

INFLATION TARGETING, ANNOUNCEMENTS, AND IMPERFECT CREDIBILITY

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Abstract

In virtually all theoretical studies of inflation targeting, the announced inflation target is treated as being fully credible. However, inflation targeting policies have typically been implemented after protracted periods of poor inflation performance when the policy authority's credibility is quite low. Because credibility imperfections may have a significant impact on inflation expectations and therefore on the monetary transmission mechanism, policies that are optimal under full credibility may not yield the best outcomes under imperfect credibility. In this article I use a simple dynamic model to study the implications that credibility imperfections have for the formulation of optimal inflation targeting policies.

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1. Introduction

Since the adoption of inflation targeting by New Zealand in 1990, the list of countries that have chosen to employ this framework for monetary policy has steadily continued to grow. Recently, there has also been a rapid expansion in the literature on inflation targeting as academics and central bankers seek to understand the conditions necessary to sustain and duplicate the successes of the early inflation targeters. The contributions to this literature are wide-ranging, and take the form of theoretical analyses such as those conducted by McCallum (2001) and Svensson (1997, 2000), empirical studies such as Huh (1996), Mishkin and Schmidt-Hebel (2001), and Rudebusch and Svensson (2000), as well as case studies, examples of which may be found in Bernanke et al. (1999), Blejer et al. (2000), and McCallum (1997). Most theoretical studies of inflation targeting assume that the policy authority's inflation target is perfectly credible. In this article I use a simple theoretical model to study the implications of imperfect credibility for the formulation of optimal inflation targeting policies.

The impact of imperfect credibility on the effectiveness of monetary policy is most often studied in the context of the time inconsistency problem as articulated by Kydland and Prescott (1977). Kydland and Prescott point out that when there is a negative relationship between unemployment and unanticipated inflation, monetary authorities have an incentive to use discretionary policy to generate price surprises. Recognizing the potential for real wage reductions, rational agents bid up wages, causing inflation to increase without any compensating decrease in unemployment. Thus, it is argued, discretionary monetary policy inevitably leads to inflationary bias in economies. Although this time inconsistency problem has attracted a great deal of academic interest, with the result that there is now a large literature concerned with eliminating the associated inflationary bias, there are a number of prominent economists who remain skeptical about the practical importance of this problem. Bean (1998), Blinder (1997), McCallum (1995), and Taylor (1983) have, at various times, stated their belief that monetary authorities understand the nature of the time inconsistency problem and simply choose not to play the game.

Bernanke et al. (1999) argue that time inconsistency is likely to be even less im-

portant in inflation-targeting countries. Although the operational details of inflation targeting differ among countries, there are fundamental elements that all inflation targeters have adopted. These common cornerstones of inflation-targeting are (1) public announcements of the official inflation targets or target ranges for specific time horizons, (2) an explicit public commitment to maintain low inflation, and (3) frequent communication with the public about the policy authority's objectives and the measures undertaken to meet these objectives. Evidently, transparency is an integral part of inflation targeting. Because transparency requires the policy authority to announce the expected future impact of its policy actions, inflation targeting inhibits the policy authority from generating price-surprises and ameliorates the time inconsistency problem. Thus, the time-inconsistency problem is unlikely to be a significant source of credibility imperfection in countries that are inflation targeters.

Regardless of its practical significance, the time inconsistency literature contains an enduring message about the importance of expectations in determining the effectiveness of monetary policy. In theoretical studies of inflation targeting, private agents are typically endowed with rational expectations. While this assumption may provide a reasonable approximation of reality during periods of economic stability, it is probably not a useful way to characterize expectation formation when there are significant regime changes. In most countries, inflation targeting was initiated after there had been a history of poor inflation performance and represented a significant change in monetary policy. Public announcements of the policy objectives and the policy measures to be employed are viewed as being crucial to successful inflation targeting because they provide information that helps to coordinate private expectations when the economic environment is undergoing significant changes. Such coordination would be unnecessary if agents were truly as well informed and rational as the rational expectations assumption implies.

In this article I study the the role that announcements play in determining the outcome of inflation-tageting policies. Because announcements are superflous when all agents are fully informed and perfectly rational, there is a sense in which inflation targeting as it is practiced and the rational expectations models used to study inflation targeting are not entirely consistent. In order to provide an avenue for announcements

to affect inflation-targeting outcomes, I follow Phelps (1967) and assume that the policy authority is fully rational but that private agents are only boundedly rational. In particular, the public forms expectations about future prices based on the policy authority's announced inflation targets and the public's assessment of the credibility of this announcement.

Characterizing private agents as boundedly rational is problematic because there are countless alternative representations, all of which are necessarily ad hoc. In this article, I take a simple approach and consider the consequences of three expectation-formation processes for inflation and output when the announced inflation target is not fully credible. The simplest case, in which the public's assessment of the achievable inflation rate is exogenous, serves as a benchmark.¹ In the other two cases, credibility assessments are endogenous and private agents amend their expectations about future inflation in each period based on a comparison between the announced inflation target and observed inflation rates. One of these endogenous processes assumes that private agents respond only to the announced long-run inflation target while the other allows expectations to respond to both long-run and intermediate target announcements. The analysis is conducted using a modified version of Svensson's (1997) dynamic inflation-targeting model.

In addition to assuming rational expectations, theoretical studies of inflation targeting usually assume that the policy authority's announcements are perfectly credible. That is, the public is assumed to fully accept the policy authority's view of the achievable target. Fischer (1986) is a notable exception. Fischer considers the impact of imperfect credibility on the effectiveness of an announced monetary policy and finds that disinflation is achieved more slowly and at greater cost (in terms of lost output) when the policy authority's announcement is not fully credible. Fischer implicitly assumes that the policy authority has full knowledge of the process by which private agents form expectations. In practice, however, the task of formulating monetary policy under conditions of imperfect credibility is complicated by the fact that the

¹Fischer (1986) studies cases in which the private sector's expectations are either exogenous or adaptive, but he does not explicitly condition these expectations on the policy authority's announcement.

policy authority generally cannot be sure of the degree to which its announcement is credible. When expectations are conditioned on the announced inflation target, erroneous conjectures about the credibility of the announcement may result in sub-optimal interest rate policies and poor inflation and output outcomes, which could further undermine the policy authority's credibility. It is therefore of interest to know how sensitive the success of inflation targeting is to the policy authority's misperceptions about the credibility of its announcements. In order to address this issue, I compare the outcomes of inflation targeting when the monetary authority knows the degree of credibility of its announcements with the outcomes that are achievable when the degree of credibility is not known.

The rest of this article is organized as follows. The model is introduced in Section 2. A discussion of the types of credibility imperfection that are considered here may be found in Section 3. Inflation targeting with exogenous credibility assessment is analyzed in Section 4. In Section 5, the optimal interest rate policy and the associated time paths for inflation and output are derived under the assumption that the public's credibility assessment is endogenous and subject to revision at the end of each period. In this section it is assumed that credibility is lower, the lower is the announced long-run inflation target relative to observed inflation. Policies that cause observed inflation to converge to the announced target therefore improve credibility. In Section 6, the analysis of endogenous credibility reassessment is modified to allow for intermediate target announcements. A summary of the main results may be found in Section 7.

2. The Model

The framework I use to study the impact of partial credibility on the effectiveness of inflation targeting policies is a modified version of Svensson's (1997) model.² In this economy, inflation and the output gap are determined as follows:

$$\pi_{t+1} = \pi_{t+1|t}^e + \alpha y_t + z_{t+1} \tag{1}$$

²The model used here differs from Svensson's only in that I do not assume that expectations are necessarily formed extrapolatively. Specifically, I do not replace $\pi_{t+1|t}^e$ with π_{t-1} .

$$y_t = \beta_1 y_{t-1} - \beta_2 (i_t - \pi_{t+1|t}^e - r) + u_t \quad (2)$$

where π_t is the inflation rate in period t , y_t is the output gap in period t , i_t is the nominal interest rate in period t , and r is the long-run equilibrium real interest rate. The notation $\pi_{t+1|t}^e$ denotes the inflation rate that private agents expect will prevail in period $t + 1$, conditional on information available in period t . The variables z_{t+1} and u_t are random disturbances which are assumed to be independently distributed with zero mean and constant variance.

It is assumed that the policy authority would like to set interest rates to minimize deviations of output and inflation from their target values. The policy authority's one-period loss function is then given by:

$$L(\pi_t, y_t) = \frac{1}{2} \left\{ (\pi_t - \tilde{\pi})^2 + \lambda (y_t - \tilde{y})^2 \right\} \quad (3)$$

where $\tilde{\pi}$ and \tilde{y} represent the policy authority's inflation and output targets, respectively, and $\lambda > 0$ is the relative weight assigned to output stabilization.³ With period-by-period losses given by (3), the policy authority's intertemporal optimization problem is:

$$\min_{i_t} E_t \sum_{\tau=0}^{\infty} \delta^\tau L(\pi_{t+\tau}, y_{t+\tau}) \quad (4)$$

where δ is the policy authority's discount factor, and E_t denotes that the expectation of future losses is conditioned on the information available at time t .

3. Imperfect Credibility

Svensson (1993) uses the real interest rates implied by the inflation target (ranges) for Canada, New Zealand, and Sweden to assess the credibility of the announced targets in these countries. Svensson rejects credibility (on a five-year horizon beginning in 1993) for Sweden and also for the period 1990 to mid-1992 for New Zealand; the results for Canada are inconclusive. Svensson's analysis shows that announced inflation targets are typically not fully credible at the time the policy is initiated.

³Cecchetti and Ehrman (2000) find that all inflation targeting central banks assign a positive weight to output deviations in their objective functions.

In this article I focus on credibility problems that are not associated with time inconsistency. The time inconsistency problem identified by Kydland and Prescott (1977) arises because the policy authority has inflation and output goals that are not mutually consistent with the underlying economic structure.⁴ In order to eliminate time inconsistency as a potential source of credibility imperfections, I assume that the monetary authority understands the source of such problems and avoids them by choosing output targets that are consistent with the inflation target, given the structure of the economy. In the context of the model used here, this means that the policy authority must set $\tilde{y} = 0$.

A zero output gap target is necessary but not sufficient for the elimination of time inconsistency problems. A further assumption is required — namely, that the public believes that the policy authority will not deliberately manipulate inflation in an attempt to push output above its long-run equilibrium level. In making these two assumptions, I am adopting Svensson’s position that inflation targeting entails the explicit choice of an inflation target and, given the economy’s structure, an implicit choice of the output path associated with that inflation target.

In this study, credibility imperfections arise when private agents do not believe that the inflation target announced by the policy authority is achievable. Although I do not explicitly model the process by which private agents form their beliefs, I assume that these beliefs have some rational basis. For example, the monetary authority may have a history of poor inflation performance or the public may be exposed to statements by elected officials that undermine the credibility of the monetary authority’s announced target.

The public’s beliefs about future inflation rates are important because they affect not only the inflation-output tradeoff described by (1), but also the real interest rate in (2). The extent to which errors about the public’s assessment of the announced target lead to errors in policy formulation, depends on the information available to the two groups of players (private agents and policy authority) at the time decisions

⁴The existence of distortionary taxes or strong labor unions, both of which, it is argued, result in the natural rate of employment being inefficiently low, are the most common explanations offered for the lack of consistency between the inflation and output objectives.

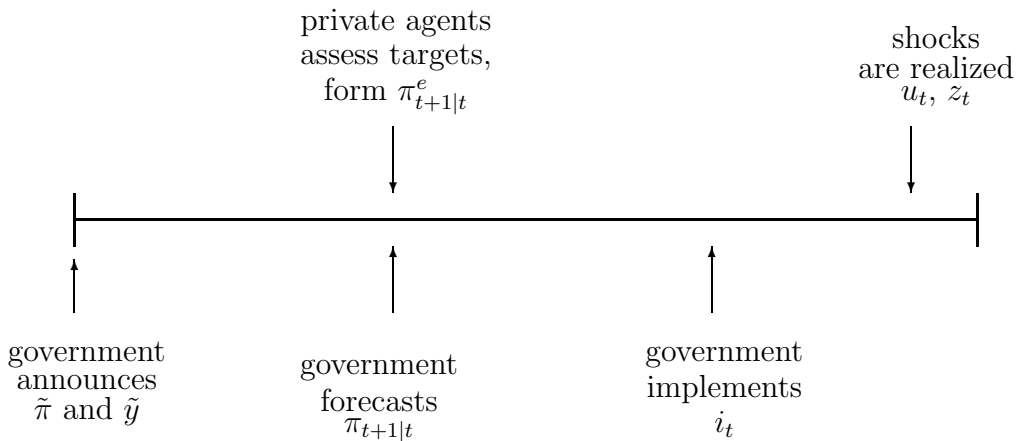


FIGURE 1

are made. For the private sector, the critical decision is the formation of inflation expectations whereas for the policy authority it is the formulation and implementation of interest rate policy.

The events that are relevant to this study occur in the following sequence. The initial event is the announcement of an inflation target, $\tilde{\pi}$, by the policy authority. Next, private agents form their expectations $\pi_{t+1|t}^e$ and the policy authority uses (1) to forecast the inflation rate $\pi_{t+1|t}$. The government then formulates and implements its interest rate policy, prior to observing the disturbances u_t and z_t ; output and inflation are assumed to be contemporaneously observable. Finally, the disturbances u_t and z_t are realized and these, together with the implemented interest rate policy and the private sector's expectations determine the rate of inflation and output gap that the economy experiences each period. This sequence of events is illustrated in Figure 1.

Duguay (1994) provides an illuminating discussion of the functioning of the monetary transmission mechanism in Canada. From Duguay's concluding comments, it is evident that central bankers are well-aware that the market's perceptions about the feasibility of announced targets may significantly influence the ultimate success of a given policy initiative. One of the questions that arises in this context is whether the central bank should adhere to a predetermined course regardless of the market's response to its announcements and/or actions, or whether the central bank's best course of action is to alter its policy to accommodate the market's perceptions. The latter

course of action is often referred to as “following the market.” In order to study this issue, I analyze the outcome of optimal inflation targeting policies under alternative assumptions about the type of credibility imperfection that the policy authority faces when implementing its inflation targeting policy. I begin, in the next section, with the simple case in which the market’s assessment of the announced policy’s feasibility is exogenous.

4. Exogenous Target Assessment

In this section I consider a situation in which the policy authority announces the inflation target pair $\tilde{\pi}$ but the public believes that the achievable inflation rate π^* . For the present, the public’s assessment of the credibility of the announced target is assumed to be exogenous.

The policy authority’s task is to solve the intertemporal minimization problem (4). This involves choosing from the feasible set of alternatives the interest rate policy that generates the best combinations of inflation and output in all time periods. From (1) and (2) it is apparent that the relationship between inflation and the output gap is recursive, with the current output gap determining future inflation. Given this recursive structure, a natural way to solve the policy authority’s minimization problem (4) is to identify the optimal output gap and then use (2) to infer the required interest rate level.

When assessment of the achievable inflation-output combination is exogenous, the optimal output gap y_t satisfies the Euler equation

$$\frac{\partial L(\pi_t, y_t)}{\partial y_t} + \frac{\delta \partial g(y_t)}{\partial y_t} \frac{\partial(\pi_{t+1|t}, y_{t+1|t})}{\partial \pi_{t+1|t}} = 0 \quad (5)$$

where

$$g(y_t) = \tilde{\pi} + \alpha y_t + z_{t+1}.$$

In (5), the terms $\pi_{t+1|t}$ and $y_{t+1|t}$ denote, respectively, the period $t + 1$ inflation rate and the output gap rates expected by the policy authority, given the information available in period t .

Using (1) and (2), and performing the differentiations indicated in (5), yields the first-order condition

$$\lambda y_t + \delta \alpha E_t \{ (\pi_{t+1} - \tilde{\pi}) - \lambda \beta_2 y_{t+1} \} = 0. \quad (6)$$

Substituting (1) into (6) results in

$$y_t = \frac{\lambda \delta \alpha \beta_2 y_{t+1|t}}{(\lambda + \delta \alpha^2)} + \frac{\delta \alpha [\tilde{\pi} - \pi_{t+1|t}^e]}{(\lambda + \delta \alpha^2)}. \quad (7)$$

When the public believes the announced target combination is achievable, so that $\pi_{t+1|t}^e = \tilde{\pi}$, the first-order condition (7) becomes

$$y_t = \frac{\lambda \delta \alpha \beta_2 y_{t+1|t}}{(\lambda + \delta \alpha^2)}. \quad (8)$$

Clearly, the optimal interest rate policy is one that results in $y_t = y_{t+1|t} = 0$. Because, by assumption, the demand disturbance u_t is not contemporaneously observable, interest rate policy is subject to a control error so that the best the policy authority can hope to achieve in the current period is $y_t = u_t$. Replacing y_t with u_t in (2) yields the optimal (implementable) interest rate policy implied by (2) and (8)

$$i_t = \frac{\beta_1}{\beta_2} y_{t-1} + \tilde{\pi} + r. \quad (9)$$

When $\pi_{t+1|t}^e = \tilde{\pi}$ and the policy authority implements (9), the time paths of inflation and output are given by

$$\pi_t = \tilde{\pi} + \alpha u_{t-1} + z_t \quad (10)$$

$$y_t = u_t. \quad (11)$$

It is apparent that when the public believes that the announced target combination is achievable, implementing the optimal interest rate rule (9) results in an average rate of inflation equal to the announced target value and an output gap that is, on average, equal to zero. However, there is no reason to suppose that the same outcome can

be achieved when the market's assessment of the feasibility of the announced target is less favorable. In analyzing the policy authority's best course of action when the public's assessment of the achievable inflation rate differs from the announced inflation target, there are two cases to be considered. In particular, the best course of action may depend on whether or not the policy authority knows what the market's beliefs are. These two cases are analyzed individually below.

4.1 Public's Assessment Known

When the public's assessment of the achievable inflation rate differs from the target announced by the policy authority and the policy authority knows what the public's beliefs are, the policy authority can successfully achieve its output target (i.e., a zero output gap) by implementing the interest rate policy

$$i_t^{*y} = \frac{\beta_1}{\beta_2} y_{t-1} + \pi^* + r. \quad (12)$$

It is straightforward to show that while (12) ensures that the output gap will, on average, be equal to zero, this interest rate policy compromises the inflation target. Substituting (12) into (1) and (2) yields

$$\pi_t = \pi^* + \alpha u_{t-1} + z_t \quad (13)$$

$$y_t = u_t. \quad (14)$$

If the policy authority wishes to hit its announced inflation target, then it must implement the interest rate policy

$$i_t^{*\pi} = \frac{\beta_1}{\beta_2} y_{t-1} - \frac{[\tilde{\pi} - \pi^*]}{\alpha \beta_2} + \pi^* + r. \quad (15)$$

Substituting (15) into (1) and (2) shows that this policy results in the following inflation and output outcomes

$$\pi_t = \tilde{\pi} + \alpha u_{t-1} + z_t \quad (16)$$

$$y_t = \frac{[\tilde{\pi} - \pi^*]}{\alpha} + u_t. \quad (17)$$

It is evident that when the public's perception of the achievable inflation rate is exogenous and differs from the inflation target announced by the policy authority, the policy authority cannot simultaneously eliminate the output gap and hit its inflation target. When the public considers the announced inflation target to be too low and expects the average inflation rate to exceed the announced target, the inflation-output trade-off that the policy authority faces deteriorates and the inflation target can only be achieved at the cost of an output level that is lower than target.⁵ Similarly, the output target can be achieved only at the cost of an inflation rate that is higher than target.

Substituting $\pi_{t+1|t}^e = \pi^*$ into (7) results in the first-order condition

$$y_t = \frac{\lambda\delta\alpha\beta_2 y_{t+1|t}}{(\lambda + \delta\alpha^2)} + \frac{\delta\alpha [\tilde{\pi} - \pi^*]}{(\lambda + \delta\alpha^2)}. \quad (18)$$

Because u_t is white noise and the public's expectations are constant over time, the best policy is also time invariant. Then, under the assumption that u_t is not contemporaneously observable, (18) implies that the policy authority's optimal strategy is to implement an interest rate policy that results in

$$y_t = \frac{\delta\alpha [\tilde{\pi} - \pi^*]}{(\lambda + \delta\alpha^2 - \lambda\delta\alpha\beta_2)} + u_t. \quad (19)$$

Substituting (19) and $\pi_{t+1|t}^e = \pi^*$ into (2) and rearranging, yields the policy authority's optimal interest rate policy

$$i_t^* = \frac{\beta_1}{\beta_2} y_{t-1} - \frac{\delta\alpha [\tilde{\pi} - \pi^*]}{\beta_2(\lambda + \delta\alpha^2 - \lambda\delta\alpha\beta_2)} + \pi^* + r. \quad (20)$$

When the policy authority knows that $\pi_{t+1|t}^e = \pi^*$ and implements (20), inflation and the output gap in the economy are given by

$$\pi_t^* = \tilde{\pi} + \frac{\lambda(1 - \delta\alpha\beta_2)(\pi^* - \tilde{\pi})}{(\lambda + \delta\alpha^2 - \lambda\delta\alpha\beta_2)} + \alpha u_{t-1} + z_t \quad (21)$$

$$y_t^* = \frac{\delta\alpha [\tilde{\pi} - \pi^*]}{(\lambda + \delta\alpha^2 - \lambda\delta\alpha\beta_2)} + u_t. \quad (22)$$

⁵Fischer (1986) obtains an analogous result using a wage-contracting model.

Equation (21) shows that when the announced inflation target is not fully credible, the policy authority's best course of action is to implement an interest rate policy that partially accommodates the public's expectations. Furthermore, (20) shows that the optimal interest rate is increasing in π^* . Empirical estimates of equations similar to (1) and (2) for various countries indicate that α and β_2 are less than 1.⁶ Thus, when the public believes the announced inflation target to be too low (i.e., $\pi^* > \tilde{\pi}$), the optimal interest rate policy results in higher interest rates than under perfect credibility and in an average inflation rate that lies between the target rate and the rate expected by the public. The optimal output level (22) lies below the target level. Clearly, a failure on the part of the policy authority to convince the public of the feasibility of the announced inflation target and of its commitment to achieving this target can seriously undermine the success of inflation targeting policies.

4.2 Public's Assessment Unknown

The results obtained above show that, in order to achieve good results, the policy authority must take the public's expectations into account when formulating policy. When the public's expectations are unknown, the best the policy authority can do is form a conjecture about the public's beliefs and implement the best interest rate policy based on this conjecture. Representing the policy authority's conjecture about the public's inflation expectations as π^c , the policy authority's first-order condition can be written

$$y_t = \frac{\lambda\delta\alpha\beta_2 y_{t+1|t}}{(\lambda + \delta\alpha^2)} + \frac{\delta\alpha [\tilde{\pi} - \pi^c]}{(\lambda + \delta\alpha^2)}. \quad (23)$$

The policy authority's best interest-rate policy is then given by

$$i_t^c = \frac{\beta_1}{\beta_2} y_{t-1} - \frac{\delta\alpha [\tilde{\pi} - \pi^c]}{\beta_2(\lambda + \delta\alpha^2 - \lambda\delta\alpha\beta_2)} + \pi^c + r. \quad (24)$$

When $\pi_{t+1|t}^c = \pi^*$ and the policy authority implements (24), inflation and the output gap in the economy are given by

$$\pi_t^c = \tilde{\pi} + \frac{\lambda(1 - \delta\alpha\beta_2) [\pi^* - \tilde{\pi}]}{(\lambda + \delta\alpha^2 - \lambda\delta\alpha\beta_2)} + \alpha\beta_2[\pi^* - \pi^c] + \alpha_2 u_{t-1} + z_t \quad (25)$$

⁶See, for example, Weymark (2001).

$$y_t^c = \frac{\delta\alpha [\tilde{\pi} - \pi^*]}{(\lambda + \delta\alpha^2 - \lambda\delta\alpha\beta_2)} + \beta_2 [\pi^* - \pi^c] + u_t. \quad (26)$$

When the announced inflation target is not fully credible and the policy authority overestimates the credibility of its announcement (i.e., $\tilde{\pi} < \pi^c < \pi^*$), the economy experiences a higher inflation rate than when the policy authority's conjecture about the public's beliefs is correct. However, the impact of this error on output is ambiguous. Imperfect credibility of the announced target worsens the inflation-output tradeoff and causes the policy authority to increase interest rates more than it would have under a fully credible policy. Nevertheless, this nominal interest rate is too low relative to inflation expectations when credibility is overestimated (i.e., when $\pi^c < \pi^*$), causing the real interest rate to be sub-optimally low. Depending on the combined impact of the degree of credibility imperfection and the magnitude of the policy authority's misperception of the real interest rate, output may increase, remain unchanged, or decrease. Thus, the possibility exists that credibility problems that are not associated with time inconsistency may generate inflation and output outcomes that mimic the time inconsistency result. In particular, an increase in inflation (which could be interpreted as inflationary bias) with no significant gain in output on average will be observed when the policy authority's conjectural error is

$$\pi^* - \pi^c = \frac{\delta\alpha [\pi^* - \tilde{\pi}]}{\beta_2(\lambda + \delta\alpha^2 - \lambda\delta\alpha\beta_2)}. \quad (27)$$

Ireland (1999) argues that the time-consistency problem provides a good explanation for the pattern of inflation experienced in the United States from the 1960s onwards. Equations (25) and (26) suggest an alternative explanation — credibility problems arising from sources other than time inconsistency could have been responsible for the inflation and output patterns observed during this period. Specifically, imperfect credibility of the announced targets together with initial conjectural errors on the part of the policy authority can account for the increase in inflation during the 1960s and 70s. Subsequent improvements in the credibility of announcements and also in the policy authority's conjectures about the public's perceptions are consistent with the decrease in inflation that occurred during the 1980s and 90s.

5. Endogenous Target Assessment

In the previous section, the public's perception of the achievable inflation-output combination was assumed to be exogenous. In this section I allow the policy authority's announcement to have an impact on the market's expectations. I assume that expectations about inflation are determined as

$$\pi_{t+1|t}^e = \tilde{\pi} + \varepsilon(\pi_t - \tilde{\pi}) \quad (28)$$

where $0 \leq \varepsilon \leq 1$.

According to (28), the credibility of the announced inflation target is inversely related to the difference between the target rate and the inflation rate observed at the beginning of the period. Thus, policy measures that move the observed inflation rate towards the announced target increase the credibility of the target. The degree to which inflation expectations diverge from the announced target depends not only on the difference between observed inflation and the announced inflation target, but also on the public's assessment of the credibility of the announced target, which is represented by the coefficient ε . When $\varepsilon = 0$, the announced inflation target is perfectly credible. Imperfect credibility is represented by values of ε greater than zero; the degree of credibility is inversely related to ε , reaching a minimum when $\varepsilon = 1$. I assume that the functional form of the expectation formation process is known to the policy authority but that the policy authority may not know the credibility coefficient ε . I also assume that ε is exogenous and constant over time.⁷ The term $\varepsilon(\pi_t - \tilde{\pi})$ can be interpreted as a penalty that the public imposes on the policy authority for poor inflation performance in the past.

When private agents form expectations about future prices as described in (28), the policy authority's optimization problem can be expressed as

⁷The assumption that ε is constant over time implies that a high degree of credibility does not reduce the output cost of disinflation. This is consistent with Debelle and Fischer's (1994) observation that the Bundesbank, which has a long history of commitment to low inflation, was forced to engineer deep recessions in the early 1980s and again in the 1990s in order to reduce inflation.

$$V(\pi_t) = \min_{y_t} \left\{ \frac{1}{2} [(\pi_t - \tilde{\pi})^2 + \lambda y_t^2] + \delta V(\pi_{t+1|t}) \right\} \quad (29)$$

subject to

$$\begin{aligned} \pi_{t+1} &= \pi_{t+1|t}^e + \alpha y_t + z_{t+1} \\ \pi_{t+1|t}^e &= (1 - \varepsilon)\tilde{\pi} + \varepsilon\pi_t. \end{aligned}$$

Because the period loss function (3) is quadratic and the constraints, (1) and (28), are linear, $V(\pi_{t+1|t})$ must be a quadratic polynomial.⁸ Let $V(\pi_{t+1|t})$ be given by

$$V(\pi_{t+1|t}) = k' + \frac{k}{2}(\pi_{t+1|t} - \tilde{\pi})^2. \quad (30)$$

Using (30) to replace $V(\pi_{t+1|t})$ in (29) and taking the derivative of the expression in braces with respect to y_t results in the first-order condition

$$y_t = - \frac{\delta \alpha k}{\lambda} (\pi_{t+1|t} - \tilde{\pi}) \quad (31)$$

where

$$k = \frac{[\delta \alpha^2 - \lambda(1 - \delta \varepsilon)] + \sqrt{[\delta \alpha^2 - \lambda(1 - \delta \varepsilon)]^2 + 4\delta \alpha^2 \lambda}}{2\delta \alpha^2}. \quad (32)$$

Details of the solution for k are provided in Appendix 1.

5.1 Credibility Assessment Known

When the policy authority knows the functional form of the endogenous expectation process as well as the credibility coefficient ε , the optimal interest rate policy results in inflation and output paths that converge to the announced targets. Maintaining the assumption that u_t cannot be observed until after interest rate policy is implemented, (31) implies that the best outcome the policy authority can achieve is

$$E_t[y_t] = - \frac{\delta \alpha k}{\lambda} [\pi_{t+1|t} - \tilde{\pi}]. \quad (33)$$

where $E_t[y_t] = y_t - u_t$.

⁸In general, this polynomial has the form $V(\pi_{t+1|t}) = k_0 + k_1(\pi_{t+1|t} - \pi^*) + \frac{k_2}{2}(\pi_{t+1|t} - \pi^*)^2$. For the problem under study, it turns out that $k_1 = 0$, so the simpler formulation (30) may be used.

Using (1), (2), and (33) to solve for the for the optimal interest rate policy yields

$$i_t^\varepsilon = \frac{\beta_1}{\beta_2} y_{t-1} + \varepsilon \left\{ 1 + \frac{\delta \alpha k}{\beta_2 (\lambda + \delta \alpha^2 k)} \right\} [\pi_t - \tilde{\pi}] + \tilde{\pi} + r. \quad (34)$$

It is straightforward to show that k is increasing in ε so that the optimal interest rate i_t^ε is also increasing in ε . Just as in the previous section, where the credibility assessment was exogenous, the optimal interest rate is inversely related to the credibility of the announced inflation target.

Substituting (28) and (33) into (1) yields the time path of inflation that is achieved when (34) is implemented

$$\pi_{t+1}^\varepsilon = \tilde{\pi} + \frac{\lambda \varepsilon}{(\lambda + \delta \alpha^2 k)} [\pi_t - \tilde{\pi}] + \alpha u_t + z_{t+1}. \quad (35)$$

The expectation formation process described by (28) satisfies what Choi and Matsui (1995) call the ‘induction property’ in that if the policy authority steadfastly sets interest rates to achieve $E[\pi_t] = \tilde{\pi}$, inflation expectations will eventually converge to $\tilde{\pi}$. However, it is apparent from (35) that adherence to such an interest rate policy is not optimal when the announced inflation target is not fully credible. As in the case of exogenous expectations, the optimal interest rate policy is one that partially accommodates the public’s expectations. However, when expectations are updated as in (28), implementing (34) brings about a gradual convergence to the long-run inflation target.

Let π_0 represent the rate of inflation that exists in the economy at the time the inflation targeting policy is announced and initiated by the policy authority. The time path of inflation generated by the inflation targeting policy when private agents form expectations according to (28) can then be expressed as

$$\pi_t^\varepsilon = \tilde{\pi} + \left[\frac{\lambda \varepsilon}{\lambda + \delta \alpha^2 k} \right]^t (\pi_0 - \tilde{\pi}) + \sum_{i=0}^{t-1} \left[\frac{\lambda \varepsilon}{\lambda + \delta \alpha^2 k} \right]^i (\alpha u_{t-1-i} + z_{t-i}). \quad (36)$$

Substituting (1), (28), (31), and (36) into $y_t = E[y_t] + u_t$ yields the following time path for output

$$\begin{aligned}
y_t^\varepsilon = & -\frac{\delta\alpha k\varepsilon}{\lambda + \delta\alpha^2 k} \left[\frac{\lambda\varepsilon}{\lambda + \delta\alpha^2 k} \right]^t (\pi_0 - \tilde{\pi}) \\
& -\frac{\delta\alpha k\varepsilon}{\lambda + \delta\alpha^2 k} \sum_{i=0}^{t-1} \left[\frac{\lambda\varepsilon}{\lambda + \delta\alpha^2 k} \right]^i (\alpha u_{t-1-i} + z_{t-i}). \tag{37}
\end{aligned}$$

Equations (36) and (37) offer a number of insights into the implications that credibility imperfections have for the effectiveness of inflation targeting policies. Under the expectation-formation process (28), an announced target is perfectly credible when $\varepsilon = 0$. Imperfect credibility is therefore represented by $0 < \varepsilon \leq 1$. With $k > 0$, it is apparent that when the extent of the credibility problem is known to the policy authority, average inflation and output converge to their announced targets in the long run.⁹ However, it is also the case that inflation is higher and output lower along the transition path, the greater is the credibility imperfection (i.e., the closer is ε to 1). It is straightforward to verify that the coefficient $(\lambda\varepsilon)/(\lambda + \delta\alpha^2 k)$ is increasing in ε . Under the assumption that the initial inflation rate π_0 exceeds the announced target $\tilde{\pi}$, (36) and (37) show that ε is positively related to the inflation rate and negatively related to the output gap. The fact that $(\lambda\varepsilon)/(\lambda + \delta\alpha^2 k)$ is increasing in ε also has implications for the volatility of inflation and output, both of which increase as the credibility of the announced inflation target declines.

5.2 Credibility Assessment Unknown

When the policy authority knows the functional form of the endogenous expectation formation process but does not know the credibility coefficient ε , the best the policy authority can do is form a conjecture about the rate of reassessment. Let the policy authority's conjecture about the public's credibility assessment be represented by γ . Then, the policy authority's best course of action is to set interest rates so as to satisfy

$$E_t[y_t^\gamma] = -\frac{\delta\alpha_2 h}{\lambda} (\pi_{t+1|t}^\gamma - \tilde{\pi}) \tag{38}$$

where

⁹The parameter λ is non-negative by assumption. It is straightforward to show that k is positive and finite for all non-negative values of λ .

$$\pi_{t+1|t}^\gamma = (1 - \gamma)\tilde{\pi} + \gamma\pi_t + \alpha E_t[y_t^\gamma] \quad (39)$$

$$h = \frac{[\delta\alpha^2 - \lambda(1 - \delta\gamma)] + \sqrt{[\delta\alpha^2 - \lambda(1 - \delta\gamma)]^2 + 4\delta\alpha^2\lambda}}{2\delta\alpha^2}. \quad (40)$$

Substituting (38) and (39) into (2) and solving for i_t yields the optimal interest rate policy

$$i_t^\gamma = \frac{\beta_1}{\beta_2}y_{t-1} + \gamma \left\{ 1 + \frac{\delta\alpha h}{\beta_2(\lambda + \delta\alpha^2 h)} \right\} [\pi_t - \tilde{\pi}] + \tilde{\pi} + r. \quad (41)$$

When the expectation formation process is (28) and the policy authority implements (41), (2) implies that the output gap is given by

$$y_t^\gamma = -\frac{\delta\alpha h\gamma}{(\lambda + \delta\alpha^2 h)}[\pi_t - \tilde{\pi}] + \beta_2(\varepsilon - \gamma)[\pi_t - \tilde{\pi}] + u_t. \quad (42)$$

Substituting (42) into (1) yields

$$\pi_{t+1}^\gamma = \tilde{\pi} + \left[\alpha\beta_2(\varepsilon - \gamma) + \frac{\lambda\varepsilon + \delta\alpha^2 h(\varepsilon - \gamma)}{\lambda + \delta\alpha^2 h} \right] [\pi_t - \tilde{\pi}] + \alpha u_t + z_{t+1}. \quad (43)$$

Again using π_0 to represent the inflation rate that exists at the time the inflation targeting policy is initiated, (43) implies the following time paths for inflation and the output gap

$$\pi_t^\gamma = \tilde{\pi} + \left[\frac{\lambda\varepsilon}{\lambda + \delta\alpha^2 h} + \Omega \right]^t (\pi_0 - \tilde{\pi}) + \sum_{i=0}^{t-1} \left[\frac{\lambda\varepsilon}{\lambda + \delta\alpha^2 h} + \Omega \right]^i (\alpha u_{t-1-i} + z_{t-i}). \quad (44)$$

$$\begin{aligned} y_t^\gamma &= \left[\beta_2(\varepsilon - \gamma) - \frac{\delta\alpha h\gamma}{\lambda + \delta\alpha^2 h} \right] \left[\frac{\lambda\varepsilon}{\lambda + \delta\alpha^2 h} + \Omega \right]^t (\pi_0 - \tilde{\pi}) + u_t \\ &\quad + \left[\beta_2(\varepsilon - \gamma) - \frac{\delta\alpha h\gamma}{\lambda + \delta\alpha^2 h} \right] \sum_{i=0}^{t-1} \left[\frac{\lambda\varepsilon}{\lambda + \delta\alpha^2 h} + \Omega \right]^i (\alpha u_{t-1-i} + z_{t-i}). \end{aligned} \quad (45)$$

where

$$\Omega = \alpha\beta_2(\varepsilon - \gamma) + \frac{\delta\alpha^2 h(\varepsilon - \gamma)}{\lambda + \delta\alpha^2 h}.$$

According to (44) and (45), inflation and output converge to their target values in the long run if and only if

$$\left| \frac{\lambda\varepsilon}{\lambda + \delta\alpha^2 h} + \Omega \right| < 1. \quad (46)$$

It is clear that it is possible for inflation and output to converge to their target values even if the policy authority does not know the credibility coefficient, ε . However, it is not the case that convergence can be achieved for all $\gamma \in [0, 1]$ so the policy authority has an incentive to learn about the market's credibility assessment.

In (44), (46) determines (i) the speed of convergence to the announced inflation and output targets and (ii) the impact that supply and demand disturbances have on inflation and output in each period. Comparing (36) and (37) in Section 5.1 with (44) and (45) yields a number of interesting insights. It is straightforward to show that k and h are increasing in their arguments ε and γ , respectively. Consequently, when (46) is satisfied and the policy authority underestimates the credibility of its announcement (i.e., $\gamma > \varepsilon$), the speed of convergence to both inflation and output targets increases, but this positive effect is offset by a larger initial reduction in output.¹⁰ Furthermore, underestimation of the public's credibility assessment increases the impact of supply and demand disturbances on inflation and output in terms of both magnitude and persistence. These effects are reversed when the policy authority overestimates the credibility of its announcements (i.e., when $\gamma < \varepsilon$).

6. Intermediate Targets

Up to this point it has been assumed that the policy authority announces only its long-run target. However, central banks that have adopted inflation targeting have typically announced medium-term intermediate targets as well as the long-run target.¹¹ The announcement of intermediate targets serves two important purposes,

¹⁰The speed of convergence is positively related to γ because, from (41), the interest rate is increasing in γ , causing output and inflation to be lower, thereby decreasing the gap between π_t and $\tilde{\pi}$ and increasing the rate of convergence.

¹¹See, for example, McCallum's (1997) description of the operational details of inflation targeting in Canada, New Zealand, Sweden, and the United Kingdom.

it contributes to transparency and also provides a coordination mechanism for private inflation expectations. In this section, in addition to the long-run target $\tilde{\pi}$ that is announced when the inflation targeting policy is initiated, the policy authority may now also choose to announce an intermediate inflation target π^a one period ahead. I assume that when the policy authority makes intermediate target announcements, the public's expectations about inflation are determined by

$$\pi_{t+1|t}^e = \pi_{t+1}^a + \varepsilon(\pi_t - \pi_t^a) \quad (47)$$

where π_t^a denotes the intermediate inflation target for period t that is announced in period $t - 1$. As before, $0 \leq \varepsilon \leq 1$.

When private agents form expectations about future prices as described in (47), the policy authority's optimization problem can be expressed as

$$V(\pi_t) = \min_{y_t, \pi_{t+1}^a} \left\{ \frac{1}{2} [(\pi_t - \tilde{\pi})^2 + \lambda y_t^2] + \delta V(\pi_{t+1|t}) \right\} \quad (48)$$

subject to

$$\pi_{t+1} = \pi_{t+1|t}^e + \alpha y_t + z_{t+1}$$

$$\pi_{t+1|t}^e = \pi_{t+1}^a + \varepsilon(\pi_t - \pi_t^a).$$

Applying the method described earlier in this section to solve (48) yields the first-order conditions

$$\lambda y_t + \delta \alpha k(\pi_{t+1|t} - \tilde{\pi}) = 0 \quad (49)$$

$$\lambda \beta_2 y_t + \delta(1 + \alpha \beta_2)k(\pi_{t+1|t} - \tilde{\pi}) = 0 \quad (50)$$

where k is given by (32).

Substituting (1) and (47) into (49) and (50), and then solving simultaneously for y_t and π_{t+1}^a , allows the first-order conditions to be expressed as

$$y_t = 0 \quad (51)$$

$$\pi_{t+1}^a = \tilde{\pi} - \varepsilon(\pi_t - \pi_t^a). \quad (52)$$

Equation (52) yields some interesting insights into what is needed in order to obtain the optimal benefit from intermediate target announcements. From (52) it is

apparent that, given any long-run target $\tilde{\pi}$, the difference between observed inflation in any period and the announced target for that period determines the intermediate announcement that is optimal for the subsequent period. If the realized inflation rate in any period exceeds the announced target for that period, then optimal inflation and output outcomes can only be achieved if the intermediate target announced for the following period is lower than the announced long-run target $\tilde{\pi}$. However, it is difficult to imagine that the public, having just experienced inflation in excess of an announced target, would believe that an even lower inflation target could be achieved in the subsequent period, particularly when the long-run target exceeds the intermediate inflation target. It follows that in order to benefit from intermediate target announcements, the policy authority must ensure that observed inflation rates fall below their target levels in each period. Intermediate targets and expected inflation will then converge to the long-run inflation target from above.

Ensuring that π_t^a exceeds π_t is problematic because the policy authority cannot observe π_t at the time π_t^a is announced and must therefore rely on a forecast. In practice, most central banks announce target ranges (rather than point targets) for inflation, using their inflation forecasts to determine the midpoint of the range.¹² The preceding discussion has an interesting implication — namely, that the upper bound of the announced target range is of greater importance than the lower bound for ensuring the success of an inflation targeting policy. Although target ranges are not explicitly modeled here, their essential feature is easily incorporated simply by interpreting the announced intermediate targets in (52) as the upper bounds of the relevant target ranges.

6.1 Credibility Assessment Known

When the policy authority employs intermediate targets, optimal policy is characterized by the combination of intermediate target announcements and interest rate settings that minimize the policy authority's losses over time. With ε and the functional form of (47) known, the optimal intermediate target for period $t+1$ (announced

¹²Bernanke et al. (1999) provide a detailed description of the inflation targeting policies implemented in Australia, Canada, Israel, New Zealand, Spain, and the United Kingdom.

in period t) is given by (52). Using (2), (47), (51), and (52) to solve for the optimal interest rate policy yields

$$i_t^\varepsilon = \frac{\beta_1}{\beta_2} y_{t-1} + \tilde{\pi} + r. \quad (53)$$

Implementation of (52) and (53) in period t results in the following outcomes

$$y_t^\varepsilon = u_t \quad (54)$$

$$\pi_{t+1}^\varepsilon = \tilde{\pi} + \alpha u_t + z_{t+1}. \quad (55)$$

The results of this section indicate that when the expectations formation process is known to the policy authority and this information is used optimally, the policy authority can bring the systematic component of an inflationary process in line with its long-run target very quickly. In the simple framework employed here, the average inflation rate converges to the long-run target within one period. That is, if, in the initial period (period 0), the policy authority announces $\pi_1^a = \tilde{\pi} - \varepsilon(\pi_0 - \pi_0^a)$ and sets the interest rate according to (53), the inflation rate in the next period (period 1) will be $\pi_1 = \tilde{\pi} + \alpha u_0 + z_1$. Note that the time required for convergence coincides with the length of the control lag.

6.2 Credibility Assessment Unknown

In the absence of perfect knowledge about the expectations formation process, the only course open to the policy authority is to form a conjecture. In this section, as in Section 5.2, I assume that the policy authority knows the functional form of the expectations process but not the credibility coefficient ε . As before, let γ represent the policy authority's conjecture about the market's credibility assessment. Then the policy authority's conjecture about the expectation formation process is

$$\pi_{t+1}^e = \pi_{t+1}^a + \gamma(\pi_t - \pi_t^a). \quad (56)$$

Given the policy authority's conjecture about the credibility of its announcement, the first-order conditions for the minimization problem (48) become

$$y_t = 0 \quad (57)$$

$$\pi_{t+1}^a = \tilde{\pi} - \gamma(\pi_t - \pi_t^a). \quad (58)$$

From (2), (56), (57), and (58), the optimal interest rate policy is

$$i_t^\gamma = \frac{\beta_1}{\beta_2} y_{t-1} + \tilde{\pi} + r, \quad (59)$$

which is identical to the optimal interest rate policy (53) that pertains when ε is known. However, because $\gamma \neq \varepsilon$, the announced intermediate target (58) does not cause the public to view the long-run target $\tilde{\pi}$ as fully credible, so implementing this interest rate policy does not result in the same outcomes as those obtained in Section 6.1. When the policy authority announces (58) and $\gamma \neq \varepsilon$, private agents expect

$$\pi_{t+1|t}^e = \tilde{\pi} + (\varepsilon - \gamma)(\pi_t - \pi_t^a). \quad (60)$$

Substituting (59) and (60) into (1) and (2) yields

$$y_t^\gamma = \beta_2(\varepsilon - \gamma)(\pi_t - \pi_t^a) + u_t \quad (61)$$

$$\pi_{t+1}^\gamma = \tilde{\pi} + [1 + \alpha\beta_2](\varepsilon - \gamma)(\pi_t - \pi_t^a) + \alpha u_t + z_{t+1}. \quad (62)$$

It is apparent that in economies with histories of poor inflation performance (i.e., economies in which $\pi_t > \pi_t^a$), overestimation of the public's credibility assessment (i.e., $\gamma < \varepsilon$) increases output at the cost of higher inflation rates.

Using (61), (62), and the initial conditions π_0 and π_0^a , the time paths of output and inflation for $t \geq 1$ can be expressed as

$$\pi_1^\gamma = \tilde{\pi} + \Lambda(\pi_0 - \pi_0^a) + \alpha u_{t-1} + z_t, \quad t = 1 \quad (63)$$

$$\begin{aligned} \pi_t^\gamma &= \tilde{\pi} + \Lambda[\gamma + \Lambda]^{t-1}(\pi_0 - \pi_0^a) + \alpha u_{t-1} + z_t \\ &\quad + \Lambda \sum_{i=1}^{t-1} (\Lambda + \gamma)^{i-1} (\alpha u_{t-1-i} + z_{t-i}), \quad t \geq 2 \end{aligned} \quad (64)$$

$$\begin{aligned} y_t^\gamma &= \tilde{y} + \beta_2(\varepsilon - \gamma)(\Lambda + \gamma)^t(\pi_0 - \pi_0^a) + u_t \\ &\quad + \beta_2(\varepsilon - \gamma) \sum_{i=0}^{t-1} (\Lambda + \gamma)^i (\alpha u_{t-1-i} + z_{t-i}), \quad t \geq 1 \end{aligned} \quad (65)$$

where $\Lambda = [1 + \alpha\beta_2](\varepsilon - \gamma)$.

In the long run, as $t \rightarrow \infty$, average inflation and output converge to their target values if and only if

$$|[1 + \alpha\beta_2](\varepsilon - \gamma) + \gamma| < 1. \quad (66)$$

Evidently, errors in the policy authority's conjecture could prevent convergence. How important such errors are depends on the magnitudes of the structural parameters α and β_2 . Erroneous conjectures about the expectation formation process are clearly more important the more sensitive inflation is to the output gap and the more responsive the output gap is to deviations of the real interest rate from its long run equilibrium level.

In Section 5.2, where there are no intermediate announcements, conjectural errors by the policy authority have a direct impact on nominal interest rates and therefore on the volatility and transition paths of inflation and output. With intermediate target announcements, it is possible for the policy authority to get the interest rate right even if there is uncertainty about the credibility of the announcement; the conjectural error shows up in the form of a sub-optimal announcement. However, the results obtained above indicate that when intermediate announcements are employed, conjectural errors about the credibility of the announced target increase (i) the length of time required to achieve the announced long-run targets and (ii) the impact of past supply and demand disturbances on inflation and output. The speed of convergence to target is slower and the impact of disturbances greater when the policy authority overestimates the credibility of its intermediate targets. Equations (64) and (65) also indicate that both inflation and output are higher in the early stages of the inflation targeting program when credibility is overestimated.

The outcomes described in (63)-(65) were derived under the assumption that the policy authority makes the same conjectural error period after period. This assumption is somewhat inconsistent with the degree of rationality I have attributed to the policy authority. The results in Section 6.1 show that, in the absence of conjectural errors, inflation and output converge to their long-run targets in one period. A rational and competent policy authority can be expected to use this information to revise its conjecture about the credibility of its announcements. When the policy authority

believes the credibility coefficient to be γ , the optimal intermediate target for period 1 is $\pi_1^a = \tilde{\pi} - \gamma(\pi_0 - \pi_0^a)$. If the true credibility coefficient is $\varepsilon \neq \gamma$, the period 1 inflation rate that private agents expect is $\pi_1^e = \tilde{\pi} + (\varepsilon - \gamma)(\pi_0 - \pi_0^a)$. Then, if the disturbances u_0 and z_1 can be observed ex post, the policy authority can use (63) to obtain an estimate of the true credibility coefficient. Comparing the period 1 inflation rates given by (63) under the alternative assumptions that $\gamma \neq \varepsilon$ and $\gamma = \varepsilon$ yields

$$\varepsilon = \gamma + \frac{\pi_1^\gamma - \pi_1^*}{(1 + \alpha\beta_2)(\pi_0 - \pi_0^a)} \quad (67)$$

where π_1^* is the inflation rate that is realized when the government's conjecture about the credibility of its announcement is correct (i.e., when $\gamma = \varepsilon$).

It was pointed out in Section 6.1, that when the policy authority knows the credibility coefficient ε , the long-run inflation and output targets could, in the absence of disturbances, be achieved within one period. When the policy authority does not know how credible its announcements are, the best it can do in period 1 is formulate policy on the basis of a conjecture about the credibility coefficient. Once the economy has responded to the monetary policy implemented in period 1, the policy authority can use (67) to revise its conjecture about the public's credibility assessment. If the policy authority has good information about the structure of the economy and the magnitudes of the disturbances u_0 and z_1 , then the long-run targets could, in the absence of further unanticipated disturbances, be achieved by the end of the second period. Given the simplicity of the model I have employed, conjectural errors are likely to be considerably more difficult to identify and correct in practice than the foregoing discussion suggests.¹³ Nevertheless, comparing the expressions in Section 5 with those obtained in this section indicates that using intermediate target announcements greatly reduces the informational burden on the policy authority.

The results obtained here have a number of practical implications. First, when an inflation targeting policy is subject to credibility imperfections, intermediate target announcements can enhance the effectiveness of the policy by significantly decreasing the time required to achieve the announced long-run targets. Second, misperceptions

¹³Svensson and Söderlind (1997) and Ruge-Murcia (2000) suggest methods by which the policy authority might obtain information about market expectations in practice.

on the part of the policy authority about the credibility of its announcements increase the length of time needed to achieve its long-run policy targets. Third, the divergence of actual inflation from the long-run inflation target in any period depends on the degree of credibility, the size of the policy authority's conjectural error, and on the magnitude of unanticipated economic disturbances. If, as in this study, credibility is adversely affected by observed inflation rates that exceed the announced target, then it is important that the policy authority announce target ranges rather than point targets. Furthermore, in determining the appropriate width of the target range, the policy authority must take into account not only the possible control errors arising from unanticipated disturbances, but also the impact of its conjectural errors about the credibility of the announced inflation and output targets. Finally, the results indicate that it is the upper bound of the announced target range that is crucial to the success of an inflation targeting policy with intermediate announcements.

7. Conclusion

Inflation targeting policies have typically been implemented after protracted periods of poor inflation performance when the policy authority's credibility is at a low ebb. Nevertheless, in virtually all theoretical studies of inflation targeting, the announced inflation target is treated as being fully credible. Because credibility imperfections may have a significant impact on inflation expectations and therefore on the monetary transmission mechanism, it is not at all clear that policies that are optimal under full credibility will achieve the best results under imperfect credibility. In this article I use a simple theoretical model to gain some insight into the implications that credibility imperfections have for the formulation of optimal inflation targeting policies.

In order to focus on the role that announcements play in determining the effectiveness of inflation targeting, I characterize private agents as boundedly rational and assume that the perceived credibility of the announced inflation target is a primary determinant of private inflation expectations. I consider the case in which the public's credibility assessment is exogenous as well as the alternative case in which private agents revise their credibility assessments based on a observed inflation performance. The results show that credibility imperfections worsen the inflation-output trade-off,

making it more difficult to achieve the long-run inflation and output targets.

When the announced targets are not fully credible and expectations are exogenous, the inflation target can be achieved only at the expense of lower output even if the extent of the credibility imperfection is known to the policy authority. Overestimation of the degree of credibility always results in higher inflation when the credibility assessment is exogenous; the impact on output is ambiguous and depends on both the absolute magnitude of the credibility imperfection as well as the magnitude of the policy authority's conjectural error. In this case, overestimation may lead to outcomes that mimic those associated with the time-inconsistency problem described by Kydland and Prescott (1977).

The results obtained here indicate that when the public's credibility assessment is endogenous, supplementing the long-run target announcements with well-chosen intermediate target announcements can greatly enhance the effectiveness of an inflation targeting policy. The results also suggest that announcing target ranges is likely to result in better outcomes than point targets and that the width of the target range should be sufficient to accommodate control errors arising not only from unanticipated shocks to the economy, but also errors arising from possible misperceptions about the credibility of the announced targets.

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Appendix Determination of k

The solution for k can be obtained by applying the envelope theorem to (29) and (30). Using (30) to replace $V(\pi_{t+1|t})$ in (29) and taking the derivative of the expression in braces with respect to π_t yields

$$V_\pi(\pi_t) = (\pi_t - \tilde{\pi}) + \delta\alpha_1 k (\pi_{t+1|t} - \tilde{\pi}). \quad (\text{A.1})$$

Using (1), (28), and (31), $\pi_{t+1|t}$ can be expressed as

$$\pi_{t+1|t} = \frac{\lambda(1-\varepsilon)\tilde{\pi}}{\lambda + \delta\alpha^2 k} + \frac{\delta\alpha^2 k \pi_t}{\lambda + \delta\alpha^2 k} + \frac{\lambda\varepsilon}{\lambda + \delta\alpha^2 k} + \frac{\lambda\alpha\tilde{y}}{\lambda + \delta\alpha^2 k}. \quad (\text{A.2})$$

Substituting (A.2) into (A.1) yields

$$V_\pi(\pi_t) = \left[1 + \frac{\delta\lambda k \varepsilon}{\lambda + \delta\alpha^2 k} \right] (\pi_t - \tilde{\pi}). \quad (\text{A.3})$$

Differentiating the conjectured solution (30) with respect to π_t yields

$$V_\pi(\pi_t) = k (\pi_t - \tilde{\pi}). \quad (\text{A.4})$$

Using (A.3) to identify the coefficient k in (A.4) then produces

$$k = 1 + \frac{\delta\lambda k \varepsilon}{\lambda + \delta\alpha^2 k}. \quad (\text{A.5})$$

Rearranging (A.5) yields the quadratic polynomial

$$\delta\alpha^2k^2 + [\lambda - (\lambda\varepsilon + \alpha^2)\delta]k - \lambda = 0. \quad (\text{A.6})$$

Solving (A.6) for k yields

$$k = \frac{[\delta\alpha^2 - \lambda(1 - \delta\varepsilon)] + \sqrt{[\delta\alpha^2 - \lambda(1 - \delta\varepsilon)]^2 + 4\delta\alpha^2\lambda}}{2\delta\alpha^2}. \quad (\text{A.7})$$

Only the positive root of (A.6) is a solution for k because, from (A.5), k must equal 1 for all non-zero values of δ and α when $\lambda = 0$; this condition is not satisfied by the negative root.