjustment programs and discusses a number of options for adapting monetary conditionality to these particular cases. The next section reviews the role of monetary conditionality in Fund-supported adjustment programs. Section 2 outlines traditional monetary policy conditionality and analyzes the practical problems that may arise in the context of inflation targeting. Section 3 then explores different options for implementing and strengthening monetary policy conditionality in the context of inflation targeting. Section 4 shows how monetary conditionality was adapted to inflation targeting in the context of the stand-by arrangement with Brazil, and section 5 tests how alternatives such as simple Taylor rules would have fared during the first year of inflation targeting in Brazil. Finally, the paper presents some preliminary conclusions, which are largely intended to stimulate further discussion.

## 1. Fund-Supported Adjustment Programs: The Role of Conditionality

In Fund-supported adjustment programs (or Fund programs), conditionality refers to the linkage between the achievement of a set of policy objectives and the continuous access to IMF resources.[2] The policy objectives are agreed between the IMF and the authorities of the member countries, and while these objectives vary, attaining a sustainable balance-of-payments position is the paramount target of every Fund program. Conditionality thus provides a safeguard for the IMF's financial resources. The specification of the policy objectives and the calibration of the quantitative targets should ensure that the need for such financing is only temporary and that the borrowed funds will be repaid. Put another way, conditionality provides a yardstick for evaluating whether the policies that are being carried out are moving the country toward the achievement of the policy objectives, in particular a

1. A number of internal documents were prepared and discussed within the IMF to clarify the various aspects of this approach. This paper reflects some of the considerations and arguments raised in those discussions.

2. The word conditionality does not appear in the IMF's Articles of Agreement, and the concept evolved in stages. See Gold (1979) for a discussion of the legal aspects of the development of IMF conditionality. Guitián (1981) discusses the evolution of Fund conditionality from an economic perspective.

sustainable external balance. By doing so, conditionality also ensures the temporary use of the IMF's resources.

The effective implementation of conditionality does not involve day-to-day monitoring of a country's macroeconomic policies, but rather requires a mechanism for assessing whether policies are on track for achieving their stated goals or whether they need to be adjusted in response to unanticipated shocks, changes in economic relationships, or other new information. The monitoring mechanism in Fund programs consists of a set of explicit criteria—particularly performance criteria, but also indicative targets and structural benchmarks—that must be met if a country wishes to make further drawings under the Fund program. These performance criteria typically refer to key macroeconomic variables that indicate whether macroeconomic policies are on track, including fiscal balances (such as overall or primary balances), indebtedness (for example, public sector debt, public external debt, and its short-term component), and monetary variables (such as NIR and NDA).[3] Fund programs may also include performance criteria related to certain structural reform measures (or structural benchmarks). While performance criteria permit a backward-looking assessment of policies, periodic program reviews, which are often carried out quarterly, provide for a forward-looking overall assessment of the Fund program vis-à-vis the government's macroeconomic policy objectives.

Quantitative macroeconomic performance criteria in Fund programs do not typically rely on a specific macroeconomic model. They do, however, make use of various balance-sheet identities that link monetary and fiscal variables with the balance of payments, which ensures that the Fund program is internally consistent. These performance criteria may best be thought of as signaling devices that flag a possible need for corrective action in case of deviations.

## 2. Monetary Conditionality: The Traditional Approach and its Implications for Inflation Targeting

Monetary policy conditionality is at the core of Fund program conditionality. As mentioned above, it has traditionally relied on two performance criteria: a ceiling on the central bank's NDA and a floor on its NIR.[4] This methodology evolved out of the concepts that arise from

3. NDA are usually defined to equal base money minus NIR.

4. While these have been by far the most common variables used in the design of monetary conditionality, other monetary aggregates have been targeted in many countries, and sub-ceilings for specific types of domestic assets have sometimes also been implemented.

the so-called monetary approach to the balance of payments, and it has been used under a variety of conditions and monetary policy frameworks. Its primary focus has always been to ensure that a Fund program leads to external sustainability rather than tight control over inflation. In this context, performance criteria that set a floor on NIR are designed to indicate whether a Fund program is likely to achieve its external objective. The ceiling on NDA serves as an additional protection, since it seeks to ensure that the external objective is not jeopardized by excessive credit expansion or by sterilized intervention, that is, by compensating unprogrammed NIR losses through additional credit creation. This framework is rooted in the assumptions that the demand for base money matters from a macroeconomic perspective and that it is stable and predictable.

In practice, the expected functioning of the NIR/NDA performance criteria would be as follows (see table 1 for an overview). An anticipated, or baseline, path for net international reserves is projected, and a floor for NIR is set at or somewhat below the baseline. At the same time, the NDA ceiling is established at a level that is consistent with the NIR baseline, in conjunction with the projected evolution of velocity. If a country's actual NIR start falling toward the agreed NIR floor—perhaps because of a sudden external shock—monetary policy needs to be tightened, usually through open market operations. The resulting increase in interest rates should stop further NIR losses. More generally, as long as actual NIR remain close to their baseline, the ceiling on NDA effectively limits base money expansion, thereby preventing monetary policies from putting additional pressure on the external balance and fueling inflation. The NIR/NDA mechanism thus sets off warning signals when NIR fall too low or when there is significant sterilization of unprogrammed sales of foreign exchange. However, the NIR/NDA framework does not prevent larger-than-programmed NIR increases from fueling monetary expansion and thus inflation.

It is within this context that the appropriateness of the traditional NIR/NDA framework under an inflation-targeting regime may be questioned. One may argue that since inflation targets go hand-in-hand with floating exchange rate regimes, floors on NIR have no place or are simply irrelevant.[5] However, while under inflation targeting the central bank would not be expected to use its NIR to stabilize the exchange rate per se, it may react to movements of the exchange rate to the

5. Of course, some inflation-targeting countries maintain (or at one time maintained) a managed float, sometimes even with exchange rate bands. This could lead to conflicting objectives between the inflation target and the exchange rate band.

**Table 1. General Overview of the Functioning of the NIR/NDA Mechanism**

| *Net international reserves (NIR)* | *Net domestic assets (NDA)* | |
|---|---|---|
| | *Higher than programmed* | *Lower than programmed* |
| Higher than programmed | Usually reflects overexpansion of base money, even exceeding the nonsterilization of the higher-than-programmed NIR; it could also reflect a flawed initial projection of base money. Policy action: monetary policy tightening to reduce NDA. | The program targets have been met. No policy action needed. |
| Lower than programmed | Insufficient monetary tightening; NIR losses have been oversterilized. Policy action: monetary tightening to reduce NDA. | Loss of NIR can be sterilized as long as actual NDA is below the NDA ceiling; interest rates are most likely kept above the assumed baseline path to stem the NIR losses. No further sterilization of NIR losses is allowed once actual NDA reaches the NDA ceiling. |

extent that they threaten the inflation target. Most floats are not pure floats, so trade-offs between domestic objectives (that is, inflation) and external objectives (that is, external sustainability) may be unavoidable, at least conceptually. Even when the exchange rate is flexible, retaining a NIR floor simply reflects the fact that one important aspect of a Fund program is to safeguard external sustainability.

An NIR floor safeguards external sustainability independently of the monetary policy framework. Retaining an NDA ceiling in the context of inflation targeting, however, may seem somewhat more problematic. If the central bank targets inflation and the Fund program focuses on the quantity-based framework of NDA ceilings, then cases could arise in which the monetary objectives underlying these programs do not correspond with the relevant instruments for achieving the inflation targets. In addition, communication with the markets and the public regarding the stance of monetary policy could easily become outright confusing. This is an important concern, because inflation targeting, by its very nature, relies critically on the transparency of the central bank's policy actions. This general problem is compounded by the fact that inflation is not primarily a function of NDA or its components, and it is therefore unlikely to respond predictably or immediately to changes in NDA or base money.

**Table 2. Monetary Conditionality with NDA and Inflation Targets**

| *Actual NDA relative to program assumption* | *Inflation target (IT)* | |
|---|---|---|
| | *Threatened* | *Not threatened* |
| Higher than programmed | NDA and IT give the same signal: tighten monetary policy. | NDA and IT give a different signal: NDA suggests tightening; IT suggests no tightening is needed. |
| Lower than programmed | NDA and IT give a different signal: IT suggests tightening; NDA suggests no tightening is needed. | NDA and IT give the same signal: no tightening of monetary policy is needed. |

Hence, an NDA ceiling could easily set off false alarms and confuse markets when there is, in fact, no need to change monetary policy from the point of view of the inflation objective. For example, actual NDA could conceivably exceed the NDA ceiling, while both actual and projected inflation are still within their target. Should monetary policy be tightened in these circumstances, or should the NDA ceiling be revised upward? Since inflation is the target, an upward adjustment of the NDA ceiling seems to be the only appropriate course of action. Similarly, when actual NIR is running significantly above the NIR floor while base money is close to the projected baseline, monetary policies could only be eased to the extent that the inflation objective is not jeopardized. As shown in table 2, when inflation is the overriding objective, having an NDA ceiling may be considered somewhat superfluous or, at least, a nonbinding constraint.

## 3. Options for Implementing and Strengthening Monetary Conditionality under Inflation Targeting

An increasing number of countries have abandoned fixed exchange rate regimes and moved toward formal inflation targeting. Given the potential inconsistencies that could arise in the context of Fund programs, monetary conditionality needed to be modified to reflect more closely the main parameters of decision making under inflation targeting. Under inflation targeting, monetary conditionality should ideally be geared toward the evaluation of the monetary policy stance vis-à-vis the government's announced inflation target. However, this would require an exceedingly good understanding of the transmission channels and the precise parameters of monetary policy.

Moreover, monetary conditionality should primarily apply to specific policy actions and policy instruments, since country authorities cannot commit to achieving a particular level of a variable over which they do not exercise some decisive degree of control. Monetary conditionality should therefore involve the parameters of a policy reaction function, that is, the summary forward-looking rule governing the policy responses to projected deviations of inflation from the inflation target. Following this reasoning, a conditionality device that could potentially be included in Fund programs under inflation targeting is an operational rule for reacting to actual or expected deviations from the targeted inflation path. This rule should ideally be a simple but robust reaction function that relates changes in an instrument (such as interest rates) to deviations of inflation from its target. In practice, however, it would be difficult, if not impossible, to specify the exact timing and size of the response parameter, for example, by how much and at what moment an interest rate should be adjusted when projected inflation deviates from its target by a given amount. Also, while a very specific reaction function may work in one program, it may not be sufficiently general and flexible to accommodate different approaches to inflation targeting. Given the IMF's commitment to providing equality of treatment to all its members, such a mechanism could possibly entail some problems of cross-country comparability.

Despite these limitations, and while it may not be possible to specify a precise and robust policy reaction function, it may still be useful to strengthen monetary policy conditionality by establishing a simple, forward-looking mechanism for gauging the monetary policy stance vis-à-vis the inflation target. Taylor rules for the short-term interest rate or McCallum rules for the monetary base, for example, are simple monetary policy rules that are quite flexible for encompassing a range of relevant information. A simple Taylor rule can be expressed as

$$r = r^* + \alpha\left(Y - Y^*\right) + \beta\left(\pi - \pi^*\right),$$

where $r$ is the nominal short-term interest rate; $r^*$ is an estimated nominal equilibrium interest rate that is consistent with the target inflation rate (that is, $r^* = \bar{r} + \pi^*$, with $\bar{r}$ being the equilibrium real interest rate and $\pi^*$ being the relevant inflation target); $Y$ is output; $Y^*$ is capacity output; $\pi$ is inflation (either actual or projected); and $\alpha$ and $\beta$ are coefficients, with $\alpha \geq 0$ (typically between 0 and 0.5, depending on the degree to which the output gap figures in the central bank's

reaction function) and $\beta > 0$ (typically between 1.5 and 2, so that the nominal short-term interest rate moves significantly in response to deviations of inflation from the inflation target).[6] In an open economy, one could add a number of other variables to this rule, such as the external current account or the foreign output gap. The rule could also include other variables that reflect conditions in the domestic economy, such as the budgetary balance or other fiscal variables.

It is also feasible to include different inflation measures in a Taylor rule, as in the following rule:

$$r = r^* + \alpha\left[\gamma\left(\pi^a - \pi^*\right) + (1-\gamma)\left(\pi^p - \pi^*\right)\right],$$

where $\pi^a$ is actual inflation, $\pi^p$ is projected inflation, and $0 < \gamma < 1$. One could include competing inflation projections in a similar fashion. Taylor rules are thus very flexible and can be specified to encompass a number of country-specific considerations.

Given that a key element in a Taylor rule is the parametric reaction to deviations between actual or projected inflation and the inflation target, an obvious weakness of such an approach is that the rule will not react to shocks to omitted variables. A Taylor rule will only show a reaction to an external shock if that shock is somehow included in the rule. A Taylor rule is thus likely to be of only limited use to policymakers facing real-time decisions, although it does serve as a simple and easily understood starting point for thinking about monetary policy.[7] Such considerations also apply for including a Taylor rule in a Fund program: it provides a rough check on the monetary policy stance. In practice, the exact specification of the rule would probably involve some trial and error. Specifying the rule somewhat cautiously could help reduce the likelihood of false alarms. For example, one might set $\bar{r}$, the equilibrium real interest rate that underlies $r^*$, slightly below the best available estimate based on historical data; this would add some limited flexibility for lowering interest rates.

In practical terms, the question of adapting monetary conditionality, beyond the incorporation of some sort of Taylor rule continues to turn on the question of the NIR/NDA framework. As discussed below in the context of the Brazilian program, the current view is that NIR floors are still necessary to safeguard the external objectives of the program, but NDA ceilings may not be the preferred choice for monetary conditionality. The

6. See Taylor (1993) for the original formulation.
7. See, for example, Kozicki (1999) for a review.

ceiling on NDA could be justified in that it would probably prevent large departures from inflation objectives, but it may not provide adequate guidance for a monetary policy aimed at a more precise inflation target. The main objective of these quantitative limits in inflation target situations would be to reinforce the country's commitment to a flexible exchange rate policy and to limit sterilized foreign exchange market intervention and base money expansion when the external position is weak.[8]

Another element in the adaptation of conditionality should be the enhanced role of policy reviews, which should be broadened to include an assessment of monetary policy in the context of inflation targeting. This procedure should entail, but not be limited to, the agreement on a reaction function or the possible specification of a Taylor rule. The program would need to specify a quarterly inflation path consistent with the authorities' inflation targets; the reviewers would then compare current and projected inflation with these targets, and they would negotiate specific policy actions whenever the outlook suggested that inflation objectives were likely to be missed.

## 4. Adapting Monetary Conditionality to Inflation Targeting: The Case of Brazil

Brazil was the first inflation-targeting country with a Fund-supported adjustment program, and it took some time to tailor the program to the floating exchange rate regime with a nominal inflation anchor. In part, this reflected the need to take into account the institutional constraints that require similar treatment across countries and, therefore, a high degree of comparability among Fund programs. The Fund program with Brazil initially relied on the standard monetary conditionality of an NIR floor and an NDA ceiling, although it introduced some interesting innovations. Thus the initial program in December 1998, which was introduced under a fixed exchange rate regime, relied mainly on a strict NDA ceiling for conditionality in the monetary area. The NDA ceilings were made less binding after Brazil adopted the inflation-targeting framework, and they were completely phased out in June 2000 when the inflation-targeting framework was fully established (see table 3). The initial program also included an NIR floor that was intentionally fixed at a low (or nonbinding) level to allow the Central Bank of Brazil to use part of its actual NIR to defend the fixed exchange rate, if

8. Such safeguards seem especially relevant when the authorities view exchange market pressures as essentially short lived.

## Table 3. Brazil: Overview of Monetary Policy Conditionality under the Standby Arrangement, 1998–2000

| *Arrangement or review* | *NDA ceiling* | *NIR floor* | *Inflation targets* |
|---|---|---|---|
| Initial standby arrangement (December 1998) | NDA ceilings were specified on the basis of a specific sterilization rule, with a sterilization parameter that became more restrictive as NIR dropped further below the projected baseline path and toward the NIR floor. | Nonbinding performance criterion on NIR consisted of a low floor of US$20 billion. | None |
| First and second reviews (March 1999) | NDA ceilings were retained; they were specified using the projected baseline paths for the monetary base and NIR (with a small cushion). | No explicit NIR floor. An implicit NIR floor was specified in the form of maximum monthly intervention limits for the sale of international reserves by the Central Bank; these intervention limits were only partly cumulative, in that only a portion of any unused intervention room could be carried over to the next month. | None |
| Third review (July 1999) | NDA specified on the basis of the NIR floor rather than the NIR baseline, which abandoned the idea of sterilization of NIR losses if actual NIR were to drop below the NIR baseline as long as they remained above the NIR floor. | The NIR floor was specified with an overall intervention room of about US$3 billion relative to the NIR baseline. | Included a general consultation clause on the implementation of the inflation-targeting framework, but without reference to the specific numerical path. |
| Fourth review (November 1999) | The NDA ceiling was downgraded from a performance criterion to an indicative target; it continued being specified on the basis of the NIR floor. | The NIR floor was established with an intervention room of about US$2 billion relative to a fairly conservatively estimated NIR baseline. | Included a specific consultation clause on the inflation target, with a quarterly inflation path and a two-tiered consultation mechanism. |
| Fifth review (March 2000) | Refrained from establishing NDA ceilings beyond June 2000. | The NIR floor was established without strict reference to the estimated NIR baseline, but instead was fixed at a flat monthly level of US$25 billion. | The two-tiered quarterly consultation mechanism on inflation was retained. |

needed. The NIR floor became the key instrument of conditionality during the first few reviews in 1999, within an environment in which uncertainty concerning the new nominal anchor was still considerably high. In July 1999, the NIR/NDA conditionality was supplemented with a general consultation mechanism on inflation targets. The program then incorporated a formal consultation band on inflation to supplement the floor on NIR in November 1999, less than six months after the inflation-targeting framework was adopted by the Brazilian authorities.

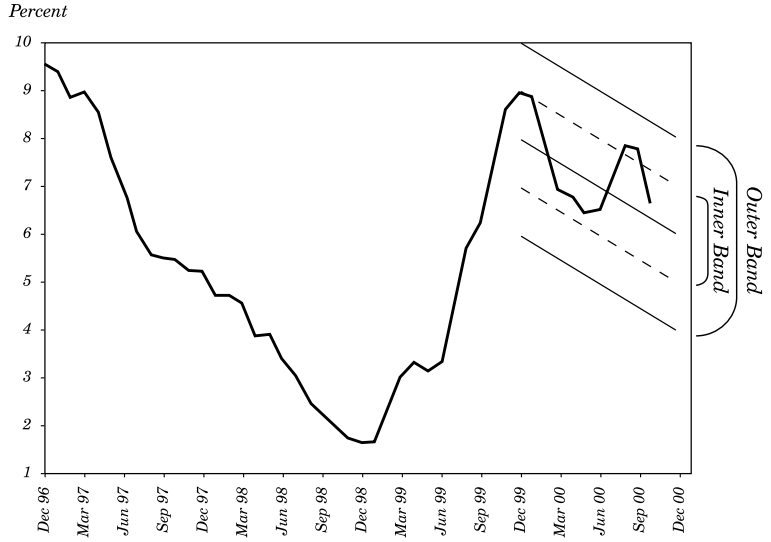
The progressive shift away from NDA ceilings following the adoption of the inflation-targeting framework reflected the need to adapt the program to the changes in the monetary policy regime. The shift also reflected the growing realization that base money did not play a significant role in the monetary transmission mechanism in Brazil.[9] Money demand in general, and the demand for base money in particular, were not very sensitive to interest rates in Brazil. Seasonalities, remonetization under the Real Plan, and the effects of tax changes were quantitatively more important and statistically more significant determinants of base money than variables like income or the interest rate.[10]

The formal consultation mechanism on inflation, which was introduced in the November 1999 review, was based on the annual central inflation target and the tolerance bands announced by the Brazilian

9. The main transmission channels of monetary policy are the exchange rate, wages, asset prices, and aggregate demand. In the case of Brazil, the economic conditions that have prevailed since the inflation-targeting framework was adopted in mid-1999 have been characterized by fairly high real interest rates, tight fiscal policy, relatively subdued aggregate demand, and negative real wage growth. The exchange rate appears to have been the main channel of transmission to inflation. This is consistent with recent findings that suggest that the unwinding of real exchange rate misalignments in the context of a depreciation is the most important determinant of inflation in developing economies (Goldfajn and Werlang, 2000; also see Schwartz, 1999, for the case of Brazil). Of course, the exchange rate itself is not a policy variable under a floating exchange rate regime. For a discussion of the transmission mechanism of monetary policy in Brazil, see Rabanal and Schwartz (2001b).

10. For establishing NDA ceilings, the demand for base money was estimated as the sum of its two parts: currency issued and reserves on demand deposits. Currency issued was usually estimated using a linear trend (to capture the ongoing remonetization of the economy), various seasonal dummies (for example, for December, January, and February), and lagged dependent variables. Demand deposits were usually estimated using seasonal dummies, dummies for tax effects (for example, changes in the tax on financial transactions and the nominal interest rate). Reserves on demand deposits were derived by applying an effective reserve rate to the projected level of demand deposits. In the short term, these projections fared quite well, but larger deviations from the econometric estimates occurred when seasonalities shifted (for example, when carnival fell in March instead of February) or when special factors (such as tax changes or the Y2K bug) did not have the anticipated effects.

**Figure 1. Brazil: Twelve-Month Rate of Consumer Price Inflation (IPCA) and Inflation Targets**




Source: Brazilian Institute for Geography and Statistics (IBGE); Central Bank of Brazil.

government.[11] The program established a simple linear quarterly path in which the central inflation target and the outer band surrounding the target decline by 0.5 percentage points each quarter. The program further established an inner consultation band of ± 1 percentage point around the target path, which follows exactly the same linear quarterly pattern as the target path and the outer band. This was the program's innovation in conditionality: the Brazilian authorities would informally consult with IMF staff on the appropriate policy response if the observed twelve-month rate of inflation were to go above the inner band; they would more formally consult with the IMF Executive Board on the appropriate policy response if the observed twelve-month inflation rate of the IPCA (a consumer price index) were to go above the outer band.

How has this mechanism worked so far? Figure 1 shows Brazil's actual inflation performance in relation to the consultation bands. The Central Bank met its official inflation targets for both year-end 1999 and year-end 2000. The Fund program's consultation mechanism on inflation was triggered in September 2000, when the twelve-month inflation

11. Specifically, 8 percent at year-end 1999 and 6 percent at year-end 2000, each with a tolerance band of ±2 percentage points (the outer band) around the central target.

rate of the IPCA reached 7.7 percent, thereby temporarily exceeding the 7.5 percent threshold requiring consultations with the Fund staff. This reflected a temporary surge in monthly inflation rates in July and August, due to unanticipated supply shocks that abated in September; core inflation had already remained relatively more subdued throughout the third quarter of 2000. As expected, and facilitated by the continued firm stance of monetary policy, the inflation rate of consumer prices declined in the fourth quarter of 2000, to match the official 6 percent target by year-end.

## 5. Actual Policies and Taylor Rules: A Simulation for Brazil

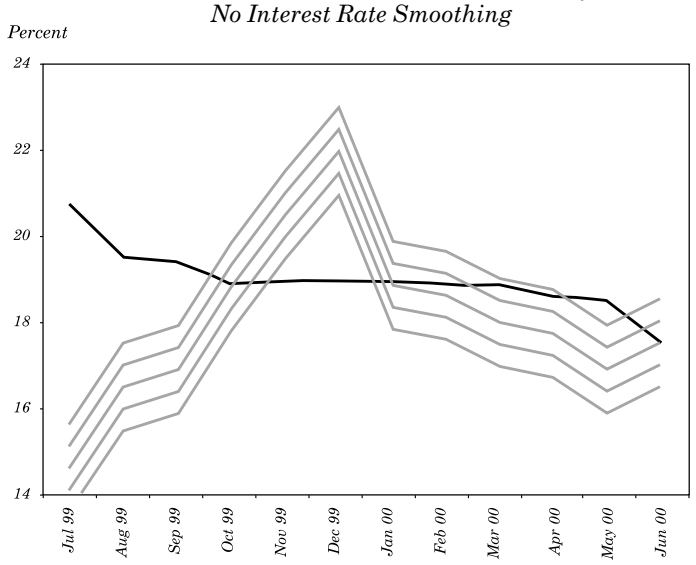
This section explores the usefulness of establishing simple Taylor rules to strengthen the monitoring of monetary policy in the context of a Fund program in a country operating under an inflation-targeting framework. The basic idea is simple: if a simple monetary policy rule can be shown to track actual policies fairly well, then it may be possible to use that rule to help evaluate the appropriateness of the current monetary policy stance vis-à-vis the inflation target. Using the experience of Brazil during its first year under inflation targeting as an example, we ask whether a simple Taylor rule—a rule of the type that could in principle be included in a Fund program—would have provided a useful assessment of the monetary policy stance.

Figures 2 and 3 show the actual interest rate, the SELIC overnight rate, plotted against two alternative Taylor rules, with different values for the $\alpha$ and $\beta$ parameters. In the first alternative, $\alpha$, the parameter on the output gap, equals 0.5 and $\beta$, the parameter on the deviation of actual inflation from target, equals 1.5. The second version is an aggressive Taylor rule, featuring only the deviation of inflation from target ($\beta = 2$). Figure 3 differs from figure 2 in that it includes an interest smoothing parameter, $\rho$, which is set at 0.6.[12] In both figures, the actual twelve-month rate of inflation is initially used in the simple Taylor rule. The Taylor rule bands shown in these two figures are generated by different assumptions on the equilibrium real interest rate, $\bar{r}$, ranging from 10.5 percent to 12.5 percent. For the purpose of the simulations, the potential output growth rate was assumed to be 4 percent, although a lower potential growth rate (of 3 percent) resulted in only a slightly higher nominal interest rate.

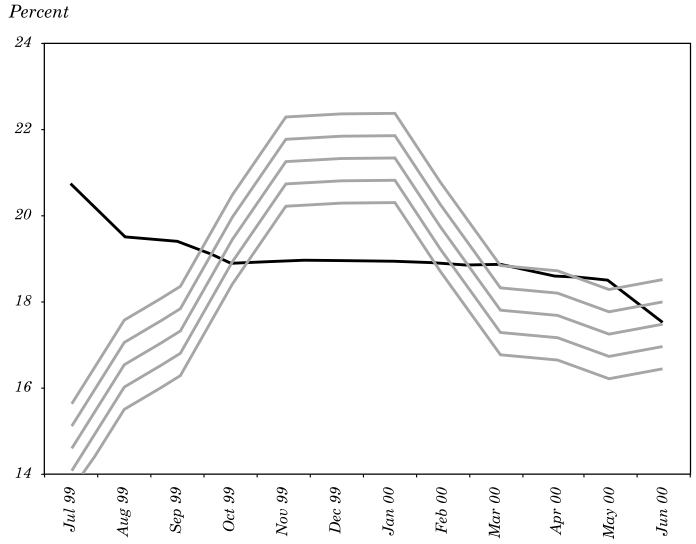
12. The interest smoothing parameter introduces some inertia into the Taylor rule by mitigating the extent to which the central bank reacts to new information. See the appendix for further detail on the simulations that were carried out.

**Figure 2. Brazil: Taylor Rules with Current Inflation**

*The SELIC and a Simple Taylor Rule ($\alpha = 0.5$, $\beta = 1.5$)*
*No Interest Rate Smoothing*



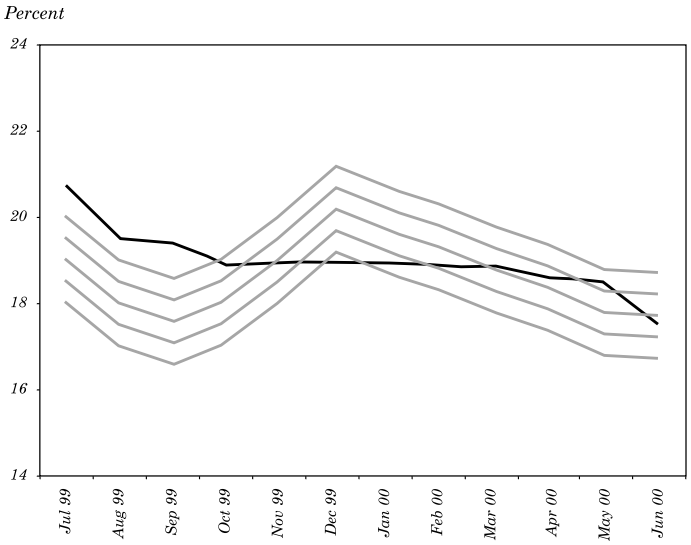

*The SELIC and a Simple Taylor Rule ($\alpha = 0$, $\beta = 2$)*
*No Interest Rate Smoothing*



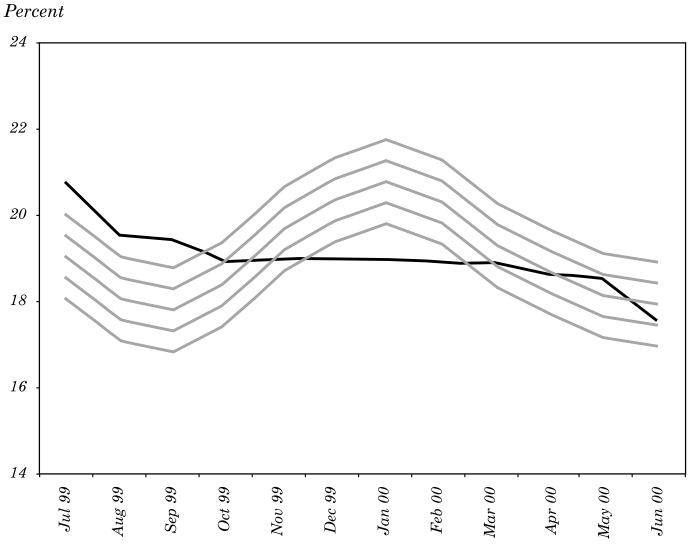

Source: Central Bank of Brazil; authors' estimates.

**Figure 3. Brazil: Taylor Rules with Current Inflation**

*The SELIC and a Simple Taylor Rule ($\alpha = 0.5$, $\beta = 1.5$)*
*Interest Rate Smoothing ($\rho = 0.6$)*




*The SELIC and a Simple Taylor Rule ($\alpha = 0$, $\beta = 2$)*
*Interest Rate Smoothing ($\rho = 0.6$)*




Source: Central Bank of Brazil; authors' estimates.

Three periods are clearly distinguishable in both figures. In the first period, between July 1999 and September 1999, the Central Bank kept the annual overnight interest rate (or the SELIC rate) at a higher level than what a simple Taylor rule would have suggested; this basically reflects the relatively low pass-through that occurred in the first couple of months after the real was left to float. When the inflation-targeting framework was launched in July 1999, inflation was at a very moderate level, but it was expected to rise. Authorities were concerned about an increasing pass-through (given the existing transmission lags), as well as about establishing the Central Bank's reputation. They therefore initially adopted a tougher policy stance than what would have been indicated by a simple Taylor rule without expectational variables.

The second period runs from October 1999 to January-February 2000 and includes the inflation peak of December 2000. The Central Bank basically held interest rates steady throughout this period. In particular, the Bank did not raise the SELIC, as would have been suggested by a simple Taylor rule. The increase implied by a simple Taylor rule would have been particularly large without interest smoothing (figure 2), whereas it would not necessarily been so with interest smoothing (figure 3), depending on the value used for the equilibrium real interest rate, $\bar{r}$ . Although inflation was higher than expected in the last quarter of 1999, the Brazilian authorities clearly perceived the situation as transitory. This view was supported by market surveys taken at the time. As a result, the actual SELIC was kept somewhat below the rate that our simple Taylor rule without expectational variables would have suggested.

The third period started in February-March 2000. In this period, inflation continued on a downward trend and remained in line with the inflation target. The reduction in inflation kept the actual SELIC within the bands of the Taylor rule. The actual SELIC remained basically unchanged at an annualized rate of 18.5 percent until June 2000, when a reduction of 100 basis points took place; a further reduction of 50 basis points (to an annualized rate of 17 percent) took place on 7 July.

The stabilization of consumer price inflation is actually quite remarkable given the presence of various factors that could have induced a temporary increase in prices, such as the increase in wholesale prices, the increase in import prices, the increase of minimum wages (and the discussion surrounding it), uncertainty about the behavior of the exchange rate in the context of more volatile international capital markets, and uncertainty stemming from the potential fiscal costs of some pending court rulings.

This simple exercise may be interpreted in different ways, which basically depend on how the Taylor rule is intended to be used. Simple, mechanistic rules are not useful in policymaking. The models used by the Central Bank of Brazil and other central banks are much more sophisticated, although they are still considered small-scale models.[13] At the same time, simple rules may provide a rough first evaluation of a policy stance. This is probably one of the reasons why the U.S. Federal Reserve Bank of St. Louis, for example, publishes the results of simple Taylor rules and McCallum rules in its monthly economic reports.[14] Simple Taylor rules may only be expected to perform satisfactorily in an environment in which relatively low inflation has already been achieved and in which the overall macroeconomic environment is fairly stable (for example, with continued tight fiscal polices and a stable exchange rate).

In a more unstable or uncertain environment, other variables should probably be included to make the Taylor rule more realistic. A more realistic Taylor rule would not necessarily involve a more complicated rule, however. Central banks do not only react to current levels of specific variables but also to their expected future levels—they are clearly forward looking. Since the different transmission channels of monetary policy are known to operate with some lags, all central banks forecast the behavior of inflation in one way or another.

Figures 4 and 5 again simulate a simple Taylor rule, but using market projections of inflation as derived from the Central Bank's daily survey on market expectations.[15] In these examples, the Taylor rule suggests that in the second period (from October 1999 to January-February 2000), the Central Bank did not need to react sharply to the pickup in inflation that occurred in the last quarter of 1999. While markets (and the Central Bank) initially may have been surprised by the inflationary outcome in the last three months of 1999, they perceived it as transitory. In early 2000 markets expected the real to appreciate in nominal terms; this was accompanied by expectations of a reduction of the inflation rate (or the pass-through). A Taylor rule that uses expected inflation thus seems to converge to the actual SELIC rate slightly faster than a rule that only uses the current inflation rate.

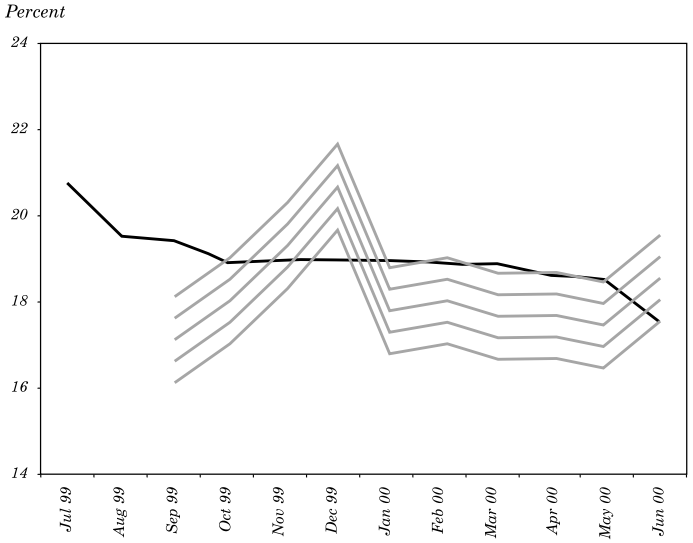
13. See Bogdanski, Tombini, and Werlang (2000). Also see Rabanal and Schwartz (2001a) for a review of the inflation-forecasting performance of the small-scale model used by the Central Bank.

14. See the Federal Reserve Bank of St. Louis (1999–2000).

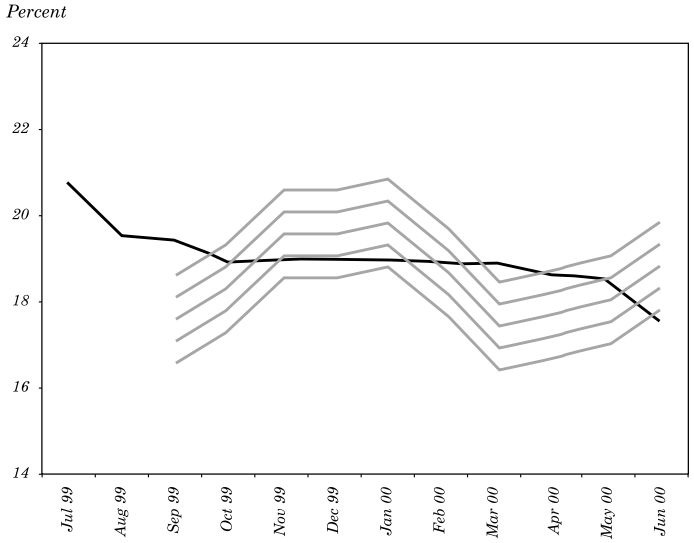
15. For the purpose of the Taylor rules, the expected inflation for a given month was generated by using the average expected inflation for that month, as shown in surveys carried out by the Central Bank in the immediately preceding month.

**Figure 4. Brazil: Taylor Rules with Market Expectations of Inflation**

*The SELIC and a Simple Taylor rule ($\alpha = 0.5$, $\beta = 1.5$)*
*No Interest Rate Smoothing*



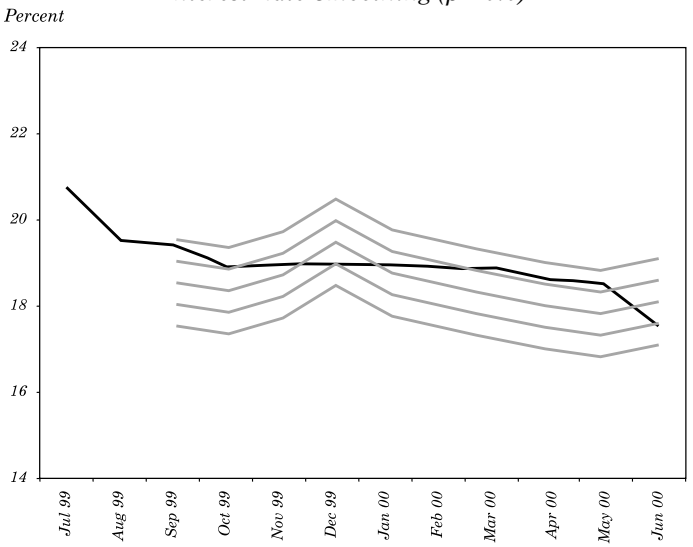

*The SELIC and a Simple Taylor Rule ($\alpha = 0$, $\beta = 2$)*
*No Interest Rate Smoothing*



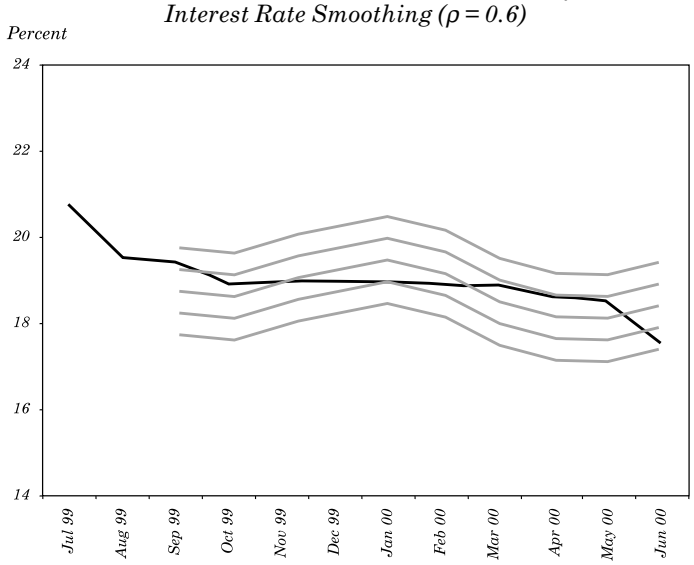

Source: Central Bank of Brazil; authors' estimates.

**Figure 5. Brazil: Taylor Rules with Market Expectations of Inflation**

*The SELIC and a Simple Taylor Rule ($\alpha = 0.5$, $\beta = 1.5$)*
*Interest Rate Smoothing ($\rho = 0.6$)*




*The SELIC and a Simple Taylor Rule ($\alpha = 0$, $\beta = 2$)*
*Interest Rate Smoothing ($\rho = 0.6$)*




Source: Central Bank of Brazil; authors' estimates.

## 6. Concluding Remarks

In Fund programs, conditionality links the achievement of a set of policy objectives to continued access to IMF resources. It provides a yardstick for evaluating whether the policies that are being carried out are moving the country toward the achievement of stated policy objectives, in particular a sustainable external balance. Conditionality thereby safeguards the temporary use of the IMF's resources.

In the monetary area, conditionality has traditionally relied on two performance criteria: a ceiling on the central bank's NDA and a floor on its NIR. The primary focus of this approach has always been a program's external sustainability, rather than inflation. The main role of the NIR floor is to indicate whether a Fund program is likely to achieve its external objective, while the ceiling on NDA seeks to ensure that this objective is not jeopardized by excessive credit expansion or by sterilized intervention, that is, by compensating unprogrammed NIR losses through additional credit creation. The framework assumes that the demand for base money matters from a macroeconomic perspective and that it is stable and predictable.

When Fund program countries base their monetary policies on explicit inflation targets, traditional monetary conditionality should be adapted to the specific features of inflation targeting. This would help to improve the correspondence between the monetary objectives of the central bank and the targets of the IMF-supported adjustment program, and it would strengthen the instruments that are used to achieve these targets and objectives. It would also facilitate the communication of central bank policies to the markets.

As a first step, a Fund program could include the government's inflation target itself, as was the case in Brazil. This may require specifying the target in more detail than the official target. For example, most countries operate with annual inflation targets; Fund programs are frequently monitored on a quarterly basis, however, such that additional quarterly inflation objectives may have to be added. Furthermore, a consultation mechanism needs to be established to allow program reviews to take place if inflation goes off-track. This, in turn, requires specifying parameters around the targeted inflation rate that would trigger such reviews. In the case of Brazil, the program established consultation bands around the central target, which would trigger consultations with either Fund staff or the Fund's Executive Board, depending on the size of the deviation from the target.

A potential drawback of monitoring a Fund program on the basis of inflation outcomes—for example, on the basis of the actual twelve-month inflation rate vis-à-vis the target twelve-month inflation rate—is that this process is largely backward looking, that is, the inflation outcome itself offers no guidance as to the appropriateness of the stance of monetary policies. Hence, inflation targets in the context of a Fund program work much the same way in which they are used by the government: they serve as a parameter for carrying out an ex post analysis of central bank policies. It is not enough to look at actual inflation, however, to analyze the appropriateness of the current monetary policy stance. This raises the question of whether additional options are available for further strengthening monetary conditionality under inflation targeting in the context of a Fund program.[16] This could be achieved either through regular, frequent consultations or through a forward-looking trigger mechanism for consultations between the country authorities and the Fund.

One option that has been explored in this paper is the use of simple monetary policy rules, such as Taylor rules or McCallum rules, as a potential trigger mechanism for such consultations. While simple policy rules are not a useful device for policymaking, they do provide a rough first evaluation of a policy stance. To illustrate the point, we tested various simple Taylor rules, using the successful experience of Brazil in its first year under inflation targeting as an example. The results of the simulations suggest that simple mechanical rules may indeed provide some rough initial guidance on the appropriate level of interest rates, particularly in an environment characterized by relatively low inflation and a fairly stable overall macroeconomic environment (featuring, for example, continued tight fiscal polices and a stable exchange rate).

Taylor rules or other rules that provide a rough evaluation of central bank policies merit further exploration as possible mechanisms for strengthening Fund conditionality and, in particular, helping monitor the stance of monetary policies vis-à-vis a government's inflation target. To be useful in the context of a Fund program, the rules should be kept simple and forward looking, in the sense that they should include inflation expectations.

16. Knight (1999) also provides suggestions on IMF conditionality in the context of inflation targeting.

## APPENDIX

### Simulation of Taylor Rules

We simulate a simple Taylor rule for Brazil during 1999–2000 to compare actual policy outcomes with rule-based policy prescriptions. Using monthly data, the simulated rule takes the standard form, with

$r_t = \rho r_{t-1} + (1-\rho)[r^* + \alpha y_t + \beta(\pi_t - \pi_t^*)]$ and

$r^* = \bar{r} + \pi_t^*$,

where $r_t$ is the annualized overnight interest rate (the SELIC rate) in period $t$; $\rho$ is the interest-smoothing parameter with $0 \leq \rho \leq 1$; $y_t$ is the output gap in period $t$; $\pi_t$ is the twelve-month inflation rate in period $t$; $\pi_t^*$ is the inflation target applicable to period $t$; $r^*$ is the equilibrium nominal interest rate; and $\bar{r}$ is the equilibrium real interest rate. Parameters $\alpha$ and $\beta$ are the parameters of the Taylor rule; for simplicity, we choose those suggested in Taylor's original formulation, with $\alpha$ equal to either 0 or 0.5, depending on whether output considerations can be assumed to be part of the central bank's objective function, and $\beta$ is either 2.0 or 1.5, accordingly.

We generally use monthly end-of-period data for the SELIC rate and the other variables in the model. The output gap was first estimated by fitting a linear trend on the natural logarithm of monthly GDP, as estimated by the Central Bank. This yielded a relatively low potential real output growth, and we subsequently used values in the more realistic range of 3–4 percent. The value of the equilibrium real interest rate was initially assumed to be 12.0 percent, but we then used values in the 10.5 percent to 12.5 percent range to generate the Taylor rule bands.

The inflation target for each month is a linear extrapolation of the quarterly targets for December 1999 to December 2000 that were used under the IMF program. For the period before December 1999, when inflation was still low, we used the lower band of the target range to simulate the Taylor rule and then linearly increased it to reach 8 percent (the central target) in December 1999. Hence, for July 1999, we assume that the Central Bank did set its inflation target in the lower limit of its annual band for 1999 (6 percent), and that it increased this linearly to reach the inflation target of 8 percent in December 1999. However, using the December 1999 target for the period leading up to December 1999 did not change the outcomes qualitatively.

We simulate four policy rules: the original Taylor rule (setting $\alpha = 0.5$ and $\beta = 1.5$) with no interest rate smoothing ($\rho = 0$); the original rule with interest rate smoothing ($\rho = 0.6$); a more aggressive rule that only targets inflation ($\alpha = 0$, $\beta = 2.0$), with no interest rate smoothing ($\rho = 0$); and the more aggressive rule with interest rate smoothing ($\rho = 0.6$). Choosing $\rho = 0.6$ strikes a balance between having a fairly high degree of interest rate smoothing and letting the effect die out after only a few periods.

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# Inflation Targeting and the Inflation Process: Lessons from an Open Economy

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Inflation targeting in an open economy involves a number of complexities that do not arise with inflation targeting in a closed economy. One of these is that central banks in open economies have to decide how to respond to changes in the exchange rate. Pitchford (1993), Svensson (1998), and Ball (1998) examine this issue theoretically, and in broad terms, they reach the conclusion that in the presence of exchange rate shocks, central banks should consider targeting a measure of nontraded, or domestic, inflation rather than the aggregate inflation rate. The implication of their analysis is that central banks should respond to developments in the exchange rate, but only to the extent that the shocks to the exchange rate stimulate output growth in the economy or affect aggregate inflation expectations.

In the broader discussion of optimal policymaking under an inflation target, several papers use the Ball-Svensson framework to explore the impact of including nontraded rather than aggregate inflation in the central bank's objective or policy reaction function.[1] Others investigate how the specifics of the exchange rate pass-through process affect the monetary policy decision.[2] In many cases, these issues are discussed in the context of policy reaction functions that are variants of the Taylor rule.

We would like to thank Adam Cagliarini and Ben McLean for superb research assistance.

1. Bharucha and Kent (1998); Ryan and Thompson (2000).
2. Cunningham and Haldane (2002).

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In this paper, we summarize the essential features of an economy that affect the choice between targeting aggregate and nontraded inflation, and we examine the issue empirically. The empirical part of the paper has two components. Section 2 uses an empirical model of the Australian economy to illustrate the choice between targeting aggregate inflation rather than a measure of nontraded inflation and outlines some of the aspects of the economy that affect that choice. We examine the tradeoff in the context of both optimal policymaking and policymaking that uses a Taylor-type rule to set interest rates. These results, however, depend on our understanding of the inflation process. Section 3 thus examines the inflation process in Australia over the last two decades, using reduced-form price equations that are often used for forecasting. Specifically, we look at changes in the responsiveness of the inflation rate to exchange rate shocks and deviations of output from potential, and we examine variations in the persistence of the inflation process over time. The results for Australia are compared with those for the United States, the United Kingdom, Canada, and New Zealand.

## 1. Which Inflation Rate To Target In An Open Economy?

An important issue that confronts an inflation-targeting central bank in an open economy is that changes in the exchange rate can have a significant effect on inflation outcomes via the prices of traded goods. If the central bank is pursuing a strict inflation target, the policy responses required to offset the effects of exchange-rate-induced changes in inflation may be damaging to the nontraded sector of the economy, and they can generate a large degree of volatility in output.

Consequently, Ball (1998) and Svensson (1998) suggest that it may be preferable for a central bank to target a measure of inflation that abstracts from these direct exchange rate effects. This section reviews their arguments and outlines the main considerations that might affect the choice of which inflation rate to target.

These issues can be illustrated by the following simple model, which is similar to that in Ball and Svensson:

$$y_t = \phi y_{t-1} - \beta r_{t-1} - \alpha e_{t-1} + \varepsilon_1 , \tag{1}$$

$$\pi_t = \pi_t^e + \delta y_{t-1} - \gamma \Delta e_t + \varepsilon_2 , \text{ and} \tag{2}$$

$$\Delta e_t = r_t - r^* + \varepsilon_3 , \tag{3}$$

where $y$ is the output gap, $r$ the real policy interest rate, $e$ the real exchange rate, and $\pi$ inflation.

The first equation is an aggregate demand equation, in which monetary policy is assumed to affect output with a one-period lag. A depreciation of the exchange rate also leads to an expansion in output with a one-period lag, through its effects on net exports. The second equation is an open-economy Phillips curve. Changes in the exchange rate are assumed to be passed through immediately to the prices of imported goods in the consumer price basket. For the moment, inflation expectations are assumed to be backward looking, depending on past values of the aggregate inflation rate; this is discussed further below. Note that exchange rate changes affect inflation more rapidly than they do output. The third equation explains the dynamics of the exchange rate in terms of an interest rate parity condition.

The central bank is assumed to have an objective function of the standard form,

$$\sum_{s=1}^{\infty} \theta^{s-1} \left[ (1-\lambda)\left(\pi_{t+s} - \pi^*\right)^2 + \lambda y_s^2 \right], \tag{4}$$

where $0 \leq \lambda < 1$. The central bank sets its policy instrument to minimize deviations of inflation from its target and to minimize the output gap. When $\lambda$ is zero, the central bank can be characterized as a strict inflation targeter, for which output considerations are always secondary to minimizing inflation variability.

Consider a temporary depreciation of the exchange rate that results from a portfolio realignment lasting only one period (that is, a decline in $\varepsilon_3$). The depreciation will generate an immediate increase in inflation as imported goods prices rise. If a rigid inflation target is in place, the increase in inflation can be counteracted by a rise in interest rates to offset the downward pressure on the exchange rate from the portfolio shift. This policy change is reversed in the following period when the downward pressure on the exchange rate dissipates. The policymaker can thus successfully stabilize the inflation rate, but at the cost of inducing additional volatility in output, as output responds to the shifts in interest rates.

If the policymaker targeted nontraded inflation rather than aggregate inflation, the policy response would be considerably more moderate. A muted response would also occur under a more flexible inflation targeting regime. Output variability would be lower in both of these cases, but at the expense of greater volatility in the aggregate inflation rate (assuming that the effect of interest rate changes

on output are more potent than exchange rate changes). Some policy response would still be necessary to reduce the volatility resulting from the effect of the depreciation on output and to offset any effect of the exchange rate movements on nontraded goods prices or inflation expectations.

Hence targeting aggregate inflation instead of nontraded inflation presents a choice between inflation variability and output variability. Responding to exchange-rate-induced fluctuations in inflation increases output variability, while ignoring them increases aggregate inflation variability.

Ball (1998, p. 19) argues that targeting a measure of long-run inflation "purged of the transitory effects of exchange rate fluctuations" is the optimal strategy for a central bank in an open economy. To bolster his argument, he raises the possibility that, in practice, the increased output variability from targeting aggregate inflation may destabilize inflation in the medium term (although such a result is not possible in his simple framework).

To make such an evaluation, however, one needs to assess the relative costs of inflation and output variability. Tradeoff curves can illustrate the various combinations of output and inflation variability that correspond to different objective functions or rules for the central bank, but the paucity of knowledge on the relative costs to society of inflation and output variability prevents an easy comparison of these combinations. The coefficient $\lambda$ in the objective function (equation 4) is a critical but unknown variable. The general assumption is that some degree of inflation variability should be permitted. The question is, how much?

One also needs to know which measure of inflation enters the objective function. The aggregate consumer price index is designed to be representative of the average consumption basket, so it would appear to be the most obvious measure to use. However, various sectors of the economy, most notably producers in the nontraded sector, may face considerably different price baskets. They would be relatively disadvantaged if an aggregate measure were targeted instead of a nontraded measure.

Nevertheless, curves showing tradeoffs between output variability and the variability of various measures of inflation can be generated and presented as a menu of options to policymakers. The rest of this section discusses some of the key features of the economy that affect the shape and position of these tradeoff curves in an open economy, and hence the relative merits of targeting aggregate versus nontraded inflation.

First, the nature of the shocks hitting the economy is important, in terms of both their source and their persistence. Bharucha and Kent (1998) examine this factor using a calibrated model similar to that presented above. They demonstrate that if the shocks occur primarily to the exchange rate (equation 3), then a nontraded inflation target may be preferable in that it reduces output variability substantially. If, on the other hand, the shocks primarily occur in the nontraded sector of the economy, then a nontraded inflation target will place much of the burden of adjustment on the traded goods sector.

With regard to the persistence of the shocks, temporary changes in the exchange rate that are likely to be unwound within a short period do not necessarily warrant a policy response. The inflationary impulse of an exchange rate temporarily below equilibrium should be offset by the disinflationary effect of the subsequent appreciation back to equilibrium. If changes in the nominal exchange rate are expected to be permanent—reflecting changes in the real exchange rate—then monetary policy needs to ensure that the resulting inflationary pressures do not lead to a permanent increase in the inflation rate. While this principle is easy to state, its practical implementation is particularly problematic. As Ball (2000) notes, it would be useful to find an alternative measure of inflation that simplified this problem in practice. The next section examines whether movements in unit labor costs may serve as a useful proxy.

A second element that affects the nature of the tradeoff is the extent to which aggregate and nontraded inflation are affected by movements in the exchange rate. The aggregate inflation rate will be affected directly according to the degree of import penetration of the consumer goods market. Exchange rate changes may also have a significant direct impact on nontraded inflation, however, if the nontraded sector is dependent on imported inputs in production.

The speed and extent of the pass-through of exchange rate changes to final goods prices is also important. A more protracted pass-through reduces the impact of a given exchange rate movement on the inflation rate and thereby reduces the size of the necessary policy response to it. Some evidence of a change in the pass-through of exchange rate movements in the 1990s is discussed in section 3.

Third, inflation expectations play a critical role. An important function of inflation targeting is to maintain stability in inflation expectations and thereby anchor ongoing inflation. The appropriate inflation targeting strategy thus depends on how inflation expecta-

tions are formed, the degree to which they are forward looking, and how well they are anchored. If inflation expectations are primarily backward looking and are dependent on movements in the aggregate inflation rate, then exchange rate movements will tend to have a larger and more persistent impact on both aggregate and nontraded inflation, as they get built into expectations. If, on the other hand, inflation expectations are forward looking, then temporary exchange rate changes will not lead to much movement in inflation expectations, since wage and price-setters recognize them as temporary. This is a key part of the process that affects the extent to which exchange rate changes lead to a temporary boost to inflation rather than a permanent pickup.

Similarly, if the inflation target is perceived as credible, inflation expectations will be well anchored on the target inflation rate and again will not respond strongly to temporary deviations in the actual inflation rate. In such circumstances, the credibility of the inflation target is somewhat self-fulfilling. Shocks to the inflation rate, from changes in the exchange rate for example, would not be expected to lead to a prolonged deviation of inflation from target. Because of this belief, expectations are not adjusted, and the inflation rate is more stable.

## 2. Evidence from a Small Empirical Macroeconomic Model

The discussion in the previous section implies that the choice of the appropriate inflation target is largely an empirical issue that depends on the structure of the economy and the specification of the welfare function. In this section, we use a small model of the Australian economy to illustrate the tradeoff curves and their sensitivity to the structure of the economy. We then draw some conclusions on the relative merits of targeting aggregate and nontraded inflation.

This analysis extends the work of Bharucha and Kent (1998), who examine the choice of inflation target in a simple calibrated version of the Ball and Svensson model, focusing on the influence of different shocks. Ryan and Thompson (2000) also examine this issue, using a model of the Australian economy and assuming the use of simple policy rules. The analysis here focuses primarily on optimal policy, although some policy rules are considered to provide a basis of comparison with Ryan and Thompson.

## 2.1 Methodology

The tradeoff curves are generated using a simple empirical model of the Australian economy similar to that in Beechey and others (2000).[3] The model is a relatively complex version of the simple Ball-Svensson framework, but the central features are the same, namely, an equation for output, an equation for aggregate inflation, and an objective function for the central bank[4]. As in the Ball-Svensson model, monetary policy is transmitted to output through two channels: directly through changes in the real interest rate (with a six-quarter lag) and indirectly through changes in the real exchange rate (with a four-quarter lag). The real exchange rate is explained by movements in the terms of trade and real interest rate differentials.

Aggregate inflation is measured by changes in the consumer price index. It depends on contemporaneous and lagged changes in import prices, lagged growth in unit labor costs and its own lags (which serve as a proxy for backward-looking expectations). There is no forward-looking component of inflation expectations.[5] The majority of the effect of exchange rate changes on import prices is assumed to occur contemporaneously, consistent with estimates of first-stage pass-through (Dwyer, Kent, and Pease, 1994). Exchange rate changes are thus transmitted immediately to aggregate inflation (although the initial impact is relatively small). Monetary policy affects aggregate inflation through its impact on the output gap in the unit labor cost equation and through its effect on import prices via the exchange rate.

For specifying an appropriate inflation target variable in an open economy, Ball (2000) advocates a measure of long-run inflation that filters out the transitory effects of exchange rate fluctuations. We initially tried a measure of inflation based on the prices of nontraded goods in the consumer price index. This proved to be dependent on exchange rate fluctuations, however, because of the importance of imported inputs in the production of nontraded goods and also because of govern-

3. The model is described in detail in Appendix A. Beechey and others (2000) also provide a summary of macroeconomic developments in the Australian economy over the past two decades, and further details are provided in Gruen and Shrestha (2000).

4. We assume the central bank doesn't discount outcomes in future periods. In equation 4, $\theta$ is assumed to be unity throughout the simulations.

5. This primarily reflects the lack of a useful measure of inflation expectations in Australia. Historically, however, backward-looking expectations have accurately characterized the inflation expectations process in Australia (Brischetto and de Brouwer, 1999).

ment-determined prices.[6] Instead we chose unit labor costs as a measure of inflation in the nontraded sector. (Hereafter we use the terms unit labor costs and nontraded inflation interchangeably.) Unit labor costs are modeled using a Phillips curve specification, with expectations modeled as a weighted average of aggregate and nontraded inflation. Hence while the exchange rate has no direct effect on unit labor costs, it does have indirect effects through the influence on inflation expectations and the output gap.

The policymaker is assumed to have an objective function as described in equation 4. Two forms of the objective function are considered: one with aggregate inflation, the other with growth in unit labor costs. To generate the tradeoff curves, the relative weight on output variability ($\lambda$) is varied between 0 and 1. The instrument of monetary policy is the nominal cash rate.

The model of the economy is then simulated by taking draws of the error terms in each equation for both exogenous and endogenous variables, using a distribution based on the estimated variance-covariance matrix. The policymaker is assumed to know the full structure of the economy but assumes the value of all future shocks are zero. Each period the policymaker chooses the optimal level and future path for interest rates either with the aim of minimizing the objective function or according to a Taylor rule. The model is simulated for 100 periods for each value of $\lambda$, and the variability of output, aggregate and nontraded inflation are calculated in each simulation.

## 2.2 Optimal Policy Results

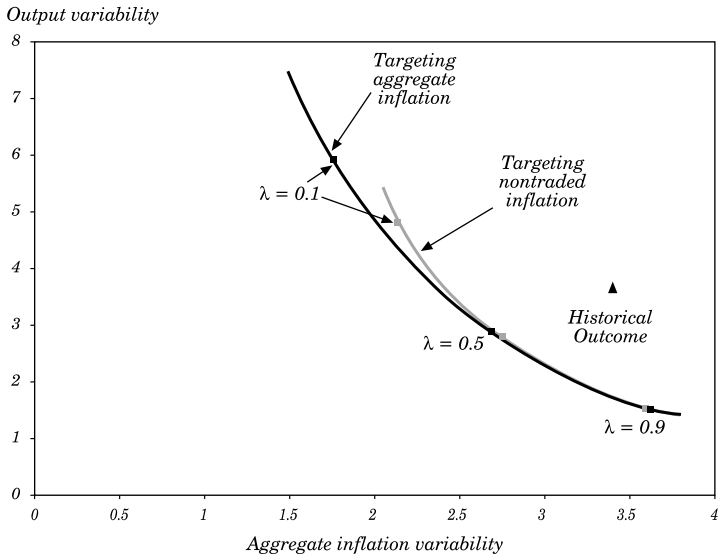
The top panel of figure 1 shows the tradeoff between output variability and aggregate inflation variability when aggregate inflation is the objective and when nontraded inflation is the objective. Similarly, the bottom panel shows the tradeoff between output variability and nontraded inflation variability for the two different objective functions. For comparison, the actual historical outcomes are also shown (for the first quarter of 1985 to the fourth quarter of 1999).

The figure illustrates the obvious conclusion that the best way to minimize the variability of a particular measure of inflation is to directly target that measure by placing it in the objective function. The upper

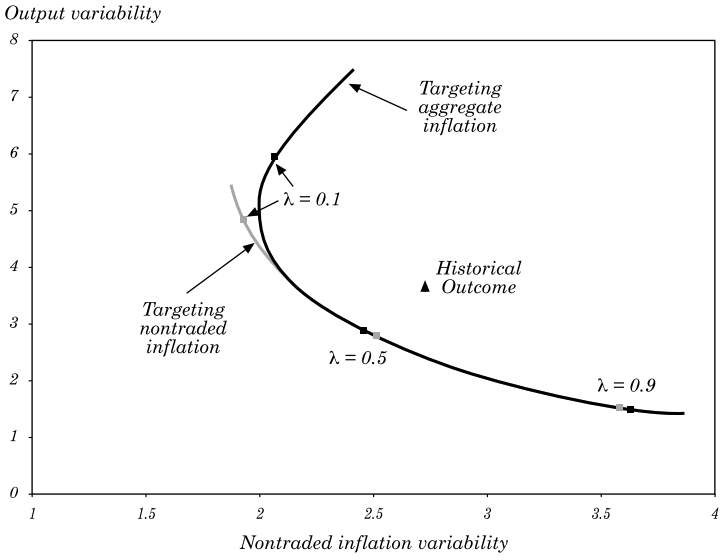
6. Ryan and Thompson (2000) also find that nontraded inflation was sensitive to exchange rate movements, and they examine a policy rule that targets unit labor costs in the nontraded sector.

**Figure 1. Optimal Policy**

*Tradeoff Curve: Aggregate inflation*




*Tradeoff Curve: Nontraded inflation*



panel of the figure, however, shows that the variability of aggregate inflation is not significantly higher when nontraded inflation is targeted. Only a small difference emerges as relatively more weight is placed on inflation variability (as $\lambda$ declines). This result is not surprising, because nontraded inflation is an important determinant of aggregate inflation. Therefore, in minimizing the variability of nontraded inflation, the policymaker also reduces the variability of aggregate inflation.

The converse is also generally true, except when a relatively large weight is placed on inflation variability (when $\lambda$ is less than about 0.25). Strict inflation targeting then generates considerably more variability in nontraded inflation. Consequently, those parts of the economy for which nontraded inflation is more important will be worse off under a strict aggregate-inflation-targeting regime.

Output variability is also considerably higher under a strict aggregate inflation target than under a strict nontraded inflation target. These results are similar to those in Svensson (1998), who finds that strict inflation targeting regimes generate a large amount of volatility in domestic inflation and output.

These simulations assume that the policymaker is able to distinguish exactly between temporary and permanent shocks to the exchange rate and to respond appropriately. Making this distinction is considerably more difficult in practice. These results suggest that there may not be much cost in focusing on a nontraded measure of inflation. That is, policymakers may only need to respond to exchange rate changes to the extent that they expect them to be reflected in movements in nontraded inflation.

The variability of interest rates associated with these tradeoff curves is considerably larger than that observed in practice. The standard deviation of the interest rate changes ranges between 2.5 and 5.5. The objective function was therefore amended in the normal way to include a term for smoothing the interest rate by penalizing interest rate variability. A weight on the smoothing term that was sufficient to reduce the volatility in interest rates to the historically observed level did not have a significant impact on the tradeoff curves: the variability in output and aggregate inflation only increased marginally. This result is similar to that in Lowe and Ellis (1997), who also find that reducing the volatility of policy interest rates does not greatly affect the variability of the other target variables. When a smoothing objective is included, however, the increase in the variability of nontraded inflation under a strict aggregate inflation target is even greater.

The model was altered in a number of ways to test the sensitivity of the results to the structure of the economy. First, we doubled the

variability of the exchange rate shocks.[7] This naturally shifted the variability frontiers up and to the right, but it did not materially alter the conclusion that the choice of inflation target does not have much impact except in the case of strict inflation targeting.

Second, we changed the process for the real exchange rate. In the model, long-run movements in the real exchange rate are driven by the terms of trade, which are assumed to be stationary. When we modeled the terms of trade as a nonstationary process, allowing for permanent shifts in the real, and thus also the nominal, exchange rate, the effect was to steepen the tradeoff curves. That is, increasing the weight on output in the objective function led to a larger reduction in output variability and a smaller increase in inflation variability than in the baseline case. However, there was very little difference in outcomes for the two different inflation objectives.

Third, we altered the expectations process in the nontraded sector to allow for some credibility in the inflation target. A positive weight was placed on a constant term set equal to the inflation target, thereby anchoring unit labor costs in the long run. Inflation expectations retained some backward-looking element, however. This change to the expectations process naturally shifted the tradeoff curves towards the origin, as the expectations process was less volatile. In other words, establishing credibility in the inflation target allows the policymaker to choose from a superior set of economic outcomes. The choice of inflation target did not result in any significant differences in the variability of either measure of inflation. However, a strict aggregate inflation target generated even more variability in output (relative to a strict nontraded inflation target) than in the baseline case.

## 2.3 Policy Rule Results

The simulations above analyzed the tradeoff between targeting aggregate and nontraded inflation assuming policy is set optimally in every period to minimize the central bank's objective function. Ball (1998), Svensson (1998), and Ryan and Thompson (2000), however, all examine the choice of the appropriate inflation target in the context of policy being set according to a Taylor-type rule. In the simple Ball-Svensson framework, the Taylor rule, or a Taylor rule that includes the exchange rate, is an optimal policy reaction function. In more complicated models like that

7. It is assumed that this change in the variability does not alter any other aspect of the model.

used above, however, such rules are only rough approximations of optimal policy. Optimal policy in these models takes account of changes in all the variables in the economy, rather than only the variables in the policy rule. The simple rules, however, may still be useful to the extent that aggregate output and inflation are summary statistics for developments in the economy, or that tractable and transparent policy rules are desirable.

To investigate the tradeoff that applies when the central bank follows a policy rule, the model is simulated in the same way as in the previous section except that the central bank is assumed to follow a rule rather than optimizing an objective function every period. We examine two policy rules, one with weights on output and aggregate inflation and the other with weights on output and nontraded inflation. In the first set of simulations, these policy rules are contemporaneous, including only current-dated measures of inflation and output. Simulations are then conducted using forward-looking rules that incorporate the forecast of output and inflation three quarters ahead.[8] In each case, a number of simulations are conducted for different sets of weights on output and inflation in the policy rule. An efficient frontier for each rule traces out the lowest combinations of inflation and output variability as these weights are varied.

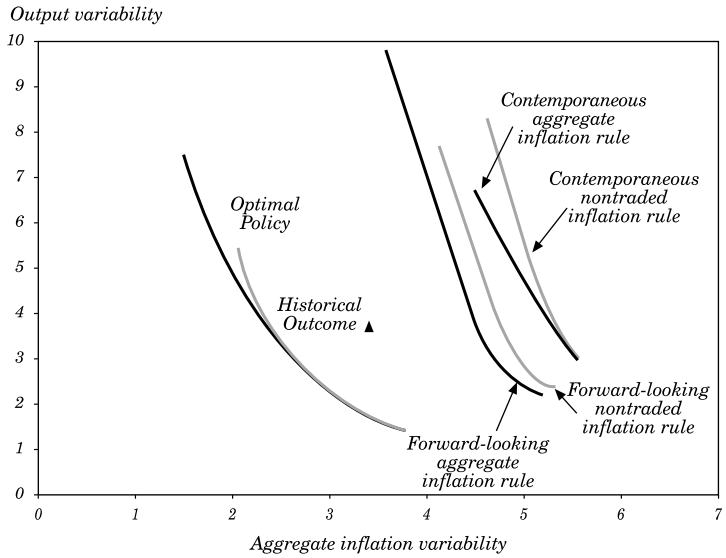
Figure 2 shows the efficient frontiers from rules that respond to contemporaneous movements in output and aggregate inflation and rules that respond to forecasts for these variables. For comparison, it also shows the optimal policy frontiers derived earlier. The frontiers for the policy rules result in significantly more variability in inflation and output than was the case for optimal policy—and more than that which was actually observed in practice. These simulations also confirm two results in Ryan and Thompson (2000). First, an aggregate inflation rule generates a more preferable tradeoff than a nontraded inflation rule, although the differences between the two rules are not stark. Second, a forward-looking rule leads to lower output and inflation volatility than a contemporaneous rule.

## 2.4 Summary

The results of these simulations suggest that in a representative model of the Australian economy, targeting aggregate inflation and targeting nontraded inflation deliver similar economic outcomes. This occurs because exchange rate changes have a muted effect on aggregate inflation. The only exception to this conclusion is that having a

8. Ryan and Thompson (2000) indicate that three quarters is the most efficient horizon for a Taylor rule in a model similar to that used here.

**Figure 2. Taylor Rule Tradeoff Curves**




strict aggregate inflation target significantly increases the variability of nontraded inflation and output, as greater reliance is placed on the faster-acting exchange rate channel of monetary transmission.

An important caveat to this conclusion is that the simulations assume the policymaker is able to distinguish between temporary and permanent movements in the exchange rate. These results are also very sensitive to the nature of the inflation process. The next section examines how this has changed over the past two decades.

## 3. Evidence of Changes in the Inflation Process

To operate an inflation-targeting regime and to assess the range of options facing policymakers, it is crucial to have a reasonable understanding of the inflation process. As well as understanding the behavior of inflation expectations, an important factor with which small open economies have to contend is that shocks to the exchange rate, which occur frequently and are often large, can have a significant direct effect on the inflation rate. Understanding the link between changes in the exchange rate and inflation is thus particularly important.

The inflation process in many industrialized countries may have changed over the last decade, however. Reports on monetary policy, or inflation, by inflation-targeting central banks, for example, allude to a fall in the extent of pass-through of exchange rate shocks to domestic retail prices in several different countries over several different episodes:

> Exchange rate pass-through continues to be more muted and diffuse than historical experience would suggest.[9]
> Staff analysis suggested that import prices had fallen by less than was expected given the rise in the exchange rate.… In other words, the pass-through from exchange rate appreciation had been unexpectedly weak. [Members concluded that] since the pass-through from the earlier, much larger appreciation seemed to be incomplete, there was a good chance that the recent depreciation would have little effect.[10]
> The exchange rate normally affects inflation through import prices… In practice, however, the weak krona has not affected either import or consumer prices as much as the Riksbank had anticipated.[11]
> Import prices have for some time exerted a restraining influence on consumer price inflation. The extent of this effect was unexpected. Historical experience suggested that, given the exchange rate depreciation between mid-1997 and late 1998… some eventual impact in the form of higher import prices at the retail level could be expected.[12]

This possibility has been raised and explored in a number of papers in recent years.[13] There have also been suggestions that the inflation process more generally may have changed in recent years. Taylor (2000) examines data for the United States and finds a reduction in the persistence of inflation shocks. That is, he finds that the inflation process in the United States was less highly autocorrelated in the 1980s and 1990s than in the previous two decades. Taylor argues that the low inflation outcomes of the last two decades may have caused this reduction in persistence. Kuttner and Posen (1999) also present evidence of a reduction

9. Reserve Bank of New Zealand, *Monetary Policy Statement,* March 1999, p. 13.

10. Bank of England, *Minutes of Monetary Policy Committee Meeting,* 8 and 9 October 1997, p. 4.

11. Speech by Sweden's First Deputy Governor Lars Heikensten, "Monetary Policy and the Exchange Rate," given in Stockholm, 19 April 1999. Available at www.riksbank.com.

12. Reserve Bank of Australia, "The Economy and Financial Markets," *Reserve Bank of Australia Bulletin,* August 1999, p. 32.

13. See, for example Cunningham and Haldane (2002); Dwyer and Leong (2000), McCarthy (1999). McCarthy (1999) finds that for the nine OECD countries he examines, pass-through is considerably lower over 1983–98 than it was over the full sample period (1976–98), although he claims that these differences are probably statistically insignificant.

in the persistence of inflation in Canada, New Zealand, and the United Kingdom in the period since each country has been inflation targeting. They argue that this reduction in persistence may reflect the success of the inflation-targeting regime in "enhancing public trust of the central bank's long-run target commitment" (Kuttner and Posen, 1999, p. 34).

Andersen and Wascher (2000) take a different perspective. They show that there was a systematic positive bias in the inflation forecasts of the Organization for Economic Cooperation and Development (OECD) in the 1990s, and they examine whether particular shocks, which have been common across countries, can explain this outcome. The paper also explores whether structural changes in the inflation process can be identified. The authors conclude that there is no systematic explanation across countries for the lower-than-expected inflation outcomes, and the structural changes they find are neither common across countries nor statistically significant.[14]

The Australian experience has been similar to that of many other OECD countries. During the 1990s, inflation was both lower and considerably less variable than would have been predicted at the beginning of the decade. The response of inflation to exchange rate shocks, in particular, was considerably more muted than expected. Dwyer and Leong (2000) examine the Australian experience, looking for evidence of a structural change in both the inflation process and the process that drives each of the major determinants of inflation. Using recursive estimation techniques, they provide tentative evidence that the speed with which exchange rate changes are passed through to consumer prices has fallen. This change is not statistically significant, but the authors emphasize that the magnitude of the change is economically significant. They also discuss changes to the wage-setting process in Australia over the last two decades, arguing that these are likely to have dampened the transmission of price shocks to wages and hence reduced the potential for wage-price spirals to develop.

This section of the paper further explores these issues. First, we estimate a simple, reduced-form price equation for Australia in an attempt to summarize the dynamics of the combined price and wage-setting processes.[15] Similar equations are estimated for Canada, New Zealand, the

14. Their paper examines forecasts and developments in eight OECD countries: Australia, Canada, Japan, Spain, Sweden, Switzerland, the United Kingdom, and the United States. It compares the behavior of inflation during the 1990s with that of the previous three decades.

15. These equations are similar to those estimated in Andersen and Wascher (2000).

United Kingdom, and the United States for comparison. Unlike earlier studies, however, we then use rolling regressions with a ten-year window to gauge the changes that are taking place in these processes. Although rolling regressions provide less efficient coefficient estimates than recursive regressions, they provide a clearer indication of structural changes as they are occurring. Our focus is as much on whether these changes would be of economic significance as on whether we can reject the statistical hypothesis of no structural change at conventional levels of significance.

We derive the equation we estimate from the following two reduced-form relationships:

$$\pi_t = \pi_t^e + \alpha_1 \left( \pi_{t-i}^m - \pi_{t-1} \right) + \alpha_2 \left( gap_{t-i} \right) + \alpha_3 \left( \Delta gap_{t-i} \right) + u_t \text{, and} \tag{5}$$

$$\pi_t^e = \left( 1 - \Sigma\beta_k \right) \pi^* + \Sigma\beta_k \pi_{t-k} \text{,} \tag{6}$$

where $\pi$ is the log difference of the aggregate price level, $\pi^e$ is expected inflation, $\pi^m$ is the log difference of import prices, and *gap* is the log of output relative to potential. $\pi^*$ is discussed below.

The first equation is a Phillips curve, where inflation outcomes depend on expected inflation, growth in real import prices (a measure of the real exchange rate), the output gap, and the change in the output gap. The last term reflects the fact that in the Australian data, the speed at which the output gap is being closed, as well as its level, is typically important.

The second equation describes the process by which inflation expectations are formed. Some proportion ($\Sigma\beta_k$) of inflation expectations is formed in a backward-looking manner, and the rest ($1 - \Sigma\beta_k$) is anchored at some constant rate of inflation, $\pi^*$, which we call the perceived inflation target. Over time it is therefore possible that both the perceived inflation target ($\pi^*$) and the extent to which inflation expectations are linked to the target rate ($1 - \Sigma\beta_k$) may change, and movements in these two can be distinguished from each other. If $\Sigma\beta_k = 1$, inflation expectations are entirely backward looking, while if $\Sigma\beta_k = 0$, they are completely anchored to the target, $\pi^*$.[16]

Substituting equation 6 into equation 5, and assuming $k = 2$, generates the equation we estimate:

$$\pi_t = \delta_0 + \delta_1 \pi_{t-1} + \delta_2 \pi_{t-2} + \delta_3 \pi_{t-i}^m + \delta_4 gap_{t-i} + \delta_5 \Delta gap_{t-i} + u_t \text{,} \tag{7}$$

16. These two equations imply that in the short run there is a tradeoff between output and inflation, but there will be no tradeoff in the long run, provided that inflation expectations eventually adjust one-for-one with actual inflation. If $\Sigma\beta_k = 1$ this will always be the case; if $\Sigma\beta_k < 1$, it requires that $\pi^*$ eventually converges on the actual inflation rate.

from which individual parameter estimates of the short-run elasticities of inflation with respect to import prices and the output gap can be calculated, together with the extent to which expectations are backward looking ($\Sigma\beta_k = \delta_1 + \delta_2 + \delta_3$) and the perceived inflation target ($\pi^* = \delta_0/(1 - \delta_1 - \delta_2 - \delta_3)$).

Before we proceed to examining the results, a couple of caveats. First, the model we are using to capture inflation expectations includes a backward-looking part and an anchored part. This is incomplete, since it does not explicitly include an alternative forward-looking indicator of inflation expectations. One justification for using such a simple model is that in the case of Australia, at least, inflation expectations seem to be quite well explained by an anchor and historical inflation outcomes.[17] Second, the constant term in the above equation ($\delta_0$), and the way it changes over time, could reflect several factors in addition to those outlined above. Mismeasurement of the true output gap, for example, would affect the estimate of the constant: if the true level of the economy's potential output were underestimated, the constant (and the implied estimates of the perceived inflation target) would be biased downward. If the degree of mismeasurement of the output gap were to change over time, this could thus explain variations over time in the estimates of the constant. The existence of other sources of structural change that are not captured in this very simple model could also affect the constant term, as would misspecification more generally. We are thus inclined to interpret any of the results pertaining to the constant term, and hence the estimates of the perceived target rate of inflation, as indicative of the changes that may be taking place, rather than as definitive evidence for them.

We now turn to the estimation results. Equation 7 is estimated for each country over the period from the first quarter of 1983 to the third quarter of 2000, using quarterly data. The dependent variable is underlying inflation in Australia's case, and either a measure of core inflation or the first difference of the private consumption deflator for each of the other countries.[18] The lag length of the output gap and import price terms were chosen for each country to best fit the data over the full sample period. The full sample estimates of these regressions are presented in table 1.

17. Brischetto and De Brouwer (1999) find that households' inflation expectations are quite well explained by a constant and lagged inflation, although the real interest rate (lagged six months) is also significant.

18. See appendix B for further details.

## Table 1. Estimated Price Equations[a]

| | *Coefficient estimates* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Country* | *Constant* | $\pi_{t-1}$ | $\pi_{t-2}$ | $\pi^{m}_{t-i}$ | $gap_{t-j}$ | $\Delta gap_{t-k}$ | *Adjusted* $R^2$ | *Standard error* | *LM test* ($1^{st}$ *to* $4^{th}$) | *Chow test*[b] |
| Australia | 0.001<br>(1.6) | 0.41<br>(3.8) | 0.46<br>(4.6) | 0.03<br>(2.4) | 0.05<br>(2.6) | 0.14<br>(3.2) | 0.84 | 0.003 | 0.27 | 0.03 |
| Canada | 0.003<br>(2.9) | 0.33<br>(2.9) | 0.30<br>(2.8) | 0.01<br>(0.3) | 0.06<br>(1.7) | 0.21<br>(2.6) | 0.33 | 0.004 | 0.51 | 0.02 |
| New Zealand | 0.001<br>(1.1) | 0.42<br>(3.4) | 0.40<br>(3.3) | 0.06<br>(2.2) | 0.08<br>(1.4) | 0.30<br>(3.3) | 0.64 | 0.007 | 0.21 | 0.001 |
| United Kingdom | 0.004<br>(3.2) | 0.33<br>(2.9) | 0.28<br>(2.6) | 0.04<br>(2.2) | 0.10<br>(2.9) | 0.14<br>(1.9) | 0.52 | 0.003 | 0.05 | 0.003 |
| United States | 0.002<br>(2.4) | 0.46<br>(3.1) | 0.25<br>(2.0) | -0.01<br>(-0.6) | 0.03<br>(1.1) | 0.07<br>(1.0) | 0.35 | 0.003 | 0.01 | 0.07 |

Source: Authors' calculations.

a. Dependent variable is the quarterly log difference of the price level. The estimation period is 1983:1 to 2000:2. The equations were estimated using the following specifications:

Australia: $\pi_t = \delta_0 + \delta_1\pi_{t-1} + \delta_2\pi_{t-2} + \delta_3\pi^m_{t-1} + \delta_4 gap_{t-2} + \delta_5\Delta gap_t + \mu_t$

Canada: $\pi_t = \delta_0 + \delta_1\pi_{t-1} + \delta_2\pi_{t-2} + \delta_3\pi^m_{t-1} + \delta_4 gap_{t-4} + \delta_5\Delta gap_{t-1} + \mu_t$

New Zealand: $\pi_t = \delta_0 + \delta_1\pi_{t-1} + \delta_2\pi_{t-2} + \delta_3\pi^m_{t-1} + \delta_4 gap_{t-3} + \delta_5\Delta gap_{t-1} + \mu_t$

United Kingdom: $\pi_t = \delta_0 + \delta_1\pi_{t-1} + \delta_2\pi_{t-2} + \delta_3\pi^m_{t-3} + \delta_4 gap_{t-4} + \delta_5\Delta gap_{t-2} + \mu_t$

United States: $\pi_t = \delta_0 + \delta_1\pi_{t-1} + \delta_2\pi_{t-2} + \delta_3\pi^m_{t-1} + \delta_4 gap_{t-4} + \delta_5\Delta gap_{t-1} + \mu_t$

Figures in parentheses are $t$ statistics. Chow and Lagrangian multiplier (LM) test results reported as $p$ values.

b. Chow breakpoint test for structural change at 1992:1.

Over the full sample, this very parsimonious model does quite a good job of capturing the inflation process. In the case of Australia, the equation explains 85 percent of the variation in quarterly inflation, which is very close to the explanatory power of more fully elaborated models of inflation estimated on the Australian data.[19] For Australia, each of the coefficients on the explanatory variables have the expected sign and are significant. They imply that a 10 percent shock to import prices would lead to a 0.6 percent increase in the price level over the following year and a 1 percent increase after two years. A 1 percentage point fall in the output gap for one year would lead to a 0.5 percent fall in inflation over the first year and a 0.3 percent fall over the second year.

For the other countries, these equations also perform quite well, explaining between 35 and 65 percent of the variation in quarterly inflation over the full sample. For the Canadian, New Zealand, and United Kingdom data, the coefficient estimates are generally of the expected sign and significant. In the case of the United States, both the import price term and the output gap term are insignificant. Across all equations, the coefficient estimates are of similar orders of magnitude.

Figures 3 through 7 show rolling regression estimates using the above specifications for each country. In each case, the window is ten years. For example, the first point on each of these graphs illustrates the coefficient estimates from the equations that were estimated using data from March 1983 to December 1992, and the last point illustrates estimates from regressions taken from September 1990 to June 2000. One standard error bands around each estimate are also presented.

For Australia (figure 3), the results point to quite a substantial change in the inflation process over the last two decades. We discuss each of the coefficient estimates in turn. First, we focus on the response of inflation to import price shocks. Panel C shows rolling regression estimates of the coefficient on import prices in these inflation equations. It shows that import prices had a significant effect on inflation in the early part of the sample, but they had no systematic effect on inflation outcomes after around 1987. In other words, once the large depreciation of the exchange rate in the mid-1980s was excluded from the estimation period, inflation was much less sensitive to exchange rate developments. This could reflect a change in the

19. Beechey and others (2000) estimate an error correction model for quarterly changes in the acquisitions consumer price index (CPI); it explains around 90 percent of the variation in quarterly inflation. This model has a richer dynamic structure, and it incorporates unit labor costs and oil prices as well as the explanatory variables included above.

price-setting process of either importers or retailers, or it could reflect a nonlinearity in the effect of exchange rate developments on inflation outcomes. It could also reflect the fact that the depreciation of the mid-1980s as well as being large, was also widely perceived to be permanent, because it coincided with a period in which commodity prices fell sharply and the current account deficit increased markedly. The depreciation was thus widely interpreted as being necessary to help the Australian economy adjust to these developments. In most other episodes, in contrast, it has been much less clear whether exchange rate changes were likely to be permanent or temporary.

The models we are estimating are designed primarily to capture the short-run dynamics of the inflation process. It would thus be unwise to use them to draw conclusions about changes in the extent of exchange rate pass-through over a long horizon. It is possible, for example, that the long-run relationship between imported prices and consumer prices has changed little, but pass-through has become more protracted. In an inflation-targeting framework, however, this change still implies that a given shock to the exchange rate would require less of a policy adjustment.

The lack of response of inflation to exchange rate developments is also evident in the New Zealand data (see panel C of figure 4, especially in the later years of the sample). In the United Kingdom (panel C of figure 5) and Canada (panel C of figure 6), these coefficient estimates have stayed roughly stable over the sample period. Thus while the recent experience in Australia and New Zealand would suggest that inflation has become less sensitive to exchange rate movements, this has not occurred in other open, inflation-targeting countries, all of which have recorded low inflation outcomes in recent periods.

The coefficient on the output gap in the Australian equation varied over the sample period (panel D of figure 3), and it was both higher and statistically more significant in the second half of the sample. On the other hand, the coefficient on the change in the output gap (panel E of figure 3) (that is, the indication that there are speed limits on growth) drifted down over the period and was insignificant in regressions starting from around 1987. The latter trend is consistent with the increasing flexibility of both product and labor markets in Australia.

For the other countries, estimates of the coefficient on the change in the output gap also varied quite a lot over the sample period. In the case of New Zealand, for example, as in Australia, the change in the output gap appears to have been a much more significant explanator of inflation developments earlier in the sample than it has been more

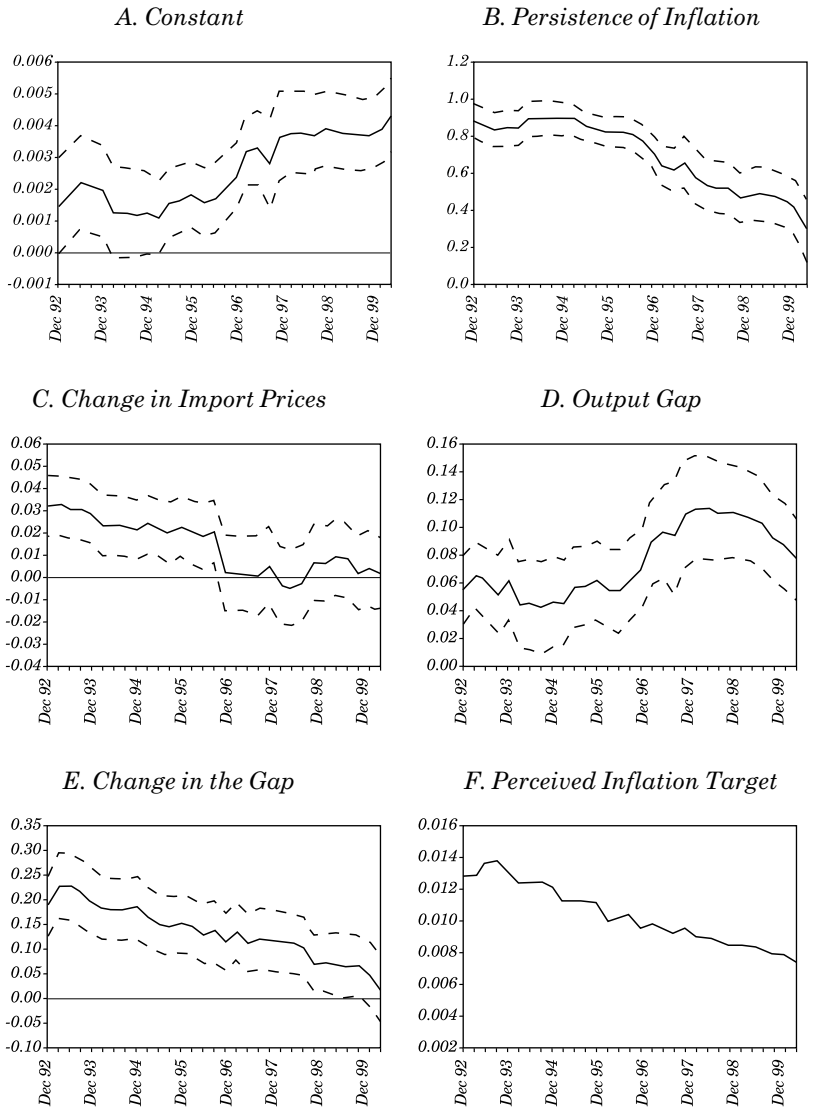
recently. The estimated coefficients on the level of the output gap were roughly stable in Canada and the United Kingdom, while for the United States, the coefficient drifted toward zero over the sample period.

We now turn to estimates of the degree of autocorrelation, or persistence, in the inflation process. In the model outlined above, these estimates correspond to estimates of the degree to which inflation expectations can be characterized as being backward looking. For Australia, panel B of figure 3 suggests that the inflation process has become markedly less autocorrelated over the last two decades. These estimates could be interpreted as implying that during the 1980s, inflation expectations were based almost exclusively on past inflation developments, while during the 1990s, close to seventy percent of inflation expectations were tied to a target rate of inflation. This result supports the Kuttner and Posen (1999) hypothesis that the adoption of inflation targeting has increased the capacity of the central bank to manage inflation, by reducing the propagation of inflation shocks. The results could also be interpreted, however, as providing support for Taylor's (2000) hypothesis that the persistence of inflation shocks decreases in a low inflation environment.

The results for the other countries qualifies these conclusions, however (see panel B in figures 4, 5, 6, and 7). Only the Australian and New Zealand data show a clear decline in the persistence of inflation over the period, although in both of these cases the decline was quite sharp. In the United Kingdom and the United States, by contrast, the degree of persistence appeared to increase quite markedly and monotonically from the 1980s to the 1990s, while in Canada it remained roughly unchanged. The results for the United States are counter to those presented in Taylor (2000); these rolling regression estimates suggest that conclusions about persistence are quite sensitive to the time period chosen.

There is no obvious explanation for the diversity of outcomes across countries. All of the countries considered (other than the United States) became inflation targeters in the early 1990s, and all achieved very low inflation outcomes in that decade. In Australia and New Zealand, other structural changes in the economy, in particular the deregulation of the labor market, could be responsible for a large part of the reduction in the degree of persistence in the inflation process. As pointed out by Dwyer and Leong (2000), around 80 percent of wages in Australia were indexed in 1985; by 1990 this proportion had fallen to less than 10 percent. Similar—and even more far-reaching—changes to the industrial relations system occurred in New Zealand. This cannot, however,

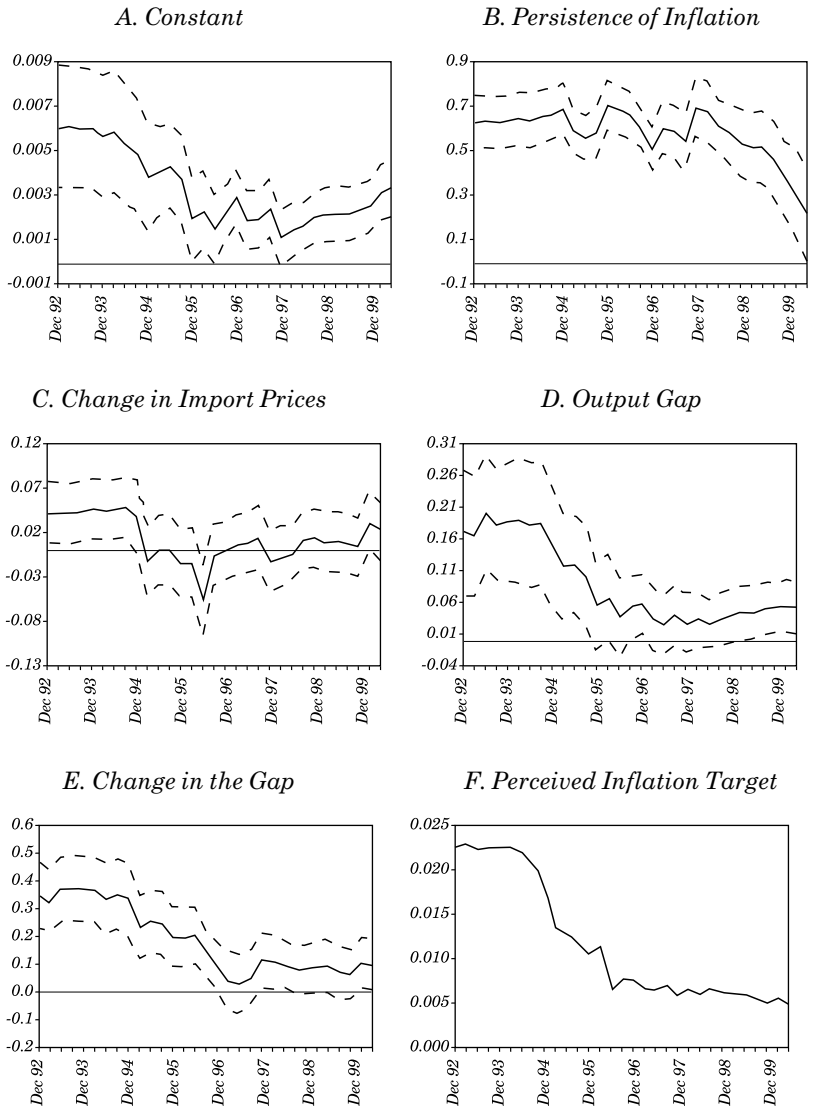
**Figure 3. Coefficient Estimates from Ten-Year Rolling Regressions for Australia, 1983:1 to 2000:2[a]**




Source: Authors' calculations.

a. Specification as in Table 1. Dashed lines are 1 standard error bands. Persistence of inflation is $(\delta_1 + \delta_2 + \delta_3)$. Perceived inflation target is $\delta_0 / [1 - (\delta_1 + \delta_2 + \delta_3)]$.

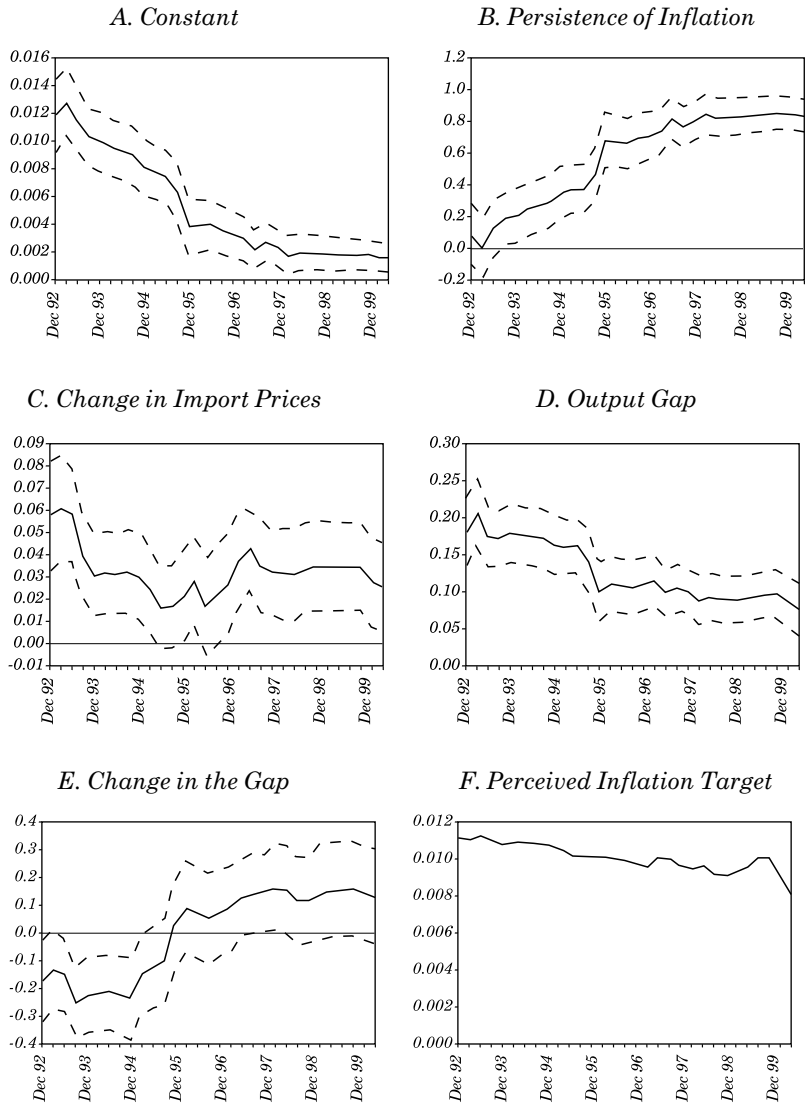
**Figure 4. Coefficient Estimates from Ten-Year Rolling Regressions for New Zealand, 1983:1 to 2000:2**[a]




Source: Authors' calculations.

a. Specification as in Table 1. Dashed lines are 1 standard error bands. Persistence of inflation is $(\delta_1 + \delta_2 + \delta_3)$. Perceived inflation target is $\delta_0 / [1 - (\delta_1 + \delta_2 + \delta_3)]$.

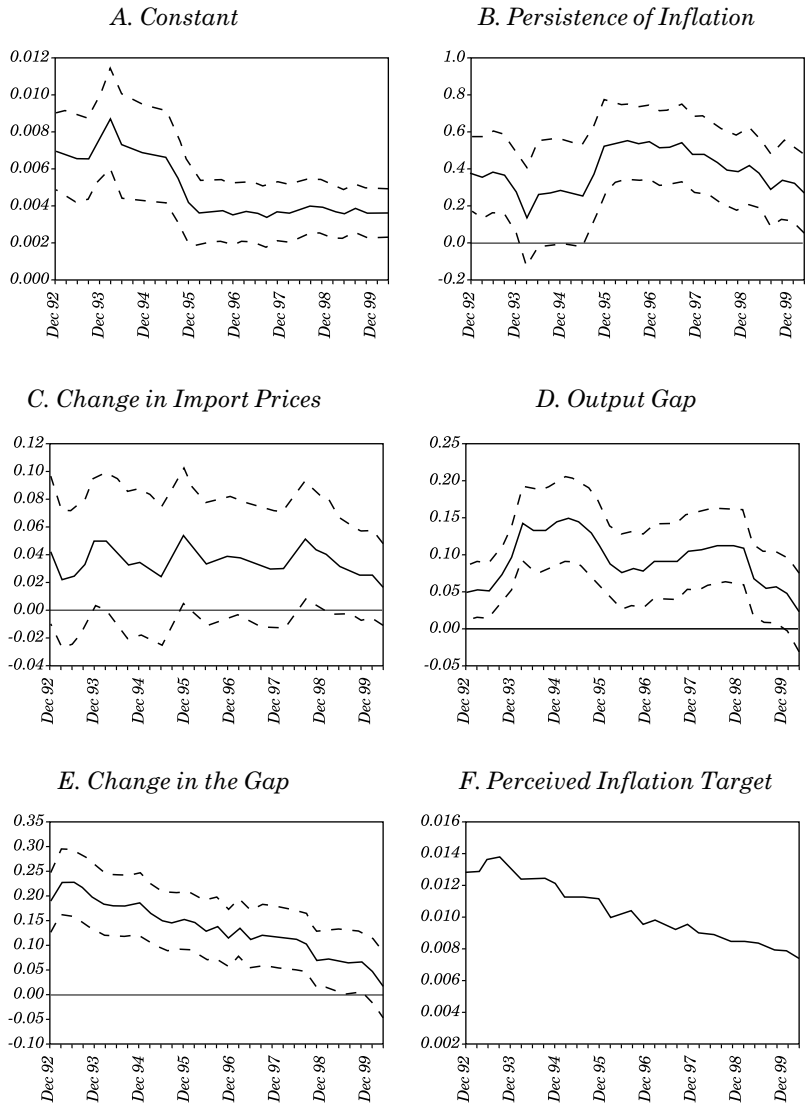
**Figure 5. Coefficient Estimates from Ten-Year Rolling Regressions for United Kingdom, 1983:1 to 2000:2[a]**




Source: Authors' calculations.

a. Specification as in Table 1. Dashed lines are 1 standard error bands. Persistence of inflation is $(\delta_1 + \delta_2 + \delta_3)$. Perceived inflation target is $\delta_0 / [1 - (\delta_1 + \delta_2 + \delta_3)]$.

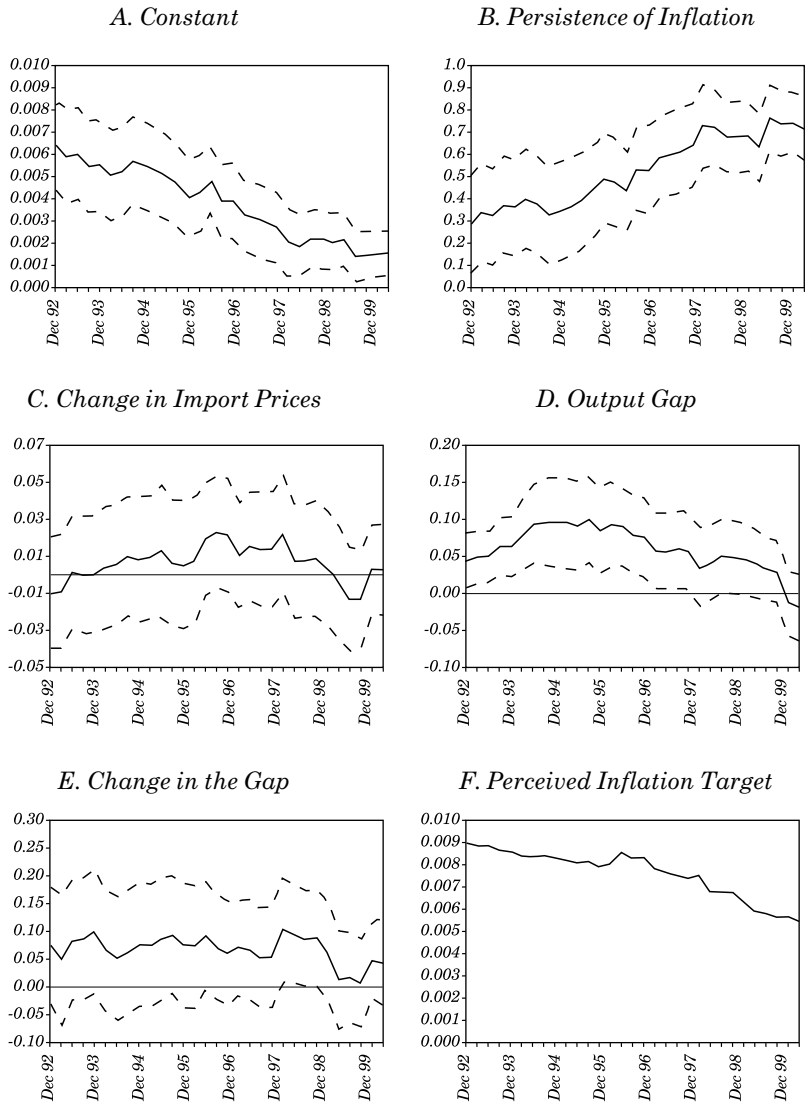
**Figure 6. Coefficient Estimates from Ten-Year Rolling Regressions for Canada, 1983:1 to 2000:2[a]**




Source: Authors' calculations.

a. Specification as in Table 1. Dashed lines are 1 standard error bands. Persistence of inflation is $(\delta_1 + \delta_2 + \delta_3)$. Perceived inflation target is $\delta_0 / [1 - (\delta_1 + \delta_2 + \delta_3)]$.

**Figure 7. Coefficient Estimates from Ten-Year Rolling Regressions for United States, 1983:1 to 2000:2[a]**




Source: Authors' calculations.

a. Specification as in Table 1. Dashed lines are 1 standard error bands. Persistence of inflation is $(\delta_1 + \delta_2 + \delta_3)$. Perceived inflation target is $\delta_0 / [1 - (\delta_1 + \delta_2 + \delta_3)]$.

explain why the persistence of inflation was so much lower in Australia and New Zealand during the 1990s than in the United States and the United Kingdom, given the flexibility of the latter countries' product and labor markets. More generally, the wide variation in these estimates over time and across countries suggests that any conclusions drawn from this sort of reduced-form price equation may not be particularly robust.

Overall, the results in this section of the paper suggest that structural changes in the inflation process may well have taken place in each of these countries between the 1980s and the 1990s. Chow tests of structural change, presented in table 1, support this conclusion at a 10 percent level for the United States and at a 5 percent level for each of the other countries.[20] Like Andersen and Wascher (2000), however, we find that the structural changes that have occurred in the inflation processes have differed quite a lot across the countries considered, and it is hard to attribute these changes to any specific global phenomenon. In particular, it seems unlikely that increased credibility can convincingly be argued to have driven the reduction in inflation persistence in Australia and New Zealand given the other countries' results.

## 4. Conclusion

Whether an open economy should target aggregate or nontraded inflation depends on the objective function of the policymaker, the nature of the shocks to which the economy is exposed, and the structural relationships in the economy. In the end, this is an empirical issue. The results in this paper suggest that for the Australian economy, the choice of inflation target does not generally make much difference to the extent of inflation or output variability. In part, this stems from

20. Table 1 reports tests for a structural break at March 1992, but the results were not particularly sensitive to the break point. For simplicity, a common break point was chosen across countries at a time that coincided roughly with the beginning of the low inflation episode for most of these countries. These results contrast those presented in Andersen and Wascher (2000), although the aim of that paper is to test whether the inflation process in the whole of the 1990s (including the disinflationary period at the beginning of the decade) was significantly different from the behavior of inflation in the previous three decades. Beechey and others (2000) similarly do not find statistically significant evidence of a structural break in the inflation process in the error correction model they estimate. That equation, however, includes unit labor costs as an explanatory variable, whereas the equation estimated above is a reduced-form price equation. Our tests for structural change are thus implicitly tests for structural change in either the price- or wage-setting process

the fact that the estimated pass-through of exchange rate changes to aggregate inflation is found to be protracted.

Changes in the structure of the economy, and particularly the inflation process, however, will affect this conclusion. This paper has shown that the inflation process has undergone significant changes over the past two decades. In Australia's case, the effect of exchange rate changes on inflation has become noticeably more moderate. The inflation process overall also appears to have become considerably better anchored. Both of these developments provide further support for the above conclusion and imply that the Australian economy has become more resilient to temporary price-level shocks.

Evidence from other countries, however, suggests a need for caution. The inflation process varies considerably both across countries and over time, in ways that seem difficult to explain. In particular, it is possible that the economy's response to specific shocks may vary from the average responses implied by reduced-form regression analysis, because of changing perceptions about the nature and likely permanence of shocks. Policymakers will always need to be mindful of the fact that such changes can have significant effects on inflation and growth outcomes, and they must therefore exercise judgement and flexibility in assessing the economic outlook.

## APPENDIX A
## A Small Macroeconomic Model of Australia

This model is similar in structure to that presented in Beechey and others (2000). The primary difference is that aggregate inflation is not modeled in an error correction framework. The model is estimated and calibrated over the period 1985:1 to 1999:4. All the inflation processes in the model are calibrated to deliver 2.5 percent inflation in steady state, which is the assumed value of the inflation target in the central bank's objective function.

### Output gap

$$y_t = \underset{(0.052)}{0.852}\, y_{t-1} + \underset{(0.061)}{0.159}\, y^f_{t-1} - \underset{(0.027)}{0.137}\left(r_{t-6} - 3.5\right) - \underset{(0.008)}{0.025}\left(rer_{t-3} - \underset{(1.83)}{464.701}\right), \tag{8}$$

where $y$ is the domestic output gap, measured using detrended real nonfarm output; $y^f$ is the foreign output gap, measured as deviations of the U.S. gross domestic product (GDP) from trend; $r$ is the real cash rate (the instrument of monetary policy less aggregate inflation); and *rer* is the real exchange rate.

### Aggregate prices

$$\Delta p_t = \underset{(0.112)}{0.246}\Delta p_{t-1} + \underset{(0.102)}{0.399}\Delta p_{t-2} + \underset{(0.108)}{0.223}\Delta p_{t-3} + \underset{(0.049)}{0.084}\Delta ulc_{t-5} + \underset{(0.015)}{0.040}\Delta pm_t + \underset{(0.016)}{0.008}\Delta pm_{t-1}, \tag{9}$$

where $p$ is the level of the consumer price index (CPI), *ulc* is a measure of unit labor costs, and *pm* is import prices. The restriction that the coefficients on prices, unit labor costs, and import prices sum to one was imposed.

### Unit labor costs

$$\Delta_4 ulc_t = \underset{(0.088)}{0.513}\Delta_4 p_{t-1} + \underset{(0.088)}{0.487}\Delta_4 ulc_{t-1} + \underset{(0.065)}{0.187} y_{t-1}. \tag{10}$$

The unit labor cost equation is a linear Phillips curve incorporating adaptive expectations. The assumption of adaptive expectations has historically provided the best fit for Australian data. The equation was

estimated with the restriction that the coefficients on lagged inflation sum to one.

## Import prices

$$\begin{aligned}\Delta pm_t = &- \underset{(0.023)}{0.748}\Delta e_t - \underset{(0.022)}{0.197}\Delta e_{t-1} + \underset{(0.022)}{0.005}\Delta e_{t-2} - \underset{(0.023)}{0.060}\Delta e_{t-3} \\ &+ \underset{(0.117)}{0.430}\Delta wp_t + \underset{(0.117)}{0.570}\Delta wp_{t-1},\end{aligned} \tag{11}$$

where $e$ is the nominal exchange rate and $wp$ represents world export prices. We assume unitary pass-through of movements in the exchange rate and world prices.

## Real exchange rate

$$\begin{aligned}\Delta rer_t = &- \underset{(0.108)}{0.331}\left(rer_{t-1} - \underset{(1.83)}{464.701}\right) + \underset{(0.102)}{0.423}\left(tot_{t-1} - \underset{(1.05)}{463.516}\right) \\ &+ \underset{(0.233)}{0.589}\left(r_{t-1} - r^f_{t-1} - 1.5\right) + \underset{(0.162)}{1.382}\Delta tot_t - \underset{(0.082)}{0.228}\Delta rer_{t-1} \\ &- \underset{(0.082)}{0.088}\Delta rer_{t-2} - \underset{(0.081)}{0.228}\Delta rer_{t-3},\end{aligned} \tag{12}$$

where $rer$ is the real exchange rate, measured using the real trade weighted index, $tot$ is the terms of trade, and $r^f$ is the Group of Three (G3) real interest rate.

## Nominal exchange rate

$$\Delta ner = \Delta rer + \Delta p^f_{t-1} - \Delta p_{t-1}, \tag{13}$$

where $p^f$ is the foreign price level, measured using Group of Seven (G7) core inflation.

## Foreign output gap

$$y^f_t = \underset{(0.047)}{1.104}\, y^f_{t-1} - \underset{(0.120)}{0.405}\left(r^f_{t-1} - 2.0\right). \tag{14}$$

## Terms of trade

$$\begin{aligned}\Delta tot_t = &- \underset{(0.047)}{0.193}\left(tot_{t-1} - \underset{(1.05)}{463.516}\right) + \underset{(0.100)}{0.217}\Delta tot_{t-1} + \underset{(0.103)}{0.215}\Delta tot_{t-2} \\ &+ \underset{(0.106)}{0.173}\Delta tot_{t-3} + \underset{(0.109)}{0.091}\Delta tot_{t-4} + \underset{(0.111)}{0.249}\Delta tot_{t-5}.\end{aligned} \tag{15}$$

### World export prices

$$\begin{aligned}\Delta wp_t &= 0.625 + \underset{(0.092)}{0.462}\left(\Delta wp_{t-1} - 0.625\right) - \underset{(0.098)}{0.118}\left(\Delta wp_{t-2} - 0.625\right) \\ &\quad + \underset{(0.091)}{0.320}\left(\Delta wp_{t-3} - 0.625\right).\end{aligned} \tag{16}$$

### Group of Seven (G7) core inflation

$$\begin{aligned}\Delta p_t^f &= 0.625 + \underset{(0.107)}{0.344}\left(\Delta p_{t-1}^f - 0.625\right) \\ &\quad + \underset{(0.106)}{0.332}\left(\Delta p_{t-2}^f - 0.625\right) + \underset{(0.113)}{0.327}\left(\Delta p_{t-3}^f - 0.625\right) \\ &\quad - \underset{(0.110)}{0.103}\left(\Delta p_{t-4}^f - 0.625\right) + \underset{(0.113)}{0.327}\,\Delta y_{t-4}^f.\end{aligned} \tag{17}$$

### Group of Three (G3) real interest rate

The following reaction function was assumed:

$$r_t^f = 2 + 0.3y_{t-2}^f + 0.1\left(\Delta p_{t-2}^f - 0.625\right), \tag{18}$$

where the equilibrium real interest rate is 2 percent and the equilibrium world inflation rate is 2.5 percent.

## APPENDIX B
## Data Sources

### Australia

*Inflation.* Defined as the median inflation index, excluding mortgage interest charges and consumer credit charges. Source: Calculated by the Reserve Bank of Australia, based on data in *Consumer Price Index*, ABS Catalog No. 6401.0.

*Output Gap.* Defined as the adjusted deviation of nonfarm GDP from HP filtered series ($\lambda = 1600$) Source: Beechey and others (2000).

*Import Prices.* Defined as the implicit price deflator for imports, excluding fuels and lubricants, civil aircraft, and Reserve Bank of Australia gold imports. Tariff adjusted. Source: Australian Customs Service, *National Income, Expenditure and Product*, ABS Catalog No. 5206.0.

### Canada

*Inflation.* Defined as the chain-linked price index of personal consumption expenditures, seasonally adjusted and adjusted for the introduction of the goods and services tax (GST) in the first quarter of 1991. Source: Statistics Canada, Datastream code CN15614.

*Output Gap.* Defined as the deviation of GDP from HP filtered series ($\lambda = 1600$), mean-adjusted assuming a sacrifice ratio of 3 percent. Source: Statistics Canada, Datastream code CNGDP…D.

*Import Prices.* Defined as the import price index, seasonally adjusted. Source: Statistics Canada, Datastream code CNB1226.

### New Zealand

*Inflation.* Defined as the implicit price deflator for private final consumption, adjusted for indirect tax changes in the fourth quarter of 1986 and the third quarter of 1989. Source: New Zealand Department of Statistics, Datastream codes NZCONEXPA and NZCONEXPC.

*Output Gap.* Defined as the deviation of GDP from HP filtered series ($\lambda = 1600$), mean-adjusted assuming a sacrifice ratio of 3 percent. Source: New Zealand Department of Statistics, Datastream code NZGD….D.

*Import Prices.* Defined as the import price index. Source: New Zealand Department of Statistics, Datastream code NZIMPPRCF.

## United Kingdom

*Inflation.* Defined as the retail price index, excluding mortgage interest (RPI-X), seasonally adjusted and adjusted for the change in the value-added tax (VAT) in the second quarter of 1991. Source: United Kingdom Office for National Statistics, Datastream code UKRPAXMIF.

*Output Gap.* Defined as the deviation of GDP from HP filtered series ($\lambda = 1600$), mean-adjusted assuming a sacrifice ratio of 3 percent. Source: United Kingdom Office for National Statistics, Datastream code UKABMI.

*Import Prices.* Defined as the import price index. Source: United Kingdom Office for National Statistics, Datastream code UKBQKS.

## United States

*Inflation.* Defined as the index of personal consumption expenditures, seasonally adjusted. Source: United States Bureau of Economic Analysis, Datastream code USCE..CE.

*Output Gap.* Defined as the deviation of GDP from HP filtered series ($\lambda = 1600$), mean-adjusted assuming a sacrifice ratio of 3 percent. Source: United States Bureau of Economic Analysis, Datastream code USGDP…D.

*Import Prices.* Defined as the chain-type price index for imports, seasonally adjusted. Source: United States Bureau of Economic Analysis, Datastream code USIMN..CE.

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# Lessons From Inflation Targeting in New Zealand

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The number of central banks that have adopted formal inflation-targeting regimes expanded over the past decade from only one to eight. The number increases even further when central banks that set policy consistent with a formal inflation target are included.[1] Commensurate with the formal or informal adoption of inflation-targeting regimes, there has been an explosion in the literature on inflation targeting. This literature can be separated into two broad categories. One set examines the macroeconomic data to assess the performance of the inflation targeters and to extract lessons from the inflation targeting experiences of the individual countries concerned.[2] The other set evaluates inflation targeting as a monetary policy strategy, as characterized by a policy rule. A model of the economy is used to assess the stabiliza-

At the time of writing this paper, Drew was with the Reserve Bank of New Zealand.

The material presented here draws heavily on the Reserve Bank of New Zealand's review of the 1991–98 business cycle, as well as papers prepared by the Bank for the 2000 Independent Review of the Operation of Monetary Policy in New Zealand. These papers may be obtained at www.rbnz.govt.nz/monpol/review/index.html. I would like to thank Adrian Orr, Don Brash, Murray Sherwin, Rod Carr, David Archer, Michael Reddell, Bruce White, Anne-Marie Brooke, John McDermott, Geoff Mortlock, Mike Frith, Tim Ng, Paul Conway, and Dean Minot. I would also like to thank Jorge Restrepo for helpful comments.

1. The Reserve Bank of New Zealand was the first to adopt a formal inflation target with the passing of the Reserve Bank of New Zealand Act in 1989. Informally, the Bank had been inflation targeting since 1988. In the 1990s Australia, Canada, Finland, Spain, Sweden, the United Kingdom, and, most recently, the member countries of the European Central Bank have adopted formal inflation targets. Countries that describe themselves as inflation targeters, but that do not necessarily pursue explicit, public commitments to specific targets include Chile, the Czech Republic, Israel, the Republic of Korea, and Mexico.

2. For a recent general assessment of the experience of industrial countries with inflation targeting to date, see Bernanke and others (1999). Recent individual country accounts by central bankers can be found in Allen (1999); Heikensten and Vredin (1998); Thiessen (1998); Stevens (1999); Sherwin (1999).

*Inflation Targeting: Design, Performance, Challenges,* edited by Norman Loayza and Raimundo Soto, Santiago, Chile. © 2002 Central Bank of Chile.

tion properties of a range of alternative policy rules under deterministic and stochastic disturbances and, increasingly, uncertainty.[3]

This paper combines elements of both strands of the inflation-targeting literature. Some of the key monetary policy issues that the Reserve Bank of New Zealand faced in the 1990s are analyzed using the Bank's economic Forecasting and Policy System (FPS) model. The Bank's policy responses to the specific shocks faced are characterized, and the implications of alternative policy responses to both specific shocks and more generalized disturbances are shown. On the basis of this analysis, the paper highlights two key lessons that the Bank has learned over the last decade. First, inflationary pressures, including those arising from wealth effects, should be preempted to the extent possible. Second, the use of a monetary condition index (MCI) as a guide for policy becomes problematic when economic fundamentals are shifting rapidly.

The paper also explores the rationale behind the evolution of monetary policy at the Reserve Bank of New Zealand. It is likely that as the structure of the economy changes, the lags in monetary policy transmission will also change, and policy design should take this into account. Since the early 1990s, the pass-through into local prices of nominal exchange rate changes has become increasingly muted in New Zealand, effectively lengthening monetary policy's lags (by elevating, in a relative sense, the role of the slower part of monetary policy transmission that works through economic activity). As the Bank has observed this development, it has tended to push out the point in the forecast horizon that it uses to guide policy decisions. This factor, together with the reduction of both inflation and inflation expectations in the 1990s, has led the Bank to adopt a more flexible inflation targeting approach that affords authorities the option of reacting to the more persistent sources of inflationary pressures when deciding on the stance of monetary policy.

The remainder of this paper is structured as follows. Section 1 provides a brief snapshot of the New Zealand macroeconomic data. This is followed in section 2 by an overview of the business cycle experienced in New Zealand in the 1990s. Section 3 examines the impact of specific shocks on the economy, the Bank's policy responses to those shocks, and the potential trade-offs associated with being more or less flexible in policymaking. Concluding comments are provided in section 4.

3. This literature is very large. See, for example, the special issue of the *Journal of Monetary Economics* 43(4) and the references therein.

## 1. The New Zealand Data Record

Before discussing the role of monetary policy in New Zealand, it is useful to briefly review the broad macroeconomic characteristics of the country in the 1990s. Figure 1 shows how inflation, gross domestic product (GDP) growth, ninety-day interest rates, and the trade-weighted exchange rate evolved after 1990. These are each discussed in turn.

### 1.1 Inflation

The 1990s represented the first complete decade of inflation targeting in New Zealand, as well as the first decade in a long time in which inflation remained low and stable. After achieving the 0 to 2 percent inflation target in 1991, monetary policy successfully anchored the inflation rate over the remainder of the decade.

From 1991 on, most standard measures of the inflation rate remained below 3 percent, and typically between 1.0 and 2.5 percent. As indicated in figure 1, inflation breached the top of the inflation target band (then 0 to 2 percent) on two occasions: in the second quarter of 1995 and throughout 1996. The Bank's measure of underlying inflation never came close to breaching the lower edge of the target; in fact, it never fell into the bottom half of the 0–2 percent target band. Inflation of the consumer price index excluding credit services (CPIX) fell to a trough of about 1 percent in late 1998 following a number of adverse shocks.[4]

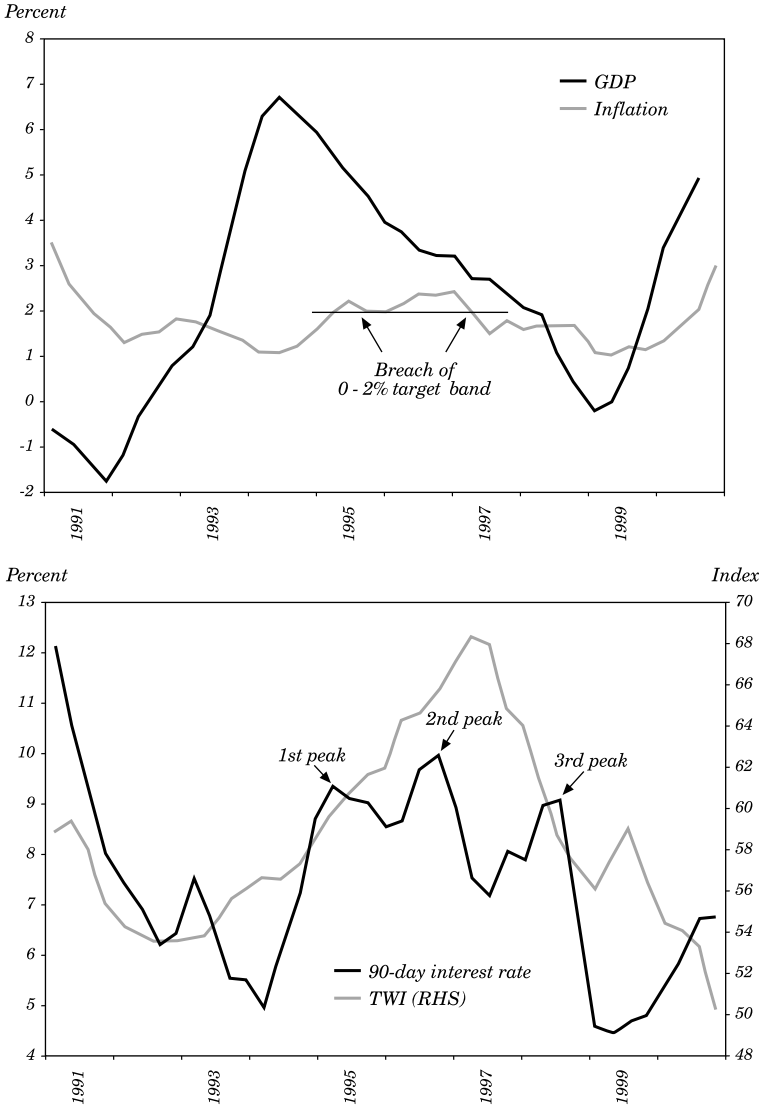
To put New Zealand's inflation record in an international context, figure 2 compares New Zealand's average rate of CPIX inflation since 1991 with the average for the member countries of the Organization for Economic Cooperation and Development. The average inflation rate has been very similar to the OECD average since 1995; before that time it was slightly lower, reflecting the earlier steps taken in New Zealand to bring inflation down.

### 1.2 Output

New Zealand experienced a significant recession in the early part of the decade, followed by a strong boom in the mid-1990s. Growth then

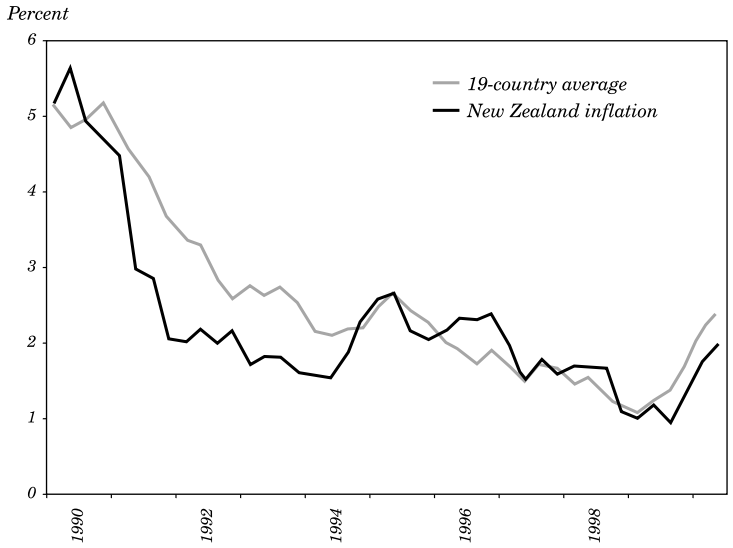
4. The Reserve Bank of New Zealand calculated and targeted underlying inflation from 1989:1 to 1997:3. It then targeted the CPIX from 1997:4 to 1999:2. Since 1999:3, the Reserve Bank has targeted headline CPI. Note, however, that Statistics New Zealand redefined headline CPI in 1999:3 such that it does not include interest charges.

**Figure 1. Real GDP Growth, CPI Target Measure of Inflation, Ninety-Day Interest Rates, and the Nominal TWI[a]**




Source: Statistics New Zealand, Reserve Bank of New Zealand.
a. GDP growth is an annual average percent change. Inflation is measured as an annual percent change. The inflation series is a spliced series of the CPI measures targeted by the Bank at different periods. These are the underlying inflation rate, the CPI excluding credit services, and the current CPI measure.

**Figure 2. CPIX Inflation in New Zealand and the OECD[a]**
Annual percentage change




Source: Statistics New Zealand and *International Financial Statistics*.
a. The OECD inflation rate is a nineteen-country average, including Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

slowed gradually, culminating in a small contraction in GDP in the first two quarters of 1998. GDP accelerated quite quickly out of the 1998 trough before returning to more moderate growth rates.

Average GDP growth rates in the 1990s were higher than those in previous decades: real GDP growth averaged 2.5 percent during the 1990s, compared with 1.8 percent and 1.7 percent in the 1970s and 1980s, respectively. New Zealand's average GDP growth in the 1990s was also quite respectable compared with that of other industrialized countries. In a sample of eighteen industrialized economies, New Zealand's average GDP growth in the 1990s was sixth highest, although the strong average growth relative to the growth in many European economies was partly due to a faster growth in the work force in New Zealand (see table 1). The variability of output growth in New Zealand was also lower in the 1990s compared to the 1970s and 1980s.[5]

5. See "Output Volatility in New Zealand" at www.rbnz.govt.nz/monpol/review/index.html for a detailed analysis of New Zealand's output variability and how this compares to other industrialized countries.

**Table 1. Real GDP Growth in the 1990s**

Percent

| *Country* | *Average growth rate* |
|---|---|
| Ireland | 6.8 |
| Australia | 3.5 |
| Norway | 3.3 |
| United States | 3.2 |
| Netherlands | 2.9 |
| New Zealand | 2.5 |
| Spain | 2.5 |
| Canada | 2.4 |
| Denmark | 2.2 |
| Belgium | 2.1 |
| Germany | 2.0 |
| United Kingdom | 2.0 |
| France | 1.7 |
| Finland | 1.7 |
| Italy | 1.4 |
| Sweden | 1.3 |
| Japan | 1.3 |
| Switzerland | 0.9 |

Source: Datastream; Statistics New Zealand

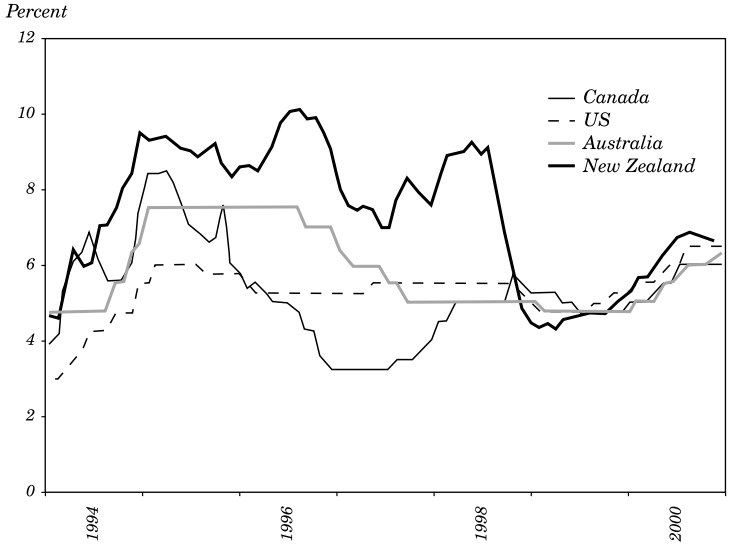
## 1.3 Interest Rates

The path of interest rates through the 1990s featured three humps: 1994–95, 1996, and 1997–98 (see figure 1). From late 1994 to early 1997, ninety-day rates in New Zealand averaged about 9 percent. This was in response to strong inflationary pressures, as discussed in following sections.

Following the 1996 peak, interest rates fell markedly to around 7 percent in early 1997, before rising again between mid-1997 and mid-1998 to nearly 10 percent. This increase in interest rates coincided with the Bank's use of the monetary conditions index (MCI) to signal the policy stance, which is discussed in detail in Section 3. Following the third peak, interest rates fell from about 9 percent to 4 percent in the latter half of 1998. They then rose gradually to just over 6.5 percent in 2000.

Figure 3 provides a cross-country comparison of short-term interest rates over this period. Because different countries feature different inflation rates, different risk premiums, different cyclical demand pressures, and other distinctive characteristics, however, a simple comparison of nominal interest rates does not always provide a good

**Figure 3. Short-Term (Official) Interest Rates of Dollar Bloc Countries[a]**




Source: Reserve Bank of New Zealand, Reserve Bank of Australia and Datastream.
a. The short-term rates charted are the US federal funds target rate; the Bank of Canada bank rate; the Australian cash rate; and the New Zealand 90-day bank bill rate. Australia's three-month bank bill rate tracks the Reserve Bank of Australia's official cash rate closely during this period.

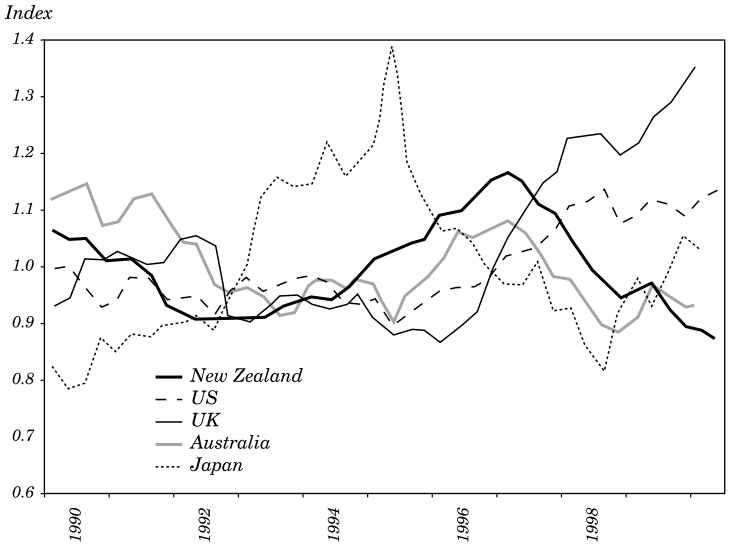
indication of the relative tightness of monetary policy in the countries under consideration.

## 1.4 The Exchange Rate

The bottom panel of figure 1 depicts a significant cycle in the New Zealand trade-weighted exchange rate index (TWI). After an appreciation of around 30 percent between the first quarter of 1993 and the first quarter of 1997, the TWI subsequently depreciated by around 30 percent. With respect to the U.S. dollar, the New Zealand dollar fell from a post-float high of nearly 72 cents in November 1996 to an all-time low of less than 40 cents in October 2000.

New Zealand was not alone in experiencing large exchange rate fluctuations. Figure 4 plots New Zealand's real effective exchange rate alongside similar measures of the exchange rate for four other countries. Although the amplitude of the cycle of the Australian exchange rate was lower than that of the New Zealand exchange rate, the swings in the yen and the pound sterling were larger than those of the New Zealand TWI.

**Figure 4. Real Effective Exchange Rates for Selected Countries[a]**




Source: International Monetary Found (IMF), *International Financial Statistics;* Reserve Bank of New Zealand.
a. The exchange rates shown are the real effective exchange rates as calculated by the International Monetary Fund, except for New Zealand where a CPI-based real trade-weighted exchange rate has been used. All the exchange rates have been re-based so that the respective indexes average 1.0 over the period shown.

## 2. The Business Cycle in New Zealand in the 1990s

New Zealand experienced a strong expansion in output from 1991 to 1997 relative to the economy's recent history as well as contemporaneous OECD country experiences.[6] This expansion was propelled by the flow on effects of structural reform undertaken in the late 1980s and by the traditional factors driving the business cycle, including robust world demand, high commodity prices for New Zealand's exports, strong net inward migration flows, high levels of business and consumer confidence boosting both consumption and investment expenditures, and later, expansionary fiscal policy.[7]

6. Using the National Bureau of Economic Research (NBER) levels-based definition of the business cycle, Brook, Collins, and Smith (1998) show that the expansion in the 1990s lasted two years longer than the previous two expansions experienced in New Zealand. They also find that output growth in New Zealand was above an eighteen-country average of selected OECD countries from 1993 to 1996.

7. For an account of the nature and scope of the New Zealand reform program, see Evans and others (1996). Brook, Collins, and Smith (1998) provide an in-depth discussion on how the reforms and cyclical pressures shaped the 1991–97 business cycle.

Inflationary pressures were strong as a result of the rapid and prolonged expansion in demand over the mid-1990s, and monetary conditions were held firm for an extended period to counter the pressures. Nominal short-term interest rates were increased over the course of 1994 from under 5 percent to almost 10 percent, as shown above in figure 1. Real short-term interest rates also rose substantially above the OECD average in 1994, and they remained high until late 1997. This monetary tightening, together with the general attractiveness of New Zealand as a destination of international capital, led to the substantial appreciation of the real exchange rate seen in the figure.[8]

The tight monetary conditions successfully held overall CPI inflation (less interest costs) within a tight band of 1.5 to 3.0 percent over the period. This stands in marked contrast to New Zealand's longer inflation record, which has generally been poor.

In late 1996 policy was eased as inflationary pressures began to wane, but three large negative shocks turned the desired soft landing into an unexpectedly harsh one. First, the East Asian crisis of 1997 significantly affected both the volume and value of New Zealand's exports.[9] Second, on the supply side, agricultural production contracted after over a year of severe drought. Finally, a change in national immigration policy caused net migration to swing very quickly from positive to negative. These factors, together with the previously tight monetary conditions, caused GDP to contract by nearly two percent over the first half of 1998. After that point, the economy grew moderately, assisted by a very competitive real exchange rate. The growth has yet to be balanced, however, as the most significant contributions to growth have occurred in the externally exposed sectors of the economy.

## 3. Key Policy Issues

Debelle and others (1998) and Bernanke and others (1999) reach the general conclusion that New Zealand's experience with inflation targeting, like that of other formal inflation targeters, has been positive. The relatively strong growth performance of the 1990s occurred in an environment in which inflation remained low and stable, in contrast to the economy's longer historical record. Perhaps not surprisingly, this conclusion is also endorsed by the Reserve Bank of New

8. See White (1998) for an account of the pressures on the exchange rate in addition to the monetary tightening.

9. East Asia accounts for over 40 percent of New Zealand's exports, and exports amount to around 30 percent of GDP.

Zealand.[10] This is not to say that it has all been plain sailing, however. To quote the Bank's main submission to the *Independent Review of the Operation of Monetary Policy,*

> With the benefit of hindsight, there are occasions in the 1990s when our assessments missed the mark. Two are worth noting. We were slow to recognize the pace of acceleration of the economy in 1992/93, and slow to recognize the joint impact of the Asian crisis and the beginning of an extended drought through 1997 and early 1998. But we would argue that we responded quickly when we recognized the emerging problem—quickly enough to prevent these large inflationary and deflationary impulses to the economy from causing substantial price instability and even larger and more costly swings in the real economy.

The Bank's approach to inflation targeting has evolved as structural relationships in the economy have altered, as it has learned from past errors and from the experiences of other inflation targeters, and as the academic research on inflation targeting has advanced. This section addresses the following two questions in relation to these issues. What lessons can be drawn from the specific shocks that occurred in New Zealand in the 1990s and the way monetary policy responded? How forcefully should monetary policy respond to more generalized disturbances, and how wide does the inflation target band need to be to reasonably accommodate most shocks? The analysis is based on deterministic and stochastic simulations of the Bank's macroeconomic model, the FPS.[11] These simulations are intended for illustrative experiments only. They do not tell us with precision how the Bank should have structured monetary policy in the past or it should do so in the future.

10. See Sherwin (1999).

11. The Forecasting and Policy System (FPS) is a large, calibrated, dynamic general equilibrium (DGE) model with the same generic structure as the Bank of Canada's Quarterly Projections Model (QPM) (see Colleti and others, 1996). These models have a two-tiered structure. The first is an underlying steady-state structure, characterized by a neoclassical balanced-growth path and based on optimizing principles. The second tier models dynamic adjustment to the steady-state path. The adjustment processes (both expectational and intrinsic) are calibrated to reflect the business cycle dynamics of the economies concerned. Although there are many sources of inflation in FPS, fundamentally it arises from the deviation of output from potential output. The monetary authority enforces a nominal anchor via a policy reaction function that sets the short-term interest rate in response to forecasted inflation deviations from the target. See Black and others (1997) for a complete description of the properties of the FPS core mode. Drew and Hunt (1998a) discuss how the FPS is used to prepare economic projections at the Bank.

## 3.1 Deterministic Simulations

This section reports the results of four sets of experiments undertaken to investigate the following questions. What would have happened if the Bank had better anticipated the increase in demand pressures that occurred in the mid-1990s? How much of an impact might an appreciation of the exchange rate, independent of interest rate effects, have had on the mix of monetary conditions and the external imbalance during this time? In formulating policy responses to the specific disturbances, how much difference does the policy horizon make? What are the implications of using an MCI to guide policy in the context of a fall in the currency that is initially seen as a portfolio shock, rather than as a necessary adjustment to evolving real conditions abroad? Each of these questions is addressed in turn.

### Household expenditure and debt

A feature of the expansion that occurred in the mid-1990s was that consumption growth outstripped income flows, leading to substantial increases in household debt. This was also observed at the national level: the ratio of New Zealand's net foreign assets (NFA) to GDP deteriorated considerably following a sequence of substantial current account deficits.[12]

The deterioration observed in NFA is consistent with households borrowing against their increased wealth, or saving less out of current income, to finance current consumption. Such behavior can be explained by standard economic theory. An increase in household wealth that households perceive to be permanent will have important so-called wealth effects on consumption. The difficulty, of course, is to quantify the extent of these effects ex ante. As discussed in Drew and Orr (1999), the Bank's inflation projections over the early 1990s did not adequately incorporate the impact on demand of households anticipating future wealth and income growth.

12. In 1992, New Zealand's nominal NFA-to-GDP ratio was around –0.72; by 1997 this had deteriorated to around –0.84. A large part of the deterioration was due to foreign investment inflows, which in a sense represented a vote of confidence in the New Zealand economy by foreign investors. The other side of the coin, however, is that New Zealander's reluctance or inability to finance the capital expansion effectively increased our indebtedness to the rest of the world, as represented by the deterioration in the NFA position. See Collins, Nadal de Simone, and Hargreaves (1998) for a more developed exposition of this issue.

Because FPS explicitly accounts for asset stocks, it can be used to examine the implications of misperceiving the willingness of households to incur debt to support consumption. I consider two alternative specifications of the model's behavioral equation for consumption of forward-looking agents. In one specification consumption is curtailed relatively strongly as the NFA-to-output ratio deteriorates from equilibrium; in the other the deviation is tolerated to a greater extent. The following three equations are a stylized representation of the dynamic structure for consumption in the model:

$$c_t = crt_t + cfl_t$$

$$crt_t = ydrt_t, \text{ and}$$

$$cfl_t = cfl\_eq_t + \alpha\left(\frac{ydfl_{t-2}}{ydfl\_eq_{t-2}} - 1\right) - \beta\left(rn_{t-2} - rn\_eq_{t-2}\right) + \delta\left(nfa_t - nfa\_eq_t\right) - cfldaj_t,$$

where $c_t$ is aggregate consumption, $crt_t$ is consumption by rule-of-thumb agents and $cfl_t$ is consumption by forward-looking agents.[13] Rule-of-thumb consumers are liquidity constrained in that they consume 100 percent of their after-tax real disposable income, $ydrt_t$. Forward-looking consumers earn income and hold financial assets, consisting of government bonds, the capital stock, and NFA (which is negative to reflect the New Zealand data). Their desired or equilibrium path for consumption, $cfl\_eq_t$, is determined by solving for a utility maximization problem.[14] Actual consumption of forward-looking agents deviates from equilibrium when real disposable income, $ydfl_t$, deviates from its equilibrium path, $ydfl\_eq_t$; when monetary policy moves away from neutral, $rn_{t-2} - rn\_eq_{t-2}$; and when NFA, $nfa_t$, deviates from its equilibrium path, $nfa\_eq_t$. The term $cfladj_t$ refers to a polynomial adjustment cost equation along the lines of Tinsley (1993). The coefficients $\alpha$, $\beta$, and $\delta$ determine the strength that any disequilibrium has on the dynamic path for *cfl*. Finally, all stocks and flows are expressed relative to output.

The coefficient $\delta$ represents the extent to which forward-looking consumers tolerate their wealth deviating from equilibrium. Following any temporary disturbance that moves NFA from equilibrium, the smaller $\delta$ is, the less forward-looking agents adjust their consumption behavior to

13. The portion of agents that are rule of thumb in the model is 30 percent.
14. See Frenkel and Razin (1992) for a complete specification of the problem.

maintain their overall financial asset position. Given that NFA is negative, any shock that moves NFA below equilibrium effectively increases the indebtedness of forward-looking agents to the rest of the world.

In the standard version of FPS used for Bank projections, $\delta = 0.12$. An alternative specification of the model increases the coefficient to 0.3.[15] Each model is then hit with a sequence of exogenous positive demand shocks of one percentage point per quarter for six quarters, applied to reflect the cyclical demand pressures faced in the mid-1990s.[16] In the first quarter of the experiment, the monetary authority observes the current demand shock only and sets policy based on its projection of inflation. In the second quarter another demand shock arrives and policy is reset, and so on for the remaining four quarters.

Three alternative scenarios are explored (see figure 5):

—Households have a relatively large appetite for debt, in which case the shock is significantly accommodated by allowing NFA to deteriorate ($\delta = 0.12$).

—Households have a relatively small appetite for debt ($\delta = 0.3$).

—Households have a relatively large appetite for debt, but the Bank sets policy assuming households have a small appetite. In other words, the Bank underestimates the extent to which the shock can be accommodated by an additional deterioration in the NFA position and thus underestimates the medium-term spending pressures in the economy.[17]

In all three scenarios the unexpected increase in demand leads to an increase in inflationary pressures (see panel B of figure 5). The central bank responds to the inflationary pressures by raising short-term interest rates, which leads the exchange rate to appreciate via an uncovered interest parity (UIP) condition (see panels C and D of figure 5). The eventual slowdown in demand occurs via four main paths. First, domestic consumption falls as forward-looking agents increase savings in response to the elevated interest rates. Second, the cost of capital increases

15. To quantify the impact of changing this coefficient, the rate of savings out of current income was compared under the two coefficient sizes following a one-quarter, one percentage point shock to demand. In both cases, the household savings rate fell as households increased consumption relative to current income. When the coefficient was 0.3, however, the savings rate fell by approximately 2 percent less than under the coefficient of 0.12, reflecting agents' greater reluctance to tolerate the deterioration in the NFA position.

16. Approximately two-thirds of the demand shocks are applied to the model's behavioral equation for consumption and one-third to the behavioral equation for investment.

17. This experiment examines what is essentially one aspect of model uncertainty. For a technical description of the technique employed to examine model uncertainty using models of the same generic form as FPS, see Laxton, Rose, and Tetlow (1994).

## Figure 5. The Implications of Underestimating Demand

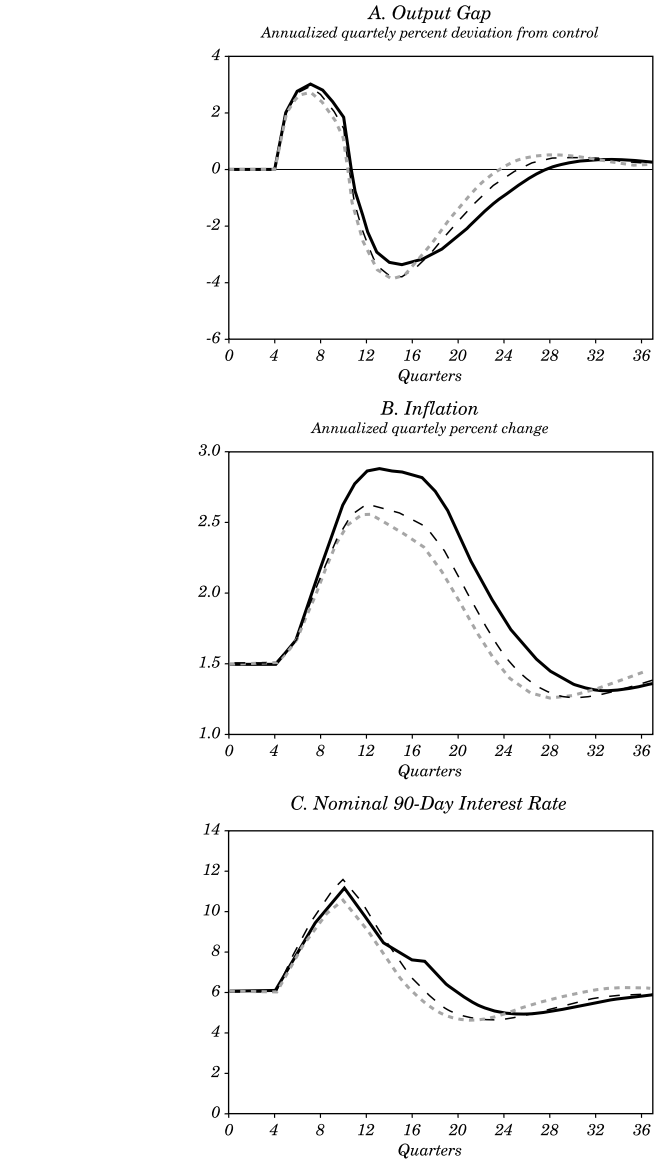
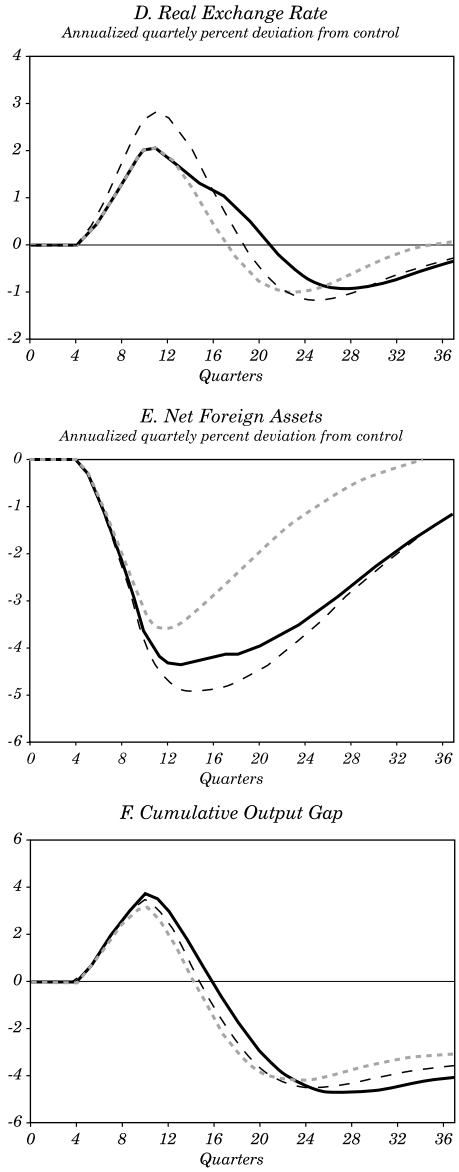


**Figure 5. (continued)**




– – *Households have a large appetite for debt (scenario 1)*
*Households have a small appetite for debt (scenario 2)*
**—** *Bank underestimates debt appetite (scenario 3)*

Source: Author's calculations.

and investment falls. Third, the exchange rate appreciation causes exports to fall and imports to rise. Finally, the decline in net exports arising from the exchange rate appreciation, together with an increase in the servicing cost of NFA arising from the policy tightening, leads to a further decline in the NFA position (see panel E). Households respond to the deteriorating NFA position by curtailing current consumption, most noticeably in the scenario in which households have a low tolerance for allowing NFA to deteriorate from equilibrium (scenario 2).

The most interesting case, however, is that in which the Bank assumes households have a relatively small appetite for debt when, in fact, the opposite is true (scenario 3). This broadly corresponds to the unexpected increase in household and national debt that was observed over the period 1991–98. In this scenario, the Bank underestimates the inflationary pressures (leading inflation to peak at around 0.5 percentage points higher, as shown in panel B of figure 5) and initially does not respond as aggressively as in the previous case. The net result is that the Bank must eventually tighten policy for a longer period, which prolongs the need for elevated real interest rates and an elevated real exchange rate (see the solid lines in panels C and D).

The results are consistent with the way in which interest rates in New Zealand remained above the OECD average throughout the cycle, thus accounting for some of the appreciation seen in the New Zealand dollar. The results suggest that if the initial policy response to rising demand had come earlier or been more aggressive, and had wealth effects been better understood, the duration of the upward pressures on interest and exchange rates might have been noticeably shorter.

## Exchange rate shock

The real exchange rate appreciated strongly during the recovery phase of the recent business cycle. Some of this appreciation can be attributed to the rise in real interest rates needed to contain inflation. Additional factors may also have temporarily supported the exchange rate. As discussed in White (1998), exceptionally low interest rates in Japan (and to a lesser extent in Europe) and the favorable marketing of New Zealand as an investment destination may have added to a strong demand for New Zealand dollar assets.

Figure 6 illustrates the impact of such a positive real exchange rate shock, on top of the demand pressures just examined. The base case in the figure is scenario 3 in figure 5, in which the economy receives a demand shock that the Bank underestimates (and which is the

**Figure 6. The Implications of Underestimating Demand with Shocks to the Real Exchange Rate**

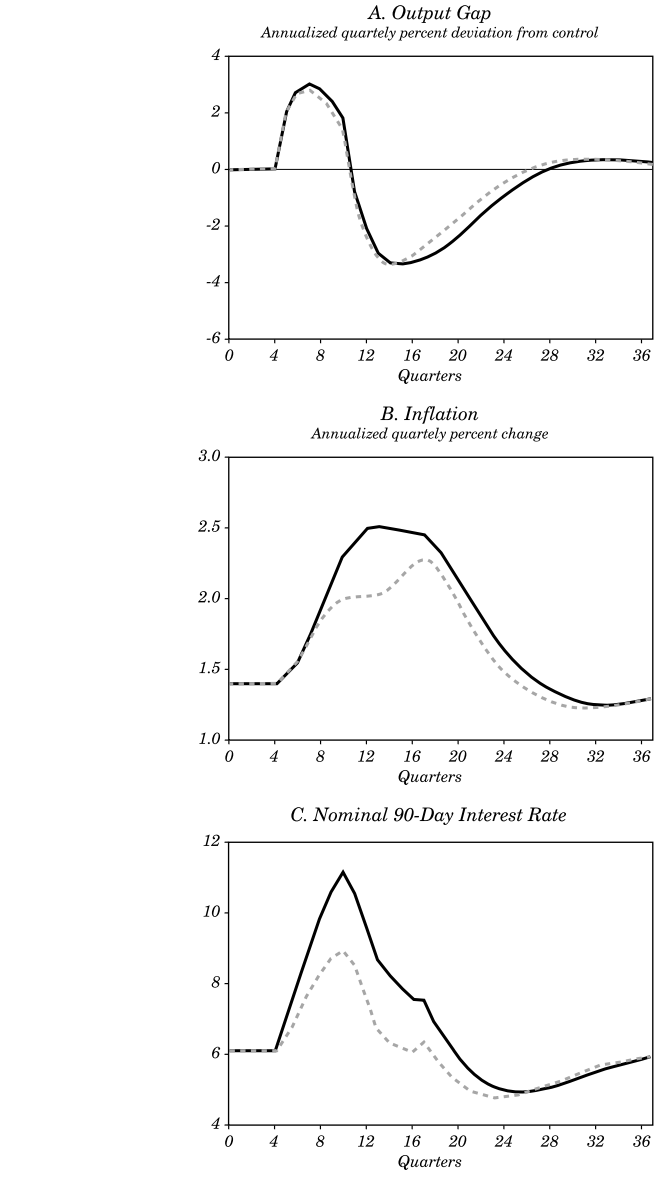
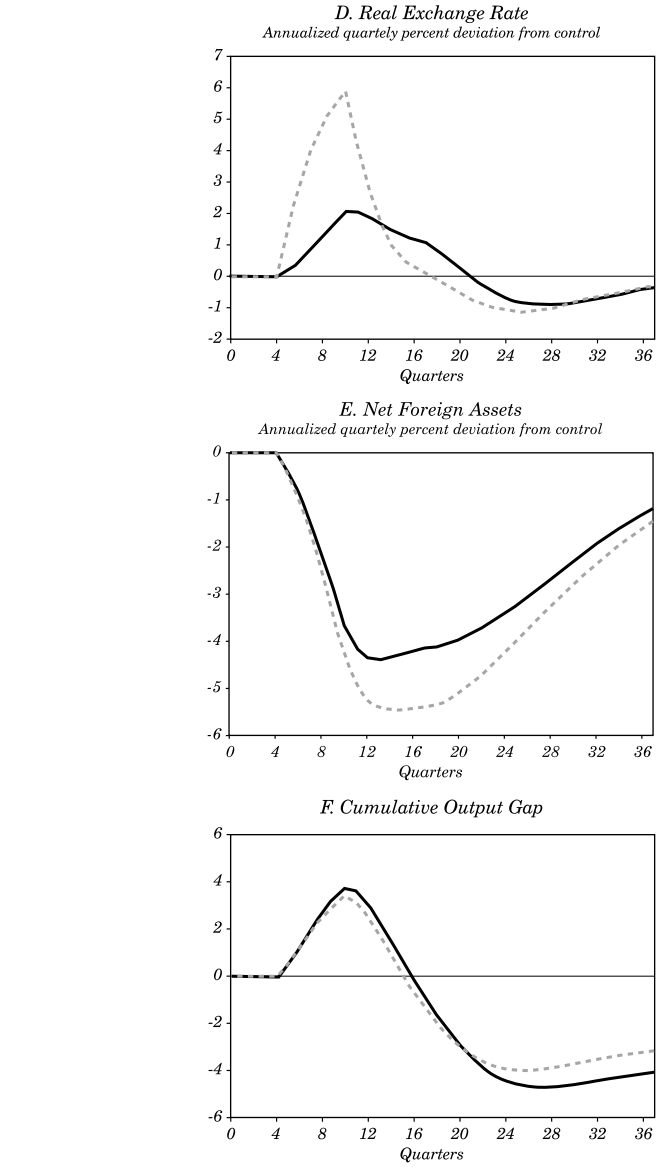


**Figure 6. (continued)**




Source: Author's calculations.

demand shock scenario that corresponds most closely with what actually happened). This situation is compared to a positive real exchange rate shock (scenario 4). That is, the real exchange rate is made to rise unexpectedly by one percent per quarter for six quarters (see panel D in figure 6).[18] As with the demand shocks, the monetary authority sets policy each quarter observing only the contemporaneous disturbances.

As a consequence of the real exchange rate shock, short-term interest rates initially rise by around two percentage points less than in the case of the demand shock alone (see panel C). The more muted interest rate response reflects the work that the real exchange rate appreciation is doing to contain demand. However, the overall NFA position deteriorates even further (see panel E). This occurs as the external sector of the economy bears more of the brunt of the policy tightening. The overall deterioration in the NFA position is around 6 percent of GDP, similar to the size of the observed deterioration in this asset stock.

## The policy horizon

The generic monetary policy reaction function used in Bank projections is an inflation-forecast-based (IFB) policy rule of the form,

$$rs_t - rs_{t-1} = \alpha\left[rs_t^* + \sum_{i=1}^{j}\theta_i\left(\pi_{t+i}^e - \pi^T\right)\right] - \alpha rs_{t-1},$$

where $rs_t$ is the nominal ninety-day rate at time $t$, $rs_t^*$ is the neutral ninety-day nominal interest rate, $\pi_{t+1}^e$ is the model's forecast of inflation at time $t+i$ and $\pi^T$ is the mid-point of the Bank's inflation-target band (that is, 1.5 percent). The parameter $\alpha$ is an interest rate smoothing constraint, and the parameter $\theta$ specifies how strongly interest rates respond to projected deviations of inflation from the target.

The demand and exchange rate shocks described above use the standard FPS policy reaction function; that is, short-term interest rates are shifted in response to projected inflation deviating from the mid-point of the inflation target band six to eight quarters ahead. Figure 7 highlights the impact of shortening this policy reaction horizon to three to five quarters ahead. Under this model and given the shocks applied, the inflation, output, and interest rate cycles are further accentuated when the horizon is shortened. This result is discussed more generally in the next section.

18. This is similar in magnitude to the real exchange rate appreciation experienced in New Zealand from late 1993 to early 1995.

**Figure 7. The Implications of Underestimating Demand, with Shocks to the Real Exchange Rate and a Short Policy Horizon**

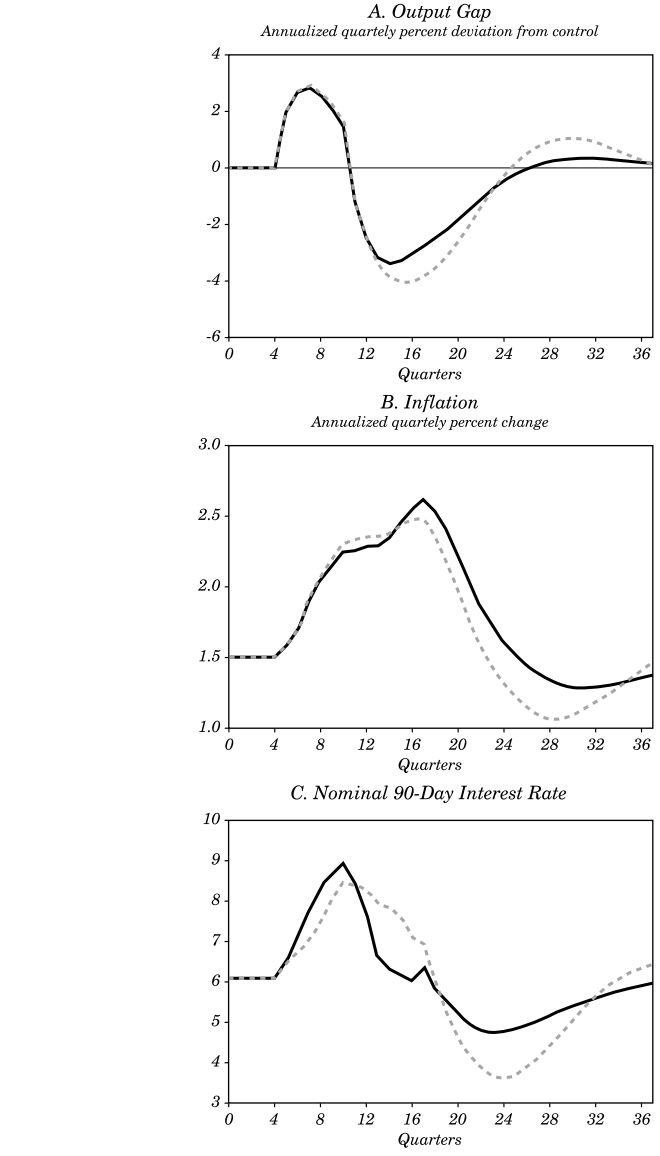
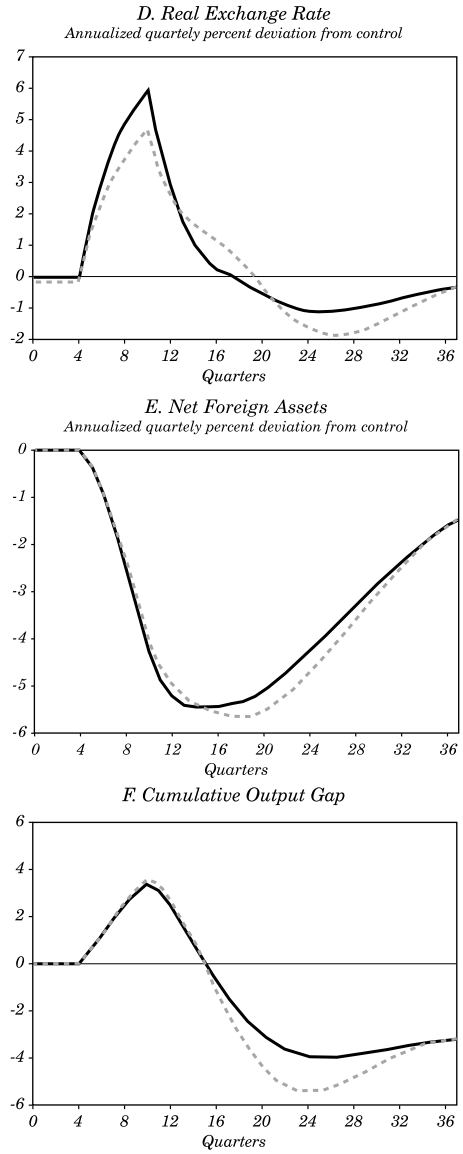


**Figure 7. (continued)**




*Bank underestimates debt appetite and exchange rate shocks (scenario 4)*
*Outcome with shorter policy horizon (scenario 5)*

Source: Author's calculations.

In shortening the policy horizon, the central bank effectively takes more account of the so-called direct channel of the exchange rate, that is, the impact on CPI inflation caused by the effect of the appreciation of the exchange rate on the price level of imported items. Accordingly, monetary policy is initially easier, since the rise in the exchange rate initially leads to lower inflation (see panel B of figure 7). The corollary is that the central bank takes less account of inflationary pressures arising from the slower-acting positive demand shock. When the central bank finally sees the implications of the demand shock, monetary policy has to be tighter for longer relative to what would have been required if policy had been more forward looking.

This stylized result sheds some light on what occurred in the mid-1990s. Monetary policy was probably at the greatest risk of operating over an excessively short-term horizon when inflation was very close to the edge of or outside the target range of 0 to 2 percent. This occurred approximately in 1995 and 1996. The Bank was very much under the spotlight during this period, and policy was almost inevitably focused on getting inflation back within the target range as soon as reasonably possible. Despite this focus, the Bank was repeatedly surprised by how long it took to achieve the goal. In successive quarters, it was projected that within two or three quarters ahead inflation would fall below 2 percent, but that outcome was not achieved until mid-1997.[19]

In hindsight, a possible explanation for the unexpected resilience of inflation during the period mid-1995 to mid-1997 was that the Bank was putting too much weight on the expected direct price benefits of the appreciating exchange rate. The Bank relied primarily on the mark-up approach to projecting inflationary pressures, in which the inflation outlook was based on cost pressures and margins.[20] The exchange rate, through its influence on import prices, was an important driver. Throughout this period, the appreciating exchange rate constrained near-term aggregate inflationary pressures, despite the more persistent inflationary pressures still in the domestic economy. Insufficient attention was initially given to these persistent domestic inflationary pressures, which are most influenced by the longer-term impact of the exchange rate and interest rates on, first, demand and then inflation.

19, See the Reserve Bank of New Zealand's *Monetary Policy Statements* over this period for a detailed account.

20. See Beaumont, Cassino, and Mayes (1994) for an in-depth discussion of this approach to modeling prices.

## The use of the MCI in 1997–98

Output growth was negative over the first half of 1998 as the New Zealand economy was negatively affected by three coincident influences: a large swing in net migration, the Asian crisis, and successive droughts throughout large parts of the country.[21] Although these shocks were unavoidable, the question remains whether monetary policy responded appropriately, thereby buffering the shocks, or whether it was unhelpful. This section outlines the Bank's view of the shocks at the time, as well as the interaction of this factor with the MCI implementation regime. The broad lessons from the period are then illustrated via stylized model simulations.

From mid-1997 to year-end 1998, a monetary conditions index (MCI) was used to signal the stance of monetary policy with the release of the Bank's *Monetary Policy Statement* each quarter.[22] In order to maintain the policy stance across quarters, any falls (rises) in the exchange rate were required to be offset by increases (falls) in interest rates.[23] Over late 1997 and early 1998, this did, in fact, lead to rising interest rates, between quarterly resets, as the exchange rate began to trend sharply downwards.

The exchange rate fell through much of 1997 and into 1998, and the Bank initially resisted the extent of the easing in monetary conditions by successively indicating desired levels of monetary conditions that were consistent with interest rates rising. This reflected the fact that the Bank thought growth conditions would be rather stronger than

21. See the paper entitled "Business Cycle Developments and the Role of Monetary Policy over the 1990s" at www.rbnz.govt.nz/monpol/review/index.html for a detailed description of the size and impacts of these shocks on output.

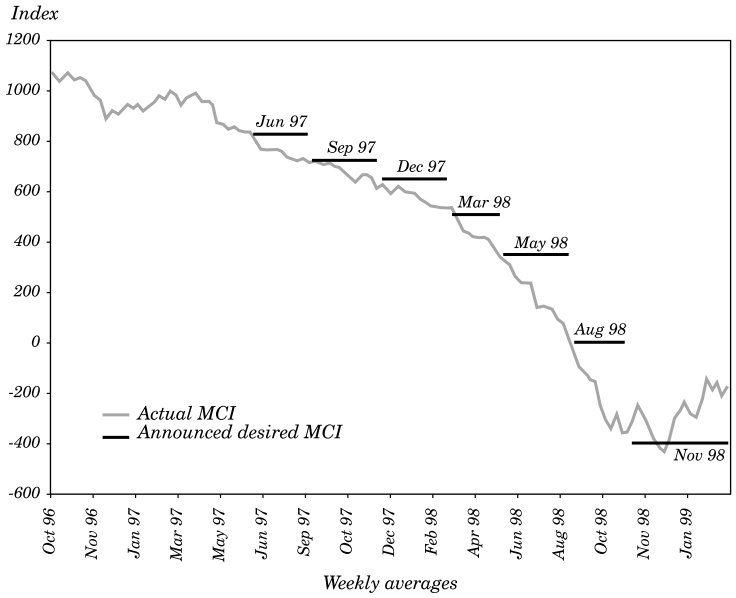
22. See Ball (2002) for a discussion of the use of an MCI as a policy instrument and Hunt (1999) for the macroeconomic implications of using an MCI in FPS under general stochastic disturbances. Also see the paper entitled "The Evolutions of Monetary Policy Implementation" at www.rbnz.govt.nz/monpol/review/index.html for a detailed description of why the Bank moved to use an MCI and then later switched to its current cash-rate system.

23. The official MCI as used by the Bank to implement monetary policy was calculated as:

$$mci_t = [90\text{-}day\ interest\ rate_t - 90\text{-}day\ interest\ rate\ at\ 1996:4 + 50\log(TWI\ exchange\ rate_t / TWI\ exchange\ rate\ at\ 1996:4)].$$

The evolution of the MCI was then relative to a base-period (1996:4). A given percentage change in the nominal ninety-day interest rate was thus given twice the weight of an equivalent-sized change in the TWI exchange rate. For example, if the TWI fell by 1 percent, interest rates would need to rise by 50 basis points to maintain the desired level of monetary conditions, all else equal.

**Figure 8. The Monetary Conditions Index and Successive Quarterly Policy Resets**




Source: Reserve Bank of New Zealand, *Monetary Policy Statements* and *Economic Projections*.

proved to be the case. It did not anticipate the full magnitude of the Asian crisis or the severity of the first drought. As the extent of the fall in economic activity became more obvious through the first half of 1998, the Bank began to encourage a more rapid easing of desired monetary conditions. This is illustrated in figure 8, which shows the profile of the MCI from late 1996 to early 1999 together with indications of the desired MCI at successive quarterly policy resets. The easing that occurred between mid-1997 and the end of that year were quite small, but they became larger after December 1997.

The Bank's policy stance was also influenced by its understanding of what was behind the fall in the exchange rate. Had it recognized the depreciation as well founded in changing fundamentals, it would have targeted a lower desired level of the MCI and allowed actual conditions to ease more quickly. In addition, at least in late 1997, the Bank lacked a full appreciation of the required cyclical amplitude of monetary conditions in the context of large exchange rate shocks. This meant that the effective magnitude of easing at each quarterly policy reset, in terms of its impact on the real economy, was rather less than expected at the time.

The overall effect on the economy of the initial interest rate rises in early 1998 is uncertain. Although the rises coincided with falls in consumer confidence, residential investment, and private consumption, such rapid transmission of policy would normally be ruled out as being implausible. Transmission times are not always and everywhere the same, however. Given the environment of considerable uncertainly resulting from the Asian crisis, it is possible that the interest rate rises could have contributed to observed falls in consumer confidence. In turn, lower confidence may have fed through to lower consumption and investment quite quickly.

To further illustrate the discussion, figure 9 shows two alternative model scenarios. In both scenarios the starting-point level of the real exchange rate is overvalued, and the model is hit with a sequence of negative shocks emanating from both the domestic and external sectors of a size that roughly corresponds to the falls witnessed in 1997–98. In the first scenario policy is set cognizant of both the shocks and the fact that the exchange rate is overvalued. Consequently, interest rates immediately decline, as seen in panel A of figure 9. In the second scenario, the central bank initially regards the fall in the exchange rate as a portfolio disturbance, and it does not foresee the fall in world and domestic demand. Hence the central bank does not seek to ease conditions as measured by an MCI to any material degree. Interest rates rise to maintain an overall level of monetary conditions. As time passes, however, the central bank updates its view of the world and allows monetary conditions to fall rapidly.[24] Interest rates eventually have to fall further than in scenario 1, since the fall in demand is larger given the initial policy mistake. The difference in the output paths, however, is small relative to the underlying cycle that is set up following the disturbances.

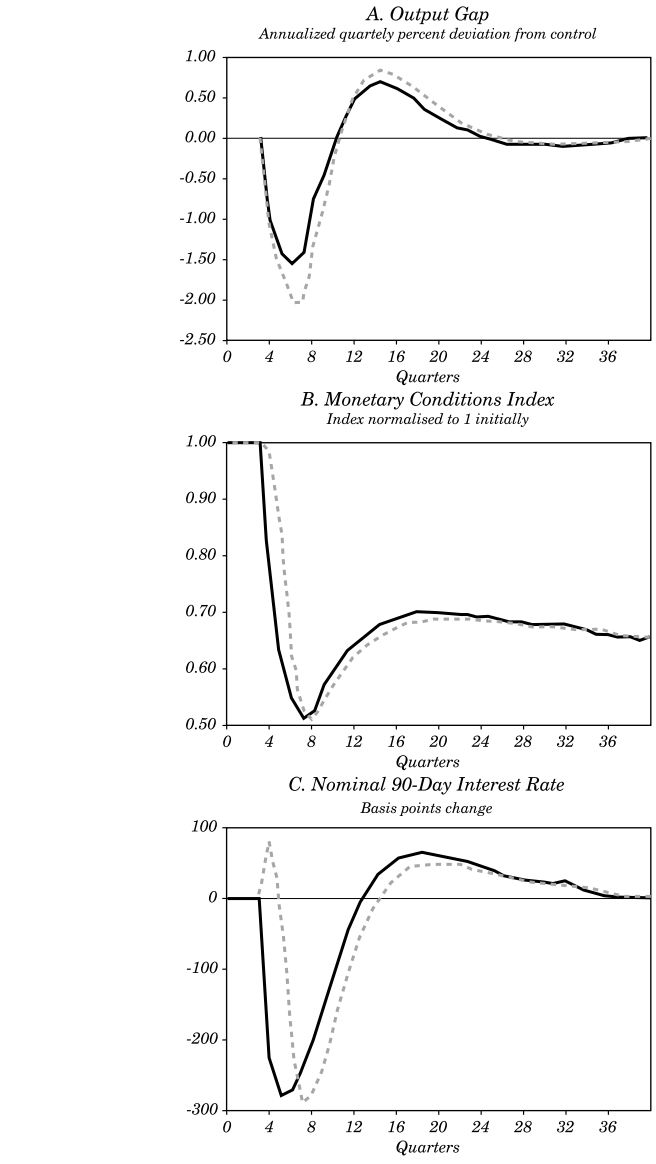
The negative impact of the sharp downturn in migration, the Asian crisis, and the drought were always going to produce a reduction in growth and potentially a recession. Although it is difficult to separate the precise impact on the economy of these factors from that of monetary conditions, the use of the MCI implementation framework probably shaped the evolution of monetary policy during that period in a manner that was, on balance, unhelpful.

## Summary

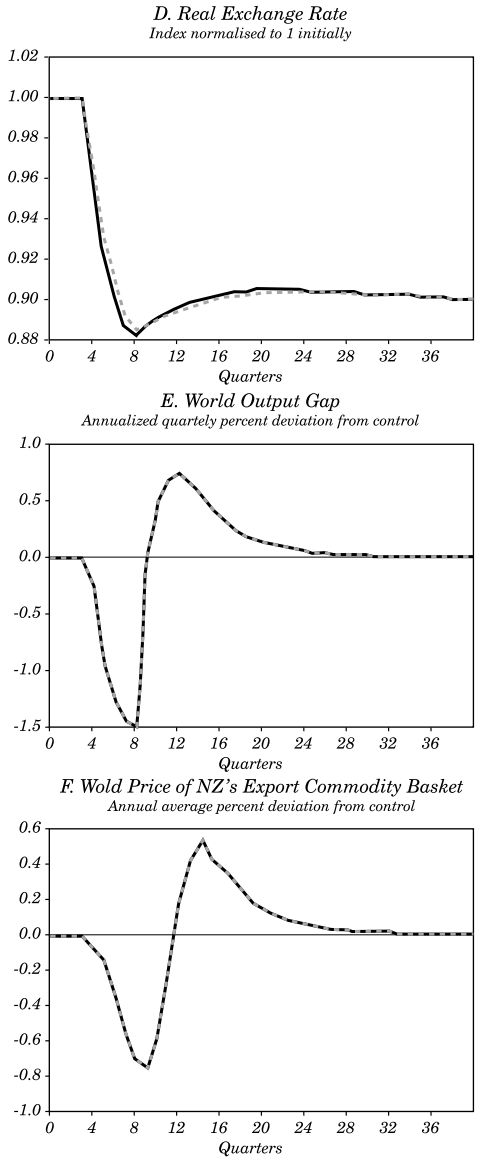
The deterministic simulations described above were designed to highlight some of the ways in which the Bank's monetary policy frame-

24. The central bank sees the full implications of the shocks after one year.

**Figure 9. The Implications of Using an MCI to Base Policy When an Exchange Rate Change is not Seen as Reflecting Necessary Adjustment**



## Figure 9. (continued)




Source: Author's calculations.

work interacted with the economic shocks experienced in the 1990s. Given a relatively short policy horizon and a misperception of wealth effects, it became more difficult for monetary policy to maintain price stability in the mid-1990s than might ideally have been possible. In hindsight, reacting sooner to the demand shocks and focussing on the persistent, domestic-based inflationary pressures could have helped moderate the business cycle. Furthermore, had policy eased more quickly in response to the Asian crisis and domestic conditions, and had an MCI not been used to implement policy, the downturn in growth might have been moderated to a significant degree.

The most important feature of the simulations is that the differences between the scenarios are relatively minor in comparison with the cycle triggered by the underlying shocks. This is not to say that monetary policy is unimportant. The simulations do not show what the cycle would have looked like if monetary policy had considerably delayed its reaction to the shocks that occurred or even completely ignored them. The Bank's contention (as indicated by the quote at the start of this section) is that the cycle would have been considerably greater in magnitude than was actually the case.[25] The alternative scenarios presented should therefore be considered more in the nature of refinements to inflation targeting than as different approaches that would have reshaped the events of the 1990s in any fundamental sense.

## 3.2 Approaches to Inflation Targeting

The scenarios just described illustrate how maintaining low and stable inflation is not incompatible with a concern for maintaining stability in the economy more generally, for example, in real output and in interest and exchange rates. While the central bank certainly cannot buy a permanent increase in output growth, it does have some influence over volatility in the economy.

In part, the volatility issues concern the choice between strict and flexible inflation targeting.[26] The key presumption that must be kept in mind is that the central bank is credible and that inflation expec-

25. Given the structure of the FPS model, this is a fait accompli. Inflation expectations are a linear combination of past outcomes and the model-consistent forward-path solution. Both actual inflation and inflation expectations therefore move away from the target following any disturbance. Monetary policy is required to re-anchor inflation expectations to the inflation target. The longer the policy response is delayed, the larger is both the initial cycle and the secondary cycle required to re-anchor inflation expectations to the target.

26. See Svensson (1997).

tations are relatively well anchored. This certainly was not the situation facing the Reserve Bank of New Zealand when it, like other central banks, embarked on the road to price stability in the mid-1980s. Given the historical circumstances, it took a concerted effort to reduce inflation in the early period of the Bank's inflation-targeting regime. The outcome of this action was that in absolute terms, the variability of both inflation and output was lower in the 1990s than in the 1970s and 1980s. This experience suggests that the variability trade-offs that are depicted in the following sections might be quite misleading during the transition to a low-inflation environment. By reducing the level of inflation, variability in output, inflation, the exchange rate, and real interest rates may all be reduced, as was the case in New Zealand in the 1990s.[27] These improvements may represent the main gains of New Zealand's inflation-targeting regime, and the refinements to the Bank's approach discussed below should be considered in the nature of marginal improvements.

## Strict versus flexible inflation targeting

A strict central bank can be categorized as being concerned only with deviations of inflation from some target level. The strict central bank will therefore aim to return inflation to its target in the shortest possible time. It is likely to be most reactive in its interest rate response to inflationary pressures projected as close as, say, two to four quarters ahead. In an open economy like New Zealand, a strict central bank would rely heavily on the direct impact of the exchange rate on consumer prices, given its immediate and transparent impact.

In contrast, a flexible central bank attaches some importance to minimizing the volatility of output as well as returning inflation to its target. It is thus likely to adjust interest rates so as to return inflation to its target more slowly, thereby avoiding large fluctuations in the policy instruments and output. In an open economy, this implies that the central bank places considerable weight on the indirect impact of the exchange rate (and interest rates) on prices.[28]

27. The macroeconomic outcomes seen in New Zealand in this regard are not unique. In many countries, inflation and output variability was considerably lower in the 1990s than in the 1970s and 1980s. Although there are certainly other factors behind the more benign economic environment of the 1990s, it is very likely that this occurred in part because of the concerted efforts that central banks took to get inflation down over the mid- to late 1980s.

28. See Svensson (2000).

The Reserve Bank of New Zealand has recognized this sort of trade-off from the outset of its inflation-targeting regime. This recognition is implicit, for example, in the caveats outlined in the successive Policy Targets Agreements and in the phased approach the Bank took in achieving low inflation.[29] More explicitly, the original target date for achieving price stability was extended, following the 1990 election, from year-end 1992 to year-end 1993 on account of the short-run output trade-off.

The decline in and anchoring of inflation expectations achieved in more recent years, in combination with the wider inflation target range established in late 1996, has afforded the Bank more flexibility in its policy approach. The advantages of this ongoing flexibility can be examined more formally using FPS, by asking whether it is possible to reduce the volatility of interest rates, the exchange rate, and output without unduly increasing the volatility of inflation.

This section addresses the volatility questions using stochastic simulations of the model. The randomly drawn shocks in this exercise affect five key macroeconomic variables: the exchange rate, inflation, domestic demand, foreign demand, and New Zealand's terms of trade. The stochastic simulation technique also accounts for autocorrelations in the data and cross-correlations between the variables. For example, shocks to foreign demand or the terms of trade will affect the exchange rate, as well. A combination of shocks, taken from New Zealand's historical experience, is selected randomly to produce one hundred simulations each quarter, running one hundred quarters into the future (generating 10,000 observations for each variable of interest).[30]

For each alternative monetary policy rule considered, the variability of inflation, output, the exchange rate, and interest rates is calculated over the full twenty-five-year period and compared. The monetary policy rule that results in the least variability in these macroeconomic variables over the entire period is considered to be preferable.[31]

## Alternative policy horizons

The policy horizon currently used in the FPS monetary policy reaction function—that is, how far ahead the model is looking in formulating its response to inflationary pressures—was chosen to reflect both views within the Bank and the findings of wider research. This research

29. See Archer and Nicholl (1992).

30. See Drew and Hunt (1998b) for technical details.

31. See Drew and Hunt (2000) for a discussion on alternative monetary policy rules using FPS.

suggests that the lag between monetary policy actions and inflation outcomes is between one and a half and two years time. The standard monetary policy reaction function is thus set so that policy responds to projected inflationary pressures about six to eight quarters ahead.

Figure 10 plots the results from simulating FPS with the same battery of shocks, but alternative policy reaction horizons. The top panel plots outcomes in terms of output and inflation volatility under different reaction horizons, while the bottom panel shows the policy instrument (interest rate) and inflation volatility. Point A relates to the most short-term, or myopic, policy reaction. This short horizon is clearly not efficient, given that a more forward-looking rule can reduce instrument, output, and inflation variability.[32] Point C is the standard FPS policy rule, and point D is the most forward-looking policy rule considered. It is clear that moving from point C to point D reduces output (and instrument) variability, but at the expense of greater inflation variability.

The results of these simulations suggest that reduced output and instrument variability can be achieved by being forward looking. As the policy horizon is extended beyond six to eight quarters (point C), however, not much is gained in terms of reduced output and instrument volatility, while inflation volatility increases quite markedly. This indicates an optimal policy horizon in the vicinity of point C.

These results are not fully independent of the FPS model, which has been constructed on the prior view that policy generally works with a lag of about six to eight quarters, but the results are not predetermined. The outcomes are generated from the interaction of the monetary policy reaction with the rest of the model—which is constructed to reflect the workings of the New Zealand economy—and thousands of randomly selected shocks. In this sense, the results provide some independent support for a reasonably forward-looking policy reaction function.[33]

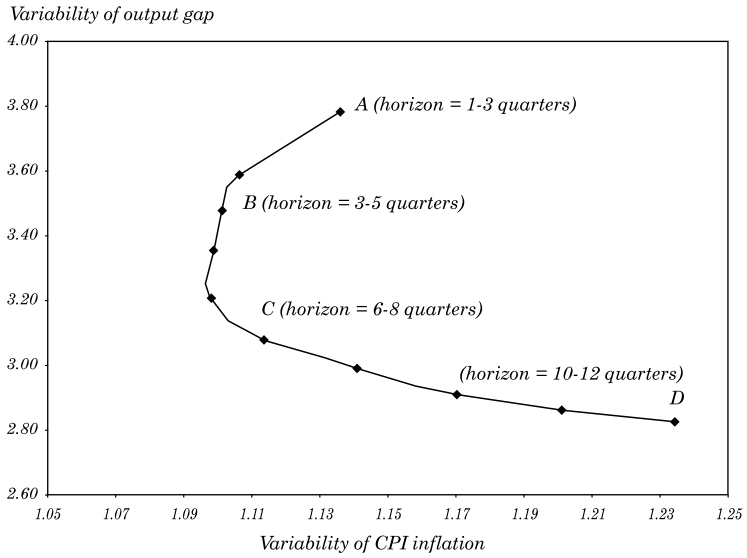
## The width of the inflation target band

The final question considered is the degree of flexibility that the current 0 to 3 percent inflation target range brings to policy, compared to the previous target range of 0 to 2 percent. It could be argued that a

32. The policy rule represented by point A fares poorly because the monetary authority tries to return inflation to the target over a horizon in which inflation outcomes are essentially predetermined, given the short-run rigidities that exist in the economy. The monetary authority therefore induces instability in the model economy.

33. For a theoretical discussion on the benefits of using policy rules based on forward-looking inflation forecasts, see Batini and Haldane (1999).

**Figure 10. The Implications of Varying the Policy Horizon**



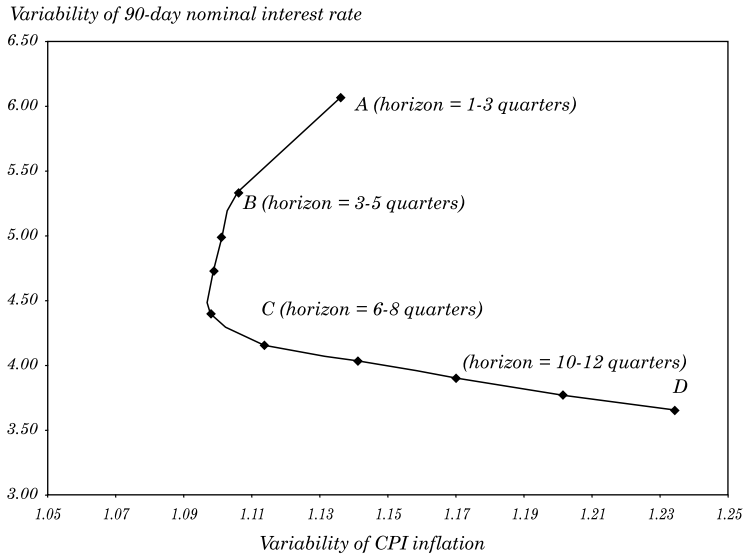



**Table 2. Alternative Band Widths for CPI Inflation Targeting Rules**

| | *Less active rule* | *Standard policy rule* | *Active policy rule* | *Very active policy rule* |
|---|---|---|---|---|
| RMSD[a] CPI inflation | 1.56 | 1.13 | 0.94 | 0.86 |
| RMSD[a] output gap | 3.06 | 3.07 | 3.24 | 3.58 |
| RMSD nominal 90-day interest rate | 3.31 | 4.08 | 5.51 | 7.65 |
| *Band Width (percent)* | *Probability that inflation lies within the given band width (percent)* | | | |
| ±1.0 | 50.0 | 64.0 | 70.0 | 75.0 |
| ±1.5 | 66.0 | 82.0 | 90.0 | 92.0 |
| ±2.0 | 80.0 | 93.0 | 97.0 | 98.0 |
| ±3.0 | 95.0 | 99.0 | 99.8 | 99.994 |

Source: Author's calculations.
a. Root-mean-square deviation.

wider target range allows the Bank to be less active in its policy, since the Bank is able to give projected inflation more time to return to its mid-point. A wider band affords this type of flexibility because it is less likely that the target will be breached.

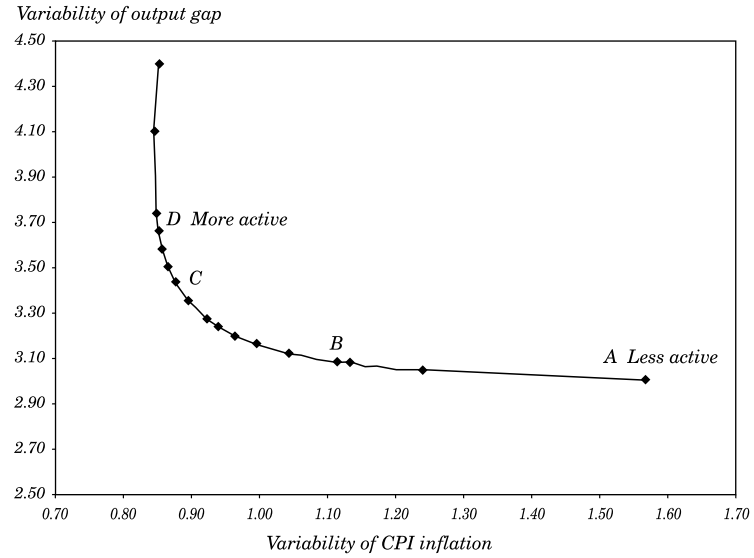
Figure 11 presents the results of further FPS stochastic simulations, this time altering the degree of policy activism. Monetary policy is made more active in the model's reaction function by increasing the size of the interest rate response to any deviations from the inflation target. Conversely, policy is made less active by decreasing the interest rate response coefficient.[34] The top panel of figure 11 demonstrates that the more active the policy response, the lower is inflation variability and the higher is output variability. This illustrates the well-known trade-off between inflation and output variability.[35] The bottom panel illustrates that as the variability of inflation is reduced, instrument variability increases. In the figure, point B represents the standard FPS policy rule. The cost of reducing inflation variability through increased policy activism is a rise in output and instrument variability.

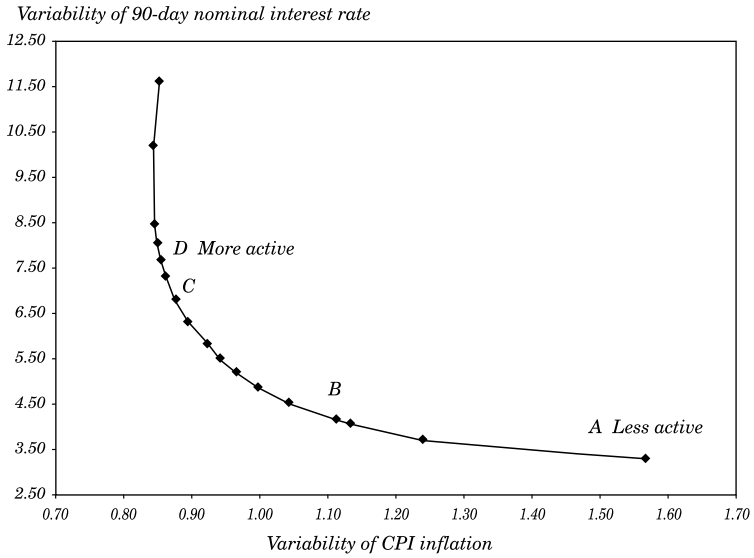
The probability that inflation will fall within a certain range around the target can also be calculated using these results (see table 2).

34. For example, in the standard FPS rule (represented by point B) the size of the interest rate response is such that if inflation is projected to be one percentage point above target over the policy horizon, short-term interest rates will be increased by around 140 basis points. Point A is a less active policy rule, while points C and D are rules that respond more vigorously to inflation deviations.

35. See Taylor (1994).

**Figure 11. The Implications of Varying Policy Activism**



Under the standard policy rule, inflation is expected to remain within our current target of ±1.5 percentage points around the mid-point about 80 percent of the time. In contrast, the less active policy rule keeps inflation within the range 66 percent of the time, while the more vigorous policy rules ensure inflation remains within the band over 90 percent of the time.

The policy dilemma is thus clear. If the Bank is to be judged purely on its achievement of keeping inflation within the target range, then it is likely to favor a more active policy approach. Similarly, if the Bank is trying to establish credibility by achieving its inflation target at all times, then it is wise to favor a more active approach and a shorter policy horizon. However, a more active policy with short horizons implies more variability in both output and the instruments. This is why the Bank—and those who monitor its performance—recognized that although the Bank should constantly aim to meet the target, it is neither sensible nor realistic to expect that inflation will always be in the range. Indeed, as inflation expectations have become more anchored on the official target over recent years, the Bank shifted toward a longer-term horizon for targeting inflation. This approach may come at the cost of slightly more variable inflation outcomes, although the wider 0 to 3 percent inflation target reduces the probability of the Bank actually breaching its target.

The simulations in this section should be interpreted as stylized results, rather than as strict quantitative assessments of, for example, the optimal inflation target range or the optimal policy horizon. Qualitatively, however, the results are intuitively appealing: the narrower the target range, the more active monetary policy must be; more activism implies more variability in interest rates, the exchange rate, and output and (up to a point) less variability in inflation; lower inflation expectations and a wider target range allow for a longer policy horizon and less active monetary policy.

## 4. Conclusions

This paper has discussed some monetary policy issues that emerged from the Bank's reviews of the conduct of monetary policy in the 1990s. Possibly the most significant conclusion relates to the importance of using a flexible, medium-term approach to inflation targeting. A key reason why the Bank has felt able to move in this direction is the rise in public confidence that low inflation is now the norm, not the exception.

One important change in policy focus relates to the role of the exchange rate. Broadly, the policy changes comprise a shift in focus from the direct impact of the exchange rate on the price of imported goods to the indirect effect on prices via the real economy and inflation expectations. This shift in emphasis is evinced by, among other things, the longer horizon over which inflation is targeted and increased focus on the key demand pressures in inflation forecasting. Another important shift is the wider target range for inflation of 0 to 3 percent, which provides additional scope for flexible policy.

The benefit of anchoring inflation expectations near the mid-point of the target range is that the Bank can afford larger, temporary deviations in actual inflation from the mid-point. This reflects the fact that the Bank recognizes that while monetary policy cannot be used to engineer sustainable faster growth in the long term, there is a trade-off between the variability of the policy instrument and output, on the one hand, and the variability of inflation, on the other.

The most significant lesson for the Bank, however, is the importance of preempting shifts in inflationary pressures. If monetary policy is able to adjust in a timely manner, then a considerable degree of interest rate, exchange rate, and output volatility may be avoided. At the end of the day, this requires that the right decisions are made when required. Given the uncertainty surrounding policymaking, this is not an easy task. I close with a quote from the Bank's submission to the *Independent Review of Monetary Policy:*[36]

> The Bank has to continually balance the risks of doing "too little too late", and possibly unnecessarily accentuating the business cycle, against the possibility of over-reacting to inflationary pressures, thereby also causing unnecessary volatility in the economy. This is often difficult, as signals from the data can be unclear or conflicting. The art of policy-making is to get a good feel for the pulse of the economy. This involves making judgements about the relative value of information in various data sets. It also involves continuously updating one's view or "model" of how the economy works. Such judgements are made on the basis of historical experience, research, intuition, and by keeping in touch with people in New Zealand engaged in a wide variety of economic activity, as well as in various institutions at home and abroad.

36. See the paper entitled "Inflation Targeting in Principle and Practice."

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# Inflation Targeting in Brazil: Shocks, Backward-Looking Prices, and IMF Conditionality

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In mid-January 1999, Brazil abandoned its crawling exchange rate band. Surprisingly enough, the country's economic performance in the aftermath of this episode was much better than expected, given the performance of other emerging market economies after a move toward floating. Despite the large devaluation of the domestic currency that followed the regime shift, gross domestic product grew 0.8 percent in 1999 and 4.5 percent in 2000. Consumer price inflation behaved much in line with the declining targets of 8 percent and 6 percent established in mid-1999.

This paper examines the main factors that helped Brazil withstand the negative effects of a change in the exchange rate regime and enabled the economy to recover rapidly, namely, the combination of fiscal restraint and a well-defined purpose for monetary policy. The following section describes the macroeconomic background that culminated in the currency devaluation, the volatile expectations environment that followed, and the evolution of monetary policy in the transition to inflation targeting. Section 2 then presents a stylized model that we use in our discussion of the transmission mechanism. Section 3 discusses the transmission mechanism, highlighting the main channels, the lag structure, and the exchange rate pass-through. These issues are presented with a prospective view of their evolution

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as the economy converges to its new steady state.

The model outlined in section 2 serves as the basis for the simulations performed in sections 4 and 5. Section 4 describes how monetary policy has reacted to shocks since the implementation of the inflation-targeting regime based on inflation forecasting. We examine the Central Bank's track record in responding to all sorts of shocks, including international oil prices, food price, and volatility in international financial markets. Given the relative weight of institutionally backward-looking prices in the consumer basket, we decompose the model into inertial prices and market prices to show how the institutional framework in Brazil affects the transmission mechanism of monetary policy and therefore its instrument's efficiency when reacting to shocks.

Section 5 focuses on alternative ways to monitor the performance of monetary policy under inflation targeting. This issue is especially relevant when a country has an ongoing program with the International Monetary Fund (IMF), since the traditional quarterly reviews demand a monitoring horizon much shorter than that of the targeting economy. We show that if the higher-frequency targets are not set in accordance with the lower frequency ones, and if policymakers try to meet all the targets, there will be suboptimal outcomes in terms of inflation and output variability. section 6 concludes.

## 1. Macroeconomic Background[1]

The Brazilian economy underwent significant structural changes in the last decade. In the early 1990s the country's real income remained stagnant, with low investment and saving rates and very limited access to international capital markets. Inflation was high and rising; this helped to conceal the serious structural imbalances of the public sector and made it extremely difficult to carry out even the simplest planning activities. Brazil started to make real progress in economic and financial stability only in 1994, with good results in terms of inflation, growth, trade liberalization, and international insertion. Despite this relative success, critical problems remained to be addressed, in particular the rising deficits in the current account and the deterioration of fiscal position. This macroeconomic evolution is critical for understanding the current economic environment, which is characterized by a consistent combination of inflation targeting, floating exchange rate, and fiscal discipline.

1. In outlinig this section, we greatly benefited from internal documents of the Central Bank Research Department, in particular the unpublished manuscript written by Fachada (2000).

## 1.1 From Exchange-Rate-Based Stabilization to Floating

The stabilization program known as the Real Plan was successful in putting an end to Brazil's history of chronic high inflation. It was preceded by a minimal fiscal adjustment and followed by tight monetary control. The key issue was to coordinate a deindexing process to break the inflationary inertia, since the automatic price adjustments to past inflation were not synchronized. The solution was the introduction in March 1994 of a new unit of account, the unified reference value (URV), whose value the Central Bank fine-tuned on a daily basis in line with the loss of the currency's purchasing power. All prices and wages, as well as the exchange rate, were denominated in URV. Prices were converted directly, while wages were converted by their average past purchasing power. Then, on 1 July 1994, the indexation mechanism was extinguished and the URV became the new currency, called the real. Demand pressures naturally arose with the sharp decline in inflation—for example, the reduction of inflation tax alone accounted for an additional disposable income of R$15 billion in the subsequent twelve months—and a very tight monetary policy was needed to counter these pressures, mainly with high real interest rates and stringent credit restrictions.

Although the stabilization program was correctly conceived with due attention to fiscal austerity, the implementation of the comprehensive agenda of structural reforms was much slower and more difficult than had been expected, especially when legislative support was needed. On the other hand, the international financial environment seemed favorable, and the Brazilian economy reentered the route of foreign investment after the rescheduling of its external debt within the Brady Plan. With these perspectives, it was natural for policymakers to concentrate first on the fight against inflation and indexation, since the immediate results on this front would determine the future of stabilization and there seemed to be enough time to address the remaining fundamentals.

Another key issue in the first phases of stabilization was the choice of a suitable exchange rate policy. The monetary authorities decided to start with a float, which immediately led to a continuous nominal appreciation, given that the high real interest rates were effectively attracting capital inflows. The Mexican crisis in late 1994 prompted a shift to a crawling band regime, which was formally adopted in March 1995. From July 1995 through mid-January 1999, exchange rate policy was conducted on the basis of an annual devaluation target of around 7.5 percent. The price stabilization plan was successful, since the

economy eliminated short-run indexation practices, and annual inflation dropped from 929 percent in 1994 to less than 2 percent in 1998.

The stabilization process included a wide program of economic reforms. The size of the public sector was substantially reduced through privatization of state companies operating in sectors like telecommunications, chemistry, steel, railroads, banking, and mining. Likewise, trade liberalization was deepened through the reduction of import tariffs and the elimination of nontariff barriers. The financial system was submitted to a full-fledged restructuring: unsound institutions were liquidated, merged, or restructured; prudential regulation was updated; and supervision was reorganized to take on a more preventive approach. This strengthening of the financial system was a crucial element in the country's reaction to the external crises that were to come.

The fiscal position gradually worsened, however, as the inflation decline unveiled the structural imbalances of public accounts due to the elimination of the so-called inverted Olivera-Tanzi effect, or the reduction of real spending that results from the postponement of nonindexed public expenditure.[2] Despite the initial fiscal adjustment, conditions for its sustainability were not created. Several constitutional reforms of high priority to the government remained stuck in the congressional agenda, including the tax reform, the establishment of limits on public spending at all levels of administration, and the social security reform for both private and public sectors. The lack of political agreement on the need to change the fiscal regime, combined with continued high interest rates and sterilized intervention—which were required to support the exchange rate policy—fuelled the public sector debt (see figure 1). Currency appreciation, growth of domestic demand, and incentives for short-term capital inflows resulted in a rapid growth of the current account deficit, thereby increasing Brazil's vulnerability to confidence shocks.

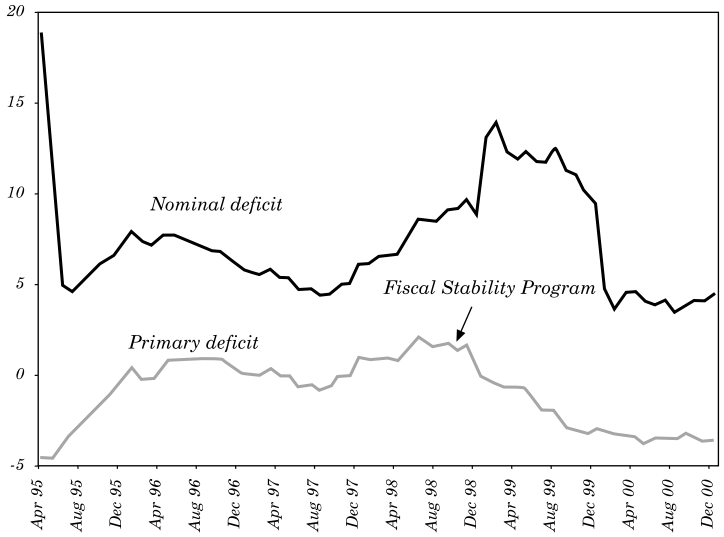
The first shock was triggered by the Asian crisis in the second half of 1997. In the face of capital outflows, the Central Bank promptly reacted by doubling the basic interest rate to 43.4 percent per year in November. The government pressed for a strong fiscal response to complement the monetary tightening. In a matter of weeks, the Congress approved a fiscal program called Package 51, which featured spending cuts and tax increases totaling R$20 billion, or about 2 percent of gross domestic product (GDP).[3] The fast recovery of international reserves that followed

2. Bacha (1999) provides a comprehensive discussion of the fiscal problems that characterized the initial years of the Real Plan.

3. The name Package 51 derives from the fact that it consisted of fifty-one different fiscal measures.

**Figure 1. Public Sector Borrowing Requirement**

*Percent of GDP in the last twelve months*




allowed the Central Bank to reduce interest rates, but only gradually: they reached their precrisis level in July 1998. The fiscal program was not fully implemented, however. In particular, the spending cuts were postponed, as the political will to undertake them diminished in line with the perceived contagion effects.

The second shock, which followed the Russian moratorium in August 1998, met a much-deteriorated fiscal outlook. The country was much more affected by international turbulence than in the previous episode as a result of a worldwide reassessment of risk exposure to emerging markets. Capital outflows were substantial in the ensuing months. The authorities responded with the same policy mix used to counter the Asian crisis effects. In September, the basic interest rate doubled to 40 percent, calling for a new fiscal tightening. This time, however, the government could not count on market support, a price it paid for not delivering the previously promised fiscal results. To address the issue of enforceability of fiscal discipline, the government sought a preventive program with the IMF. The financial support package amounted to US$41.5 billion, with about two-thirds of the total becoming available in the first year. However, expectations deteriorated further at the end of 1998 after Congress rejected a bill to increase social security contributions for civil servants and to extend it to pensioners.

This time, the fiscal tightening measures were mostly implemented. Market confidence, however, continued to erode up to January 1999, partly reflecting concerns over the newly elected governors' commitment to adjust their states' finances. Any new sign of potential deviation from the fiscal target induced extreme market nervousness. Given its limited ability to sustain the exchange rate crawling band regime, the Central Bank tried to promote a controlled devaluation of the real in the second week of January, but the absence of credibility led the market to bet massively against the new arrangement. Without alternatives, the monetary authority allowed the exchange rate to float, and the dollar value quickly moved from R$1.21 prior to the devaluation to nearly R$2.00 at the end of January (see figure 2).

The exchange rate devaluation had an immediate impact on tradable goods prices at the wholesale level, fuelling expectations of a permanent rise in consumer inflation. The wholesale price index (IPA) increased 7 percent in February, the highest monthly rate since 1994, while consumer price inflation rose less, at slightly more than 1 percent. Given the change in the exchange rate regime, the agreement with the IMF had to be reformulated. The estimates set in the reviewed Memorandum of Economic Policy were –3.5 percent for GDP growth and 17 percent for inflation, measured by the general price index.[4] The great uncertainties surrounding the country's future prompted a volatile expectations environment, with inflation and recession forecasts much larger than those above.

At the beginning of March, a new Board of Governors took office at the Central Bank. The policy guidelines set by the new team had two aims: to control inflation expectations, thereby reducing the degree of uncertainty in the short run, and to design the new monetary regime based on inflation targeting.

## 1.2 Transition to Inflation Targeting (March to June 1999)[5]

The shift to a floating exchange rate regime occurred in a moment of crisis. Even so, the regime seemed reasonable for Brazil. The country does not present the classical features required for an optimal currency area with the dollar or any other currency, and it is hard to find

4. The general price index in Brazil is a weighted average of wholesale prices (60 percent), consumer prices (30 percent), and civil construction prices (10 percent)

5. Fraga (2000) provides a comprehensive discussion of the problems faced by the Central Bank at this period and the steps taken to deal with them. This subsections draws a lot on this article.

**Figure 2. Evolution of the Exchange Rate**




arguments to justify the adoption of a fixed exchange rate regime, even in the more recent literature about monetary integration as a credibility instrument. Therefore, the first task of the Central Bank's new board was to find a monetary policy strategy compatible with the floating exchange rate regime.

A fully discretionary monetary policy did not seem suitable, given the unstable nature of expectations during the transition period. It was natural to opt for a more rigid system, one that would represent a definite, strong commitment but that could also offer some indication of the future path of the economy; one that would allow enough flexibility for policymaking but that could also effectively anchor the public's expectations. The authorities therefore decided to set up an inflation-targeting regime.

An interesting feature of the new monetary policy regime was its gradual implementation. Adopting formal inflation targets was not feasible right after the floating, given the uncertainties surrounding the post-devaluation inflationary process. At the same time, the adoption of the framework required institutional changes to ensure operational independence for the Central Bank, as well as time for consolidating the shift in fiscal policy. The Central Bank therefore immediately announced its intention to adopt an inflation-targeting framework, but it

left the formal introduction of the program, together with the specification of the target value, to the second half of the year.

In relation to fiscal policy, a series of reforms were in course. In January, Congress approved an increase in social security contributions for working and retired civil servants (the same bill that had been rejected one month earlier), as well as the 1999 budget. In March, the bill extending the Provisional Contribution on Financial Transactions (CPMF) was approved, though with a five-month delay in the government's original schedule. Additional temporary tax increases and spending cuts were set up in the first quarter to compensate for this loss of revenues and to ensure strict adherence to the fiscal targets (namely, a consolidated public sector primary surplus of 3.1 percent of GDP in 1999). These measures included an increase in the turnover tax (COFINS) from 2 to 3 percent and its extension to financial institutions; an increase in the social contribution on net profits (CSLL) from 8 to 12 percent; and a marginal 0.38 percent increase in the tax on financial operations (IOF) in investment fund deposits and credit operations.

All of these actions provided a clear demonstration of the government's commitment to fiscal adjustment. Policymakers seized the opportunity created by the crisis to enforce a major shift in the fiscal regime, thus laying a fundamental pillar to support inflation targeting. Although the reforms that were needed to ensure long-run fiscal equilibrium were far from complete, the government had the necessary instruments to achieve a reasonable fiscal performance for at least a decade. Even the most skeptical analysts had to acknowledge the feasibility of the announced fiscal targets.

The new Board took office at the Central Bank on 4 March, and the team immediately worked to calm financial markets. The expectation that an inflation hike could cause the real rates of return on public debt instruments to drop into the negative range was the first to be attacked. The Monetary Policy Committee (Copom), whose voting members are the Governor and Deputy Governors, raised the basic short-term interest rate (the Selic) from 39 percent per year to 45 percent per year, taking into account that the future contracts for the next maturity were already trading at 43.5 percent. The idea was to accommodate the devaluation shock, but to counter its further propagation. It was acceptable that the relative price movements set in march with the devaluation would shift the price level upward, but the interest rate had to be set high enough to prevent the second-round inflationary process that could follow. The question was how to translate these ideas into practice, given the then chaotic state of expectations.

Expectations therefore had to be anchored one way or another, and for that purpose clear communication was crucial. The Committee therefore released a brief explanation of the policy decision right after the meeting—the minutes used to be released only after 3 months—asserting that "maintaining price stability is the primary objective of the Central Bank."[6] Other official declarations indicated that price stability meant a monthly rate of inflation in the range of 0.5–0.7 percent by the end of the year. Moreover, "in a floating exchange rate regime, sustained fiscal austerity, together with a compatible monetary austerity, supports price stability; as fiscal policy is given in the short-run, the control over inflationary pressures should be exerted by the interest rate; observed inflation is due to the currency depreciation, and markets expect a further rise in the price level this month; the basic interest rate should be sufficiently high to offset exchange-rate-based inflationary pressures; and so, we decided to raise the basic interest rate to 45 percent per year, but with a downward bias,[7] for if the exchange rate returns to more realistic levels, keeping the nominal interest rate that high would be unjustified."[8]

In addition to the interest rate hike, the remunerated reserve requirement on time deposits was raised from 20 to 30 percent to reduce bank liquidity. Temporary incentives for capital inflows were granted in the form of tax reductions scheduled to last until the end of June. In the foreign exchange market, the rule was free floating, but the Central Bank kept the prerogative to undertake a limited amount of unsterilized intervention to counter disorderly market conditions (Ministry of Finance of Brazil and IMF, 1999). The efforts to seek the voluntary commitment of foreign banks to maintain their exposure to Brazil continued.

The general outlook started to improve soon after, with a reversal of the exchange rate overshooting (the exchange rate fell from R$2.20 in the first week of March to R$1.66 at the end of April) and a reduction in both observed and expected inflation rates. The downward bias was applied twice before the Copom's next meeting: the interest rate was reduced to 42 percent in late March and then to 39.5 percent in early April.

6. "Explanatory Note to Copom's Decision" (www.bcb.gov.br/htms/copom/not1999030433.shtm#_notexp [4 March 1999]).

7. The bias on the interest rates was also an important novelty: it delegated to the Central Bank's Governor the power to alter interest rates during the period between two ordinary Committee meetings (usually five weeks). A downward bias allows the Governor to reduce the interest rate. However, if an increase in the interest rate is needed instead, while a downward bias is valid, an extraordinary meeting is required.

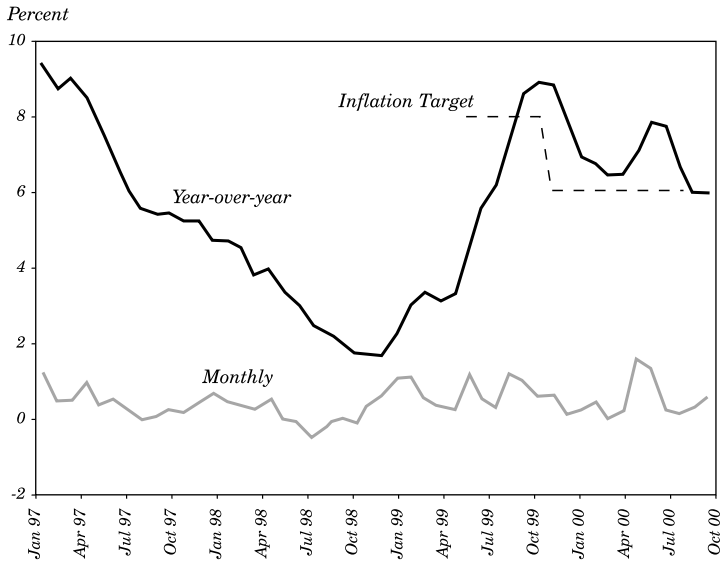
8. "Explanatory Note to Copom's Decision" (www.bcb.gov.br/htms/copom/not1999030433.shtm#_notexp [4 March 1999]).

Market confidence was also strengthening as a result of delivered fiscal promises. The public sector primary surplus reached 4.1 percent of GDP in the first quarter, in excess of the government's target. The first evidence of decelerating inflation materialized in the April figures (figure 3). The reversal of the exchange rate overshooting and the effect of the new crop on food prices were held responsible for the immediate decline in inflation. The wholesale price index, in which tradable goods have a large weight, registered negative changes in April (–0.3 percent) and May (–0.8 percent). Consumer inflation measured by the broad consumer price index (the IPCA) fell to 0.6 percent in April and 0.3 percent in May (figure 3). Inflationary expectations followed suit: the median of market forecasts of consumer inflation for 1999 was revised from 13 percent in March to 7.7 percent at the end of May.[9]

The positive evolution of the macroeconomic environment allowed further reductions of the basic interest rate. However, the level of uncertainty rose again as a result of external developments. By mid-May, the U.S. Federal Reserve Board introduced an upward bias for the federal funds rate, which remained constant at 4.75 percent after December 1998, signaling a gradual monetary tightening for the second half of the year. Expectations of higher international interest rates undermined risk perception, as did potential contagion effects stemming from doubts about the electoral process and the currency board sustainability in Argentina. The immediate repercussions were on market-determined interest rates and the exchange rate. The slope of the term-structure curve turned from negative to positive, and the exchange rate moved upward to the R$1.75–1.80 range (figure 4). A subjective explanation to this new depreciation then became popular in the specialized press and was to recur in similar subsequent episodes: foreign exchange market participants, who were still unused to the new floating regime, tried to infer the Central Bank's intervention band—if there was one, considering the limits imposed by the performance criterion on net international reserves set up in the IMF agreement. More objective factors included the concentration of amortization payments of private sector external debt due in June, the combination of a rising risk premium and a declining interest rate differential, and the near termination of

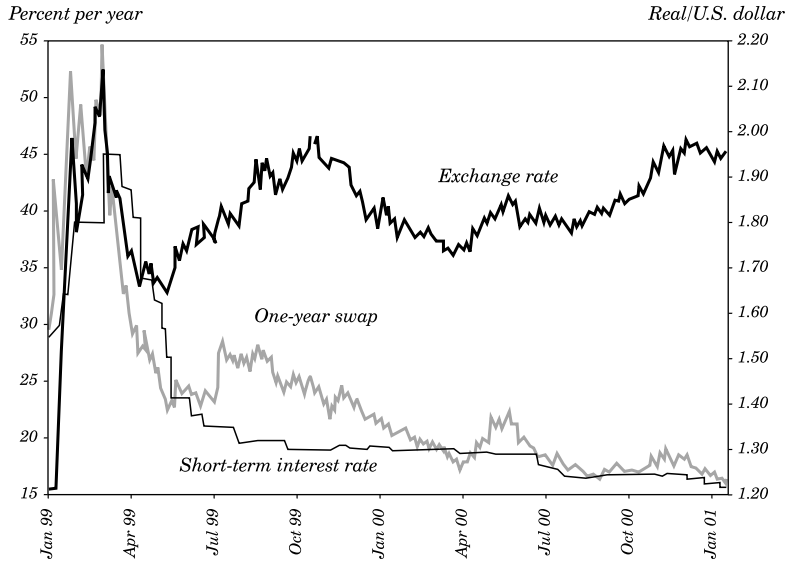
9. The Central Bank's Institutional Communications Group (GCI) collects market inflation forecasts daily, sampling seventy financial institutions and consulting companies. The survey was initiated in April 1999. The data are available on CD-ROM (*Focus and other Reports: 1999–2000*) and at www.bcb.gov.br/updatescd/default.asp. For IPCA, the survey begins in June, when this index was chosen as the reference for inflation targeting. Data before June are based on a preliminary unpublished survey of a very small number of institutions.

## Figure 3. The Evolution of Inflation




Source: Central Bank of Brazil.

## Figure 4. Interest Rates and the Exchange Rate




Source: Central Bank of Brazil.

the temporary tax incentives on capital inflows introduced in March. Therefore, monetary policy became somewhat more conservative, reducing the interest rate at a slower pace.

In sum, the policy response to the crisis triggered by the initial exchange rate devaluation consisted of fiscal and monetary tightening, and it was successful in subduing inflation expectations. Although an inflation-targeting framework was not formally in place, the Central Bank already justified its monetary policy decisions as if it were. The short-term interest rate became the main instrument for attaining the inflation objectives, and with inflation expectations under control, it was cut in half in less than four months.

## 2. The Stylized Structural Model[10]

According to Mishkin and Savastano (2000), inflation targeting comprises five main features: the public announcement of medium-term numerical targets for inflation; an institutional commitment to price stability as the primary goal of economic policy, to which other objectives are subordinated; an information-inclusive strategy, encompassing the use of several variables and models that enable the monetary authority to set policy instruments; a transparent monetary policy strategy that ascribes a central role to communicating to the public the plans, objectives, and rationale of the central bank's decisions; and mechanisms for making monetary authorities accountable for achieving the inflation targets. The first feature, a numerical target value, must be low, feasible, and compatible with the macroeconomic outlook.

With this in mind, the Brazilian authorities placed a high priority on understanding the transmission mechanism of monetary policy to prices, with emphasis on developing a set of forecasting tools, including structural models for the transmission mechanism, nonstructural time-series vector autoregression (VAR) and autoregression moving average (ARMA) models for short-term forecasting, measures of core inflation, leading inflation indicators, and surveys of market expectations. The most important of these tools is the family of structural models, which is estimated and calibrated with the dual objective of identifying the mechanism of monetary policy and assessing the transmission lags involved. A representative model contains four basic equations. The first is a standard IS equation that captures the aggregate demand response to the real interest rate and the real exchange rate. The second is a typical

10. This section is based on Bogdanski, Tombini, and Werlang (2000).

open economy Phillips curve, representing the supply-side trade-offs. The third is an equation for the exchange rate, and the fourth is an interest rate rule that is essential for simulations.

The standard specification of an IS curve with a quarterly frequency could be as follows:

$$h_t = \beta_0 + \beta_1 h_{t-1} + \beta_2 r_{t-1} + \beta_3 \theta_t + \varepsilon_t^h , \quad (1)$$

where $h$ is the log of the output gap; $r$ is the log of the real interest rate, $\log(1 + R)$; $\theta$ is the log of real exchange rate; and $\varepsilon^h$ represents a demand shock. Other specifications might include different lag structures or additional explanatory variables. Bogdanski, Tombini, and Werlang (2000), for example, present a fiscal IS specification, which explicitly considers the effects of the shift in fiscal regime on aggregate demand.

The first problem for the Central Bank was how to measure the variables that are not directly observable, like the output gap. The usual starting point is the calculation of potential output, either by extracting a linear time trend from historical GDP data, by filtering out the GDP series, or by estimating production functions. In the Brazilian case, the linear trend and the Hodrick-Prescott (HP) filter were preferred since both produced similar results. The output gap was then obtained by the difference between actual and potential GDP, allowing direct estimates of the different IS curves. However, research efforts on this crucial topic are far from over.

The estimation results posed a second problem, since they were heavily influenced by post-Real Plan data (third quarter 1994 to fourth quarter 1998). As mentioned in the previous section, the managed exchange rate regime in the Real Plan was very instrumental in reducing inflation and keeping it low, at the cost of setting domestic interest rates high enough to attain a balance-of-payments position that was compatible with the desired parity. The equilibrium real interest rate under the current floating exchange rate regime should therefore be substantially lower than under the previous regime. The transition effects stemming from the new equilibrium level of real interest rates called for a long-term calibration of the demand-side reduced-form model. In the long-run steady state, the output gap should remain constant at zero. As a first approximation, it is assumed that the long-term equilibrium real interest rate must equal the potential GDP growth rate. A thorough analysis of this question should also include fiscal policy considerations, such as the long-run fiscal balance and debt administration issues, which may add or subtract a few percentage points to the

first approximation of the neutral rate. In the IS curve specification above, this is equivalent to setting $\bar{r} = -(\beta_0/\beta_2)$, since $\beta_3$, the real exchange rate coefficient, is very close to zero. A straightforward calibration would thus consist of estimating the IS curve with the additional restriction on the pair $(\beta_0,\beta_2)$, whose ratio must equal the long-term equilibrium real interest rate.

The supply side of the economy is modeled with a Phillips curve specification, directly relating price inflation to some measure of real disequilibrium (typically the output gap), inflation expectations, and changes in the real exchange rate. For example,

$$\pi_t = \alpha_1\pi_{t-1} + \alpha_2 E_t(\pi_{t+1}) + \alpha_3 h_{t-1} + \alpha_4\Delta(p_t^F + e_t) + \varepsilon_t^n, \quad (2)$$

where $\pi$ is the log of consumer price inflation, $h$ is the log of the output gap, $p^F$ is the log of the foreign producer price index, $e$ is the log of the nominal exchange rate, $\Delta$ represents the first-difference operator, $E_t(\cdot)$ is the expectation operator (conditional on information available at time $t$), and $\varepsilon^n$ stands for a supply shock. The coefficients on the right-hand side of the equation, except for the output gap, are constrained to sum to unity; this ensures the long-run verticality of the Phillips curve, that is, that inflation is neutral with respect to real output in the long run.

This specification combines backward and forward-looking elements. A purely backward-looking specification would be simpler to estimate and would fit past data. However, it would also be vulnerable to the Lucas critique. Its predictive power would be weak because of the recent changes in monetary policy and exchange rate regimes, which almost certainly have altered the formation of inflation expectations and the short-run trade-off between inflation and output. Using a purely forward-looking specification would be an attempt to overcome the parameter instability commonly found after structural breaks. It might also stem from the natural assumption that as the inflation-targeting regime gains credibility, expectations tend to converge to the targeted value. Such a specification raises difficult estimation issues, however, about the appropriate measures of expectations, especially when reliable survey data are not available.

The Central Bank tested different assumptions about the expectations mechanism, but the estimations generally led to a weighted average of past and future inflation, with at least 60 percent on the forward-looking component. The preferred Phillips curve specification, together with the other equations in the complete model, exhib-

ited the desired dynamic properties of the economy. Inflation persistence arose from sluggish adjustment forced by the backward-looking terms, while the rational expectations environment was preserved by the forward-looking component, thought to be increasingly important in the transition period after the changes in monetary policy and exchange rate regimes.

For the purpose of running simulations to investigate the implications for inflation and output of different monetary policy rules, it is easy to experiment with alternative assumptions about the expectations formation mechanism. For example, expectations can be taken exogenously from a market survey and augmented by a hypothesis about how they react to new information, or they can be calculated recursively to ensure consistency with the model.

The pass-through of exchange rate changes to domestic inflation is another key issue in the Phillips curve setup. Several linear and nonlinear specifications for the pass-through coefficients were tested, and the alternatives implemented in the preferred simulation tool were narrowed down to four. The first is a standard constant coefficient, $\alpha_4$ = constant, simply estimated from a suitable sample of past data. The second is a quadratic transfer from exchange rate variations to inflation, $\alpha_4 = \alpha_{41} + \alpha_{42}\Delta(p^F_{t-1} + e_{t-1})$. The third is a level-dependent coefficient, $\alpha_4 = \alpha_{41} + \alpha_{42}e_{t-1}$, which is estimated under the assumption that the pass-through depends on the level of the log of the nominal exchange rate. Finally, the fourth is a quadratic function of the nominal exchange rate level,

$$\alpha_4 = \alpha_{41}\frac{E^2_{t-1} - \alpha_{42}}{E^2_{t-1} + \alpha_{42}},$$

where $E_{t-1}$ is the nominal exchange rate in $t$–1 motivated by a simple partial equilibrium model in which exchange rate devaluations shift the supply curve of competitive producers of tradable goods.[11] All nonlinear variants aim to capture more precisely the effects of a temporary exchange rate overshooting. Given the small number of observations available in a quarterly frequency, however, their results were very close to the linear variant and consistent with international evidence that the pass-through coefficient is inversely proportional to the degree of real exchange rate appreciation at the moment prior to the devaluation.

The determination of the nominal exchange rate is as important as it is difficult. The Central Bank's first approach was to use an uncovered

11. See Goldfajn and Werlang (2000, appendix).

interest parity (UIP) condition to model the link between the exchange rate and the interest rate through capital markets. The UIP condition relates expected changes in the exchange rate between two countries to their interest rate differential and a risk premium:

$$E_t e_{t+1} - e_t = i_t - i_t^F - x_t , \tag{3}$$

where $e$ is the log of the exchange rate, $i$ is the log of the domestic interest rate, $i^F$ is the log of the foreign interest rate, and $x$ is the log of the risk premium. Taking the first difference $E_t e_{t+1} - E_{t-1} e_t - \Delta e_t = \Delta i_t - \Delta i_t^F - \Delta x$ and assuming for simplicity that the expectation change follows a white noise process, $E_t e_{t+1} - E_{t-1} e_t = \eta_t$,[12] it is possible to specify the exchange rate dynamics as

$$\Delta e_t = \Delta i_t^F + \Delta x_t - \Delta i_t + \eta_t . \tag{4}$$

This equation contains two exogenous variables: the foreign interest rate and the risk premium. Given the relative stability of foreign interest rates, reasonably accurate projections can be obtained from contracts traded in international futures markets. However, the risk premium, which can be measured by the spread between U.S. Treasury bonds and Brazilian sovereign debt, has presented high volatility in recent years. The risk premium is usually associated with macroeconomic fundamentals and a number of other subjective factors that are not easily anticipated. Two alternative approaches were therefore considered. The first was to gather the opinions of Copom members about the future evolution of the country's risk premium, conditional on the overall scenario and based on anecdotal evidence; these opinions were then translated into an exogenous expected path to be used in simulations. The second approach was to make assumptions linking the risk premium behavior to the main objective factors thought to influence it, thereby allowing the model to endogenously determine the premium. A list of these factors would typically include the fiscal stance, perspectives on the current account balance, international liquidity conditions and interest rates, the performance of foreign capital markets, commodity prices, and country rating.

Finally, the fourth equation is left unspecified in the general model. Since the primary instrument of monetary policy is the short-term

12. This is equivalent to a random walk with monetary surprise, in which a surprise is characterized by changes in interest rate differentials or in risk perception.

interest rate set by the Central Bank, it is necessary to choose a policy rule in order to run simulations in any of the different reduced-form model specifications. The rules can be divided in three basic families: fully exogenous interest rate paths, linear combination of system variables, and optimal response functions. An exogenous interest rate path is useful for analyzing the consequences of a particular interest rate trajectory, such as that implied by financial market instruments or considered in the government budget. A particular rule of this family is helpful for institutional communication. The inflation forecasts published in the quarterly inflation report are traditionally constructed under the assumption that the short-term interest rate will remain constant at the current level along the projection period. This projection is illustrated through an inflation fan chart, which shows the probability distribution around the central forecast for each quarter. On visual inspection, one can infer whether monetary policy should be altered and in which direction.[13]

The interest rate rule can also be written as a linear function of certain system variables. For example, monetary policy can react contemporaneously to the output gap and deviations of inflation from target: $i_t = (1-\lambda)i_{t-1} + \lambda(\omega_1(\pi_t - \pi^*) + \omega_2 h_t + \omega_3)$. When $\lambda = 1$, this is equivalent to a standard Taylor rule, whereas it is a Taylor rule with interest rate smoothing when $0 < \lambda < 1$. The values of $\omega_i$ can be set arbitrarily or using specific optimization procedures available in the simulation tool. Finally, an optimal interest rate rule can be found by minimizing an appropriate loss function, subject to the model in use.

## 3. The Transmission Mechanism

The initial modeling efforts succeeded in reaching an early mature stage—that is, a reasonable degree of reliability and sensible dynamics. Two qualifications must be stressed, however. First, the general limitations stemming from model and parameter uncertainty apply. Second, the statistical time series for the Brazilian economy after the floating is too short to yield sufficiently robust results. Moreover, a sequence of failed stabilization plans from 1986 to 1994 produced important structural breaks in many economic series, thus making it

13. Britton, Fischer, and Whitley (1998) explain how to interpret inflation forecasts presented as fan charts. Haldane (1997) discusses how the introduction of a partially subjective probability distribution may help clarify the policymakers' assessment of the current economic stance. The Brazilian *Inflation Reports* make use of both resources to convey information about monetary policy decisions.

extremely difficult to treat them with the usual econometric techniques. The various nonstructural tools are therefore fundamental for complementing and checking the consistency of structural modeling results. Policymakers are well aware of the limitations of the available tools and have no illusions about their effectiveness. Nonetheless, the models have been very useful and have helped discipline the discussion on monetary policy within the Central Bank.

This modeling approach embodies the understanding that as in most economies, the most important transmission channels are through aggregate demand, the exchange rate, and expectations. Preliminary estimation results with quarterly data indicate that permanent changes in the basic interest rate take one to two quarters to affect aggregate demand. This aggregate demand response, in turn, takes an additional quarter to be fully perceived in consumer inflation. Changes in short-term interest rates are thus transmitted to inflation through the aggregate demand channel with an estimated lag of two to three quarters. The exchange rate channel is estimated to have a shorter transmission lag: the effect of permanent interest rate changes on consumer prices through this channel is contemporaneous (on a quarterly basis), but its magnitude is smaller than through the demand channel. These results are based on the strong assumptions that expectations remain consistent with the model after any policy change and that the policy change itself is a sufficiently small departure from the initial position so that the log-linear approximation remains valid.

Further qualifications come into play at this point. First, the lag structure in the Brazilian aggregate demand channel is shorter than that found in the majority of either industrialized or developing economies. This may be the result of the large swings in real interest rates that characterize the post-Real Plan sampling period. These large swings generated prompt output and inflation responses, although the magnitude of the responses was relatively small in comparison with the interest rate variations. The lag is expected to increase gradually as the economy converges toward its long-run steady-state equilibrium.

Second, although the lag structure is short, the overall effect is modest, for several reasons. The financial system, for example, is overregulated, with a variety of credit restrictions, mandatory allocation of funds, and distorting taxes. The banking spread has therefore remained extraordinarily high, and the system as a whole presents a low leverage compared to international standards. This banking spread makes the transmission channel from the basic interest rate to market-determined final loan rates much weaker than desirable, and it explains part of the

high volatility of interest rates observed in the last three to five years. This fact leaves the impression that a slight deviation from the expected path requires a significant change in the basic interest rate to bring the economy back to the central path. In other words, the interest rate elasticity of the macroeconomic equilibrium is low. A series of parallel projects is underway to correct these distortions in the financial system and improve the efficiency of the transmission mechanism.

The third qualification has to do with the pass-through. Goldfajn and Werlang (2000), who analyze panel data, conclude that the pass-through coefficient generally depends on four main factors: the degree of overvaluation of the exchange rate prior to the devaluation, the previous level of inflation, the degree of openness, and the economic activity level. On this ground, Brazil shifted to a floating exchange rate regime with good prospects for a low degree of pass-through, since inflation was low and the exchange rate showed clear signals of overvaluation after the deterioration of the terms of trade and the Russian crisis in 1998. Open and heated economies tend to present higher pass-through coefficients, other things equal. Although trade liberalization progressed well and fast in the 1990s, the degree of openness of the Brazilian economy (around 14 percent) is considerably low in comparison with international standards. Furthermore, the economy evolved below its potential after the Russian crisis. When the real floated, the output gap was undoubtedly negative, which provided a major force for countering pass-through pressures. Preliminary results thus confirm the tendency for a low pass-through.

## 4. Policy Reaction to Shocks

In this section we examine how monetary policy reacted to shocks after inflation targeting was implemented in Brazil. We begin by identifying the main shocks that occurred after July 1999 and the corresponding policy behavior. The identification addresses the nature as well as the duration of shocks. This task is obviously easier with the benefit of hindsight, although in some cases even the ex post interpretation of shocks is not straightforward.

The problem of inflation persistence is another key factor for understanding the policy reaction. Given the Brazilian institutional setting, which features a high weight of backward-looking prices in the consumer basket, policy responses are different from those in an environment in which all prices are forward-looking. Other peculiarities of the Brazilian inflation-targeting framework are also relevant for dis-

cussing policy reactions. These include the absence of escape clauses, the use of a headline price index, and the adoption of multi-year targets. All these peculiarities leave relatively little room for accommodation by monetary policy.

The term backward-looking prices deserves an explanation. These prices are also known as government-managed prices, given that they used to be arbitrarily set by the government before the privatization of state companies. Government-managed prices are now those that, in one way or another, are defined or affected by a public sector agency, independently of current supply and demand conditions, but not arbitrarily. The major administered prices and respective weights in the reference consumer price index (IPCA) fall into two categories: those that are defined at the federal government level, including oil by-products (6 percent), electricity fees (3.3 percent), telephone and postal services fees (3 percent), and the minimum wage (3 percent), and those that are defined at the local governments level, including water and sewage fees (1.5 percent), public transportation (6 percent), and property taxes (1 percent)[14] . Taken together, these components account for around 25 percent of the IPCA, reflecting their importance in daily household expenditures in the income bracket of one to forty minimum wages. It is important to stress that managed does not mean controlled. Public utility fees constitute a substantial component of these prices. Their adjustment leaves no room for discretion: they follow the terms of their concession contracts; this links them to the past behavior of general price indexes and thus justifies the designation of institutionally backward-looking prices. The minimum wage, in turn, is set by the Congress. The central government only has effective direct control over the wholesale prices of oil by-products, and it has been resetting these in accordance with international prices, in anticipation of the full liberalization of the domestic oil market scheduled for 2002.

## 4.1 Description of Main Shocks and Corresponding Policy Behavior

We identified a total of eight shocks between July 1999 and November 2000, including a wide variety of supply and financial shocks. The supply shocks were primarily associated with food market conditions and backward-looking prices, which include the effects of international oil prices. The financial shocks mainly derived from increased interna-

14. These figures are approximations, given that the actual weights vary over time.

tional volatility and deterioration of the market perception of Brazil's risk premium, which immediately alters the exchange rate value. Seven out of eight are classified as adverse shocks to the extent that their preponderate effect was to press inflation upward. The taxonomy is somewhat dubious, given the fact that the economy is generally hit by more than one shock at the same time. Disentangling the combined effects of simultaneous shocks is impossible without some arbitrariness, as it is to associate monetary policy decisions with individual shocks.

The Brazilian economy in this period was far from its long-run balance, particularly with regard to the level of nominal and real interest rates. This means that in the absence of shocks, the interest rate would be expected to follow a declining path. Therefore, when policy reacted by keeping the interest rate constant, this actually represented a policy tightening, and not an accommodative stance.

Table 1 summarizes the main shocks that hit the Brazilian economy in the first eighteen months of inflation targeting. The shocks that we classify as backward-looking prices (BLP) stem from the annual resetting of public utility fees (including electrical energy, telecommunications, and water and sewage) that occurs at the beginning of the third quarter in most of the eleven cities covered by the IPCA.[15] A great part of these services were privatized in the late 1990s, and their price adjustment follows contracts linked to the past variation of general price indices. The first shock (number 1 in table 1) is considered so because market participants did not anticipate it correctly. After the inflation figures for July 1999 were released, inflation expectations rose by one full percentage point (see figure 5). However, Copom had been taking this temporary inflation rise into consideration since the first issue of the Central Bank's *Inflation Report* (June 1999). The committee decided to reduce the basic interest rate, since forecast year-end inflation was very close to the targeted level.

When the second BLP shock (number 2) occurred one year after the first, it was fully anticipated. Throughout the previous three quarters, monetary policy decisions had been explained to the public as aiming to counter possible second-round effects of this expected rise in backward-looking prices. This shock coincided with other two adverse developments, however. First, the domestic price of oil by-products was raised as a result of a new upsurge in international prices. Second, bad weather conditions throughout the country pushed food prices strongly upward.

15. Other managed prices, like the minimum wage, oil by-products, and urban bus fares, are not necessarily readjusted at the beginning of the third quarter.

**Table 1. Main Shocks and Policy Reaction**

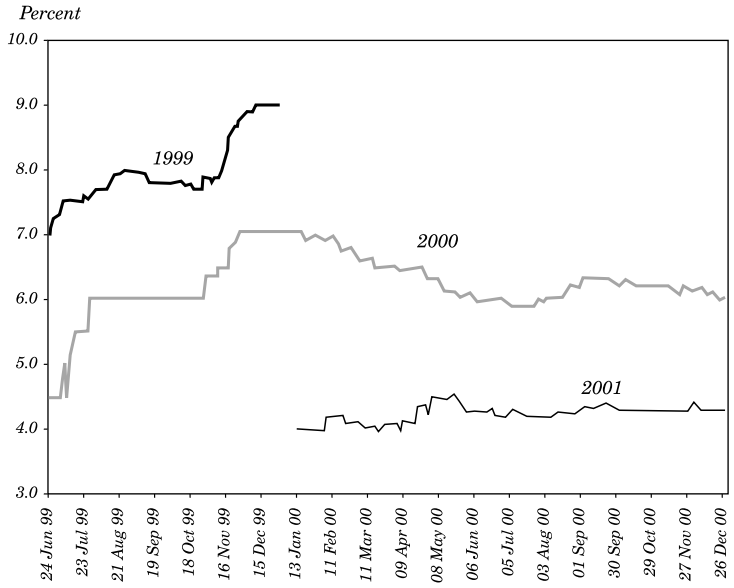
| *Identification number and type of shock* | *Timing* | *Description* | *Reaction* |
|---|---|---|---|
| 1. Backward-looking prices (BLP) | July 1999 | BLP higher than expected by the market; oil price | Interest rate reduced from 22% to 21% |
| 2. BLP | July-Aug 2000 | BLP accompanied by adverse oil and food prices | Interest rate held constant at 16.5% |
| 3. Food prices | June 2000 | Inflation much lower than expected in the first half | Interest rate reduced from 18.5% to 17.5% |
| 4. Financial | Aug 1999 | Disagreement with monetary policy; increased hedging demand | Interest rate held constant at 19.5% |
| 5. Financial | Oct 1999 | Inflation above expectations; trade deficit; concerns about pass-through and Y2K-related capital outflows | Interest rate held constant at 19%; NIR floor reviewed |
| 6. Financial | April-May 2000 | International stock market volatility; oil price upsurge; robustness of fundamentals | Interest rate held constant at 19% |
| 7. Financial | Nov 2000 | Oil price; Argentina | Interest rate held constant at 16.5% |
| 8. Oil prices | Dec 1999 | Concerns about tightening abroad, oil price evolution, and BLP for 2000; unexpected rise in food prices | Interest rate held constant at 19%; foreign exchange auctions |

Consequently, the inflation forecast for the year was revised upward, and the interest rate was held constant. At the time, evidence from previous episodes (for example, in the last quarter of 1999) indicated that the effects of supply shocks vanish quickly once they are recognized as temporary, and they seem to have no impact on inflation expectations. This low price inertia was confirmed by the substantial decline in inflation that was observed in September and October 2000 (see figure 3).

The food price shock (number 3) was the only positive supply shock in the covered period.[16] It consisted of a gradual reduction in food prices that began in February 2000, but became stronger only in May and June. Thus, although this shock was identified early, the presence of other shocks in April and May concealed its effect on inflation expectations. The exter-

16. Positive here means that it contributed to bringing inflation down.

**Figure 5. Inflation Expectations** [a]




Source: Central Bank of Brazil., Investor Relations Group.
a. Median of market expectations for year-over-year IPCA inflation.

nal uncertainties were attenuated in late June, and the inflation forecast was revised downward with the positive influence of food prices, allowing a one percentage point reduction in the basic interest rate.

The shocks we denominate as financial comprise four episodes featuring considerable shifts in the financial market perception of risks, which led to an increased difference between medium- and short-term interest rates, as well as to changes in the value of the exchange rate. These financial shocks reflect both the market reaction to monetary policy stance and changes in the risk premium motivated either by domestic fundamentals or by external developments.

The first of these shocks (number 4), which hit the economy in August 1999, stemmed from a combination of factors. First, as shock number 1 caused market inflation expectations to rise sharply in July, the pace at which the Central Bank was reducing the interest rates was seen as too rapid (see figure 5). Second, the level of external uncertainties was rising fast, mainly because monetary tightening in the United States generated concerns that financing for the Brazilian private sector would be inadequate, especially toward the end of the year. Also, for the first time since the Gulf War, oil prices became a serious

concern, together with their potential inflationary impact on Brazil. This caused a continuous depreciation of the real, and the demand for hedging instruments against further devaluation rose. Monetary policy response was twofold. First, hedge demand was matched by increased placement of dollar-indexed liabilities, since private market instruments were not available in appropriate amounts.[17] Second, the interest rate was held constant, interrupting the sequence of reductions initiated in mid-March 1999 (see figure 4). The interest rate level was thought to be enough to control inflationary pressures through the aggregate demand channel. If expectations deteriorated further, however, then the pass-through could endanger the achievement of the year target, making a tougher policy response advisable. The strategy was successful, as expectations improved: fiscal policy delivered better results than targeted, observed inflation fell until September, and sovereign risk perception started a continuous decline that ended only in April 2000.

In October the foreign exchange market experienced a liquidity shrink that coincided with a concentration of amortization payments of private sector debt (shock number 5). Moreover, the trade deficit was not recovering at the expected velocity, and there were mounting concerns that Y2K fears would trigger capital outflows by the end of the year. These factors brought about renewed pressure on the exchange rate. The policy reaction this time was of a different nature, aimed at coping with the temporary liquidity shortage expected for the upcoming weeks. The measures included lowering the floor on net international reserves (NIR)—a performance criterion in the IMF agreement—by around US$2 billion; issuing new sovereign bonds; and arranging a loan from the Inter-American Development Bank (IDB). In early December, the Central Bank structured two forward foreign exchange auctions, in which it would sell a certain amount of dollars in the end of December and repurchase the same amount in the beginning of January, thereby eliminating doubts about possible currency shortages arising from Y2K problems. The strategy was instrumental for improving confidence, and as a result, capital inflows that were expected only for the next year were in fact registered in late 1999.

Shock number 6 is a good example of how the robustness of domestic fundamentals is capable of avoiding the harmful effects of high external volatility. It started in April 2000 with the strong asset price correction in international markets, combined with a new upsurge in oil prices and an

17. These dollar-indexed bonds are not foreign debt, as they are payable in domestic currency even though their face value is adjusted according to the current exchange rate at maturity. The share of these bonds in total public domestic debt had been declining gradually since January 1999.

additional rise in the U.S. federal funds rate. As in all other recent cases of increased external uncertainty, the risk premium was the first variable to adjust to the new conditions. Inflation expectations did not deteriorate, however. Expectations even improved somewhat, as the domestic macroeconomic outlook presented no fundamental misalignment and the food price shock kept current inflation low. The foreign exchange market adjusted itself smoothly without any intervention. There was no perceptible increase in hedging demand, and the maximum exchange rate variation was less than 7 percent during the April-May period (see figure 4). Copom held the interest rate constant in this period, but it clearly signaled in the minutes from the April meeting that the real interest rate would decline as soon as the external uncertainties were mitigated.

This brief description of the Brazilian experience shows that there is no unique prescription for how monetary policy should react to shocks. Similar events may demand different responses that reflect the overall economic conditions. Inflation targeting in Brazil was subject to serious tests right from start. For example, the oil price shock, which pervaded this entire period, led to a substantial rise in domestic fuel prices, which more than doubled in less than a year. Nonetheless, inflation was kept within target in 1999 and 2000.

## 4.2 Monetary Policy Response: Theoretical and Empirical Evidence

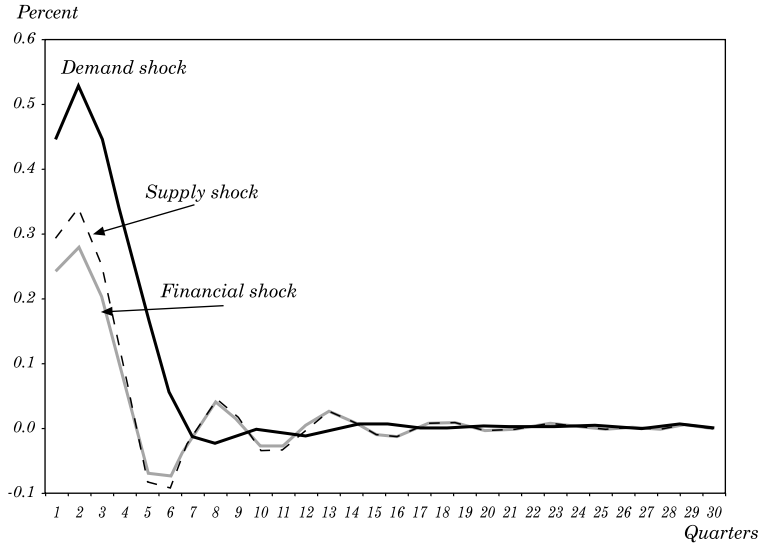
This section presents impulse response functions to different shocks and compares them to the actual reaction of monetary policy to supply and financial shocks. The results are summarized in figures 6 through 9.

We suppose that the economy can be described by the three-equation system presented in section 2: the IS curve specification is given in equation 1, the augmented Phillips curve in equation 2, and the exchange rate dynamics in equation 4. To complete the model, we assume that the interest rate is set by the Central Bank with the objective of minimizing the loss function,

$$\min_{\{i\}} L_t = \sum_{j=1}^{T} \rho^j [\omega_\pi D_{t+j} (E_t \pi_{t+j} - \pi^*_{t+j})^2 + \omega_h (E_t h_{t+j})^2 + \omega_i (\Delta i_{t+j})^2] .$$

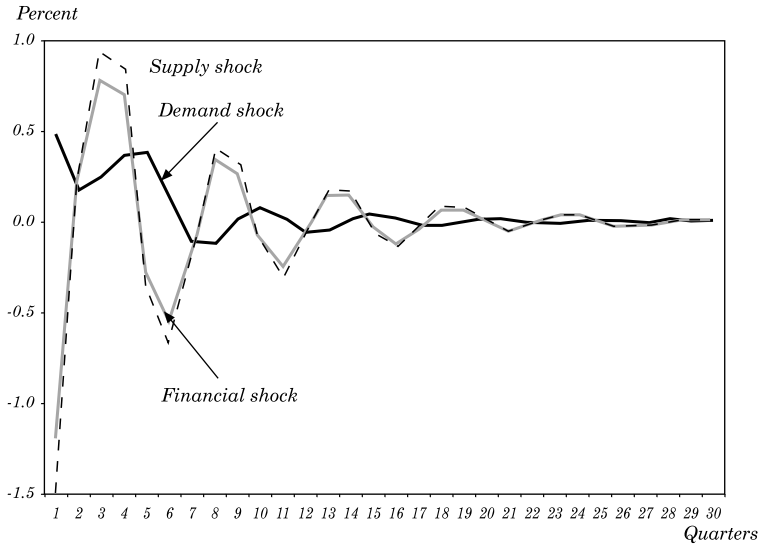
This loss function is a weighted average of the squares of the deviation of expected inflation ($\pi$) from the target ($\pi^*$), of the expected output gap (h), and of the nominal interest rate variation. The weighted average is discounted by a factor $\rho$ ($0 < \rho < 1$). *D* is a dummy variable that

## Figure 6. Impulse Response of the Nominal Interest Rate



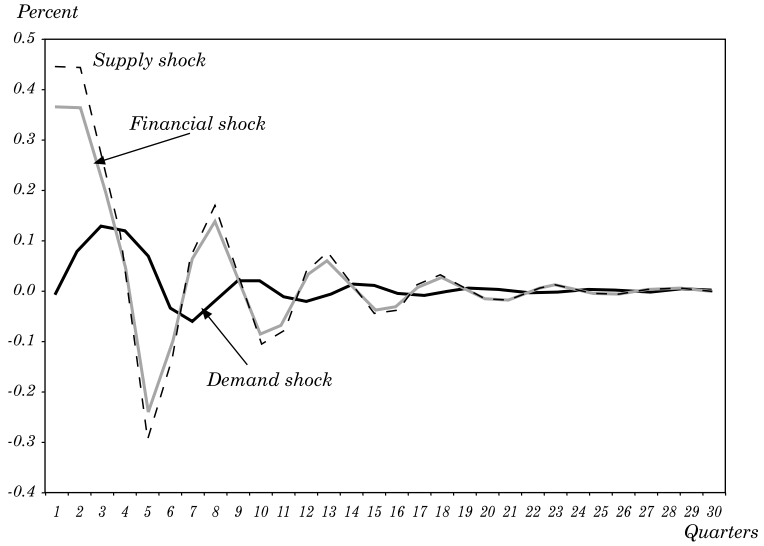

Source: Authors' calculations.

## Figure 7. Impulse Response of the Real Interest Rate



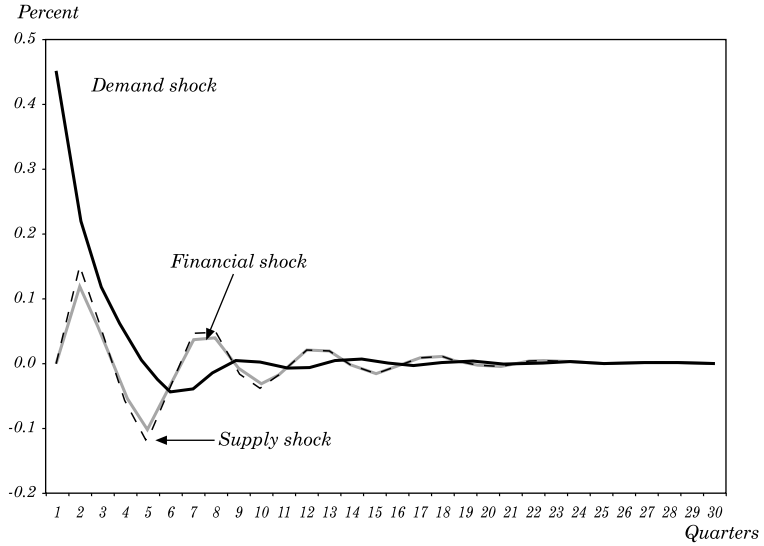

Source: Authors' calculations.

## Figure 8. Impulse Response of Inflation




Source: Authors' calculations.

## Figure 9. Impulse Response of the Output Gap




Source: Authors' calculations.

equals 1 in the last quarter of each year and 0 otherwise; it characterizes the fact that the Central Bank is concerned only with year-end deviations of realized inflation from the established target.

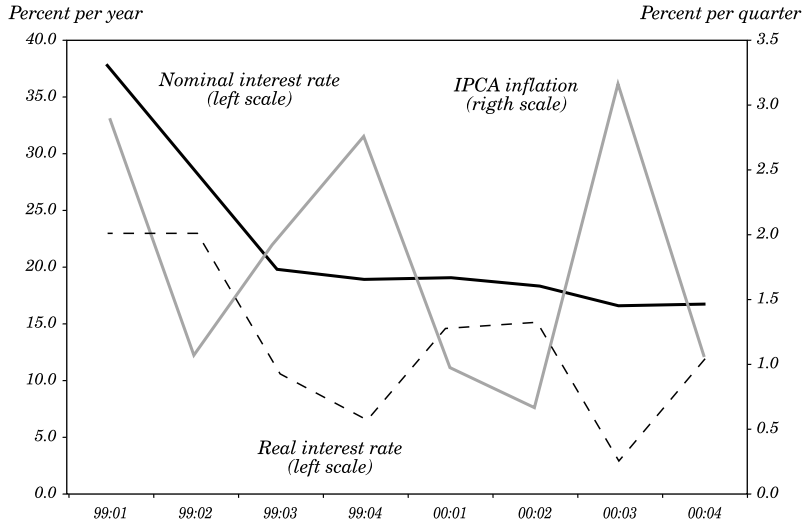
We assume that the economy starts from a steady-state equilibrium and is hit by shocks of one standard deviation, whose magnitudes are 0.3 percentage points for supply (equation 2), 0.45 percentage points for demand (equation 1), and 5 percentage points for financial shocks (equation 4).

As standard models would predict (see Clarida, Galí, and Gertler, 1999), demand shocks require the largest reaction. Figure 6 shows that demand shocks lead to the highest nominal interest rates during the first six quarters. Supply and financial shocks lead to very similar reactions, despite the fact that the financial shock is almost ten times as large as the supply shock. This can be explained by the fact that the reaction of monetary policy to financial shocks is mainly through its effect on inflation, with a negligible influence on the output gap. Since the pass-through from exchange rate variations to inflation is about 10 percent, the final impact of a financial shock on inflation is approximately the same as the supply shock, which suggests that a similar reaction is appropriate for both cases.

The real interest rate presents a different response pattern. It increases in the first period after a demand shock, but it decreases in the first period after supply and financial shocks. In other words, right after the economy is hit by the latter two shocks, the optimal response of the Central Bank is to increase nominal interest rates by a lower amount than the increase in inflation, thus bringing about an initial reduction in real interest rates. In the following periods, however, real interest rates rise above equilibrium, putting inflation into a sine-wave convergence path to its steady-state value. Figure 7 shows that the deviations of real interest rates from equilibrium after supply and financial shocks are usually higher than those observed after demand shocks. The counterpart of this finding is a more stable path for the output gap following supply and financial shocks, as shown in figure 9. The accumulated deviations of the output gap, measured by the area between the impulse response curve and the horizontal axis, can be interpreted as the sacrifice ratio. After one year, the accumulated deviation of the output gap is 0.83 for demand shocks, 0.14 for supply shocks, and 0.12 for financial shocks; the long-run values are 0.73, 0.04, and 0.03, respectively.

One should not expect the real economy to replicate the behavior of an impulse response function, since it is awkward to identify and iso-

**Figure 10. Quarterly Inflation and Interest Rates**




Source: Central Bank of Brazil.

late the effects of individual shocks. However, an analysis of figure 10 reveals some similarities between the actual behavior of the nominal interest rate and inflation and the prediction of the impulse response functions. Only supply and financial shocks occurred after the devaluation of the real in early 1999, as described in section 4.1.

It is interesting to examine the shocks that hit the economy in the second half of 1999. The exchange rate depreciated by 10 percent from the second to the third quarter of that year; backward-looking prices increased 8 percent in the third quarter and 3 percent in the last quarter; and food inflation reached 5.6 percent in the last quarter. In the face of such supply shocks, the Central Bank kept the nominal interest rate constant for almost six months. Given the prevailing out-of-equilibrium environment, this procedure was equivalent to an increase in the nominal interest rate when the economy is in steady state. It took from two to three quarters for the nominal interest rate to resume its downward trajectory, as in the impulse response cases.[18] The behavior of the real interest rate was also consistent with the predictions of the

18. The overnight rate was lowered from 21 percent to 19.5 percent in July 1999, and it remained constant until October, when it was reduced by 0.5 percentage point. The overnight rate was not lowered again until March 2000, this time to 18.5 percent (see figure 4).

impulse responses: despite an "increasing" nominal interest rate in the first period (fourth quarter 1999), there was a contemporaneous reduction in the real interest rate. In the following quarter, however, the real interest rate did rise. Finally, as predicted, inflation increased in tandem with the shocks, but it declined faster than expected: in the first quarter of 2000, IPCA inflation was already below the target value for the year, if expressed in annualized terms.

## 4.3 Inflation Targeting and Backward-Looking Prices

In the Brazilian framework, the inflation target is set for the annual variation of the IPCA, a consumer price index in which the weight of backward-looking prices is approximately 25 percent. This particularity poses an additional challenge for monetary policymaking, since backward-looking prices are insensitive to interest rate decisions.

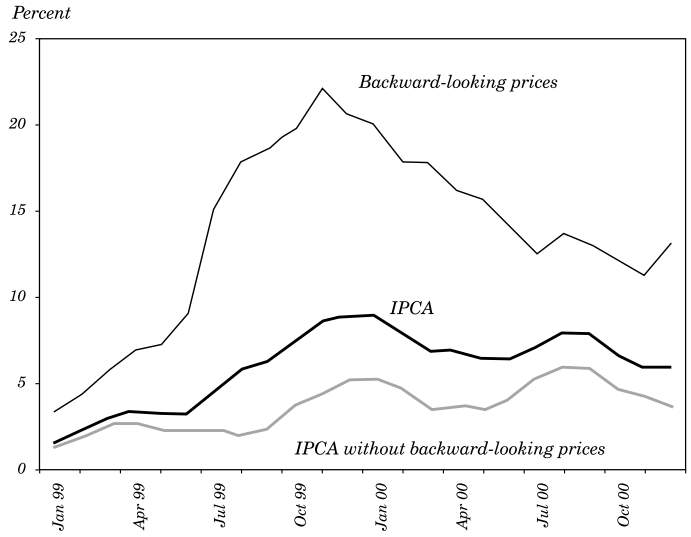
The most important items with backward-looking prices are public utilities, fuel, public transportation, and the minimum wage.[19] The adjustment of these prices follows several rules. To respect contractual clauses, increases in utility fees are generally based on past inflation as measured by the general price indexes. Prices of gasoline and oil byproducts tend to increase in accordance with the exchange rate and international oil prices. Finally, the annual adjustment of the minimum wage is not defined by formal rules, but the political discussion in Congress usually starts from past consumer price inflation.

The group of backward-looking prices accumulated a 36.6 percent increase in 1999–2000, while other prices of the economy rose only by 8.8 percent. Figure 11 shows the evolution of headline IPCA inflation, along with a breakdown of the behavior of backward-looking prices and the remaining prices. Because the targets are set for headline IPCA inflation, the behavior of backward-looking prices clearly imposes an important restriction on monetary policy: real interest rates need to be high in order to keep the forward-looking prices at levels below the inflation target.

To quantify the influence of backward-looking prices on monetary policy decisions, we simulate the behavior of monetary policy from 2000 to 2002, assuming that the economy starts from the initial conditions that prevailed at the end of 1999. We then compare this behavior using

19. In the IPCA, the minimum wage variation corresponds to the full variation of the domestic employee category, whose weight is around 3 percent.

**Figure 11. Year-over-Year Inflation**




Source: Central Bank of Brazil.

different assumptions about the weight of backward-looking prices in the IPCA and about their adjustment rules. The results of the exercises are based on the four-equation model presented in section 2. The only difference is that the Phillips curve is modified to take explicit account of backward-looking prices in explaining inflation.

The estimation of the Phillips curve is based on the following system:

$$p_t = \omega p_t^m + (1-\omega) p_t^{bl}, \tag{5}$$

$$z_t = e_t + p_t^*, \tag{6}$$

$$p_t^m = \delta w_t + (1-\delta) z_t, \text{ and} \tag{7}$$

$$w_t - w_{t-1} = \psi E_{t-1}\pi_t + (1-\psi)\pi_{t-1} + \kappa h_{t-1}. \tag{8}$$

All variables are expressed in logarithms; $p$ stands for the price level, $w$ for wages, $h$ for the output gap, $e$ for the nominal exchange rate, the superscript $m$ for market goods (that is, goods and services whose prices are free to adjust to market conditions), and the superscript $bl$ for backward-looking prices.

Equation 5 establishes that consumer prices are a weighted average of market and backward-looking prices. Equation 6 defines the

variable $z$ as international prices ($p^*$) expressed in terms of the domestic currency. Note that the exchange rate, $e$, is the number of units of domestic currency needed to buy one unit of foreign currency, such that an increase in $e$ means a depreciation of the domestic currency. Equation 7 is the price equation for market goods. Such prices are a weighted average of international prices and domestic wages. Equation 8 defines the wage dynamics, which depend on expected inflation, past inflation, and the output gap. The restriction that the coefficients of expected and past inflation sum to one guarantees the verticality of the Phillips curve.

After differentiating equations 5 and 7 and substituting equations 7 and 8 into equation 5, we get the reduced-form Phillips curve:

$$\pi_t = \omega\delta\left[\psi E_{t-1}\pi_t + (1-\psi)\pi_{t-1} + \kappa h_{t-1}\right] + \omega(1-\delta)\Delta z_t + (1-\omega)\pi_t^{bl}. \quad (9)$$

The estimated coefficients presented the expected sign, and all were significant at conventional values. Wald tests also showed that the reduced-form coefficients were statistically different from zero at conventional significance levels.

Varying the value of $\omega$, the weight of market prices in the consumer basket, generates a family of Phillips curves. We now define the market inflation equation as the Phillips curve that results when $\omega = 1$. Otherwise, we refer to the headline inflation Phillips curve. Before comparing the two curves, it is necessary to model backward-looking prices. By assumption, they are a weighted average of past inflation and external price variation:

$$\pi_t^{bl} = \beta\pi_{t-1} + (1-\beta)\Delta z_{t-1}. \quad (10)$$

Table 2 shows the difference between the estimated coefficients of the market and headline inflation equations, for different values of $\beta$. The degree of inertia, measured by the estimated coefficient of past inflation in the reduced form, depends positively on the value of $\beta$. When $\beta$ increases, headline inflation shows stronger persistence, as evidenced by a larger coefficient of $\pi_{t-1}$, while for $\beta = 0$, market inflation is more lag dependent. The exchange rate pass-through is smaller for market inflation only if $\beta = 1$. Finally, as expected, the sensitivity of inflation to the output gap is larger in the absence of backward-looking prices ($\omega = 1$). In this case, the transmission mechanism of monetary policy through the aggregate demand channel is relatively efficient.

**Table 2. Difference between Headline and Market Inflation Coefficients**

| | *Headline inflation coefficient minus market inflation coefficient* | | |
|---|---|---|---|
| *Variable* | $\beta = 1$ | $\beta = 0.5$ | $\beta = 0$ |
| Inflation expectations, $E(\pi)$ | –0.073 | –0.073 | –0.073 |
| Past inflation, $\pi_{t-1}$ | 0.086 | 0.017 | –0.052 |
| Output gap, $h$ | –0.031 | –0.031 | –0.031 |
| Exchange rate pass-through, $\Delta z_t + \Delta z_{t-1}$ | –0.012 | 0.056 | 0.125 |

Source: Authors' calculations.

A more reactive monetary policy is expected under strong inertia, as in the case $\beta = 1$, since the interest rate level needed to reduce inflation by any amount is higher than in the case of weak inertia. On the other hand, since monetary policy is relatively inefficient in this environment and the Central Bank's loss function is assumed to include output gap and interest rate smoothing, monetary policy should not react strongly to deviations of inflation from the target, as Clarida, Galí, and Gertler (1999) point out. Henceforth, we refer to these two factors as inertial and efficiency effects. Since they work in opposite directions, it is not possible to tell a priori in which case the Central Bank would be more aggressive.

Based on the equations for headline and market inflation, we ran simulations with the assumption that the economy starts from the initial conditions that prevailed at the end of 1999 and that the Central Bank chooses the interest rate path (from 2000 to 2002) to minimize the loss function presented in section 4.2:

$$\min_{\{i\}} L_t = \sum_{j=1}^{T} \rho^j [\omega_\pi D_{t+j} (E_t \pi_{t+j} - \pi^*_{t+j})^2 + \omega_h (E_t h_{t+j})^2 + \omega_i (\Delta i_{t+j})^2]. \qquad (11)$$

Tables 3 and 4 display the results of the simulations under two alternative rules for the adjustment of backward-looking prices, that is, two different values of $\beta$. The first column in table 3 presents the baseline case of year-end market inflation, generated from simulations using the estimated coefficients of the Phillips curve ($\omega = 1$). The remaining columns in

the table show how the baseline results change in the presence of backward-looking prices, when their weight in the Phillips curve is increased to 13 percent and 20 percent. These columns exhibit the difference between the cases of headline and market inflation for three variables: year-end inflation and the yearly averages of nominal and real interest rates. Finally, table 4 shows the difference in results that arise when we simulate a faster disinflation, that is, instead of pursuing inflation targets of 6 percent, 4 percent, and 3.5 percent from 2000 to 2002, the Central Bank would need to meet targets of 5 percent, 3 percent, and 2.5 percent.

**Table 3. Effect of Backward-Looking Prices**

| | | *Difference between the cases of headline and market inflation* | | | | | |
|---|---|---|---|---|---|---|---|
| | | *β = 1* | | | *β = 0* | | |
| *Parameter and period* | *Baseline case: market inflation (ω=1)* | *Year-end inflation* | *Nominal interest rate* | *Real interest rate* | *Year-end inflation* | *Nominal interest rate* | *Real interest rate* |
| Weight of backward-looking prices = 13% | | | | | | | |
| 2000 | 5.55 | –0.03 | 0.55 | 0.55 | –0.27 | –1.59 | –1.22 |
| 2001 | 4.05 | 0.16 | 0.58 | 0.39 | 0.03 | –0.50 | –0.52 |
| 2002 | 3.64 | 0.03 | –0.15 | –0.18 | –0.10 | –0.68 | –0.55 |
| Weight of backward-looking prices = 20% | | | | | | | |
| 2000 | 5.55 | –0.01 | 0.93 | 0.90 | –0.32 | –2.39 | –1.93 |
| 2001 | 4.05 | 0.24 | 0.80 | 0.52 | –0.02 | –0.95 | –0.89 |
| 2002 | 3.64 | 0.01 | –0.37 | –0.36 | –0.18 | –1.05 | –0.83 |

Source: Authors' calculations.

**Table 4. Effect of a Faster Disinflation (ω = 0.87)**[a]

| | *Market inflation* | | | *Headline inflation (β = 1)* | | | *Headline inflation (β = 0)* | | |
|---|---|---|---|---|---|---|---|---|---|
| *Period* | *Year-end inflation* | *Nominal interest rate* | *Real interest rate* | *Year-end inflation* | *Nominal interest rate* | *Real interest rate* | *Year-end inflation* | *Nominal interest rate* | *Real interest rate* |
| 2000 | –0.97 | –0.56 | 0.50 | –0.98 | 0.06 | 1.10 | –1.15 | –1.75 | –0.45 |
| 2001 | –0.95 | –0.85 | 0.19 | –0.79 | –0.24 | 0.61 | –0.88 | –1.04 | –0.07 |
| 2002 | –0.97 | –0.89 | 0.12 | –0.95 | –1.10 | –0.10 | –1.04 | –1.32 | –0.22 |

Source: Authors' calculations.

a. Inflation targets are reduced by 1 percentage point, to 5 percent for 2000, 3 percent for 2001, and 2.5 percent in 2002; the weight of backward-looking prices (1 – ω) is 13 percent.

For 2000 and 2001, when the degree of inertia is the highest ($\beta = 1$), the inertial effect dominates the efficiency effect. Nominal and real interest rates would have to be about half a percentage point higher in the case of the headline inflation Phillips curve than in the case of the market inflation Phillips curve (see table 3). The difference in interest rates would have to be even greater if the weight of backward-looking prices increased from 13 percent to 20 percent. This pattern is reversed for 2002, however: nominal and real interest rates are smaller under headline inflation than under market inflation. We attribute this result to the offsetting nature of the inertial and efficiency effects. To achieve the target in 2000, inflation must be reduced by 2.9 percentage points, which is the difference between observed inflation in 1999 (8.9 percent) and the 6 percent target for 2000. For 2001, inflation would have to be reduced by 1.55 percentage points in the market inflation case. For 2002, however, the disinflation effort is significantly smaller, at 0.55 percentage points for market inflation. The inertial effect thus dominates the efficiency effect when annual disinflation is high. The figures in table 4 are consistent with this interpretation. When disinflation is rapid, the interest rate differential between headline and market inflation rises to 1.10 and 0.61 percentage points in 2000 and 2001, respectively, implying a stronger inertial effect.[20]

It is more difficult to compare the case of headline inflation when $\beta = 0$ with the baseline market inflation case. The higher pass-through may slow the reduction in interest rates, given the inflationary effects of the consequent exchange rate depreciation. On the other hand, the case of $\beta = 0$ presents a relatively small degree of inflation inertia and a reduced efficiency of monetary policy, which encourages the Central Bank to cut interest rates aggressively. According to table 3, the balance of all these factors favors a fast reduction in interest rates when the Central Bank faces a headline inflation Phillips curve with $\beta = 0$.

## 5. Monitoring Inflation Targets under an IMF Program

This section focuses on alternative ways of assessing the monetary policy stance in inflation-targeting countries that have an ongoing program with the IMF. Brazil was the first country to adopt inflation

20. A faster disinflation allows the Central Bank to set relatively lower nominal interest rates. In the model, this results from the fact that a smaller target for inflation would also reduce inflation expectations and, hence, current inflation. Since the optimal real interest rates are higher, a faster disinflation still implies a tighter monetary policy.

targeting while a financial support program was under way. This raised some important issues with regard to assessment. The usual performance criterion on net domestic assets is not adequate for an inflation-targeting regime, because it harms transparency and may induce unnecessary monetary movements.

We compare the behavior of inflation, the output gap, and interest rates under alternative criteria for evaluating the monetary policy stance, which may be more suitable for an inflation-targeting country. We first describe four accountability alternatives:

—Year-end inflation target. This is the original inflation-targeting framework in Brazil. The Ministry of Finance sets the year-end target and the tolerance bands two years in advance. The current targets are 6 percent, 4 percent, and 3.5 percent for 2000, 2001, and 2002, respectively. The Central Bank is considered successful in achieving the target if actual year-end inflation falls within a ±2 percentage point band around the target.

—Quarterly inflation targets set by a linear convergence rule, as established in the fourth review of the current agreement with the IMF. According to this criterion, twelve-month inflation for each quarter should equal the value obtained by linear interpolation of the adjacent year-end targets. For example, given the 6 percent and 4 percent year-end targets for 2000 and 2001, the target path from the first to the third quarters of 2001 should be 5.5 percent, 5 percent, and 4.5 percent. A potential problem with this criterion is the fact that shocks in a given year contaminate the quarterly twelve-month inflation figures of the following year; the criterion forces the monetary authority to react unnecessarily to such shocks.

—Quarterly inflation targets that take into account the actual outcomes observed in the previous year. Whereas the previous alternative outlines a quarterly target path based on year-end targets, this criterion is based on the actual inflation figures of the previous year. In logarithmic terms, this target is set according to the following formula:

$$\pi^{*}_{T,i} = \sum_{\substack{j=i+1 \\ i<4}}^{4} \pi_{T-1,j} + \frac{i}{4}\pi^{*}_{T}.$$

where $\pi^{*}_{T,i}$ is the twelve-month inflation target for quarter $i$ in year $T$; $\pi_{T-1,j}$ is the actual inflation observed in quarter $j$ in year $T-1$; and $\pi^{*}_{T}$ is the inflation target for year $T$. The target for the first quarter of a year would be the actual inflation observed in the last three quarters of the previous year, plus one-fourth of the inflation target for the current

year; the target for the second quarter would be actual inflation observed in the second half of the previous year, plus one-half of the inflation target for the current year; and so on. The target path must be reset at the beginning of each year, once the previous year's inflation is known. This criterion overcomes one of the major drawbacks of the last alternative, namely, the fact that shocks in a given year contaminate monetary policy decisions in the following year, irrespective of the effects such shocks have on inflation. Both criteria, however, have the potential drawback of increasing the frequency of monetary performance evaluation, from yearly to quarterly.

—A Taylor-type rule. The starting point of the analysis is to assume the Central Bank sets the nominal interest rate $i$ to minimize the loss function described in equation 11, which is repeated here for reference:

$$\min_{\{i\}} L_t = \sum_{j=1}^{T} \rho^j [\omega_\pi D_{t+j} (E_t \pi_{t+j} - \pi^*_{t+j})^2 + \omega_h (E_t h_{t+j})^2 + \omega_i (\Delta i_{t+j})^2],$$

subject to

$$\pi_t = \alpha_1 E_t \pi_{t-1} + \alpha_2 \pi_{t-1} + (1 - \alpha_1 - \alpha_2)\Delta(e_t + \pi^f_t) + \alpha_3 h_{t-1} + \varepsilon_{\pi,t}, \quad (12)$$

$$h_t = \beta_0 + \beta_1 h_{t-1} + \beta_2 (i_{t-1} - \pi_{t-1}) + \beta_3 \theta_{t-1} + \varepsilon_{h,t}, \quad (13)$$

$$\Delta e_t = i^f_t + x_t - i_t + \varepsilon_{e,t}, \text{ and} \quad (14)$$

$$\Sigma = \begin{bmatrix} \sigma^2_\pi & \sigma_{\pi,h} & \sigma_{\pi,i} \\ \sigma_{\pi,h} & \sigma^2_h & \sigma_{h,i} \\ \sigma_{\pi,i} & \sigma_{h,e} & \sigma^2_e \end{bmatrix} = \begin{bmatrix} \sigma^2_\pi & 0 & 0 \\ 0 & \sigma^2_h & 0 \\ 0 & 0 & \sigma^2_e \end{bmatrix}. \quad (15)$$

The value of the dummy variable, $D$, varies according to the alternative chosen. For the first alternative, in which the Central Bank cares only about year-end inflation, $D$ equals 1 in the last quarter of each year and 0 in all other quarters. Under the second and third alternatives, $D$ equals 1 in all quarters, meaning that monetary policy should be evaluated every quarter.

Equations 12, 13, and 14 are the constraints of the minimization problem; they form a small structural macroeconomic model similar to that presented in section 2. Condition 15 assumes a diagonal variance-covariance matrix. Additionally, the error terms are assumed to independent, identically distributed, and normally distributed. The calibrated values that we use for the standard errors are 0.5 percentage

point for output gap, 0.3 percentage point for inflation, and 5 percentage points for the exchange rate.

To run stochastic simulations, we assumed the Central Bank minimizes the loss function taking into consideration eight periods ahead, with a discount rate of 1 percent ($\rho = 0.99$). This horizon might be considered relatively short by international standards, but it is a reasonable hypothesis for the Brazilian economy, which is characterized by a higher level of uncertainty since it is still in transition to its steady-state inflation level. Furthermore, evidence shows that optimizing periods beyond eight quarters do not yield gains in terms of efficiency in the output-inflation variability locus (see Freitas and Muinhos, 2001). Finally, this optimization horizon is also in line with the *Inflation Report,* which releases inflation forecasts up to two years ahead.

In the stochastic simulations, we assumed that at the beginning of quarter $t$, when the interest rate is set, the Central Bank knows the realization of all variables up to $t$–1, but does not know the shock. The results presented in table 5 were obtained after 150 simulations. We performed the simulations as if the economy were at the beginning of 2000. All variables took their actual values as initial conditions, except for the output gap, which was set to 0 at the end of 1999. This modification in the initial conditions regarding the output gap allows us to concentrate on the contamination effect described in the second alternative above, since IPCA inflation in 1999 was 0.9 percentage points above the target.

Finally, the simulations for the fourth alternative do not need the optimization procedure, since the Taylor-type rule sets the interest rate according to observed outcomes. The specification of the traditional Taylor rule is

$$i_t = i_t^* + 1.5(\pi_{t-1} - \pi_{t-1}^*) + 0.5h_{t-1}\,, \tag{16}$$

where $i$ is the annualized quarterly interest rate and $i^*$ is the equilibrium nominal interest rate. To be consistent with the loss function, we introduced interest rate smoothing: the actual interest rate is the weighted average of the previous value of the interest rate and the one given by equation 16, with weights of 0.60 and 0.40, respectively.

Table 5 shows that all alternatives lead to a level of expected year-end inflation that is well within the ±2 percentage point tolerance band established in the Brazilian inflation-targeting framework, despite the initial conditions (inflation was almost 1 percentage point above the target). Such results can be explained by the short lag of the transmission

## Table 5. Results of the Stochastic Simulation for Four Policy Alternatives[a]

| Year and quarter | *Twelve-month inflation* | | | | *Standard deviation of inflation*[b] | | | | *Standard deviation of output gap* | | | | *Probability* ($\pi - \pi^* > 1$ *percentage point*) | | | | *Probability* ($\pi - \pi^* > 2$ *percentage point*) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *I* | *II* | *III* | *IV* | *I* | *II* | *III* | *IV* | *I* | *II* | *III* | *IV* | *I* | *II* | *III* | *IV* | *I* | *II* | *III* | *IV* |
| 2000:1 | 8.28 | 8.26 | 8.27 | 8.14 | 0.51 | 0.50 | 0.53 | 0.56 | 0.45 | 0.41 | 0.47 | 0.46 | 3.0 | 3.3 | 7.3 | 9.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2000:2 | 8.65 | 8.63 | 8.54 | 8.28 | 1.53 | 1.50 | 1.44 | 1.26 | 0.52 | 0.52 | 0.55 | 0.61 | 67.0 | 72.7 | 66.0 | 43.7 | 13.0 | 10.7 | 10.0 | 8.7 |
| 2000:3 | 7.62 | 7.59 | 7.49 | 7.19 | 1.24 | 1.22 | 1.12 | 0.98 | 0.56 | 0.56 | 0.54 | 0.64 | 50.5 | 52.0 | 45.3 | 30.0 | 5.5 | 4.7 | 2.0 | 4.3 |
| 2000:4 | 6.03 | 5.99 | 5.91 | 5.66 | 0.60 | 0.55 | 0.53 | 0.72 | 0.57 | 0.57 | 0.57 | 0.76 | 11.0 | 7.3 | 5.3 | 17.0 | 0.0 | 0.0 | 0.0 | 0.3 |
| 2001:1 | 5.22 | 5.22 | 5.14 | 4.89 | 0.56 | 0.63 | 0.61 | 0.89 | 0.59 | 0.64 | 0.58 | 0.95 | 7.0 | 10.0 | 10.7 | 25.3 | 0.0 | 0.7 | 0.0 | 1.3 |
| 2001:2 | 5.11 | 5.12 | 5.11 | 4.72 | 0.68 | 0.67 | 0.67 | 0.74 | 0.66 | 0.65 | 0.53 | 0.96 | 14.0 | 11.3 | 12.7 | 20.0 | 0.0 | 0.7 | 0.0 | 0.0 |
| 2001:3 | 4.94 | 5.01 | 4.98 | 4.55 | 0.82 | 0.87 | 0.83 | 0.81 | 0.65 | 0.57 | 0.54 | 1.06 | 22.5 | 27.3 | 23.3 | 21.3 | 0.5 | 1.3 | 0.7 | 1.7 |
| 2001:4 | 4.29 | 4.40 | 4.29 | 3.95 | 0.69 | 0.74 | 0.71 | 0.84 | 0.59 | 0.63 | 0.58 | 1.05 | 13.0 | 20.0 | 14.7 | 24.0 | 0.5 | 0.0 | 0.7 | 0.7 |
| 2002:1 | 3.61 | 3.64 | 3.57 | 3.57 | 0.61 | 0.68 | 0.61 | 0.87 | 0.65 | 0.64 | 0.62 | 1.08 | 10.0 | 15.3 | 9.3 | 22.0 | 0.0 | 0.0 | 0.0 | 2.3 |
| 2002:2 | 3.28 | 3.33 | 3.31 | 3.48 | 0.79 | 0.73 | 0.75 | 0.84 | 0.66 | 0.57 | 0.66 | 1.12 | 20.5 | 14.7 | 17.3 | 22.3 | 1.0 | 0.7 | 0.7 | 1.3 |
| 2002:3 | 3.39 | 3.47 | 3.44 | 3.57 | 0.65 | 0.62 | 0.67 | 0.80 | 0.58 | 0.57 | 0.65 | 1.19 | 12.0 | 10.7 | 13.3 | 20.0 | 0.5 | 0.0 | 0.0 | 1.0 |
| 2002:4 | 3.58 | 3.69 | 3.66 | 3.57 | 0.60 | 0.65 | 0.66 | 0.89 | 0.58 | 0.59 | 0.60 | 1.15 | 9.5 | 14.0 | 12.0 | 22.7 | 0.0 | 0.0 | 0.7 | 2.7 |

Source: Authors' calculations.

a. Alternative I: year-end inflation target; alternative II: quarterly inflation targets set by a linear convergence rule; alternative III: quarterly inflation targets based on previous year's outcomes; alternative IV: a Taylor rule.

b. The standard deviation of inflation refers to deviations from the target, not from the mean. Since no quarterly target is defined for Alternative I, the standard deviation was estimated using the target set for alternative II.

**Table 6. Absolute and Relative Losses**

| | *Alternative*[a] | | | |
|---|---|---|---|---|
| *Loss* | *I* | *II* | *III* | *IV* |
| Absolute loss | 0.85 | 0.99 | 0.97 | 5.29 |
| Relative loss (%) | — | 16.20 | 14.00 | 521.40 |

Source: Authors' calculations.

a. Alternative I: year-end inflation target; alternative II: quarterly inflation targets set by a linear convergence rule; alternative III: quarterly inflation targets based on previous year's outcomes; alternative IV: a Taylor rule.

mechanism. Decisions regarding interest rates affect inflation contemporaneously through the exchange rate channel and take only two quarters to affect inflation through the aggregate demand channel. The output gap performance was also good, in the sense that it stayed within a band of ±1 percentage point during most of the period for all alternatives.

It is difficult to rank the alternatives by looking only at the variability of inflation and output. Only the Taylor rule yielded generally higher volatility for both inflation and output. The figures for the other three alternatives do not prompt clear-cut conclusions, either because the qualitative pattern is not stable or because the differences in standard deviations are small. The results presented in table 6 were calculated from the loss function for the first alternative (in which only year-end inflation rates matter). The performance of the Taylor rule[21] was clearly the worst, while the second and third alternatives (the linear target path and the target path based on the previous year's outcomes) yielded a relative loss of approximately 15 percent.

The similar performance of these three alternatives is a surprising result. We expected the first alternative to present a visibly better performance for year-end inflation, because it ignores inflation outcomes in the first three quarters of the year, while the second alternative was expected to yield the worst outcome, since it forces monetary policy to react to large deviations of inflation from the target in the previous year. The presence of output gap and interest rate variation in the loss function in all quarters may have contributed to making the three alternatives more similar. Another possible explanation is related to the backward-looking component of inflation. To meet the year-end inflation target, the monetary authority needs to put a high weight on the inflation outcomes of the interim quarters. Therefore, the effect of changing the accountability frequency may have been mild.

21. It is possible, however, that the performance of the Taylor rule could dramatically improve if a different set of parameters is chosen.

These findings, however, do not imply that the Central Bank should be indifferent in choosing among the first three alternatives. If the Central Bank is, in fact, concerned only with the year-end accumulated inflation, then setting a quarterly target path for inflation is not likely to severely alter the behavior of macroeconomic variables. Should monetary policy be evaluated on a quarterly basis, however, there is a high probability that unnecessary false alarms would be triggered in the course of the year. In the context of the current agreement, an informal consultation with the IMF is triggered if inflation deviates from the target path by more than 1 percentage point, and a formal consultation is required if the deviation exceeds 2 percentage points. The probability of inflation deviating from the target by more than 1 percentage point falls significantly as the year progresses (see table 5). This is a particularly delicate issue for an emerging economy, because false alarms may trigger a confidence crisis and thus make the conduct of monetary policy more difficult. A compromise solution to this problem would be to increase the tolerance interval for the first three quarters of the year; this would preserve the quarterly accountability frequency while reducing the probability of triggering false alarms.

## 6. Conclusions

The relative success of economic policy in Brazil since the 1999 devaluation stems from a variety of factors, including the initial macroeconomic conditions, the strong international support, and the inflation-targeting regime that provided an adequate and timely anchor for expectations. The most important factor, however, was the long-awaited fiscal reversal, which was a necessary (but obviously not sufficient) condition for the sustainability of the inflation-targeting framework.

Despite the huge devaluation in early 1999, the year ended with single-digit consumer price inflation, which fell within the target set by mid-year, and with nearly 1 percent GDP growth, which was well above the preliminary prospects. Inflation behavior showed a very low pass-through, which can be attributed to the output gap in the period, the overvalued real just before the floating, and the low initial inflation. The inflation-targeting regime guided expectations in line with the multi-year disinflation targets, allowing the relative price realignment after the devaluation to be processed without igniting overwhelming pressures on consumer prices.

However, the large swing in relative prices poses some idiosyncratic challenges for the monetary authority. The evolution of the back-

ward-looking prices is of particular concern. Such prices correspond to around 25 percent of the IPCA and have increased by 36.6 percent in 1999–2000, while all other prices taken together rose by only 8.8 percent in the same period. The results of simulation using different assumptions regarding the adjustment rule and the weight of backward-looking prices in the IPCA show that when the adjustment of these prices is based on past inflation, the degree of inertia increases and forces the Central Bank to be more restrictive in order to disinflate the economy. Nominal and real interest rates are 0.5 percentage point to 1.0 percentage point higher when the Central Bank faces a Phillips curve with backward-looking prices. When inflation is closer to its steady-state value, however, the presence of administered prices in the IPCA does not alter the behavior of monetary policy significantly.

We presented a brief description of the Brazilian experience, showing how monetary policy reacted to different shocks. In the inflation-targeting period, all the shocks that hit the economy propagated their effects mainly through the supply side and financial markets. Although the shocks displayed some common features, such as rising oil prices, the rapidly changing overall economic conditions demanded different responses.

We confronted the theoretical policy prescriptions with estimated impulse responses to different kinds of shocks in a simple empirical model. As expected, the results showed that a central bank should be fairly restrictive when countering aggregate demand shocks, but it should partially accommodate supply and financial shocks by contemporaneously increasing nominal interest rates while allowing real interest rates to fall. Real interest rates eventually rise with the subsequent fall in inflation. This pattern, suggested by the impulse response functions, was observed in recent episodes in Brazil. When facing supply and financial shocks in the last two quarters of 1999, the Central Bank kept nominal interest rates constant at a level above long-run equilibrium and allowed real interest to fall. With inflation under control, real interest rates rose again in the following quarter, and the Central Bank resumed the trend of reducing interest rates.

Finally the paper addressed the issue of how to monitor inflation targeting under agreements with the IMF. We used a simple structural model to show that except in the case of a Taylor rule, the behavior of relevant macroeconomic variables does not change significantly when the frequency at which monetary policy is evaluated increases from yearly to quarterly. However, a central bank should not be indifferent when choosing between year-end accountability only

and quarterly monitored accountability, such as that established in recent Brazilian agreements with the IMF. The reason is simple: if the relevant macroeconomic variables are initially out of equilibrium, then the probability of meeting the target by year-end may be high while the probability of breaching the tolerance bands in the intermediate quarters is also high. Monitoring quarterly figures under such circumstances can send unnecessary false alarms, introducing an unwarranted noise in the conduct of monetary policy by affecting expectations.

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# A Decade of Inflation Targeting in Chile: Developments, Lessons, and Challenges

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In the twentieth century, Chile experienced most monetary and exchange rate regimes. Periods of fixed exchange rates usually ended in speculative attacks as a result of inconsistent policies or significant external shocks, generating serious real costs and larger exchange rate volatility. As in many other countries, fiscal policy became extremely expansive and eventually irresponsible, and the government continuously operated without a balanced budget. Monetary policy was almost always an expression of fiscal needs; high and volatile inflation was an unsurprising outcome. Chile's average annual rate of inflation from 1890 to 1998 was 31 percent, with a standard deviation of 79 percent.[1] After 1930, when the state's intervention and relevance within the economy began to grow, average annual inflation reached 45 percent, with a standard deviation of 96 percent. Widespread regulation and intervention in markets, together with endemic macroeconomic instability, caused disappointing growth throughout much of the century.

Inflation was a major issue for governments all along, and its reduction was a matter of debate and public concern for decades. These intentions were never translated into consistent policies, however, and temporary successes always ended in fiscal expansion, balance-of-payments crisis, and an inflation upsurge.

Inflation became an extremely serious concern when hyperinflation threatened the economy in the early and mid-1970s. This trig-

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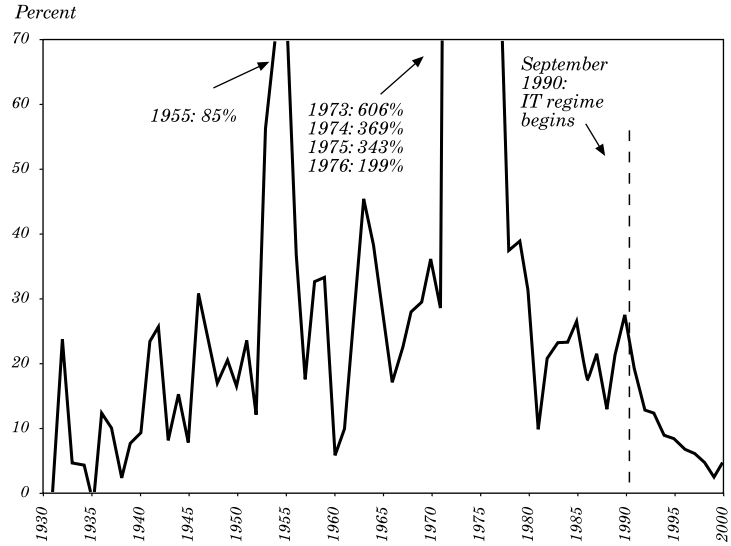
1. Historical information on inflation and GDP growth is taken from Lüders (1998).

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gered a sharp change in policies. Tight fiscal and monetary discipline was implemented as part of a far-reaching program of deep promarket reforms, but the combination of widespread price and wage indexation, the subsistence of inflationary expectations, and adverse external shocks led to unsatisfactory results. A fixed exchange rate regime was then adopted in 1979, with the purpose of obtaining the textbook result of domestic inflation convergence to external inflation. Although inflation did slow down, indexation and a massive inflow of foreign capital made convergence a very gradual process. The real exchange appreciation that followed, a weak financial sector, and a severe negative external shock finally ended with the abandonment of the fixed parity (after three years), a sharp devaluation, and a deep recession in 1982–83. The economy recovered in the ensuing years, but inflation rose again, this time to moderately high levels averaging around 20 percent until 1990. Figure 1 depicts the evolution of Chile's inflation since 1930.

When the Central Bank became independent in 1989, a lot had been accomplished in terms of stabilization and inflation control, but the task was far from complete. Fifteen years of anti-inflation programs had reduced inflation from the three–digit level at which it had begun, but the growth of prices was still above 20 percent. The final stage of

**Figure 1. Annual CPI Inflation, 1930–2000**




Source: Lüders (1998); Central Bank of Chile.

inflation reduction and the convergence to low, stable levels was the next step. In the context of a healthy financial system and robust external accounts, the Central Bank was able to focus on reducing inflation, for which it implemented a monetary framework resembling what would later be known as inflation targeting.

A decade of Central Bank independence and explicit inflation targets appears to have produced satisfactory results. Chile's endemic inflation has finally been defeated, and its level (3.4 percent on average in 1999–2000, with even lower core inflation) is both comparable to industrial-country levels and consistent with the Central Bank's current medium-term inflation target of 3 percent per year, within a 2–4 percent range. The inflation-targeting regime was adapted to the more steady-state goal of keeping inflation low (as opposed to reducing inflation year after year) in September 1999, when the crawling exchange rate band in operation since 1985 was abandoned to eliminate a possible source of policy inconsistencies between two (eventually) conflicting objectives.

The current framework and policy mix—namely, inflation targeting and exchange rate flexibility—is increasingly popular worldwide, both in industrial and emerging economies. For a small, open economy like Chile, which is characterized by a degree of domestic price inflexibility and significant vulnerability to external shocks, this choice currently seems to dominate the main alternative of giving up the national currency in favor of another country's currency or a supranational currency.

This paper identifies lessons that can be derived from the Chilean experience and that have been valuable in the design and improvement of monetary policy within the Central Bank of Chile. Many of these lessons, however, are only preliminary hypotheses, which have not been the object of exhaustive empirical testing. Alternative interpretations of the Chilean experience cannot be discarded, and a complete empirical examination is an open field for future research. The paper also describes the different phases of monetary policy implemented in Chile in the last decade and how they were determined by the evolution of inflation in the same period. However, a detailed analysis of the recent experience with significant external shocks and recession is not included, although tentative links are made with the evolution of monetary policy since 1998.

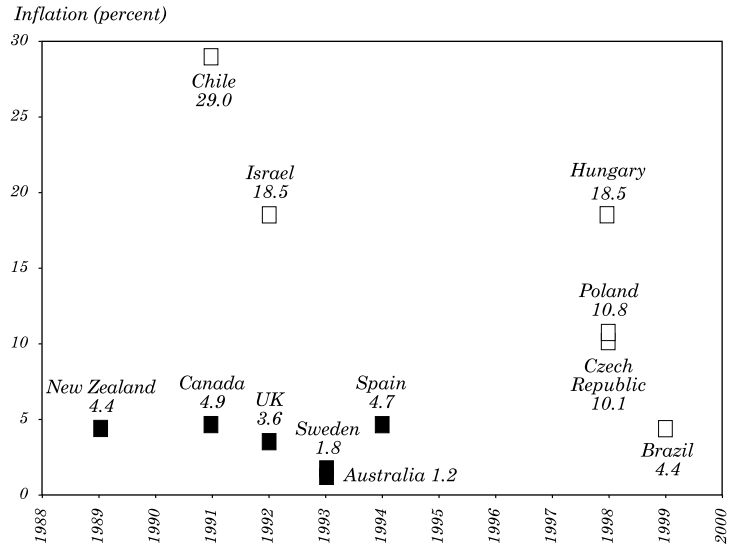
The paper is organized as follows. Section 1 describes the origin, peculiarities, and main results of inflation targeting in Chile in the last decade. Section 2 describes the two phases of inflation targeting, while section 3 deals with the main lessons learned thus far from Chile's experience. Section 4 presents some challenges for the future in continuing to apply inflation targeting. Finally, section 5 concludes.

## 1. Origin and Peculiarities of Inflation Targeting in Chile

Inflation targeting is an increasingly popular monetary framework in modern economies, although its existence does not date back further than a decade. Figure 2 presents the year and inflation level at which these countries adopted inflation targeting. Emerging economies that have adopted inflation targeting clearly had higher rates of inflation than industrial countries that have done so. Among them, Chile had the highest inflation when the new regime was implemented. This difference between the two types of countries raises the issue of transition between inflation at the moment of adopting the target and its steady-state value, which is discussed below.

As established by Svensson (2000), the relative merit of inflation targeting is that it grants the monetary authority degrees of constrained discretion. If fully operational, an inflation-targeting regime sets spe-

**Figure 2. Year of Adoption and Initial Inflation in Inflation-Targeting Countries[a]**




Source: IMF.

a. Initial inflation is calculated as CPI growth of the quarter prior to the adoption of the inflation target, compared to the same quarter of the previous year. For Brazil, an average of preceding and current quarters is used.

cific, accountable goals for the Central Bank. It enhances transparency and credibility while giving the Central Bank freedom in the use of instruments and policy to achieve the target. Communication with the public is improved with the existence of a simple, easily comprehensible indicator, providing a strong effect on inflationary expectations.

This concern for inflation does not mean that inflation targeters are inflation nuts, as labeled by King (1997). The role of output stabilization is not ruled out in the short run, and discretion is constrained to some degree in both the regime and the main parameters (namely, the target horizon, escape clauses, the price index, and the range). However, the concern for output stabilization must be consistent with achieving the inflation target in the medium term. How much weight is given to output stabilization within an inflation-targeting framework will probably depend on the initial level of inflation and the credibility of the central bank.

The Central Bank of Chile initiated a monetary policy framework based on an explicit, publicly announced, annual inflation target in an early stage in the history of these schemes, when the term inflation targeting had not even been formalized. The first target was announced in September 1990 for the subsequent calendar year. At the time, annual inflation was around 25 percent, which is very close to the observed average for the 1980s. This procedure was adopted in part by accident, in part out of necessity, in part for lack of alternatives, and in part in reflection of a longer-run view of monetary policy. The move was accidental in that the recently inaugurated independent Central Bank was required by its charter to present a report to Congress each September, outlining the prospects for the economy for the following calendar year (in particular with regard to inflation, growth, and the balance of payments). A target for inflation fit naturally with the price stabilization goal established in that charter.

The necessity for an inflation-targeting regime arose as a result of the important increase in inflationary pressures caused by expansionary policies in 1988–89 and the oil price shock stemming from the 1990 Gulf War. The Central Bank wanted to signal that it was in command of the situation and that it would reduce inflation by applying the corresponding contractionary monetary policy. This factor also partially explains why the inflation projection was treated as a target, in contrast to the growth projection, which was treated as a forecast developed through a consistency exercise.

With regard to alternatives, no other monetary regimes seemed feasible. Announcing a target for the nominal exchange rate (that is, adopting a fixed exchange rate regime) was unwise for several reasons: the

tendency of the Chilean economy to suffer real shocks from abroad; a high degree of rigidity in domestic prices due to indexation; the country's negative experience with fixing the exchange rate in the 1960's and 1980's; an initial inflation that was only moderately high; and the widespread conviction (right or wrong) that a fixed exchange rate was bad for export growth. Setting a target for monetary aggregates did not make much sense, either, because of the alleged instability of money demand.

Finally, a major reason for Chile's early adoption of an inflation target was the belief that providing the public with an explicit inflation objective—and committing to its attainment by implementing a supportive monetary policy—would diminish the widespread use of indexation mechanisms, thereby reducing the cost of stabilization.

Chile's experience with inflation targeting is unique on at least five counts. First, as already suggested, a long inflationary tradition has made the Chilean economy one of the most indexed in the world: backward indexation mechanisms are widely used in many nontraded goods, labor, and financial markets. Even policy instruments are indexed, including income taxes and the monetary policy interest rate (in this last respect, Chile is the only case in the world).

Second, the high degree of indexation has made Chile's program of price stabilization extremely gradualist: inflation has been reduced step by step—almost monotonically—from around 25 percent in 1990 to the current level of just over 3 percent in core measures. From 1990 to 1999, the inflation target for the following year was set each September at a figure lower than the previous year (sometimes as much as 30 percent lower, sometimes as little as 10 percent). In a sense, the reduction of the inflation rate (and target) was as much a goal as the particular number set for the inflation target. Among countries that target inflation, only Israel (a clear inflation targeter) and Colombia (a partial inflation targeter) share this gradualism, although the convergence has been much less monotonic in both countries.

Third, in Chile the de facto inflation target is set by the Central Bank itself, following consultations with the government.[2] The monetary authority thus enjoys both instrument and goal independence. This is very rare among inflation-targeting countries: only Sweden (with

2. It is de facto and not de jure because there is no law or decree that requires either the Central Bank or the government to set any inflation target per se. The Central Bank charter establishes that the monetary authority should aim to preserve the value of the currency and the adequate working of the internal and external payments system. The preservation of the value of the currency has been interpreted as price stability and thus as a mandate to reduce inflation and keep it low. This is the basis for the Central Bank's de facto power to set the inflation target.

qualifications) and Spain (before joining the euro agreement) have granted their central banks this special entitlement.

Fourth, inflation is not the only variable for which a target has been set. The Central Bank also sought to achieve a sustainable current account deficit through 1998, first within the range of 2 to 4 percent of GDP (until 1995) and later within the 4 to 5 percent range (between 1996 and 1998).[3] This goal tended to be asymmetrical (generating more concern when the current account deficit threatened to go above the ceiling than when it fell below the floor) and the target range was generally less explicit (and thus softer) than the inflation target. It was supported by the administration of monetary policy (through the usual channel of interest rates, domestic spending, and imports); the setting of a wide, crawling exchange rate band (until September of 1999); significant and mostly sterilized accumulation of foreign exchange reserves in a context of heavy capital inflows (until 1997); and mild controls on those capital inflows (which were finally dismantled between September 1998 and May 2000). However, whenever a clear conflict arose between reaching the inflation target and this current account deficit goal—as reflected, for example, in pressures for a peso appreciation beyond the exchange rate band—the Central Bank chose to maintain the inflation target and modify the parameters of the exchange rate band (or strengthen the regulation of capital inflows or resort to sterilized interventions). Israel and Colombia have also attempted to reconcile inflation targeting with an exchange rate band, as Chile did until 1999. Because of different policy priorities, however, both of these central banks were ultimately more committed to their exchange rate policy than was the Central Bank of Chile. That perhaps explains why inflation has been less stable in both Israel and Colombia and has converged less monotonically to a long-run goal.[4]

Finally, after reaching what it considers a reasonable steady-state inflation rate (around 3 percent per year in 1999), the Central Bank adapted its policy mix to a somewhat different inflationary objective: namely, keeping the inflation rate within a 2–4 percent range in the

3. The presumption is that foreign investors might perceive the high current account deficits as a signal of problems in the economy's fundamentals that could lead to a foreign exchange liquidity or solvency crisis. Foreign lending would therefore become more expensive and less available, and capital would eventually move out of the country. To prevent these developments, a conservative authority uses its policy instruments to keep the current account deficit within a sustainable range. This is also the motivation behind the Central Bank of Chile's broad goal of preserving the stability of the external payments system.

4. Colombia finally abandoned its exchange rate band and moved to a floating regime in late 1999.

medium term, rather than reducing inflation year after year.[5] Chile has thus entered a new stage in its inflation-targeting history, which is much more similar to the practices observed in most other inflation-targeting countries.[6]

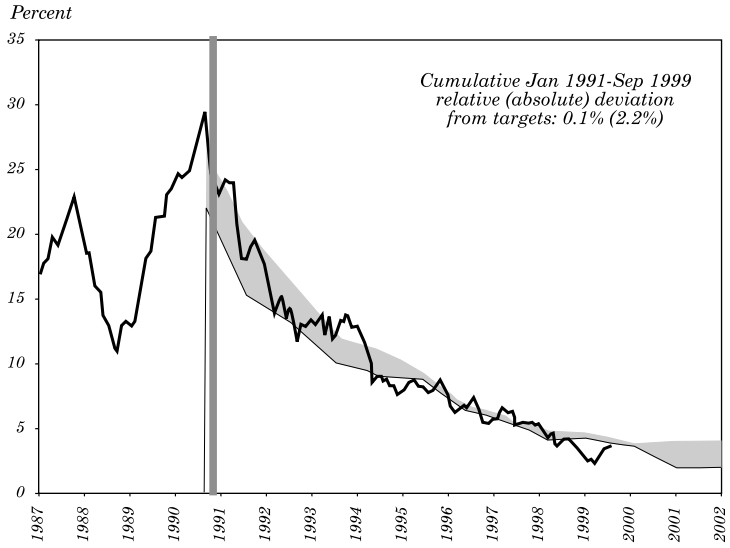
In terms of results, the decline of inflation in the 1990s was gradual, solid, and permanent. Inflation began at almost 25 percent in 1990; it was only 2.3 percent in 1999, a figure not seen since the deflationary experiences of the 1930s. The upsurge to 4.5 percent registered in 2000 was essentially the outcome of cost pressures from the tripling in the world oil price after mid-1999. Core inflation in 2000 remained at a level similar to that observed in 1999. Economic growth reached 6.4 percent in the 1990s despite the mild recession experienced in 1999 in the aftermath of the Asian crisis. Figures 3 and 4 present the result in terms of inflation (together with the inflation target) and GDP growth since 1990. Excluding the 1999 recession, inflation reduction was correlated with high GDP growth and relatively low unemployment. This outcome is not the sole merit of monetary policy and inflation targeting, although the close achievement of announced targets was certainly relevant. Structural reforms implemented in the 1970s and 1980s established the conditions for massive capital inflows in the 1990s, which fostered growth and favored inflation control. The other key factor was a significant contribution of fiscal saving to total national saving (which was high for Latin American standards), although fiscal saving declined significantly in 1997–99.

One could argue that inflation reduction was a common feature worldwide in the 1990s, both with and without inflation targeting, and that Chile's experience was not markedly different from other countries that did not pursue an inflation-targeting regime. A recent study, however, compares the performance of inflation targeters and nontargeters (all of them with their own national currencies) from 1985 to 1997. Inflation targeters reduced inflation by more than 7 percent on

5. Central Bank of Chile (2000) contains a number of arguments to support the choice of a 3 percent level for Chile. Some critics hold that such figure was too strict, in terms of welfare, as a mid-run perspective in 1998, when the external conditions faced by the Chilean economy had drastically worsened. The literature establishes that the welfare gains from inflation reduction are bigger when passing from moderately high levels to a 5–6 percent range than when reducing it below 5 percent per year (see De Gregorio, 1999). However, it is not reasonable to propose an steady-state inflation above 5 percent in an economy (such as Chile in 1998) that has already reached levels below 5 percent after a persistent program of gradual reductions and that follows a fiscal surplus policy.

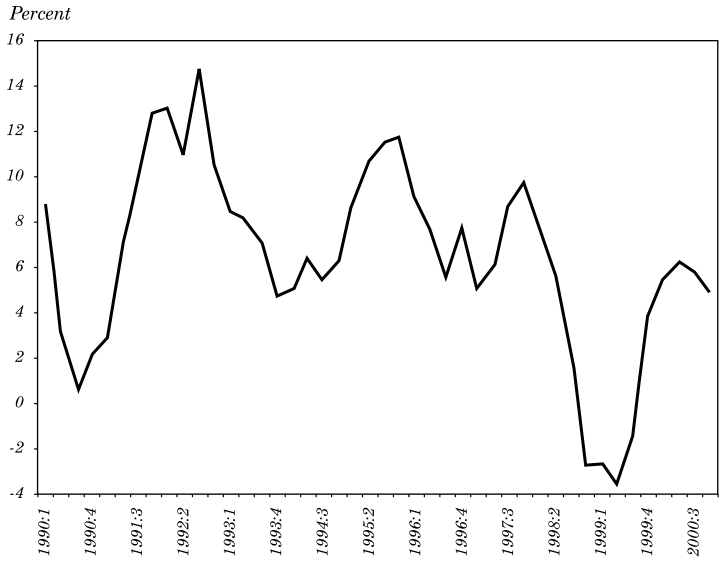
6. Israel similarly achieved a low inflation rate, although while maintaining an exchange rate band.

## Figure 3. Inflation and Inflation Targets in Chile, 1987–2002




Source: Central Bank of Chile.

## Figure 4. Annual GDP Growth, 1990–2000[a]




Source: Central Bank of Chile.

a. Annual GDP growth measured over same quarter of previous year.

average between 1985–89 and 1993–97, compared with 3.5 percent in the case of nontargeters (Cecchetti and Ehrmann, 2002).

A further objection might be that the undershooting of inflation in 1999 (2.3 percent actual versus 4.3 percent target) reflected the recession of 1999 and that the upsurge of inflation in 2000 (to 4.5 percent) in the context of economic recovery shows that a steady state had not yet been attained. However, core inflation indicators for 2000 ranged from 1.4 percent to 3.4 percent, which is not significantly different from those observed in 1999. The rise in total inflation thus stemmed solely from the significant growth in the international price of oil.

A decade of inflation targeting in Chile has successfully attained the main goal of price stabilization: inflation was gradually reduced from two-digit levels to values comparable to those observed in developed countries, while high rates of GDP growth were also achieved. Maintaining inflation within the 2–4 percent range set by the Central Bank appears to be perfectly consistent with a level of GDP growth that fulfills the economy's potential.

## 2. More Details on Chile's Two-Phase Inflation Targeting

Although a fully fledged inflation-targeting framework could be defined very flexibly, it must have some essential ingredients. First and foremost, it must involve an explicit numerical goal for inflation—the inflation target itself—that is to be achieved within a specific horizon. Second, the commitment to that target should override any other policy objective that might conflict with inflation. Third, the central bank must at least have instrument independence to be able to apply its monetary policy in response to any foreseeable gap between forecast inflation and the inflation target. And fourth, the central bank must have the technical capability for developing and implementing reasonable empirical models to predict inflation. Many of the parameters involved in this framework must be set by each central bank or government to reflect the particular conditions of the individual country.

Since much of what can be expected from the inflation-targeting framework stems from its role in affecting peoples' expectations about the future course of inflation (the nominal anchor role of the inflation target), many authors stress the benefits of transparency in the monetary policy decisionmaking process as a means of enhancing the central bank's credibility and, ultimately, the policy's effectiveness in achiev-

ing price stability.[7] This explains the popularity of inflation reports and the increasing use of explicit forecasts in these reports.[8]

An analysis of these inflation-targeting features in Chile reveals that the country has experienced two separate phases of inflation targeting. The first phase, which started in September 1990 and continued through September 1999, encompassed the transition from moderately high inflation rates to the 3 percent benchmark established as a long-run goal. In this phase, the Central Bank upheld an image of toughness as it defined a short-run horizon for the inflation target (each September for the next calendar year), applied a point target (at least since 1994), and used headline inflation as the target. However, the reduction in inflation was planned to be very gradual (it took nine years to reach the final goal), reflecting concern for economic growth in the short and medium term. Also, as mentioned above, the Central Bank jointly pursued a relatively loose target for the current account deficit and an explicit target (complementary to the current account deficit goal) for the nominal exchange rate, although within a wide flotation band. Finally, monetary policy was not conducted systematically in terms of its transparency: the Central Bank did not issue detailed, regularly written accounts justifying policy actions, with the exception of the annual report presented before the Senate.

The second phase started in September 1999, when the exchange rate band was finally abandoned and inflation became the Central Bank's sole formal, explicit target.[9] This stage only recently became fully operational, with the improvement of statistical and analytical models within the Bank, the publication of the *Monetary Policy Report* (our version of an inflation report, with explicit forecasts for inflation and growth), the public announcement six months in advance of scheduled monetary policy meetings, and the publication of the minutes from these meetings with a ninety-day lag. Table 1 compares both phases of inflation targeting in Chile with the main characteristics of other relevant inflation-targeting countries.

The distinction between the two phases does not imply an evaluation or comparison of their relative merits. Nor does it imply, as some

7. See, for example, Svensson (2000) and the public statements made by various inflation-targeting central banks.

8. The fan charts inaugurated by the Bank of England a few years ago are an example.

9. The Central Bank maintains its interest in keeping indexes of external vulnerability as favorable as possible for the country at large. One of these indexes is the current account deficit, which for the time being is low enough. The current policy mix—especially the free float—is expected to prevent these indexes from worsening in the absence of substantial real external shocks.

**Table 1. Comparison of Chile's Two Phases of Inflation Targeting with Other Inflation-Targeting Economies**

| *Characteristic* | *Chile (Phase I)* | *Chile (Phase II)* | *Brazil* |
|---|---|---|---|
| Central bank independence | | | |
| Formal | Yes, since 1989 | Yes | No |
| Goal independence | Yes | Yes | No |
| Instrument independence | Yes | Yes | Yes |
| Absence of conflict with other targets | Exchange rate band (until Sept 1999) | Yes | Yes |
| Index used for target | CPI | CPI (core CPI inflation is monitored) | CPI |
| Adoption date | Sept 1990 | 2000 | 1998 |
| Current target tolerance level | ± | Range | Range |
| Targets: | | | |
| Initial | 15–20% (1991) | ±3.5% (2000) | 6–10% (1999) |
| Current | | ±3.5% (2000) | 4–8% (2000) |
| Future targets | ±3.5% (2000) | 2–4% (2001 onward) | 2–6% (2001), 1.5–5.5% (2002) |
| Target horizon | Dec to Dec | Medium term (2001 onward) | Annual targets for 1999–2001 |
| Years of convergence from adoption to steady state | 11 years | — | 3 years + |
| Exemptions/escape clauses | None | None | If targets will be breached, the Central Bank President issues an open letter to the Minister of Finance |
| Publications | | | |
| Board meeting minutes | Yes (extracts) | Yes | Yes |
| Inflation forecasts | No | Yes | Yes |
| Inflation report | No | Yes | Yes |
| Accountability | Parliament | Parliament | Minister of Finance |

**Table 1 (continued)**

| *Characteristic* | *Israel* | *New Zealand* | *United Kingdom* |
|---|---|---|---|
| Central bank independence | | | |
| Formal | No | Yes, since 1989 | No |
| Goal independence | No | No | No |
| Instrument Independence | Yes | Yes | Yes |
| Absence of conflict with other targets | Exchange rate band | Yes | Yes |
| Index used for target | CPI | Adjusted CPI | Adjusted retail price index |
| Adoption date | 1991 | March 1990 (informally, April 1988) | October 1992 |
| Current target tolerance level | Point | Range | ± 1% |
| Targets: | | | |
| Initial | 14–15% (1992) | 0–2% (Dec 1992 onward) | ±2.5% (1997 onward) |
| Current | 3–4% (2000–01) | 0–3% (1997–2003) | |
| Future targets | 3–4% | 0–3% | ±2.5% |
| Target horizon | Annual Multi-annual targets (1999 onward) | Governor's term of office | Parliamentary exercise |
| Years of convergence from adoption to steady state | 9 years + | 1.5 years | 1.5 years |
| Exemptions/escape clauses | None | If target is missed, Reserve Bank of New Zealand presents Policy Statement, announcing corrective measures | If inflation deviates from target range, Bank of England is required to write open letter to Chancellor |
| Publications | | | |
| Board meeting minutes | No | No | Yes |
| Inflation forecasts | No | Yes | Yes |
| Inflation report | Yes | Yes | Yes |
| Accountability | Parliament | Parliament, Minister of Finance | House of Commons, Chancellor |

Source: Author's compilation, based on data from the central bank of each country.

authors claim, that Chile became an inflation targeter only in the second phase. The definition of fully fledged inflation targeting is simply an assessment of features that have been present in a majority of countries labeled as inflation targeters. Chile was a pioneer in adopting an inflation-targeting regime, at a time when the concept of fully fledged inflation targeting had yet to be formulated. The description of two phases in Chile's inflation-targeting regime simply establishes the evolution of the country's disinflation program, which reflects the lessons learned over the course of almost a decade and the Central Bank's success in attaining the established goals. Moreover, the essential ingredients of inflation targeting defined above were basically fulfilled in the first phase: the Central Bank's commitment to its target was undisputed, the Central Bank enjoyed both instrument and goal independence, and whenever other objectives conflicted with the inflation target, the Central Bank chose to stick to the target and modify the other goals. The only missing ingredient was a higher degree of transparency in all the aspects of implementation of monetary policy beyond the announcement of the target itself.

## 3. Main Lessons

Chile's experience with inflation targeting reveals at least five lessons.

### 3.1 The Nominal Anchor Role of Inflation Targeting

In the transition from moderately high inflation rates to a low steady-state rate, overemphasizing the nominal anchor role of inflation targeting might be justified. Whereas most industrialized countries adopted an inflation-targeting regime in a context of decreasing inflation, in the case of Chile inflation had been increasing and was still moderately high when the Central Bank announced its first explicit inflation target in 1990. Adopting the target was thus a risky move aimed at lowering inflation expectations in the face of widespread backward-looking indexation.

The specific political context in which inflation targeting was adopted cannot be overlooked. Not only was the economy overheated in 1990, but a great degree of uncertainty surrounded the new government's implicit loss function vis-à-vis inflation. At the same time, the newly independent Central Bank faced three challenges in terms of public perception: lowering inflation expectations that had been in the neighborhood of 20 to 25 percent for many years; establishing its autonomy from the government; and conveying to markets its commitment to price stability

and its aversion to inflation. In other words, there was a pressing need to build an appropriate reputation. Choosing a clear and widely understood index like the headline consumer price index (CPI) was therefore considered crucial or enhancing the Bank's effectiveness in communicating the inflation target, especially since indexation mechanisms were (and still are) mainly based on lagged headline CPI inflation.

Similarly, the preference for point targets, the choice of a short-term horizon (each December), and the absence of escape clauses all point in the same direction: clear, easily accountable, fairly rigid goals that reinforced commitment. Point targets ensure that during transition from moderately high to low inflation, the central bank is not subject to pressure from the government or public opinion to bias its commitment toward the range's upper bound. In the case of Chile, ranges specified by the Central Bank were very narrow relative to the inflation levels involved. Point targets were also preferred because they provide a powerful tool for communications. Calendar-year horizons, in turn, help to build a solid reputation for anti-inflationary commitment because progress is observed periodically, people are accustomed to measuring inflation in terms of calendar year growth, and the results are easily accountable. The absence of escape clauses tightens the Central Bank's compromise: the goal must be achieved, and no excuses are accepted. This eliminates any space for cheating.[10]

The trade-off is clear: the greater the emphasis on commitment and reputation building through strict inflation-targeting parameters, the lower is the flexibility for accommodating real shocks that eventually lead to higher inflation in the short run.[11] This carries the risk of an overly active monetary policy and higher output variability. During most of the 1990s, however, the economy's general context was favorable in that no important negative real shocks hit Chile until 1997–98 and there was a fiscal surplus until 1998. Disinflation could therefore be achieved together with high growth and low unemployment. Moreover, the Central Bank usually attained its annual target, missing it only marginally on four occasions.[12] Inflation fell consistently throughout the decade.

Strict parameters thus provided important signals for effectively reducing inflation. To support this claim, as well as the more general

10. However, the target was set in terms of $\pm x$ percent, such that the plus-or-minus sign reflected some degree of flexibility.

11. This trade-off is very common in policymaking and has been termed the credibility-flexibility trade-off. Frankel (1999) and Edwards and Savastano (1999), for example, discuss this trade-off in terms of the choice of exchange rate regimes.

12. A target is here considered unattained if effective inflation was above the target.

assertion that inflation targets had an independent effect on reducing inflation, Landerretche, Morandé, and Schmidt-Hebbel (2000) run vector autoregressions (VARs) to estimate the role of inflation targeting in the 1990s. Their estimation examines the extent to which inflation targeting served as a credibility-enhancing device and thereby contributed to the convergence of Chile's inflation to low, stable levels. The present paper extends the sample by two years, and the main results remain unchanged. The exercise consists in comparing inflation forecasts based on an unrestricted VAR model with the actual outcome of inflation and the inflation target. The VAR is estimated for each policy announcement (that is, the target announcement in September), using all information available until the month preceding this event. A dynamic simulation is performed for the sixteen-month-ahead forecast (September of the current year to December of the next year), which applies to the corresponding target. This implies the estimation of nine VARs (from 1990–91 to 1998–99), with each regression including twelve more months of information than its predecessor. The VAR considers six endogenous variables (namely, the interest rate, wages, GDP, the CPI, money, and the nominal exchange rate) and two exogenous variables (terms of trade and relevant foreign CPIs). Exogenous variables become endogenous when performing the dynamic forecasts. A trend is included in one of the estimations.[13] A longer description of the series and VARs statistical properties can be found in the original paper.

Figures 5 (with trend) and 6 (without trend) present the results of the replicated initial exercise, with the addition of 1997–98 and 1998–99. Two main results are obtained. First, including a time trend generates forecasts that are much closer to actual inflation. This is unsurprising, given the clearly negative trend experienced by annual inflation throughout the 1990s. The nontrend VAR model cannot be neglected, however, since the negative trend that characterized the 1990s could not be observed ex ante. (Until 1994 or 1995, a reversion to higher past was totally feasible, as it indeed had occurred in the 1980s.) Second, inflation forecasts are typically higher than both actual inflation and the inflation targets. This suggest that in the absence of other elements (such as an inflation target) the best forecast of future inflation (based on a model) reverts to inflation's higher historical levels and, therefore, that the announcement of targets has helped lower inflation forecasts.

13. The trend reflects the effect of a constant diminishing of inflation expectations through time.

**Figure 5. Inflation Targets and Forecasts, without Nominal Exchange Rate and with Trend**

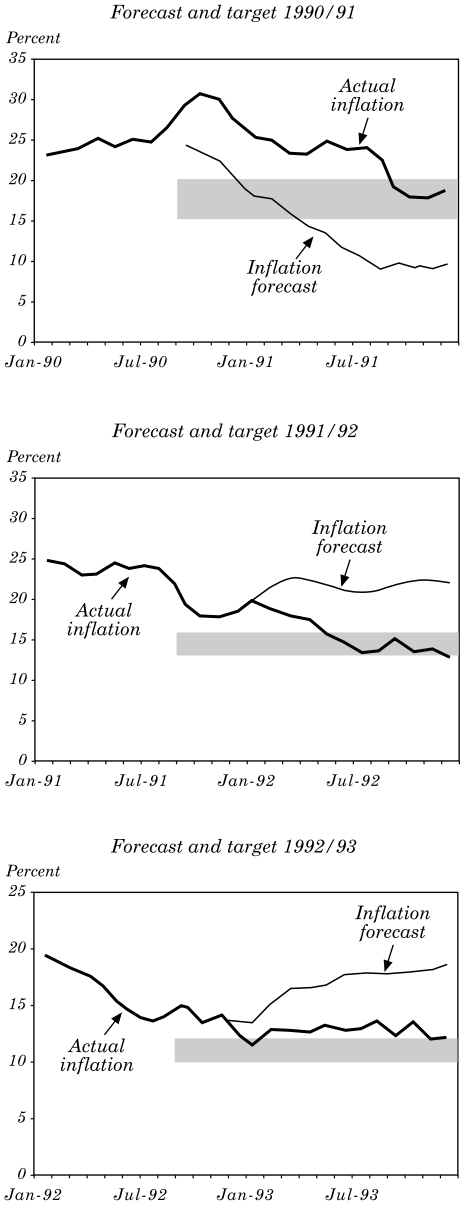
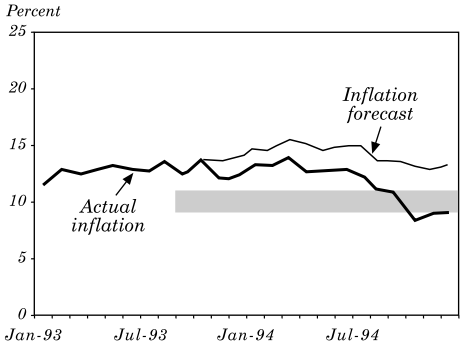
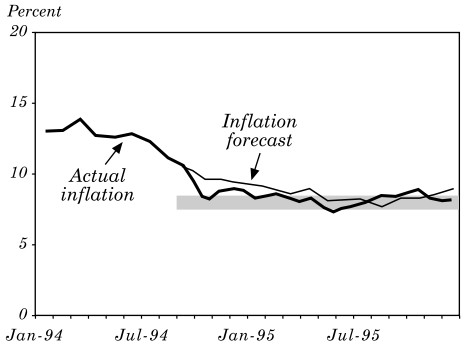


**Figure 5 (continued)**

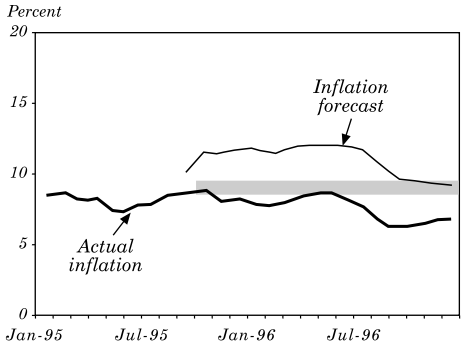
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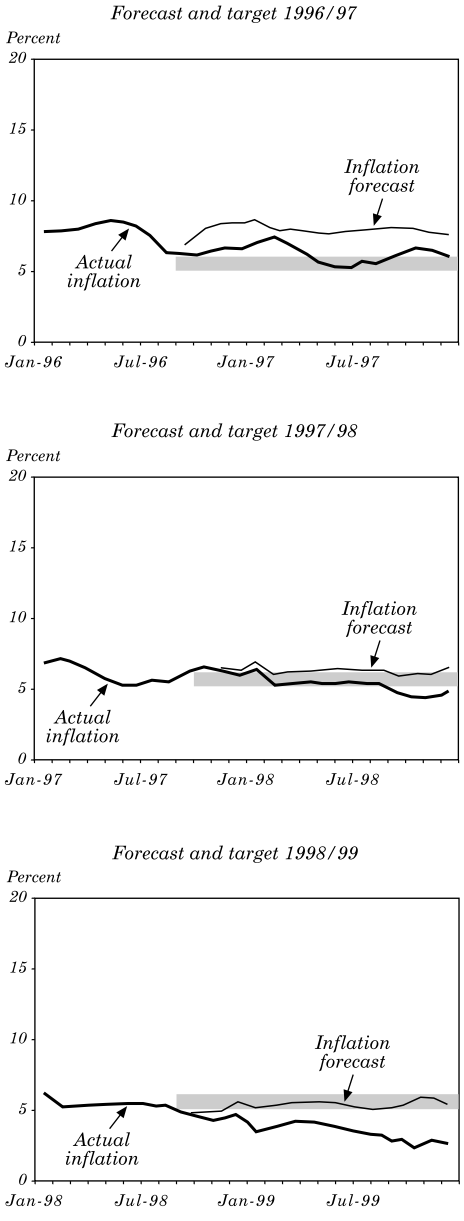

*Forecast and target 1994/95*




*Forecast and target 1995/96*

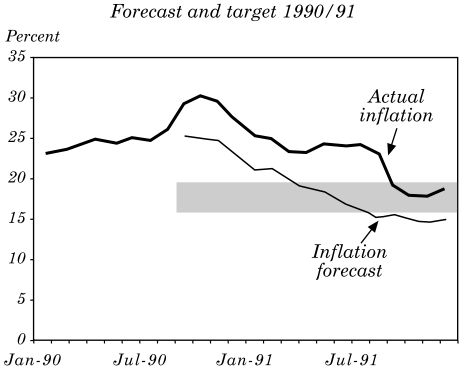


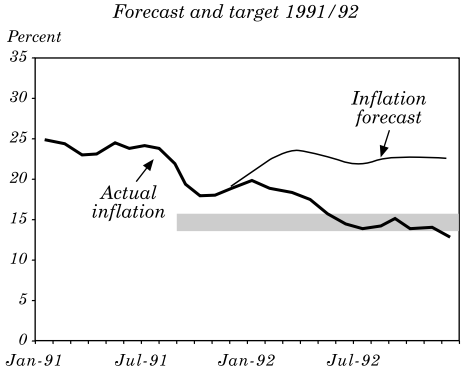
## Figure 5 (continued)




Source: Author's calculations.

**Figure 6. Inflation Targets and Forecasts, without Nominal Exchange Rate and without Trend**



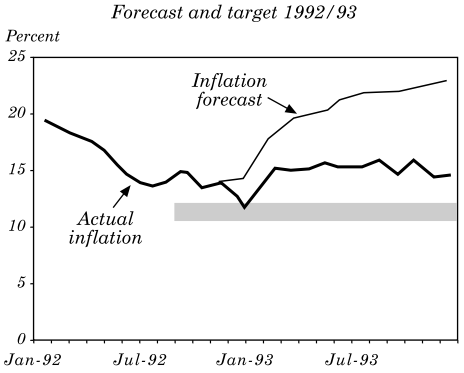
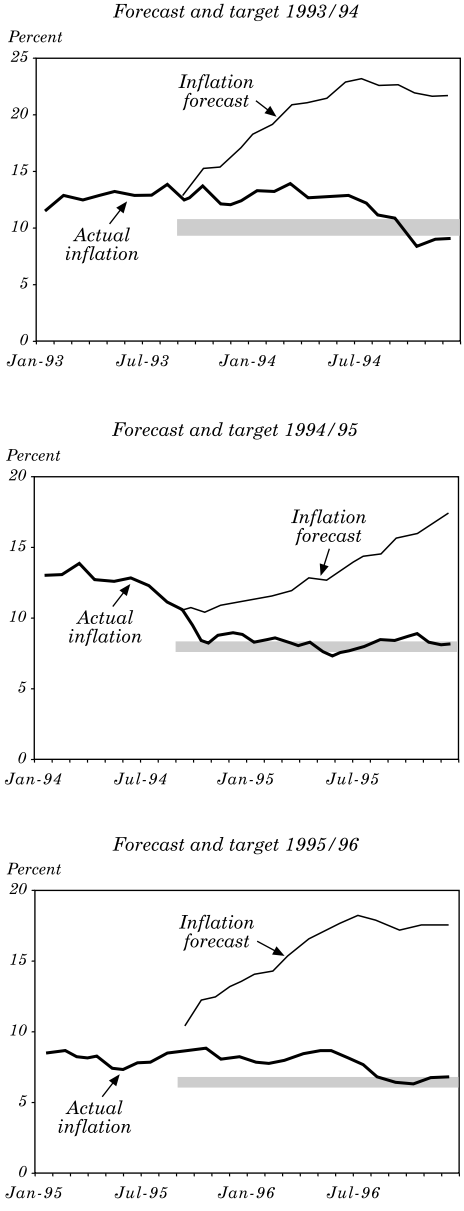
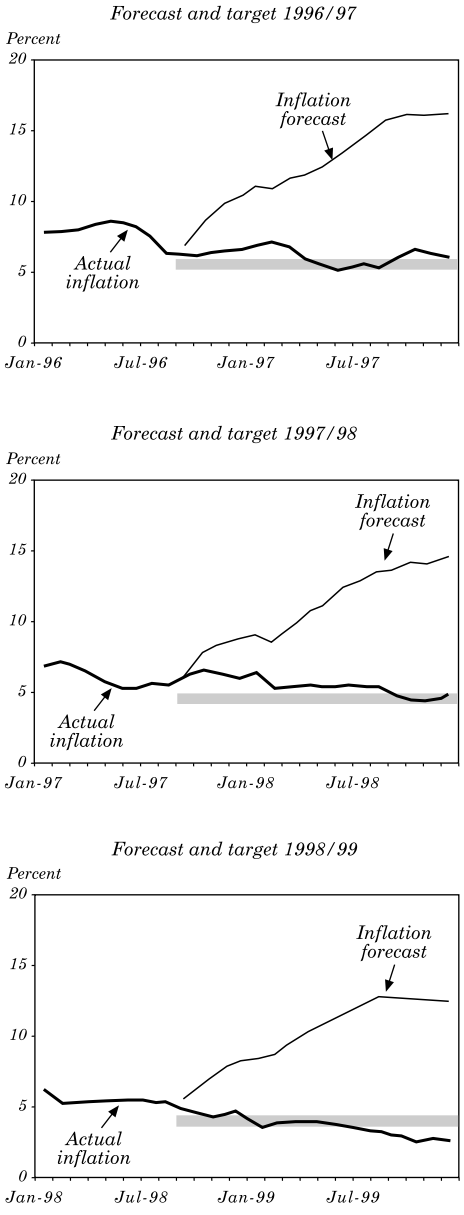



**Figure 6 (continued)**



## Figure 6 (continued)




Source: Author's calculations.

Corbo (1998) performs a different type of econometric analysis that explains the successful reduction of inflation in Chile through three channels: a change in the expectations process regarding future inflation; a real exchange rate appreciation as a result of fiscal and monetary policies; and a slowdown in the growth rate of labor's unit cost stemming from previous structural reforms that increased average labor productivity. Corbo's simulations, which are based on equations for prices, wages, the exchange rate, and inflation expectations (where specification of the expectations equations changes when inflation targeting is introduced), confirm the significant effect of the reduction of inflation expectations, owing to the tough stance assumed by the Central Bank at the beginning of the 1990s. Lower inflation expectations translated into lower wage inflation and ultimately, a lower path for inflation. The other two channels were relevant, but less important than expectations.

In a more recent study, Corbo and Schmidt-Hebbel (2000) extend Corbo's model, introducing equations for the current account, the Central Bank's reaction function (with the current account and inflation as arguments), unemployment, and the output gap. They use their model to simulate several scenarios. When inflation targets are not revealed to the public, for instance, inflation expectations are generated by the same process as in the 1980s. They find that simulated inflation in this scenario is significantly higher than actual inflation until 1996, which indicates that apart from monetary policy itself, the use of explicit targets contributed to the reduction of inflation.

García (2000) follows the approach proposed by Christiano, Echenbaum, and Evans (1995). This implies the use of a semi-structural VAR that includes nonpolicy variables that are not affected contemporaneously by policy variables; policy variables; and nonpolicy variables that are affected contemporaneously by policy variables. The paper finds evidence supporting the view that unexpected policy rate shocks negatively affect inflation (that is, there is no price puzzle, as found by Calvo and Mendoza, 1998). García also simulates the effect of an exogenous and explicit decreasing path for inflation targets, and he confirms its effect on decreasing inflation without output costs. He also provides evidence of the higher importance of inflation targets relative to real appreciation in inflation reduction, although both factors appear to have been relevant for the success of Chile's stabilization program.

The design of inflation targeting from 1990 to 1999 (the first phase) was thus significantly influenced by the initial conditions of the economy and the Central Bank's need to build a solid reputation for its anti-inflationary stance using the nominal anchor role of inflation targets. In the absence of negative real shocks until 1997–98 and with the help

of other conditions favorable to disinflation, this choice was effective in permanently reducing inflation toward international levels.

It is important to note, however, that at this stage, two particular characteristics of the inflation-targeting regime, namely, accountability and transparency, were interpreted in a particular way and came to be represented by a single element, the inflation target for the calendar year. It seems that the authorities and the market were both happy to define the Central Bank's transparency in terms of stating the goal for inflation. At the same time, the Central Bank was annually judged on (and held accountable for) its success in achieving the previously announced target. This fusion was never questioned while the economy maintained a steady growth rate and inflation diminished in line with the annual targets, an outcome that was supported, as previously stated, by the absence of relevant external shocks and the existence of favorable conditions in international financial markets. None of the problems associated with rigid inflation targeting in the context of small open economies made an appearance until 1997.

## 3.2 Gradualism in Target Setting

Being harsh on inflation-targeting parameters does not mean being an inflation nut. Gradualism in target setting is a key factor in the transition from moderately high to low inflation,.

The most recent literature on inflation targeting commonly distinguishes between a control horizon and an implicit targeting horizon (also called an optimal policy horizon).[14] The former reflects the time lag with which a monetary policy change affects inflation. The targeting horizon, in contrast, is the period in which the central bank or government wants the economy to be back on target after either current or forecast inflation has been hit by a shock. These two concepts can differ because the central bank and the government are concerned not only about inflation but also about developments in the real economy. For example, if an unexpected shock leads to an increase in forecast inflation, the central bank knows approximately by how much it has to raise its monetary policy rate to bring inflation down to the target level in two years. If this more restrictive monetary policy stance would affect economic activity growth too strongly, however, then the central bank might decide to increase its policy rate by less or to increase it more gradually, such that inflation would fall to the target level more slowly (requiring more than two years) but with less output sacrifice in

14. See Apel and others (1999); King (1997); Batini and Nelson (1999).

the short run. The implicit targeting horizon in this case is longer than the control horizon. The general rule is that the former is at least as long as the latter, because both inflation and output stabilization matter in the central bank's policy reaction function (and perhaps in its objective function, as well).

In the case of Chile, the bulk of the effect of a monetary policy change (that is, a change in the reference interest rate) on inflation is felt between four and eight quarters. This time lag, which is very common worldwide, could be termed the control horizon. What about the implicit target horizon? The current approach to inflation targeting in Chile (the second phase) calls for keeping the inflation rate around 3 percent per year, within a 2–4 percent range. If forecast inflation in the next four to eight quarters threatens to surpass 4 percent or fall below the 2 percent floor, then a policy action is warranted today. This acknowledges the control horizon but also sets the same time span for the implicit targeting horizon: the Central Bank wants forecast inflation to be back around 3 percent in at most two years.

This was not the case before 1999. As mentioned above, one of the peculiarities of Chile's experience in price stabilization in the 1990s is that the process was extremely gradual: it took nine years to reach what was originally conceived as a long-run objective, namely, an inflation rate of 3 percent annual. The implicit targeting horizon during the transition from moderately high to low inflation was thus no less than nine years.[15] This interpretation that the control horizon and the implicit targeting horizon were different is supported by the following exercise. The policy reaction function of the Central Bank of Chile estimated in the Central Bank's econometric model is[16]:

$$r_t^{pol} = 0.6 * r_{lr}^{pol} + 0.4 * r_{t-1}^{pol} + 53 * \left( \frac{\pi_{t+1}^e + \pi_{t+2}^e + \pi_{t+3}^e}{3} - \pi^* \right) + 12 * \left( \frac{y_{t-1}^{gap} + y_{t-2}^{gap}}{2} \right), \quad (1)$$

where $r_t^{pol}$ is the Central Bank's current policy rate,[17] $r_{lr}^{pol}$ is the long-run

15. It was actually larger. Before the 1998–99 slowdown and global deflation, the goal was to reach the 3 percent benchmark in either 2000 or 2001.

16. The exercise uses a quarterly sample from the beginning of 1986 to the end of 1999.

17. In Chile, this and other rates are expressed in Unidades de Fomento (UF), a unit account that is adjusted daily according to last month's inflation. Thus it resembles a real interest rate.

(or neutral) policy rate,[18] $\pi^{e}_{t+i}$ is forecast inflation (quarterly), $\pi^*$ is the inflation target, and $y^{gap}_{t-i}$ is the estimated lagged output gap (using a Hodrick-Prescott, or HP, filter for potential output).

This exercise, which is drawn from the Central Bank of Chile's econometric model, illustrates the choice of a gradual disinflation path over shock therapy. If the simulation is set in mid-1990 and given an the inflation target of 3 percent instead of the actual 17.5 percent (the midpoint in the 15–20 percent range set for 1991), then the Central Bank would have had to raise the policy rate to 18 percent real, causing the economy to fall into a recession (GDP would have dropped 3 percent between the first quarter 1991 and the first quarter of 1992) just to achieve the 3 percent target in three years instead of nine (see figure 7).[19] Analysts at the Central Bank performed this sort of exercise year after year, so it is no wonder that the inflation target was reduced very gradually.[20] Indeed, carrying out the same simulation for 1995 (setting the 1996 target at 3 percent instead of the actual 6.5 percent) shows that economic growth would have been reduced to 4.8 percent in 1996 and 3.1 percent in 1997.[21]

Other recent studies perform similar exercises. Corbo and Schmidt-Hebbel (2000) use their model to test alternative disinflation scenarios. They find that more aggressive (gradualist) targets would have lead to higher (lower) unemployment as a result of inflationary inertia in wages and prices. However, the reduction of inflation under the cold-turkey strategy is not as significant as its cost in terms of unemployment. The simulated values for the gradualist strategy tend to converge to actual values at the end of the simulation. García (2000) uses

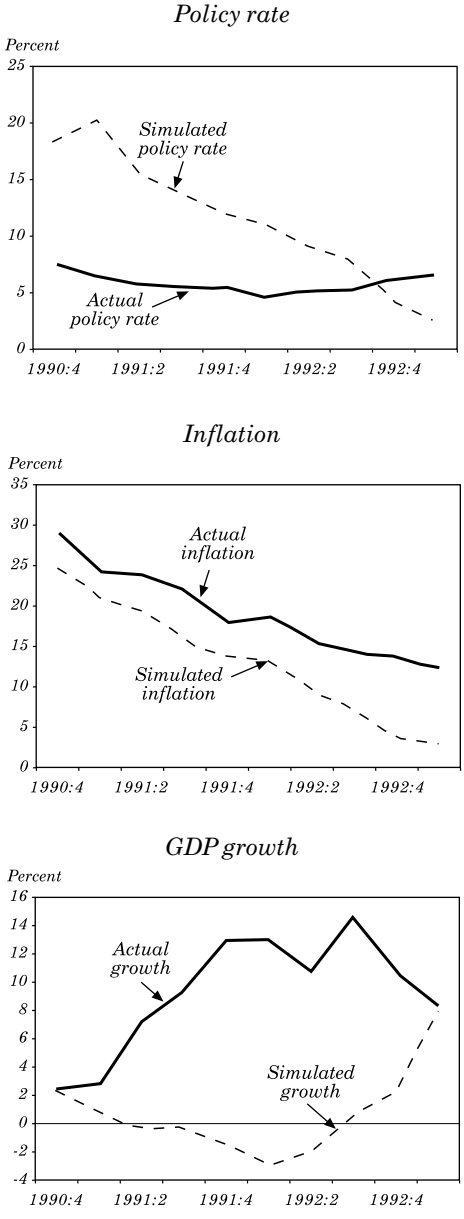
18. The neutral rate is assumed to be the average policy rate throughout the whole sample (1986–99).

19. The exercise is sensitive to how far into the future the simulation is carried, because the policy rate is endogenous and, at the same time, it was the main driving force of both inflation and the output gap. Although the numbers could change, it is clear that a recession in 1991 and 1992 would have been unavoidable if the 3 percent long-run target had been imposed much sooner.

20. This exercise specifies a target horizon that is shorter than the authorities' control horizon. It is still valuable, however, as a qualitative illustration of the effects of an extremely tough target.

21. It is debatable to use the policy reaction function that is derived from the whole 1990s data for carrying out simulations for decisions made early in the decade. The Lucas critique applies, as the evolution of the economy after a policy change is simulated assuming that the reaction of investors and consumers follow the same parameters as in the previous regime. Even if the reaction function were different, however, the result probably would have been much the same qualitatively. This is also what common sense and intuition indicate.

**Figure 7: Three Percent Target, 1990**




Source: Author's calculations.

a semistructural VAR to simulate the effect of a tougher path for inflation targets; he finds that such a strategy would have caused an important drop in output.

Alternative interpretations are also possible.[22] One possibility is that the control horizon was shorter than four to eight quarters during the transition from moderately high to low inflation (the first phase). This could have been the case if the main transmission mechanism of monetary policy was the effect of inflation targets on people's expectations. The mere announcement each September of the inflation target for the ensuing calendar year was a strong enough force to push actual inflation downward. Thus both the implicit and explicit targeting horizons could have been as short as two to six quarters and still have been at least as long as the control horizon. Why, then, is the Central Bank working with a longer control horizon in the current second phase, if this argument is right? The answer could be that the emphasis in the first phase was on reducing inflation by enforcing the credibility side of the credibility-flexibility trade-off, which involves the nominal anchor feature of inflation targeting. In other words, the short-term targeting horizon, among other inflation-targeting parameters, was meant to reduce the control horizon and increase the power of monetary policy. This line of argument does not deny that there could be have been two targeting horizons during the first phase, with an explicit target for the short term (the following calendar year) and an implicit target for the long term (nine or ten years).

This leads to another, complementary interpretation that identifies an additional monetary policy instrument in the first phase: namely, the rate of decay of the annual inflation target. The inflation stabilization program was clearly gradual from the beginning, that is, it was long term in nature. The Central Bank soon revealed its intention of making steady progress year after year, by setting an inflation target for the next calendar year that was always lower than the previous year's actual inflation. In a sense, the rate at which inflation was being reduced was as much a target (albeit an implicit one) as was the particular number to be achieved at the end of each year. The framework thus encompassed a long-term control horizon (the time in which the whole inflation reduction program was in place) to which the long-term implicit targeting horizon could be compared.

22. I owe these alternative interpretations to discussions with Jorge Marshall, who has been a member of the board of directors of the Central Bank of Chile since 1993.

The following model formalizes these ideas, in the context of a closed economy with staggering prices and an active central bank:

$$y_t = \theta\left(\pi_t^* - \pi_{t-1}\right) - \beta\left(r_{t-1} - r_N\right) + \varepsilon_t, \tag{2}$$

$$\pi_t = \frac{1}{2}\pi_{t-1} + \frac{1}{2}\pi_{t+1}^e + \frac{\gamma}{2}\left(y_t + y_{t+1}^e\right) + \eta_t, \tag{3}$$

$$r_t = r_N + \phi\left(\pi_{t+1}^e - \pi_{t+1}^*\right), \text{and} \tag{4}$$

$$\pi_t^* = \rho\pi_{t-1}, \tag{5}$$

where $y_t$ is the output gap (deviation of current output from its natural level), $r_t$ is the real interest rate, $\pi_t$ is the inflation rate, $r_N$ is the neutral interest rate, $\pi_t^*$ is the inflation target for period $t$, $x_{t+1}^e$ is the mathematical expectations of the value in $t + 1$ of variable $x$, and $\varepsilon_t$, $\eta_t$ are random disturbances.

Equation 2 is innovative in relating the output gap to macroeconomic policies. In addition to the expected effect of the traditional monetary policy stance on the output gap (represented by the coefficient $\beta$), the equation incorporates the direct effect of the gap between the inflation target for the current year (set the previous year) and the actual inflation rate registered one year earlier (in $t$ - 1). The rationale for this term lies in the alleged transmission mechanism of monetary policy through expectations: if the inflation target set for next year is close to (far from) the current inflation rate, the Central Bank sends a soft (tough) signal to markets in terms of inflation and thereby reduces the contractionary effect on the output gap. This relation acknowledges the two instruments of monetary policy that are relevant for an inflation reduction program.

In this staggering pricing environment, inflation is determined by an equation like equation 3, assuming that the length of contracts is generally two years (see Taylor, 1979; Morandé, 1986). Equation 4 shows a reaction function for the monetary policy interest rate (in real terms), which for simplicity is written as a function of the expected gap between actual inflation and the inflation target for the next year. Finally equation 5 establishes the reaction function of the inflation target as a linear function of the previous year's actual inflation. The parameter $\rho$ in this equation, which is between 0 and 1, is what I call the

monetary policy decay factor: for higher values of $\rho$ (closer to one), the implicit long-run horizon is greater, the time need to bring inflation down to 3 percent is longer, and the effect on GDP growth over the cycle (as represented by the output gap) is reduced. In other words, monetary policy is softer as $\rho$ approaches one.[23]

Given rational expectations in solving the model and plausible values of the structural parameters $\theta$, $\beta$, and $\gamma$, the reduced-form dynamic expression for inflation is as follows:

$$\pi_t = \lambda\pi_{t-1} + \upsilon_t \,, \tag{6}$$

where $\upsilon_t$ is a random disturbance, $0 \leq \lambda \leq 1$ for a stable solution, $\lambda = \lambda\ (\rho, \phi)$, and $\partial\lambda/\partial\rho > 0$; $\partial\lambda/\partial\phi < 0$.

In other words, inflation is more persistent when the decay parameter is softer and less weight is assigned to inflation in the interest rate policy reaction function. At the same time, however, the output gap is less affected and presumably less volatile. This result is the well-known inflation-output stability trade-off, extended to the case in which inflation targets are a separate monetary policy instrument.[24]

### 3.3 Redefining the Framework As the Economy Approaches Its Steady State

When inflation has reached a figure close to what could be seen as its long-run or steady-state level, then the central bank can loosen inflation-targeting parameters while redefining the implicit targeting horizon to make it explicit and bring it closer to the control horizon. The credibility-flexibility trade-off must favor credibility when the initial conditions involve high inflation, a record of poor inflationary performance, a past weak commitment to price stability, and backward-looking indexation. This was the case in Chile in 1990, and it took many years to change these conditions and accustom people to the idea that stable prices could be the norm rather than the exception. Once stabilization policies have brought inflation to a rate comparable to that seen in industrialized countries, then the central bank has established its reputation and can

23. This setting is for a systematic program of inflation reduction from moderately high inflation rates.

24. The distinction between inflation targets and the monetary policy rate as two independent policy instruments cannot be overemphasized. The central bank must enforce its intention to achieve the stated inflation target by applying a consistent monetary policy rate. Choosing a lower $\rho$ is likely to entail a more restrictive interest rate if the inflation target is not fully credible.

shift the emphasis to the flexibility side of the trade-off.

The move from the first phase to the second in 1999 reflected this kind of reasoning within the Central Bank of Chile. Two factors precipitated the move. First and foremost, the long-run goal was achieved at least one year ahead of schedule, when inflation stood below 3 percent for most of 1999.[25] Second, a real shock hit Chile in late 1997 and 1998 beginning with the Asian crisis and continuing with the Russian moratorium, which highlighted for the first time in almost a decade how harsh the credibility-flexibility trade-off could turn. As the Asian crisis took its toll on Chilean exports in late 1997 and early 1998, the Chilean peso started to depreciate quickly after many years of steady appreciation. Given a history of a high pass-through from depreciation to domestic inflation (deemed between 0.4 and 0.6 in a twelve-month time span), this sudden and apparently strong depreciation in early 1998 set off many alarms. The Central Bank's immediate fear was that it would not be able to meet the year-end inflation target of ±4,5 percent for the first time in eight years, thus threatening to ruin a carefully built reputation. Domestic demand was growing at a very rapid pace (12 percent in the first quarter of 1998), which created room for a drastic tightening in monetary policy. Many other developments in 1998 contributed to that year's slowdown in economic activity and the recession of 1999, but even if only a small part of this outcome could be attributed to the harsh monetary policy tightening undertaken in early 1998 to reduce inflationary pressures in a short period of time (ten months), it made the explicit short-run policy horizon a natural candidate for debate. The same occurred with the lack of an explicit range (or the setting of a point target).

As inflation reached its predefined steady-state level in 1999, there was no point in continuing to stress credibility over flexibility. It was time to launch the second phase, with less strict inflation-targeting parameters. Two points are worth mentioning, however. First, although the parameters have been made somewhat more flexible, the implicit targeting horizon is tougher: it is not nine to ten years, but rather two years (the same as the control horizon). Second, credibility is not being neglected. It is currently pursued through transparency instead of through reaching a single number for headline inflation at year-end. Enhanced transparency now encompasses not only the precise target to be attained, but also the analysis and policymaking process of the

25. As stated above, this resulted from an acceleration of worldwide disinflation after the Asian crisis, the domestic contraction that followed the substantial impact of the turbulence in world markets, and the restrictive monetary policy pursued in 1998.

Central Bank. Starting in May 2000, an inflation report is published three times a year, containing the past developments of inflation, a base scenario for explicitly forecasting future inflation and growth, and an assessment of the many risks that the Central Bank believes can affect the base scenario in the ensuing twelve to twenty-four months.[26] Being this transparent allows the Bank to focus on inflation forecasts that eventually become an intermediate target in themselves. As long as the forecasts are in line with market expectations, then credibility is much more an issue of whether the Central Bank reacts on time and appropriately to a change in these inflation forecasts than whether a particular number is achieved by a certain date.

### 3.4 The Role of the Current Account Deficit

The inclusion of a nonsymmetrical (and lexicographic) target for the current account deficit made monetary policy more active in the first phase. There were two main reasons for the long presence of a current account objective. First, foreign investors use the current account deficit as an indicator of the degree of external financial vulnerability of emerging economies. This assessment has ramifications for the availability and cost of foreign savings and, in extremes cases, the probability of a financial crisis (after a balance-of-payments crisis or speculative attacks against the local currency). The second reason has to do with the real exchange rate. In the early 1990s, the Central Bank shared the common wisdom that a depreciated peso in real terms was good for the economy: it promotes exports and economic growth. Sustaining a depreciated peso was feasible in the 1980s, when foreign financing was severely restricted in Chile, but it became increasingly difficult with the return of massive capital inflows in the 1990s.[27] Although many efforts were undertaken to prevent the ensuing real appreciation becoming excessive or occurring too quickly, the Central Bank soon abandoned the goal of keeping the peso depreciated in favor of not allowing the current account deficit to go beyond some threshold

26. As mentioned above, the dates of the board's policy meetings are announced six months in advance and the minutes of those meetings are published with a short delay. Both of these developments were introduced in the second phase.

27. Even in the 1980s, this target was not innocuous in terms of inflation, although capital inflows were small and a real appreciation was needed. Average inflation through the period was about 20 percent annually and very volatile.

28. Even this looser goal was still difficult to achieve permanently, as monetary policy is ineffective in influencing the long-run values of real variables.

deemed compatible with an equilibrium real exchange rate.[28]

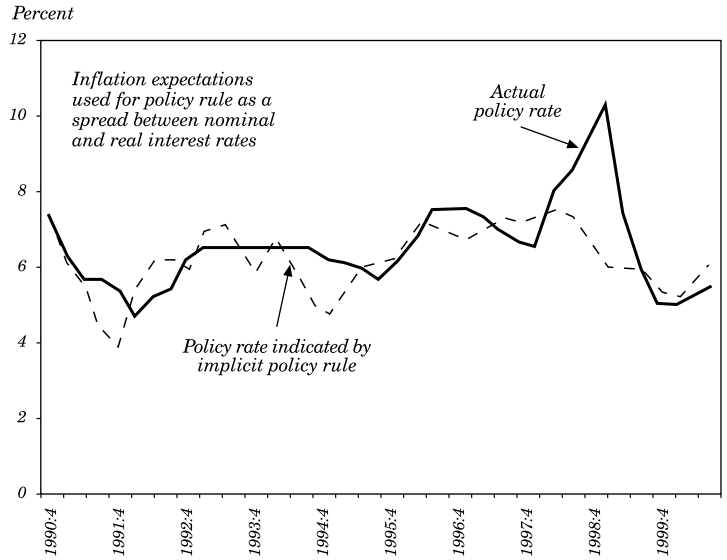
The current account objective tended to be asymmetrical, however, since what mattered most was avoiding a deficit that was greater than what the market perceived the country to be able to finance easily. If that situation arose, a policy action was seen as rapidly necessary. If, on the other hand, the current account deficit fell to a low number, the policy reaction tended to be less aggressive. The threshold was a fairly loose target range that increased from about 2–3 percent of GDP in the early 1990s to 4–5 percent of GPD in the mid-1990s, as the capital account registered huge surpluses of around 10 percent of GDP. Perhaps more importantly, the ordering of arguments in the Central Bank's policy reaction function was somewhat lexicographic. The current account deficit was essentially a dormant objective when it remained below the threshold, such that equation 1 reflected the policy reaction function. When the current account deficit threatened to surpass the threshold, however, this objective took over equation 1 and, in particular, supplanted the output stabilization goal.

Figure 8 compares the actual policy rate and that simulated by the rule in equation 1. The fit is reasonable except in two main episodes, one in 1995 and the other in 1998. Figure 9 shows the visual correlation between the residual of equation 1 (that is, the difference between the actual and simulated rates) and the current account deficit (measured quarterly as the accumulated figure for the previous four quarters). The current account deficit clearly became an overriding objective in these two episodes, especially in mid-1998. This is also supported econometrically by a simple regression between the residual of equation 1 and contemporaneous and past current account deficits, such as the following (standard errors in parentheses):

$$\mathrm{DIF}_t = \underset{(0.1554)}{0.8034}^{*}\,\mathrm{DIF}_{t-1} - \underset{(0.1471)}{0.3462}^{*}\,\mathrm{DIF}_{t-2} - \underset{(0.0342)}{0.0924}^{*}\,CA_t,$$

with an adjusted $R^2$ of 0.53, a Durbin-Watson statistic of 2.11, and a sum of squares of the regression (SSR) of 16.57, and where the dependent variable is the difference between the actual policy rate and the rate implied by the policy rule (with a proxy for inflation expectations as the difference between nominal and real interest rates). The estimation uses quarterly data ranging from 1991:2 to 2000:1. According to the estimation, a 1 percent of GDP increase in the current account deficit (that is, a fall in current account) would imply approximately 10 additional basis points in this difference. In the long run, the coefficient rises to 0.168; the effect would thus imply

**Figure 8. Actual Policy Rate and Policy Rate Indicated by Implicit Policy Rule,1990–2000**




Source: Author's calculations, based on information from the Central Bank of Chile.

around 17 basis points.

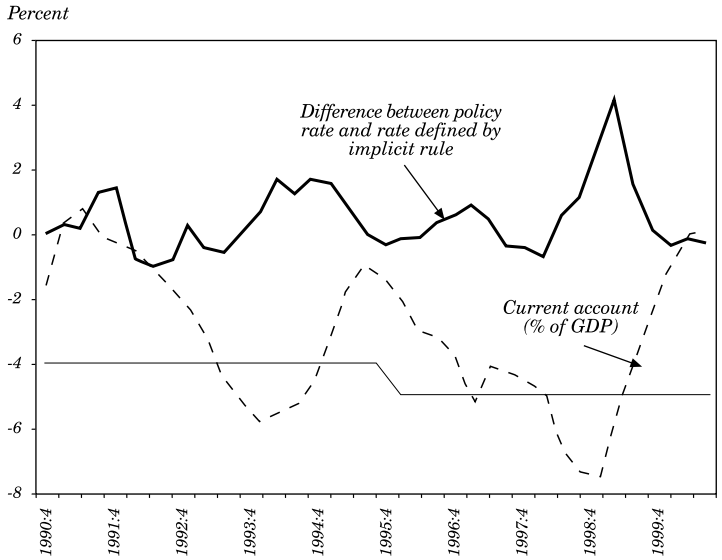
Another simple exercise involves the regression of the level of the actual policy rate in the policy rate implied by the rule and the current account; this should capture the whole set of determinants influencing the policy rate. The data set and estimation period are the same as in the previous case.

$$r_t^{pol} = \underset{(0.084)}{0.3176} * r_t^{polrule} - \underset{(0.047)}{0.1629} CA_t + \underset{(0.082)}{0.6183} * r_{t-1}^{pol},$$

with an adjusted $R^2$ of 0.7621, a Durbin-Watson statistic of 1.68, and an SSR of 11.21. In the long run, the coefficients associated with the actual policy rate are 0.83 (the policy rate implied by the rule) and 0.42 (the current account level).

Note that in the short run the asymmetrical current account deficit objective only overrides the output stabilization goal and not the inflation goal. This makes sense because the policy reaction to a sudden and seemingly uncontrolled deficit is to tighten monetary policy in order to reduce the growth in domestic spending and then imports.

**Figure 9. Current Account and Difference between Actual Policy Rate and Policy Rule Rate[a]**




Source: Author's calculations, based on information from the Central Bank of Chile.
a. Policy rule rate calculated using inflation expectations obtained as the spread between nominal and real interest rates.

Additionally, the implied higher interest rates will attract increased capital inflows at the margin, causing pressure for a peso appreciation. Both effects tend to reduce inflation. As long as both the current account deficit objective, when binding, and the inflation goal itself were asymmetrical in the same direction, there was no conflict between them. On the contrary, they reinforced each other and possibly implied a more aggressive (and more conservative) monetary policy than would otherwise have been the case. This is exactly what Medina and Valdés (2000) find in a theoretical model and simulation.

It is also what occurred in 1998. After the policy rate was increased from 6.5 percent to 8.5 percent (indexed rates) in January and February, aggregate spending showed no signs of a significant decline in the short run. In August the Russian crisis tripled the spread that local corporations were paying for foreign resources, and these resources became scarce. Given the very deteriorated terms of trade, the devastated markets in Asia, and the financial chaos following the bailout of the Long-Term Capital Management hedge fund, maintaining a current account

deficit that threatened to reach more than 8 percent of GDP was highly risky in many respects. The Central Bank's reaction, correct or not, was simply to overshoot the policy interest rate to quickly restore confidence and sharply reduce the current account deficit, giving less weight to the impact of this move on short run economic activity. Of course, the final goal was to preserve macroeconomic stability in the long run by preventing a major economic and financial crisis that could have triggered a much deeper recession, higher unemployment, and higher inflation. A more pronounced and faster depreciation of the peso was another option, but this was deemed inadvisable and dangerous because it represented a high risk to the inflation target, to inflation reduction, and, indirectly, to the health of the financial system (because of balance sheet effects).[29]

Before 1998, the situation was much different. The main push for a current account deficit came from massive capital inflows that caused pressure for an appreciating peso. Although in some instances this push was countered with a more restrictive monetary policy (as in 1994), the Central Bank used other, somewhat less orthodox, instruments, like capital account regulations, to contain those inflows. It also tried to contain the peso appreciation that followed the capital inflows by resorting to an exchange rate band with a center adjusted for purchasing power parity and the sterilized accumulation of foreign exchange reserves. However, the Central Bank's commitment to the exchange rate band was loose (until 1998), and the parameters were often changed to resolve an apparent conflict between the band and the inflation target. This reflected the dilemma of trying to achieve too many objectives with just one policy, namely, monetary policy.

### 3.5 Moderating the Business Cycle

The disinflation program did not imply significant costs, on aver-

29. The conservative fiscal stance, which had been a significant aid during the 1990s, deteriorated significantly after 1997 with the adoption of an expansionary position. The shock was intensified by an evident tension between the Central Bank's anti-inflationary commitment and the evaluation and goals of the executive power. Note that the balance sheet effect of a sudden and pronounced depreciation of the local currency is realized in the nontradable corporate sector, which is heavily indebted in foreign currency and whose assets and income are in local currency (and are not hedged). This could become a policy problem if the corporations are large enough and have also borrowed money (in either currency) in the domestic financial system, because of the risk of crisis. However, this has to be compared with the systemic risk of excessively high real interest rates, which could arise in defending the local currency against a speculative attack.

age, in terms of real variables. On the contrary, the balance indicates that a lot of attention was paid to achieving less pronounced business cycles, and the attempt was successful.

Much has been said about the high real costs supposedly paid by the Chilean economy in the 1990s as a result of the program for abating inflation. This criticism is strongly influenced by the recent experience of 1998 and the ensuing recession, an episode when, as discussed above, monetary policy was tightened to control the huge current account deficit projected after the Asian and Russian crises in the context of an overheated domestic economy. In contrast, figures 3 and 4 above suggest that the gradual reduction of inflation took place while economic growth was fast and strong, allowing a sustained decline in unemployment.

How does this combination of outcomes compare with previous decades? Table 2 presents data for the first four moments of the distributions of inflation, GDP growth, real exchange rate, and real interest rates for the 1960s to the 1990s. The same information is presented for the periods spanning 1984 to 1990 and 1991 to 1997, to provide a closer look at the last two decades without the 1982–83 and 1998–99 recessions. The 1990s beat any other decade in terms of average inflation and growth. They also rank first in terms of growth, real exchange rate volatility, and real interest rate volatility. Therefore, business cycles were decidedly less pronounced in the 1990s than in any of the three previous decades. This is corroborated by figure 10, which illustrates the shapes of the distributions of real variables for 1984–90 and 1991–97. The distributions are more concentrated around the mean and median (lower kurtosis) in the latter period.

Oddly enough, however, inflation tended to be slightly more volatile in the 1990s than in some of the other decades, as judged by normalized standard deviations. This can be attributed to the steady, permanent reduction in inflation from 25 percent in 1990 to 2.3 percent in 1999. Overall volatility of inflation could actually have been lower in the 1990s. Figure 11 also plots the shapes of the inflation distributions for 1984–90 and 1991–97, indicating a higher concentration around the mean and the median in the 1990s (lower kurtosis), except for some outliers (a different skewness).

Could a different policy have done better? With the benefit of hindsight, the answer is probably yes, but it would have been very difficult to improve the policy design ex ante. A simpler, although very tentative, exercise is to compare the actual evolution of growth, inflation, and the real exchange rate from 1991 to the end of 1997 (thus excluding the most recent turbulences) with the simulated paths of

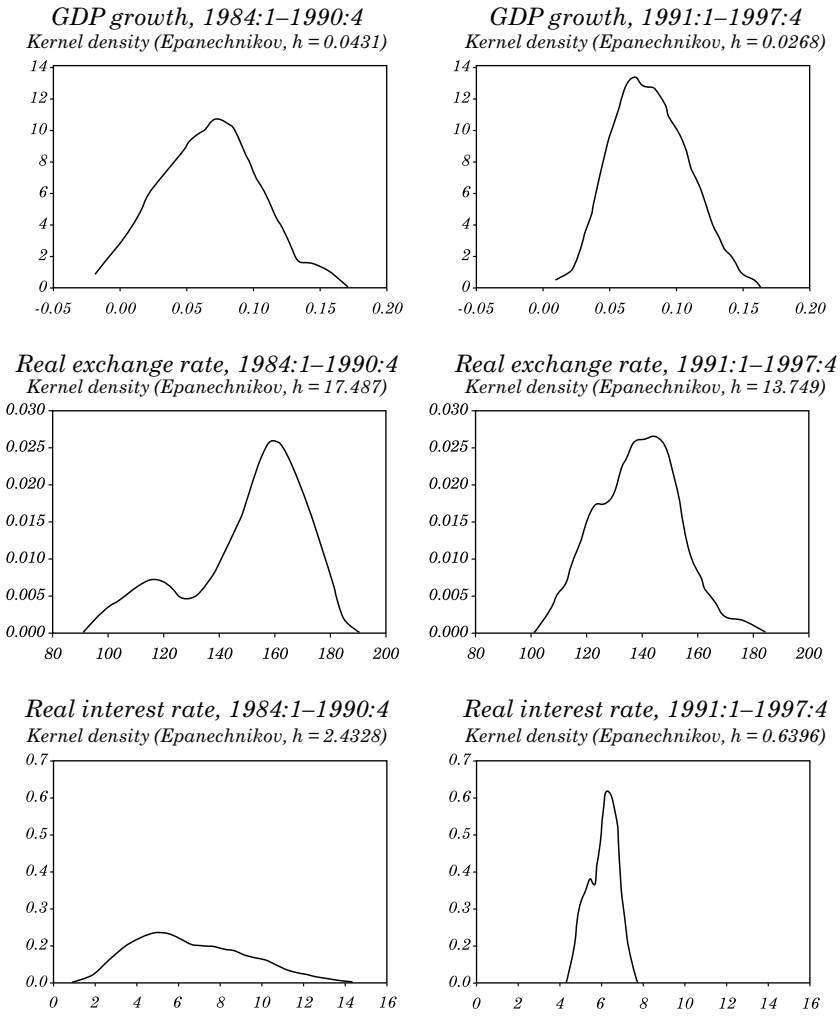
**Table 2. First Four Moments of Distributions**

| *Variable* | *Average* | *Standard deviation (variability)* | *Skewness* | *Kurtosis* |
|---|---|---|---|---|
| Quarterly inflation (%) | | | | |
| 1960s | 6.28 | 3.75 (0.59) | 0.81 | 3.14 |
| 1970s | 25.70 | 24.45 (0.95) | 2.08 | 9.08 |
| 1980s | 4.77 | 2.54 (0.53) | 0.78 | 4.19 |
| 1990s | 2.24 | 1.23 (0.54) | 1.01 | 3.29 |
| 1984–90 | 4.97 | 2.21 (0.44) | 1.11 | 4.65 |
| 1991–97 | 2.53 | 1.21 (0.47) | 0.99 | 4.59 |
| Annual inflation (%) | | | | |
| 1960s | 23.59 | 9.63 (0.41) | –0.07 | 2.32 |
| 1970s | 90.88 | 63.32 (0.64) | 0.44 | 1.76 |
| 1980s | 18.49 | 5.84 (0.32) | –0.24 | 2.83 |
| 1990s | 9.62 | 5.11 (0.53) | 0.81 | 2.85 |
| 1984–90 | 19.05 | 4.79 (0.25) | 1.11 | 4.65 |
| 1991–97 | 11.15 | 4.73 (0.42) | 0.79 | 3.06 |
| GDP growth (%) | | | | |
| 1960s | 4.14 | 4.40 (1.06) | 0.07 | 3.33 |
| 1970s | 2.49 | 9.09 (3.65) | –0.62 | 2.77 |
| 1980s | 3.58 | 7.89 (2.20) | –1.57 | 5.04 |
| 1990s | 6.49 | 4.22 (0.65) | –0.84 | 3.44 |
| 1984–90 | 6.62 | 3.48 (0.53) | 0.05 | 2.48 |
| 1991–97 | 8.02 | 2.66 (0.33) | 0.21 | 2.45 |
| Real exchange rate | | | | |
| 1960s | 79.65 | 9.48 (0.12) | –0.27 | 2.52 |
| 1970s | 100.15 | 24.09 (0.24) | –0.08 | 2.31 |
| 1980s | 133.13 | 32.52 (0.24) | –0.46 | 1.78 |
| 1990s | 134.52 | 14.49 (0.11) | 0.35 | 2.13 |
| 1984–90 | 150.45 | 19.92 (0.13) | –1.03 | 2.84 |
| 1991–97 | 138.56 | 13.68 (0.10) | 0.07 | 2.60 |
| Real interest rate | | | | |
| 1980s | 7.88 | 3.64 (0.46) | 0.98 | 3.40 |
| 1990s | 6.45 | 1.39 (0.21) | 2.38 | 10.51 |
| 1984–90 | 6.54 | 2.42 (0.37) | 0.51 | 2.20 |
| 1991–97 | 6.11 | 0.63 (0.10) | –0.37 | 2.08 |

Source: Author's calculations.

these variables under the assumption that the policy interest rate was fixed at 6.9 percent (the period's average). In other words, this entails the abolition of the reaction function in equation 1. The simulated trajectories indicate that the alternative policy would have rendered 2 percent less growth per year, on average, more volatility in this variable, a more depreciated (and slightly less volatile) peso, and, surprisingly enough, an inflation rate that converged to low levels faster

## Figure 10. Distribution of Real Variables, 1984:1–1990:4 and 1991:1-1997:4[a]



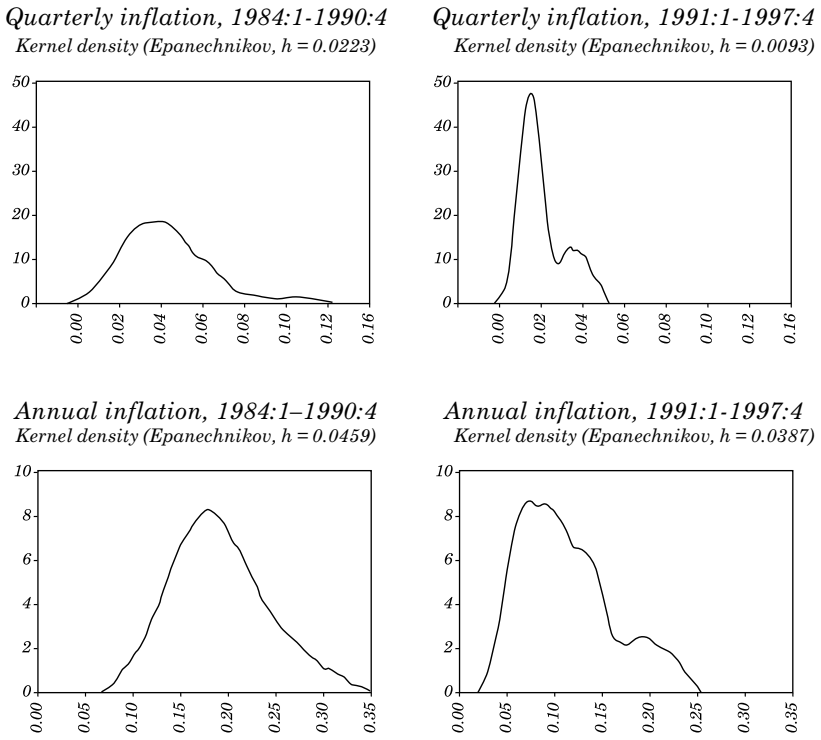

Source: Author's calculations, based on data from the Central Bank of Chile.

a. A kernel is a function that smoothens the series' histogram, presenting it as a continuous density function. The function estimated by the kernel for series $X$ can be written as

$$f(x) = \frac{1}{Nh}\sum_{i=1}^{N} K\left(\frac{x - X_i}{h}\right),$$

where $N$ is the number of observations, $h$ is the band with (or smoothing factor), and $K$ (in percent) is kernel function integrated in 1.

**Figure 11. Distribution of Quarterly and Annual Inflation, 1984–90 and 1991–97**




than actually happened (bringing inflation to negative numbers by 1996).[30] The simulations suggest that despite the widespread belief that the Central Bank of Chile has been very hawkish since its independence, in reality it has paid a lot of attention to developments in the real sector, a behavior that is well reflected in the very gradual approach applied to reduce inflation (the ρ parameter in equation 5).

This positive evaluation of the real effects of active monetary policy compared with a nonactivist stance complements the second lesson, which establishes that harsher reductions in inflation would have im-

30. These results should be taken with extreme caution since the econometric estimates of the parameters and elasticities were taken from a sample covering 1986 to 1999, including the period 1991–97, when an active reaction function like that in equation 1 was in place.

plied significant costs in terms of lower inflation (see Corbo and Schmidt Hebbel, 2000; García, 2000). A rigorous welfare analysis is not currently possible, however, as no updated, complete macroeconomic model that is founded on first principles is available.[31]

## 4. Concluding Remarks: Some Issues for the Future

The inflation-targeting regime has proved to be a reasonable and flexible monetary scheme that has disciplined market expectations and enhanced the effectiveness of the Central Bank of Chile's policies. The achievement of a long-run target for inflation in 1999 allowed the authority to move toward the flexibility side of the flexibility-credibility trade-off after a decade of focusing on credibility. The upgraded inflation-targeting regime, together with a flexible exchange rate policy, should become the base for preserving price stability in the future.

As Mishkin and Schmidt-Hebbel (in this volume) argue, inflation-targeting regimes are continually evolving, and both practice and new research continually suggest improved ways of conducting monetary policy. The monetary framework of inflation targeting in Chile is no exception. A first issue is the compatibility of exchange rate fluctuations and inflation targets. So far, the current phase has not been affected much by exchange rate volatility (and a generally depreciating peso) because the pass-through effect to domestic inflation has been minimal. How much of this outcome is linked to the current cool phase of the business cycle and how much to a structural response to the new policy mix remains to be seen. There is reason to believe that the pass-through has been permanently lowered, as the floating regime is characterized by an exchange rate that can go either way temporarily and thus calls for exchange risk coverage. To ensure that the structural reasons are primary, one pending task is to consolidate foreign demand for Chilean pesos in order to diversify exchange risks at the domestic level.

A second—and related—issue is how to correctly asses external vulnerability. Now that the current account of the balance of payments is no longer paramount, a battery of indicators must be developed to provide an early signal of potential crises originating abroad. One of these indicators should be the current account, but attention should also be paid to stocks and balance sheet indicators. The floating exchange rate

31. The design of such a model is an ongoing task within the Research Department of the Central Bank of Chile. Efforts in this regard can be found in Schmidt-Hebbel and Servén (2000) and in some preliminary sketches of real business cycle models.

helps a lot, but it is still work in progress.

A third issue has to do with the validation of our forecast models, which are fairly new and based on a sample characterized by various policy and perhaps structural changes (1986–2000). Complementary models are needed to provide a better idea about deep parameters in the economy and to calibrate possible reactions to different policies. This is part of the current agenda, of course. For now, however, none of the competing model in the local market yield significantly different forecasts.

Fourth, the amount and the quality of macroeconomic data must be improved, although much has been done in this respect in the last few years. A task like this takes time and money; it will continue to be a high priority in the coming years.

Finally, a number of issues concerning some of the parameters of the current inflation-targeting framework are permanently under scrutiny. One of these is the use of core inflation indicators in both monitoring inflation and setting the target. Another is the desired level of inflation in the very long run: the current target range of 2–4 percent, centered at 3 percent, is perfectly reasonable for a country like Chile, but circumstances can change in the future, perhaps allowing a more ambitious goal. Still another issue is how to further improve the communication properties of the current scheme, for example, in managing the biases or outlooks announced for future decisions on monetary policies.

This agenda of future challenges shows that a long road still lies ahead in the effort to enhance the design and performance of Chile's monetary policy framework based on an inflation-targeting regime.

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# 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.[1] 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

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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 macroeconometric 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.[2] 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.[3]

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 that 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[4]

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.

$$\Delta y = \Delta\bar{y} \underset{(-1.83)}{-0.16}(y-\bar{y})_{-1} \underset{(-4.00)}{-0.50}(r_{-1}-\bar{r}) \underset{(-1.71)}{-0.54}(R_{-2}-\bar{R}) \underset{(-3.52)}{-0.49}(r^*-\bar{r}^*)_{-2}$$

$$\underset{(3.61)}{+0.98}(\Delta y-\Delta y^*)_{-2} \underset{(2.22)}{+0.22} f_{-1} \underset{(2.29)}{+0.08}\left(e-\bar{e}\right)_{-3} \underset{(-3.12)}{-0.38}\Delta y_{-1} \underset{(-1.37)}{-0.17}\Delta y_{-2}$$

OLS estimation
Newey-West t-stats in parenthesis 1990–98
Adjusted $R^2 = 0.52$
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 ecuations 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.[5]

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.[6] The exclusion of the LM curve is not a substantial deviation from traditional Keynesian modeling.[7] 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.[8] 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:

$$R = \underset{}{\bar{R}} + \underset{(5.50)}{0.28}(R_{-1} - \bar{R}) + \underset{(12.49)}{0.60}(R_{+1} - \bar{R}) + \underset{(2.24)}{0.03}(r - \bar{r})$$

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:

$$e = \underset{(2.16)}{0.23}e_{-1} + \underset{(5.80)}{0.63}e_{+1} + 0.14\bar{e} + (r^* - r)$$

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

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

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:

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

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.[9] Most of the results of the paper, however, are apparent from the first, simpler exercise.

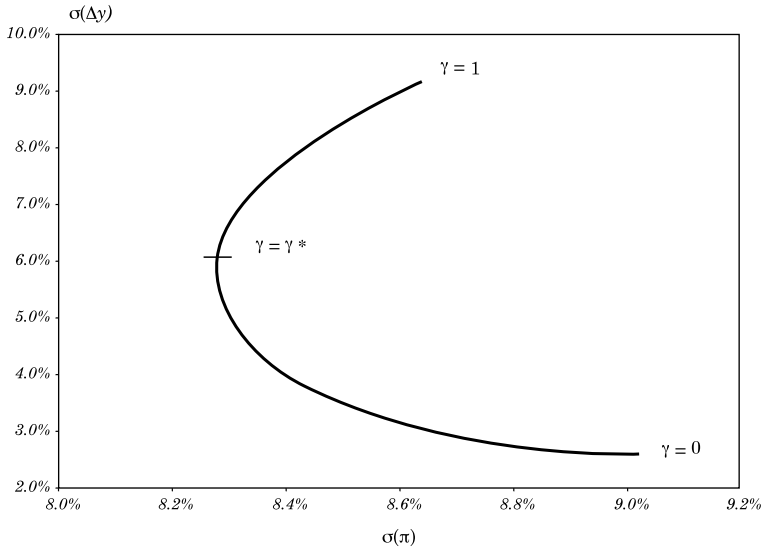
On the basis of this analysis, we derive three main results. First, biasing monetary policy responses toward output stabilization is efficient. Second, while it is inefficient to target core inflation, targeting forecast headline inflation does improve efficiency. Finally, leaning against movements in 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 ($\theta = 40$, $\rho = 0.4$)**



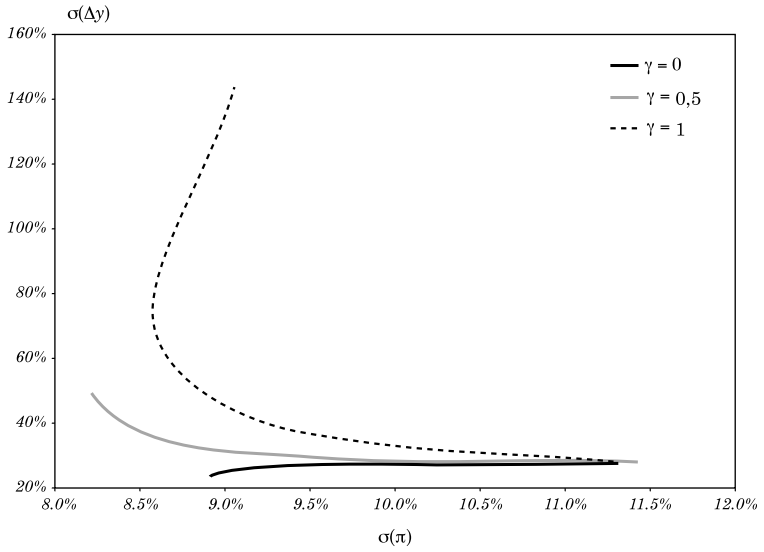

Source: Authors' calculations.

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**



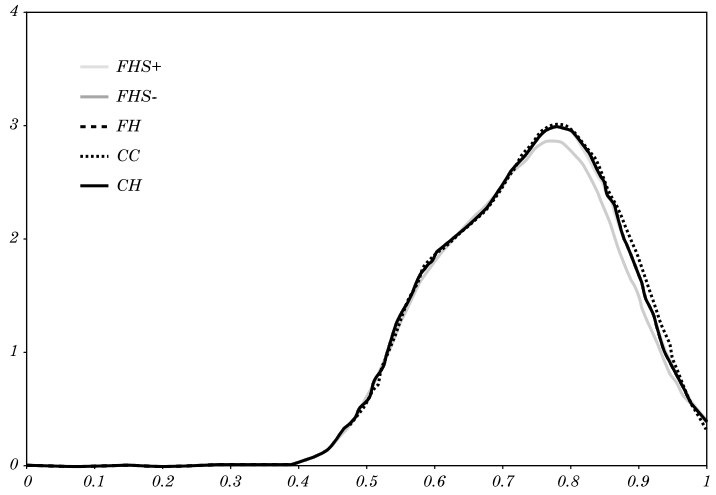

Source: Authors' calculations.

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 $\gamma^*$**



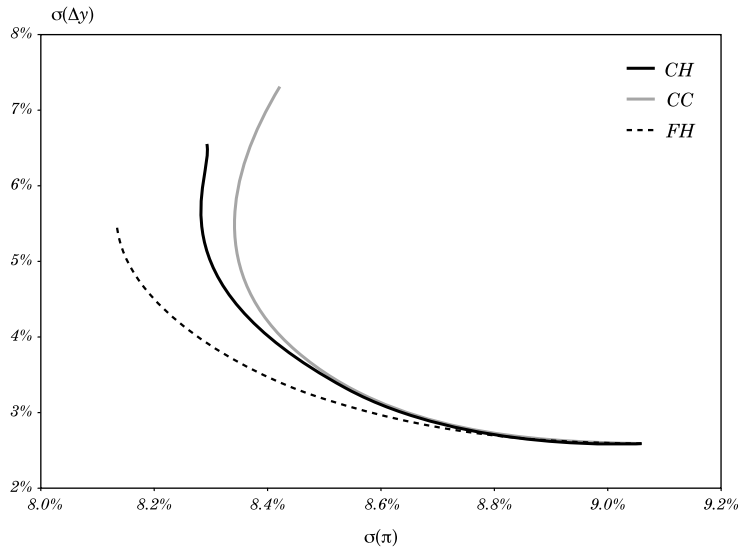

Source: Authors' calculations.

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.[10] 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.[11] 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.

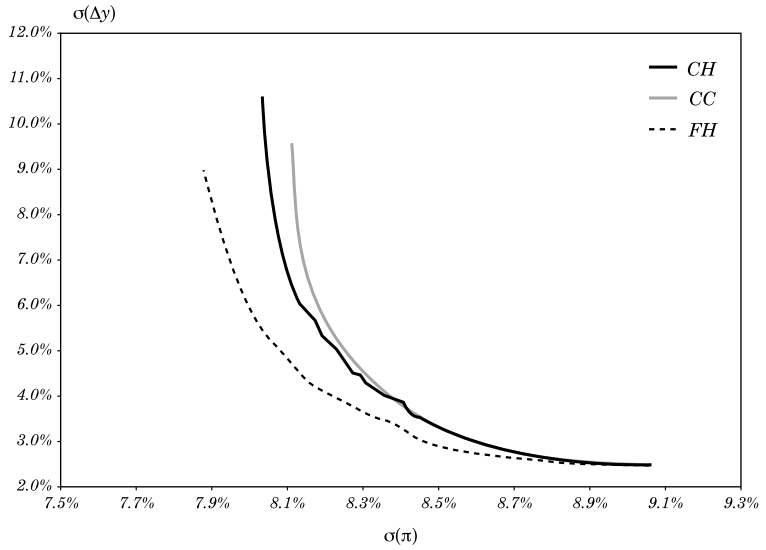
Again, the differences between targeting current core versus current headline inflation are small when the weight on the output gap is large. These results are robust to different parameterizations. Figure 5 shows the efficiency frontiers for a broad set of activism, anti-inflationary zeal, and persistence 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**



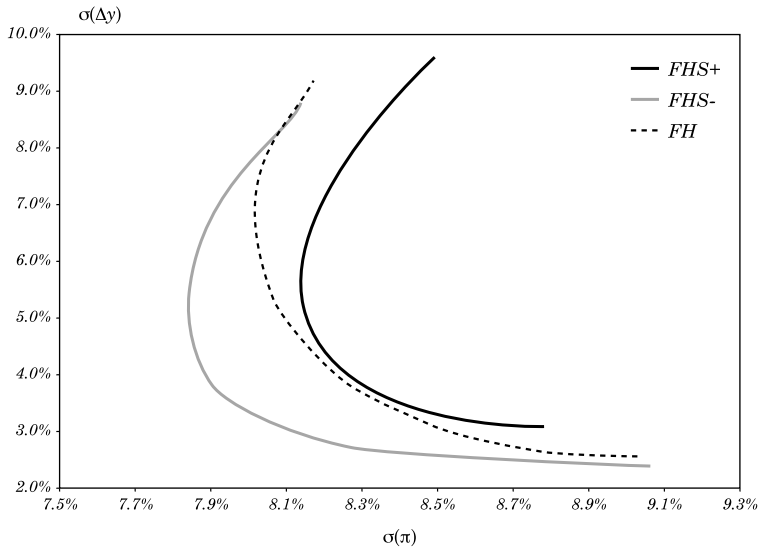

Source: Authors' calculations.

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 ($\theta = 50$, $\rho = 0.4$)**

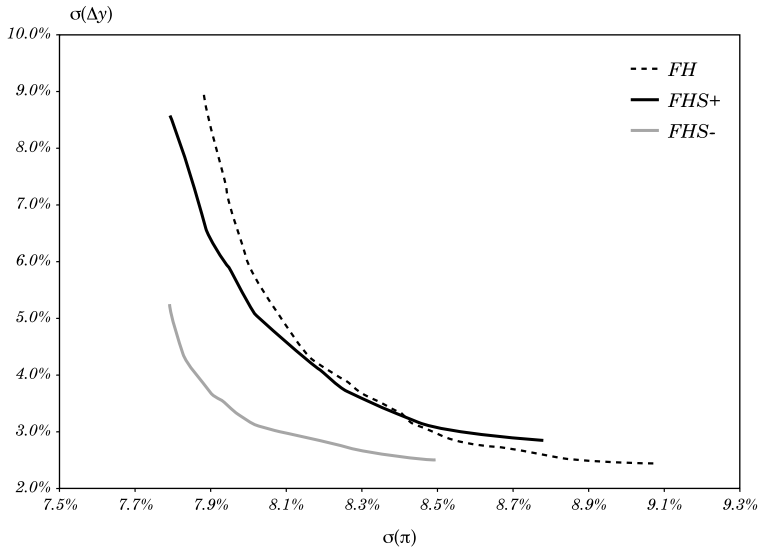



Source: Authors' calculations.

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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