Accountability, Transparency, and Inflation Targeting

Carl E. Walsh*

March 2002

Abstract

Inflation targeting regimes define a performance measure for the central bank. A regime that places a large (small) weight on achieving the target is analogous to a high (low) powered incentive scheme. High-powered incentive structures promote accountability but may distort stabilization policy. The optimal power under inflation targeting is derived under perfect and imperfect information. The fundamental trade-off between accountability and stabilization depends on the degree of transparency, defined as the ability to monitor the central bank's performance. Multiplicative uncertainty increases the optimal weight to place on achieving an inflation target.

* Professor, Department of Economics, University of California, Santa Cruz, CA 95064 and Federal Reserve Bank of San Francisco (walshc@cats.ucsc.edu). An earlier version of this paper was prepared for a workshop on monetary policy held at the Reserve Bank of New Zealand and was partially supported by a grant from the National Science Foundation. I would like to thank the editor and referees, participants at the RBNZ workshop, those at a workshop on political economy at UCLA, Henrik Jensen, Alina Carare, Øistein Røisland, and seminar participants at the Bank of Spain, the Norges Bank, and at the Universities of Southampton, Stanford, and Warwick for helpful comments and discussion. Any opinions expressed are those of the author and not necessarily those of the Federal Reserve Bank of San Francisco or the Federal Reserve System.

Accountability, Transparency, and Inflation Targeting

1. Introduction

During the past decade, inflation targeting has grown in popularity among central bankers and economists. While New Zealand was one of the first countries to adopt an explicit inflation targeting regime, it is certainly no longer alone. Canada, the Czech Republic, Israel, Mexico, Sweden, and the U.K. have all adopted some form of inflation targeting, as had Finland and Spain prior to entering the European Monetary Union. [1] The trend towards inflation targeting by central banks, as well as the academic interest in inflation targeting, reflects two themes. One theme, that of accountability, has stressed the need to solve the credibility problems that can arise when policy is determined under discretion. General solutions to the accountability problem include the conservative central banker approach due to Rogoff (1985) and the inflation contracting approach developed in Walsh (1995a). Both can be interpreted as types of inflation targeting regimes (Svensson 1997a) that alter either the central bank's preferences or incentives in ways that reduce the inflation bias. Establishing an explicit target strengthens accountability by providing a clear goal against which the public can judge the conduct of the central bank.

The second theme, that of implementation, has stressed the role inflation targets might play in guiding the actual setting of monetary policy instruments. In the recent academic literature, Svensson (1997b, 1999a, 2000) has analyzed the implications of inflation targeting in closed and open economies, Ball (1999) relates flexible inflation targeting to efficient policy rules, and Bernanke and Woodford (1997) discuss some difficulties, including the possibility of multiple equilibria, that may arise under inflation forecast targeting. General issues associated with the design and implementation of an inflation targeting regime are also discussed by Svensson and Woodford (1999).

In the existing discussions, the definitions of inflation targeting have often differed. At one extreme, Bernanke and Mishkin (1997) characterize inflation targeting as a framework for policy rather than in terms of a more specific operational definition. At the other extreme, Svensson (1997b) models inflation targeting in terms of an objective function for the central bank that depends only on squared target misses. A targeting regime in which the central bank cares *only* about meeting its target for inflation is consistent with legislative reforms in which price stability or low inflation is identified as the sole objective of monetary policy. The Reserve Bank Act of 1989 in New Zealand and the Maastricht Treaty's framework for the European Central Bank provide examples of such legislated goals (Walsh 1995b). In such regimes, the key (in fact, the only) aspect that needs to be determined is the actual target inflation rate. Is the target constant? Is it in some way state contingent? Is it set by the government or by the central bank? These questions are all critical for a complete evaluation of inflation targeting.[2]

A broader interpretation of inflation targeting is that the central bank's objective function includes some weight on achieving the inflation target, but that this is not the only factor in the objective function. For example, Svensson (1997b, 1999a, 2000) considers situations in which the central bank cares about target misses *and* about other macroeconomic objectives such as output volatility. In this environment, the choice of a target rate continues to be of importance, but the *weight* to place on the target objective relative to other macro objectives is also critical.

This paper focuses on the role the target inflation rate and the weight on the target objective play in affecting the incentives of the central bank when the central bank operates with discretion. Under inflation targeting, inflation outcomes become the measure of central bank performance, and the weight placed on achieving the target is a measure of the power of the incentive structure facing the central bank. Incentive schemes that are too low powered fail to ensure accountability, while ones that are too high powered can distort policy responses to changing economic conditions. The contribution of this paper is to provide a framework for deriving the optimal weight to place on achieving an inflation target. While this weight is often interpreted in terms of the degree of central bank conservatism (Rogoff 1985), I show how it can be related to the literature on optimal performance measures (Baker 1992) and to issues of accountability and transparency.

The optimal targeting weight balances the need for accountability with the imperfect ability to monitor the central bank. Monitoring is imperfect if the information on which the central bank bases policy is private and publicly unverifiable. The ability to monitor can also be described in terms of the "transparency" of policy; a transparent policy improves the ability to monitor. If monitoring is perfect, the central bank is instructed to care only about achieving a state contingent target for inflation; this solves the accountability problem without distorting stabilization policy. When monitoring is incomplete due to imperfect information, it is optimal to place less weight on achieving the inflation target to avoid distorting stabilization policy.

The next section sets out the basic model. Political pressures are assumed to operate on the incentive to engage in expansionary policies. These pressures lead to socially undesired fluctuations in inflation. Inflation shocks provide a role for stabilization policies. Section 3 analyses non-state contingent and state-contingent inflation targets. Section 4 shows how multiplicative uncertainty of the type that leads to caution (Brainard 1967) affects the optimal target weight. Conclusions are contained in section 5.

2. The basic model

The basic model is motivated by recent work, often labeled as new Keynesian, that analyzes monetary policy in models based on optimizing private sector behavior and nominal rigidities. For example, see Clarida, Galí, and Gertler (1999) or McCallum and Nelson (1999) and the references they cite. These models typically consist of an aggregate demand specification derived from the representative household's optimal consumption decision and a forward-looking inflation adjustment equation. Monetary policy is formulated in terms of control over the nominal interest rate, but the policy problem can be simplified by treating the output gap -- output relative to the flexible-price equilibrium level -- as the instrument of monetary policy. The aggregate demand specification can then be used to recover the interest rate setting consistent with the choice of the output gap. Since the focus in this paper is not on the behavior of the nominal interest rate, the only aspect of the model that is relevant is the inflation adjustment equation.

Accountability issues are introduced by assuming the central bank is subject to pressures attributed to exogenous variation in political support for greater economic expansion. These pressures are taken to be unobservable by the public, or at least unverifiable. Similarly, the central bank's information on aggregate inflation shocks is interpreted as an internal forecast that is not publicly verifiable.

2.1 Output and inflation

The private economy is characterized by an expectations augmented, forward looking Phillips curve:

$$p_t = b\, \mathrm{E}_t p_{t+1} + d x_t + e_t \qquad (1)$$

where p_t is the inflation rate, $\mathrm{E}_t p_{t+1}$ is the private sector's expectation of future inflation, x_t is the output gap, e_t is an inflation or cost shock, and b is the discount rate ($0 < \beta < 1$). The parameter $d > 0$ is the output gap elasticity of inflation and captures the effects of the gap on real marginal costs and marginal cost on inflation (see Galí and Gertler 1999). The cost shock e is assumed to be serially uncorrelated, although this assumption is relaxed below.

To capture the notion that the central bank may have private information, I assume the central bank is able to condition its policy actions (the setting of x_t) on an internal forecast of e_t. This forecast, denoted e_t^{cb}, is private information. This follows Canzoneri (1985) who stressed the role private information can play in making the accountability problem more difficult. By private information, I mean that the central bank's forecasts cannot be publicly verified in a way that would allow the central bank to be monitored *ex post* based on its forecasts.

2.2 Policy objectives

As in any model of delegation, it is necessary to distinguish between the objective function of the principal, referred to as the government (or the public), and the agent, the central bank. The role of the public will be to design the targeting regime under which the central bank conducts policy. This involves deciding on the definition of the central bank's target and any penalty associated with a failure to achieve the target. The targeting regime is defined in what Lohmann (1992) refers to as the institutional design stage. This stage may involve multi-party cooperation as in Alesina and Gatti (1995), with the actual conduct of policy then affected by the preferences of the particular party holding office. In Waller and Walsh (1996), the preferences of the median voter are assumed to be subject to random shifts, with the institutional design stage reflecting the unconditional mean of the distribution of preferences. Actually policy then reflects the preferences of the current realization of median voter preferences.

The expected social loss function is assumed to take a form that is standard in this literature:

$$L_t^s = \frac{1}{2} E_t \sum_{i=0}^{\infty} b^i \left(l x_{t+i}^2 + p_{t+i}^2 \right) \tag{2}$$

where $l > 0$ is the relative weight placed on the output objective. Social loss depends on inflation variability and variability of the output gap. Because the overly ambitious output target common in the Barro-Gordon framework is absent here, discretionary policy implemented to minimize (2) would not lead to an average inflation bias.

Actual monetary policy, though, is implemented under discretion by a central bank that is subject to political pressures for economic expansions, and the strength of these pressures is assumed to vary randomly. Woolley (1995), for instance, provides examples of pressures the Nixon administration brought to bear on the Federal Reserve during 1972. In the early 1980s, bills were introduced in both the U.S. Senate and House of Representatives that would have required the Fed to target low real interest rates by announcing targets for short-term real interest rates consistent with historical levels.[3] While this legislation did not go far in Congress, one can view its introduction as designed to bring pressure on the Fed. Presidents and their cabinet officers have similarly applied public pressure on the Fed. These political pressures are captured by allowing for random fluctuations in the central bank's output goal.[4] The central bank is also charged with an inflation targeting objective, defined by the target and the weight placed on achieving the target. Thus, actual monetary policy is implemented to minimize the conditional expectation of the loss function

$$L_t^{cb} = \frac{1}{2} E_t^{cb} \sum_{i=0}^{\infty} b^{\,i} \left[l \left(x_{t+i} - u_{t+i} \right)^2 + p_{t+i}^{2} + t \left(p_{t+i} - p_{t+i}^{T} \right)^2 \right] \qquad (3)$$

where u_t is the mean zero period t realization of the net pressures for expansion, t is the weight the central bank places on achieving its inflation target objective, and p_t^T is the period t inflation target.[5] The superscript on the expectations operator in (3) reflects the fact that the central bank's information set at the time it makes its decisions may differ from that of the public. In addition to its forecast e^{cb}, the realization of u is known by the central bank, although it is assumed to be unverifiable private information. As a consequence, the target inflation rate cannot be conditioned on the realization of u.

In the central bank's loss function, t is the (penalty) weight on deviations from target, and p^T is the actual target rate. These are the parameters that characterize alternative inflation targeting regimes. Ignoring irrelevant constants and terms independent of the central bank's actions, the central bank's single period loss function can be written as

$$\frac{1}{2} E_t^{cb} \left[l x_t^2 - 2 l u_t x_t + (1+t)\left(p_t - p_t^T \right)^2 + 2 p_t^T p_t \right]. \qquad (4)$$

The first term in the brackets is identical to the output term in the social loss function. The second term is equivalent to the linear term in output that often is included in the central bank's utility function (e.g. Barro and Gordon 1983). The weight on this term depends on the random disturbance u. It is useful, therefore, to interpret u as the random effect of political pressure for more economic expansion. The third term shows that the penalty weight t plays the role of Rogoff's weight conservatism (Rogoff 1985) in making the central bank act as if it placed greater weight on inflation objectives. The setting of the target inflation rate (the fourth term) then influences the linear penalty associated with inflation (Svensson 1997a). This linear term can offset any average inflation bias as in the optimal contract formulation of Walsh (1995a), but a non-zero t distorts stabilization policy by altering the relative weights on output and inflation objectives.

This specification differs from that of other authors who have stressed the role of imperfect information about the central bank's preferences. For example, Briault, Haldane, and King (1996), Schaling (1997), and Nolan and Schaling (1997) treat the weight λ as random. In their framework, political pressures on the central bank distort both stabilization and the average inflation bias, and their focus is on the effects of preference uncertainty on average inflation. Similarly, Beetsma and Jensen (1998) constrain the sum of the weights on x^2 and p^2 to be $\lambda + 1$, as in society's loss function, but they assume the relative weights on output and inflation volatility are random. They examine how preference uncertainty affects the optimal linear inflation contract and do not relate the weight on inflation objectives to issues of accountability and monitoring. By treating u as reflecting political pressures, the assumption in (4) is that these pressures influence the degree to which the central bank is pushed to expand the economy but do not influence the relative weight the central bank places on output stabilization versus inflation stabilization.[6]

A *pure inflation targeting regime* occurs when $t \to \infty$ so that the central bank's loss function becomes simply $(1/2)E^{cb}\left(p_t - p_t^T\right)^2$. In this case, the central bank always ensures that $E^{cb}p_t = p_t^T$. Note that if the target is state contingent, $t \to \infty$ is not equivalent to a Mervyn King (1997) inflation “nutter,” because the target inflation rate may depend on other macroeconomics variables such as the output gap. Finite penalties correspond to flexible inflation targeting regimes in which the central bank may decide to miss its inflation target so as to achieve other macroeconomic goals.

3. Optimal targeting regimes

In this section, non-state contingent and state contingent targeting regimes are considered. In all cases, the central bank is assumed to act with discretion in making its policy choices. That is, the central bank's policies are time consistent (Svensson and Woodford 1999). The government establishes a targeting regime, and then, given that regime, the central bank implements the time-consistent discretionary policy. Throughout, the emphasis is on incentives and accountability in the face of the pressures on policy represented by the *u* disturbance. This is in contrast to research that focuses on discretion in the absence of political pressures and considers alternative targeting schemes that introduce inertia into policy to more closely mimic the timeless precommitment equilibrium studied by Svensson and Woodford (1999) and Woodford (1999).[7]

3.1 A non-state contingent target

In a non-state contingent targeting regime, the target inflation rate p^T is a constant. Since there is no average inflation bias in the present model, the appropriate target is $p^T = 0$. In addition, the only state variable is the exogenous cost shock e_t. If this is serially correlated, private expectations of future inflation will depend on its realization, but as this does not depend on the central bank's actions at time t, the central bank treats expectations of future inflation as given in setting x_t. The first order condition for the central bank's decision problem is

$$E^{cb}\left[l\left(x_t - u_t\right) + d\left(1+t\right)p_t\right] = 0\,. \qquad (5)$$

Equations (1) and (5) can be solved jointly for the equilibrium output gap and inflation rate under discretion with a non-state contingent target of zero inflation. This yields

$$x_t^{nsc} = \left[\frac{l}{l + d^2\left(1+t\right)}\right]u_t - \left[\frac{d\left(1+t\right)}{l + d^2\left(1+t\right)}\right]e_t^{cb} + y_t \qquad (6)$$

and

$$p_t^{nsc} = \left[\frac{ld}{l + d^2\left(1+t\right)}\right]u_t + \left[\frac{l}{l + d^2\left(1+t\right)}\right]e_t^{cb} + dy_t + v_t \qquad (7)$$

where $?_t$ is the central bank's error forecasting any aggregate demand disturbances (which would cause its planned value of the output gap to differ from the realized value of the gap) and v_t is the error in forecasting e_t. In the subsequent analysis, the demand forecast error $?_t$ does not play a role, so it will be set equal to zero to simplify the presentation.

Both inflation and output respond to the stochastic and unverifiable realization of u, which is socially inefficient.[8] The effect of u on inflation and output is decreasing in t; placing greater weight on achieving the inflation target reduces the impact of u shocks.

Increasing the target weight, however, also affects the way inflation and the output gap respond to the central bank's forecast of the cost shock, and this may distort stabilization policy. The optimal targeting weight will balance the need for accountability (to prevent inflation from responding to *u*) and the need for stabilization (to allow inflation to adjust optimally in the face of inflation shocks).

The optimal target weight is obtained by substituting (6) and (7) into the social loss function given by equation (2) and minimizing with respect to t. The first order condition for the optimal t yields

$$t^{nsc} = \frac{\left(l + d^2\right)s_u^2}{s_e^2 - s_v^2} \tag{8}$$

where $s_e^2 - s_v^2$ is the variance of the central bank's forecast e_t^{cb}.[9] The derivation of the optimal target weight leads to a very simple expression; the reason is that the social loss function does not contain a bias in its target for output, and the accountability problem arises from the pressures for greater output, not for more stable output.[10]

The optimal penalty weight is increasing in the accountability problem as measured by s_u^2; it is decreasing in $s_e^2 - s_v^2$. Equation (8) reflects the standard trade-off between accountability and stabilization, but the appropriate measure of the gain from allowing for flexibility differs from the usual one. Typically, the gain from flexibility is proportional to the variance of the cost shock, s_e^2. According to (8), the appropriate measure is given by the variance of the central bank's forecast, $s_e^2 - s_v^2$. For given s_e^2, the optimal target weight is increasing in the central bank's forecast error variance s_v^2. If s_v^2 is large, then the central bank has little information on *e* and the costs of distorting stabilization policy become less important relative to the need to address the accountability problem. As a result, the optimal target weight rises. The penalty for target misses declines as the central bank's information about *e* improves. The optimal target weight depends not on the "size" of the stabilization problem -- that is measured by s_e^2. Instead, it depends on the central bank's ability to estimate the underlying economic disturbances. If this improves, the potential cost of limiting the central bank's flexibility rises, so the optimal target weight falls.

It is worth noting that by setting t equal to the value given by (8), the government is implementing its optimal precommitment policy. Woodford (1999) has shown that optimal precommitment policies involve inertia when inflation depends on expected future inflation. This inertia is absent under discretion. While the government might desire to improve the output-inflation trade-off by introducing inertia into policy, it cannot do so with a non-state contingent target. It must optimize subject to the constraint imposed by the knowledge that once the targeting regime is set, the central bank will act with discretion.

If the inflation shock *e* is serially correlated, the expression for the optimal targeting weight is more complicated, but the intuition gained from equation (8) continues to hold. Assume *e* follows an AR(1) process,

$$e_t = re_{t-1} + e_t$$

where ε_t has mean zero, is serially uncorrelated, and $|r| < 1$. The equilibrium expression for inflation will take the form $p_t = Au_t + Be_t$. Assume the private sector can condition its expectation of p_{t+1} on e_t. Then, $E_t p_{t+1} = Bre_t$. Using this expression, together with (1) and (5), one finds that

$$x_t^{nsc} = \left[\frac{l}{l + d^2(1+t)}\right]u_t - \left[\frac{d(1+t)}{l(1-br) + d^2(1+t)}\right]e_t^{cb}$$

and

$$p_t^{nsc} = \left[\frac{ld}{l + d^2(1+t)}\right]u_t + \left[\frac{l}{l(1-br) + d^2(1+t)}\right]e_t^{cb} + v_t\,.$$

The first order condition for the optimal choice of t takes the form[11]

$$t^* = \frac{br}{1-br} + \left[\frac{l(1-br) + d^2(1+t)}{l + d^2(1+t)}\right]^3 \left(\frac{l + d^2}{1-br}\right)\left(\frac{s_u^2}{s_e^2 - s_v^2}\right). \tag{9}$$

While this does not yield a closed form solution for t, the presence of *?* does not affect the basic comparative statics. The optimal t is increasing in s_u^2 and decreasing in $s_{cb}^2 = s_e^2 - s_v^2$. Note also that the first term on the right side is equal to the optimal degree of Rogoff conservatism obtained by Clarida, Galí, and Gertler (1999) for the case of serially correlated inflation shocks and no accountability problem. When $s_u^2 > 0$ so that an accountability problem arises, equation (9) implies even more weight should be placed on achieving the inflation target. The optimal t is increasing in *?*.

Further insight can be obtained by an alternative derivation of the optimal targeting weight. The first order condition for society's choice of t can be written as

$$\frac{\partial E(L^s)}{\partial t} = E\sum b^i\left[(l x_{t+i} + dp_{t+i})\frac{\partial x_{t+i}}{\partial t}\right] = 0. \tag{10}$$

From the central bank's first order condition (5) and equation (7),

$$E^{cb}(lx_t + dp_t) = lu_t - dtE^{cb}p_t = l\left[\frac{(l + d^2)u_t - dte_t^{cb}}{l + d^2(1+t)}\right]$$

when *? = 0*. This means equation (10) become

$$\frac{\partial E(L^s)}{\partial t} = \left(\frac{l}{1-b}\right) E\left[\frac{\left(l + d^2\right)u - d t e^{cb}}{l + d^2(1+t)}\right]\left(\frac{\partial x_t}{\partial t}\right) = 0.$$

Solving for t,

$$t = \frac{\left(l + d^2\right) E\left(u \frac{\partial x}{\partial t}\right)}{d E\left(e^{cb} \frac{\partial x}{\partial t}\right)}. \qquad (11)$$

Since equation (6) implies $\mathrm{E}\left(\mathrm{u}\partial \mathrm{x}/\partial t\right) = -\left[1/\left(l + d^2(1+t)\right)\right]^2 l d^2 s_{\mathrm{u}}^2$ and $\mathrm{E}\left(\mathrm{e}^{\mathrm{cb}}\partial \mathrm{x}/\partial t\right) = -\left[1/\left(l + d^2(1+t)\right)\right]^2 l d s_{\mathrm{cb}}^2$, (11) gives the same solution as (8), but (11) turns out to provide additional insight into the factors that determine the optimal target weight.[12]

To help understand the intuition behind (11), it is useful to recall the results on optimal performance measures from Baker (1992).[13] Baker shows that, with a risk neutral agent and a moral hazard problem, the optimal power of the incentive contract -- that is, the impact of a change in the performance measure on the agent's pay -- is related to the covariance between the marginal effect of the agent's effort on the performance measure and the marginal effect of effort on the principal's objective. That is, if $V(\varepsilon)$ is the principal's objective as a function of the agent's effort ε, and $P(\varepsilon)$ is the performance measure, then the power of the incentive contract is increasing in $\mathrm{Cov}(V_\varepsilon, P_\varepsilon)$. If V_ε and P_ε are highly positively correlated, the optimal contract calls for a high powered incentive contract.

This reasoning can be applied to (11). If *u* is large just when the target particularly bites, then the covariance of *u* and *?x/?t* will be large (in absolute value), and it will be optimal to have a severe penalty on target misses (a high powered incentive scheme).

This is justified because the target helps to reduce the impact of u on output and inflation. If the target has a large effect when e^{cb} is large, then the covariance of e^{cb} and $?x/?t$ will be large. In this case, the target will distort the central bank's stabilization response too much, and, as a consequence, the optimal value of t will be small (a low powered scheme is optimal).

3.2 A stochastic inflation target

In the previous section, the trade-off between accountability and flexibility arose from the assumption that the target was constant, even though both the severity of the accountability problem (the realization of u) and the need for stabilization (the realization of e^{cb} were random. In situations of imperfect information, it is not feasible to implement the optimal state-contingent inflation target, but a targeting regime can improve over the case of a non-state contingent target by allowing the target to depend on publicly verifiable information. In this section, two cases are considered. In the first, it is assumed that the central bank's forecast e^{cb} is publicly verifiable *ex post*. This provides a benchmark case in which the inflation target can be made conditional on e^{cb} . The second case considered is that of a general stochastic target. In practice, a central bank might be held accountable for achieving a target defined in terms of a number of alternative inflation measures (CPI, GDP deflator, CPI minus food and energy, etc.), each of which can be viewed as a stochastic and imperfect measure of the true inflation objective. It is shown that the desirability of a particular target is a function of a simple forecast error variance.

3.3 Verifiable central bank forecasts

Suppose the target can be made contingent on the central bank's forecast of the inflation shock. This can be interpreted as a regime of complete transparency; the central bank makes public its forecasts for the economy and the information on which those forecasts are based. The central bank is then held accountable for achieving a target defined in terms of the information about the economy (i.e., e^{cb}) on which policy is actually based. The case of a state contingent inflation target provides a benchmark case that illustrates the optimality of a pure inflation targeting regime when transparency is complete.

Assume initially that the cost shock is serially uncorrelated (*? = 0*), and suppose e^{cb} can be observed *ex-post*. Then the inflation target for which the central bank is held accountable can be set equal to $p_t^T = qe_t^{cb}$ for some constant *?*. It is straightforward to show that the planned output gap and inflation rate with this state contingent target are

$$x_t^{sc} = \left[\frac{l}{l + d^2(1+t)}\right]u_t - d\left[\frac{1+t(1-q)}{l + d^2(1+t)}\right]e_t^{cb} \tag{12}$$

$$p_t^{sc} = \left[\frac{ld}{l + d^2(1+t)}\right]u_t + \left[\frac{l + td^2q}{l + d^2(1+t)}\right]e_t^{cb} + v_t. \tag{13}$$

The optimal targeting regime is a choice of t, the weight to place on achieving the target inflation rate, and *?*, governing the way the target inflation rate is made contingent on the central bank's verifiable forecast. These are chosen to minimize the unconditional expected value of the loss function (2), subject to the constraints implied by equations (12) and (13). Ignoring constants that are independent of t and *?*, the unconditional expected loss is

$$E\left(L^s\right)=\frac{1}{2}\left(\frac{1}{1-b}\right)\left[\left(l+d^2\right)\left(\frac{l}{l+d^2(1+t)}\right)^2 s_u^2+l\left(\frac{d\left[1+t(1-q)\right]}{l+d^2(1+t)}\right)^2 s_{cb}^2+\left(\frac{l+td^2q}{l+d^2(1+t)}\right)^2 s_{cb}^2\right].$$

Differentiating expected loss with respect to *?* and solving yields

$$q^*=\frac{l}{l+d^2}.$$

Substituting this expressing into the first order condition for the optimal target weight *t* yields

$$\frac{\partial E\left(L^s\right)}{\partial t}=-\frac{l d^2\left(l+d^2\right)s_u^2}{\left[l+d^2(1+t)\right]^2}<0$$

implying that the target weight is infinite. Substituting *?** into equations (12) and (13) and letting t? 8, the output gap and inflation are given by

$$x_t^{sc}=\lim_{t\to\infty}\left\{\left[\frac{l}{l+d^2(1+t)}\right]u_t-\left(\frac{d}{l+d^2}\right)e_t^{cb}\right\}=-\left(\frac{d}{l+d^2}\right)e_t^{cb} \qquad (14)$$

$$p_t^{sc}=\lim_{t\to\infty}\left\{\left[\frac{ld}{l+d^2(1+t)}\right]u_t+\left(\frac{l}{l+d^2}\right)e_t^{cb}\right\}=\left(\frac{l}{l+d^2}\right)e_t^{cb}. \qquad (15)$$

This outcome corresponds to the equilibrium during the first period of the fully optimal commitment policy, and it is the same equilibrium as would occur if the central bank could commit to the optimal simple rule making inflation (and the output gap) a function of the current state variable e^{cb}.[14] Thus, if the central bank's forecast is public information, the central bank should be held accountable only for achieving its state contingent inflation target. When the central bank focuses exclusively on achieving this target, the central bank simply minimizes $E^{cb}\left(p_t - p_t^T\right)^2 = E^{cb}\left(p_t - qe_t^{cb}\right)^2$, and inflation replicates the outcome under commitment to the optimal simple rule.

Even when $t < 8$ so that the central bank continues to care about output fluctuations, equations (14) and (15) show that policy responds to the cost shock forecast in a manner identical to the way it would if it could commit to a simple rule.[15]
An alternative interpretation of this targeting regime is in terms of “underlying inflation.” In New Zealand, the Reserve Bank constructs a measure they describe as underlying inflation that adjusts CPI (headline) inflation for various factors such as the interest rate components of the CPI, changes in government charges or indirect taxes, and supply disturbances that are viewed as generating one-time price level effects. In the present model, the appropriate adjustment is given by qe_t^{cb}, so underlying inflation would be defined as $p_t^u = p_t - qe_t^{cb}$. With $t ?\ 8$, inflation targeting with a state contingent target is equivalent to targeting underlying inflation around the socially optimal average inflation rate (in our case, zero), since the loss function of the central bank in this case can be written as:

$$E^{cb}\left(p_t - p_t^T\right)^2 = E^{cb}\left(p_t^u\right)^2.$$

Such a targeting regime is optimal in the sense that it mimics outcomes under optimal commitment to a simple rule if the target can be conditioned on the central bank's information. It is not necessary that the true realization of the inflation shock be verified.

Tedious algebra reveals that this result also carries through to the case in which the cost shock is serially correlated. By setting
$q^*(r) = l\left[(1 - br)(1 + t) - 1\right]/t\left[l(1 - br)^2 + c^2\right]$ and letting t go to infinity, the targeting

regime delivers the same outcome as would be obtained by committing to the optimal simple rule.

3.2.2 Verifiable shock realizations

As Canzoneri (1985) first noted, imperfect information adds to the difficulty of monitoring central bank behavior. Canzoneri focused on the case of private information about the economy. Briault, Haldane, and King (1996), and Beetsma and Jensen (1998) argue that central banks are likely to have private information on their preferences, not on the economy. The implications are similar -- imperfect information generally makes incentive design and monitoring more difficult. When the central bank's private information is on its own forecasts of the underlying disturbances (i.e., as in Canzoneri 1985), then the inability to observe the central bank's forecast does not lead to monitoring difficulties in the present model for one very simple reason. By observing x and p ex post, the public can observe the true disturbance e. Given this ability to infer e, suppose the target is set equal to *?e*.[16] At the time the central bank sets policy, it does not know the true value of e, so the *ex post* target is also unknown. The central bank's actions, though, will depend on its expectation of the target, and this is equal to qe_t^{cb}. So a target set on the basis of the realization of e is equivalent to one set on the basis of the central bank's private information. If either e_t or e_t^{cb} is public information, the optimal policy structure is a strict focus on achieving the state-contingent inflation target.[17]

One finally case desires mention. The analysis in this section has considered targets based on the current cost shock or a forecast of this shock. A pure inflation targeting regime then achieves the same outcomes as would occurred if the central bank were able to commit to the optimal simple rule. This outcome is identical to the outcome in the first period of a fully optimal commitment policy. Woodford (1999), however, has emphasized that in subsequent periods, the fully optimal commitment policy imparts an inertia into policy that is not captured by the optimal simple rule. Woodford describes a policy as optimal from a timeless perspective if the policy implemented in period *t* is the policy that a central bank able to commit would have chosen at some period in the distant past to implement at time *t*. This definition is discussed by McCallum and Nelson (2000) and utilized in Jensen (2002) and Walsh (2002).[18] If one restricts attention to the timeless precommitment policy, the results of this section continue to hold. A pure targeting regime can support the optimal timeless precommitment equilibrium if the target can be based on the inflation shock, but to introduce the optimal degree of inertia, the target inflation rate must depend on both current and past cost shocks. Specifically, assume for simplicity that $e^{cb} = e$. Then one can show that the optimal rate of inflation under the timeless precommitment policy is

$$p_t^{pc} = g p_{t-1}^{pc} + \left(\frac{l}{l(1+b-bg)+d^2} \right)(e_t - e_{t-1}) \equiv p_t^{pc}.$$

where *g* is the solution to *?ßg² - (?+d²+lß)g + l = 0*. Suppose the government can commit to a path for the inflation target p_{t+i}^T for all *i = 0* such that $p_t^T = p_t^{pc}$. Then the central bank operating under discretion implements the optimal timeless precommitment policy if *t ? 8* .

3.3 A general stochastic target

The assumption that underlying disturbances are observed *ex post* is clearly unreasonable; seldom do we know with certainty the sources of economic fluctuations. If either the inflation rate or the output gap is measured with error, *ex post* observations on p and x will not allow the realizations of the underlying shock e to be recovered. In this case, any inflation target is, at best, an imperfect estimate of underlying inflation. Under perfect information, the target would depend on the realizations of e. With imperfect information, the target might still be stochastic and, for example, be based on an estimate of e_t^{cb}.[19]

Let p_t^T be the *ex post* realization of the target. The target must be *ex post* verifiable by the public, and, since the central bank's behavior can only depend on $E^{cb}p^T$, any variation in the target that is unpredictable by the central bank will have no effect on policy choice. Therefore, one can without loss of generality assume that the central bank actually observes p_t^T. Let $x(p_t^T)$, $p(p_t^T)$, and $t(p_t^T)$ denote the output gap, inflation and the target weight for a target p_t^T. The optimal weight for target p_t^T will be denoted $t^*(p_t^T)$.

The central bank's loss function is given by (4). The central bank's first order condition for the minimization of expected loss under discretion is

$$E^{cb}\left[l(x_t - u_t) + d(1+t)p_t - dtp_t^T\right] = 0. \qquad (16)$$

When both u_t and e_t are serially uncorrelated with zero means, there is no average inflation bias. Any stochastic target should therefore also have a zero expected value; this ensures expected inflation is zero. Solving (16) for the output gap,

$$x_t(p_t^T) = \frac{lu_t - d(1+t)e_t^{cb} + dtp_t^T}{l + d^2(1+t)}. \qquad (17)$$

Inflation is then given by

$$p_t\left(p_t^T\right) = \frac{l\,d\,l u_t + l e_t^{cb} + d^2 t p_t^T}{l + d^2(1+t)}. \qquad (18)$$

The institutional design problem is to pick t to minimize expected social loss given by equation (2) when $x = x(p^T)$ and $p = p(p^T)$. The first order condition for this problem implies

$$E\left\{\left[l x\left(p^T\right) + d p\left(p^T\right)\right]\frac{\partial x\left(p^T\right)}{\partial t}\right\} = 0.$$

Proceeding as we did to obtain equation (11) yields

$$E\left[l x\left(p^T\right) + d p\left(o^T\right)\right]\left(\frac{\partial x\left(p^T\right)}{\partial t}\right) = -\left(\frac{l + d^2}{l + d^2(1+t)}\right) E\left(l u - d t z\right)\left(\frac{\partial x\left(p^T\right)}{\partial t}\right)$$

where $z = [?/(?+d^2)]Ee - p^T$ is the difference between the inflation response to the expected inflation shock under commitment to an optimal simple rule and the target p^T. Solving for the optimal target weight reveals that it can be written as[20]

$$t^*(p^T) = \frac{l E\left(u \frac{\partial x}{\partial t}\right)}{d E\left[\left(q E e - p^T\right)\frac{\partial x}{\partial t}\right]} = \left(\frac{l}{d}\right)\left[\frac{d q s_u^2 - Cov\left(u, p^T\right)}{s_z^2 - q d Cov\left(u, p^T\right)}\right]. \qquad (19)$$

The optimal weight to place on achieving the target inflation rate depends positively on the accountability problem represented by s_u^2, and negatively on the variance of the target around the inflation rate under the optimal commitment policy, s_z^2. Since this variance would be minimized if the target were the public's best estimate of the underlying inflation adjustment, greater emphasis should be placed on the target (i.e., t^* increases) if the public is able to improve its estimate of underlying inflation (i.e., policy becomes more transparent).

If the target is correlated with the *u* shock, there are two conflicting effects on the optimal target weight. If $Cov(u_t, p_t^T) > 0$, then the target inflation rate tends to be high just when the central bank faces strong pressures to expand. This means the targeting regime is less effective in preventing *u* shocks from affecting output and inflation, so less weight should be placed on the target. The converse holds if $Cov(u_t, p_t^T) < 0$. This effect operates through the presence of $Cov(u_t, p_t^T)$ in the numerator of (19). However, $Cov(u_t, p_t^T)$ also appears in the denominator of (19) with a negative sign, indicating a positive covariance increases the optimal targeting weight. Note that $s_z^2 - qdCov(u_t, p_t^T) = s_z^2 + qdCov(u_t, z)$. If $Cov(u_t, z) > 0$, then *z* is likely to be positive when *u > 0*, implying that the optimal inflation rate *?e* is above the target rate just when *u* is also positive. Making *t* too large in this case (to dampen the effect of *u*) would also distort output stabilization policy by keeping inflation too stable. It is optimal in this case to have a smaller weight on the target objective.

If $Cov(u_t, p_t^T)$ is positive and large, it is possible that t^* in (19) could be negative and the central bank penalized for hitting its inflation target. This somewhat perverse outcome would only occur if the movement of the target (increasing when *u > 0* and decreasing when *u < 0*) was amplifying the distortion caused by *u*. However, while this possibility cannot be ruled out, it only occurs if the variable chosen as the inflation target increases when the political pressures on the central bank to inflation are highest and decreases when they are smallest.

Equation (19) when $Cov(u_t, p_t^T) = 0$ can be compared to the case of a non-state contingent target. In this latter case, the optimal target weight was given by (8). If the public is able to forecast the central bank's information to any degree, $Var\left(qEe_t - p_t^T\right) < q^2 s_{cb}^2$. Hence, the optimal target weight is larger with a state contingent target. An increase in the ability to monitor what the central bank should have done supports a stricter targeting regime.

A candidate for an inflation target is a publicly verifiable estimate of underlying inflation. Recalling the definition of underlying inflation as $?e^{cb}$, a policy that holds the central bank accountable based on a publicly verifiable forecast of underlying inflation requires that $p_t^T = qE^p e_t^{cb}$, where $E^p e^{cb}$ is the public's estimate of e^{cb} conditional on information available to the central bank at the time policy is set and verifiable *ex post*. Substituting this into the equation for the optimal target weight when $Cov\left(u_t, p_t^T\right) = 0$ yields

$$t^*\left(qE^P e^{cb}\right) = \frac{l s_u^2}{qE\left(e^{cb} - E^p e^{cb}\right)^2} = \frac{\left(l + d^2\right)s_u^2}{s_f^2} \qquad (20)$$

where $f = e^{cb} - E^p e^{cb}$. Note that s_f^2 is the variance of the public's error in estimating the central bank's forecast e^{cb}. The more precisely the central bank's private information can be estimated (or the more credibility the central bank can reveal its information--the more transparent the central bank is), the more high powered the incentive structure should be. Imperfect information about underlying inflation reduces the reliance on inflation targeting (i.e., lowers the optimal value of t). What is relevant, though, is the verifiability or observability of the central bank's information. Greater transparency increases the optimal weight to place on achieving the target.

4. Caution

The preceding model only incorporated additive uncertainty. Recently, a number of authors have introduced multiplicative uncertainty into models of optimal monetary policy (see, for example, Estrella and Mishkin 1999, Rudebusch 2001, Peersman and Smets 1999, Svensson 1999a, Schellekens 1999, and Söderström 2000). Brainard (1967) showed that multiplicative uncertainty can make policy makers more cautious--they react less strongly to disturbances. This is consistent with Alan Blinder's characterization of decision making at the Federal Reserve.[21]

In this section, I examine whether multiplicative uncertainty increases or decreases the role of an inflation target. The model of the previous sections is modified by introducing stochastic fluctuations in the linkage between the output gap and inflation. Under pure discretion, this uncertainty does lead to caution. However, it also increases the optimal weight that should be placed on achieving the inflation target.

Equation (1) is replaced with

$$p_t = bE_t p_{t+1} + d_t x_t + e_t \qquad (21)$$

where d_t is distributed with mean d and variance s_d^2. The actual realization of d_t is determined after the central bank has made its policy choice. To further simplify the model of this section, assume the central bank correctly observes e and that e is serially uncorrelated. Finally, assume there is a non-state contingent target set equal to zero. In this case, the first order condition for the central bank operating under discretion is

$$E^{cb}\left[l(x_t - u_t) + d_t(1+t)p_t \right] = 0. \qquad (22)$$

Using (21), this becomes $E^{cb}\left[l(x_t - u_t) + d_t^2(1+t)x_t + d_t(1+t)e \right] = 0.$ Evaluating expectations,

$$x_t = \frac{\lambda u_t - \delta(1+\tau)\varepsilon_t}{\lambda + (\delta^2 + \sigma_\delta^2)(1+\tau)}$$

and

$$\pi_t = \delta_t\left[\frac{\lambda u_t - \delta(1+\tau)\varepsilon_t}{\lambda + (\delta^2 + \sigma_\delta^2)(1+\tau)}\right] + \varepsilon_t.$$

Parameter uncertainty ($\sigma_\delta^2 > 0$) reduces the effect of u_t on x_t and therefore might be thought to reduce the need to impose a targeting regime on the central bank. However, σ_δ^2 also acts to reduce the impact of an inflation shock on the output gap and increase its impact on inflation. How this should affect the optimal target weight is not clear. The first order condition for the optimal τ^* is given by

$$E\left[(\lambda x_t + \delta_t \pi_t)\frac{\partial x_t}{\partial \tau}\right] = 0.$$

Using (22), this becomes

$$E\left[(\lambda u_t + \delta_t \tau \pi_t)\frac{\partial x_t}{\partial \tau}\right] = 0,$$

so

$$\tau^* = \frac{\lambda E\left(u_t \frac{\partial x_t}{\partial \tau}\right)}{E\left(\delta_t \pi_t \frac{\partial x_t}{\partial \tau}\right)} = \left(1 + \frac{\sigma_\delta^2}{\delta^2}\right)\frac{(\lambda + \delta^2 + \sigma_\delta^2)\sigma_u^2}{\sigma_\varepsilon^2}. \qquad (23)$$

Inspection of (23) shows that the optimal target weight is increasing in σ_δ^2. Uncertainty about the linkage from output to inflation makes policy more cautious. This more cautious policy under discretion reduces the role to be played by monetary policy in stabilizing the economy. As a consequence, it becomes optimal to place more weight on achieving the inflation target. The relative importance of reducing the impact of *u* shocks increases because there is less of a role for stabilization policy.

5. Conclusions

Optimal inflation targeting regimes balance the need to ensure accountability with the ability to monitor. If the central bank has little information about inflation shocks, or if policy is transparent in that the public can verify the central bank's information, more weight should be placed on achieving the target rate of inflation. In the first case because the costs of distorting stabilization policy are small and in the second because the target can be made state contingent. When monitoring is perfect, the optimal targeting regime can replicate the equilibrium that occurs with optimal commitment. In the case of a stochastic inflation target, that is, one whose value depends on random but verifiable variables, the optimal target weight is decreasing in the variance of the target around a measure of “underlying inflation” -- inflation adjusted for cost shocks. One implication of the analysis is that a structure that induces the central bank to truthfully reveal its information, that is, a transparent structure, can support a stricter targeting regime. Multiplicative uncertainty--here modeled as a stochastic effect of the output gap on inflation--leads to more cautious policy as Brainard long ago showed, but it also makes it optimal to hold the central bank more accountable for achieving the target rate of inflation.

References

Alesina, Alberto and Roberta Gatti, "Independent Central Banks: Low Inflation at No Cost?" American Economic Review, 85 (May 1995), 196-200.

Ammer, John and Richard T. Freeman, "Inflation Targeting in the 1990s: The Experiences of New Zealand, Canada and the United Kingdom," Journal of Economics and Business, 47 (May 1995), 165-192.

Baker, George, "Incentive Contracts and Performance Measures," Journal of Political Economy, 100 (June 1992), 598-614.

Ball, Laurence, "Efficient Rules for Monetary Policy," International Finance, 2 (April 1999), 63-83.

Barro, Robert J. and David B. Gordon, "Rules, Discretion, and Reputation in a Model of Monetary Policy," Journal of Monetary Economics, 12 (July 1983), 101-121.

Beetsma, Roel M.W.J. and Henrik Jensen, "Inflation Targets and Contracts with Uncertain Central Bank Preferences," Journal of Money, Credit, and Banking, 30 (Aug. 1998, pt. 1), 384-403.

Bernanke, Ben S., Thomas Lauback, Frederic S. Mishkin, and Adam Posen, Inflation Targeting: Lessons from the International Experience, Princeton: Princeton University Press, 1998.

Bernanke, Ben S. and Frederic S. Mishkin, "Inflation Targeting: A New Framework for Monetary Policy?" Journal of Economic Perspectives, 11 (Spring 1997), 97-116.

Bernanke, B. and Woodford, M.,"Inflation Forecasts and Monetary Policy," Journal of Money, Credit, and Banking, 29 (Nov. 1997, pt. 2), 653-684.

Blinder, Alan, Central Banking in Theory and Practice, Cambridge, MA: The MIT Press, 1998.

Brainard, William, “Uncertainty and the Effectiveness of Policy,” American Economic Review, 57 (May 1967), 411-425.

Briault, Clive, Andrew Haldane, and Mervyn King, “Independence and Accountability,” Institute for Monetary and Economic Studies Discussion Paper 96-E-17, Bank of Japan, March 1996.

Canzoneri, Matthew, “Monetary Policy Games and the Role of Private Information,” American Economic Review, 75 (Sept. 1985), 1056-1070.

Canzoneri, Matthew, Charles Nolan and Anthony Yates, “Mechanism for Achieving Monetary Stability: Inflation Targeting Versus the ERM,” Journal of Money, Credit and Banking, 29 (Feb. 1997), 46-60.

Clarida, Richard, Jordi Galí, and Mark Gertler, “The Science of Monetary Policy: A New Keynesian Perspective,” Journal of Economic Literature, 37 (Dec. 1999), 1661-1707.

Cukierman, Alex, “Accountability, Credibility, Transparency and Stabilization Policy in the Eurosystem,” Jan. 2000.

Dennis, Richard, “Pre-commitment, the Timeless Perspective, and Policymaking From Behind a Veil of Uncertainty,” August 2001.

Dixit, Avinash, “A Repeated Game Model of Monetary Union,” The Economic Journal, 110 (Oct. 2000), 759-780.

Eijffinger, Sylvester C.W., Marco Hoeberichts, and Eric Schaling, "Optimal Conservativeness in the Rogoff (1985) Model: A Graphical and Closed-Form Solution," CentER Discussion Paper No. 95121, Dec. 1995.

Estrella, Arturo and Frederic S. Mishkin "Rethinking the Role of NAIRU in Monetary Policy: Implications of Model Formulation and Uncertainty," in John B. Taylor (ed.) Monetary Policy Rules, Chicago: University of Chicago Press, 1999, 405-430

Faust, Jon and Lars E.O. Svensson, "Transparency and Credibility: Monetary Policy with Unobservable Goals," International Economic Review 42 (May 2000), 369-397 (a).

Faust, Jon and Lars E.O. Svensson, "The Equilibrium Degree of Transparency and Control in Monetary Policy," NBER Working Paper No. 7152, May 2000, Journal of Money, Credit, and Banking, forthcoming, (b).

Galí, Jordi and Mark Gertler, "Inflation Dynamics: A Structural Econometric Analysis," Journal of Monetary Economics, 44 (Oct. 1999), 195-222.

Goodhart, Charles A.E., "What Should Central Banks Do? What Should Be Their Macroeconomic Objectives and Operations?" The Economic Journal, 104 (Nov. 1994), 1424-1436.

Haldane, Andrew G., "Some Issues in Inflation Targeting," Bank of England Working Paper 97-74, Dec. 1997.

Herrendorf, Berthold and Ben Lockwood, "Rogoff's 'Conservative' Central Banker Restored," Journal of Money, Credit, and Banking, 29 (Nov. 1997, pt. 1), 476-495.

Jensen, Henrik, "Targeting Nominal Income Growth or Inflation?" American Economic Review, forthcoming, (2002).

King, Mervyn, "The Inflation Target Five Years On," Bank of England Quarterly Bulletin, 37 (1997), 434-442.

Leiderman, Leo and Lars E.O. Svensson, editors, Inflation Targets, London: CEPR, 1995.

Lohmann, Susanne, "Optimal Commitment in Monetary Policy: Credibility versus Flexibility," American Economic Review, 82 (March 1992), 273-286.

McCallum, Bennett T., "Inflation Targeting in Canada, New Zealand, Sweden, the United Kingdom, and in General," NBER Working Paper No. 5579, Feb. 1998.

McCallum, Bennett T. and Edward Nelson, "An Optimizing IS-LM Specification for Monetary Policy and Business Cycle Analysis," Journal of Money, Credit, and Banking 31 (August 1999), 296-316.

Muscatelli, Anton, "Optimal Inflation Contracts and Inflation Targets with Uncertain Central Bank Preferences: Accountability through Independence," The Economic Journal 108 (March 1998), 529-542.

Nolan, Charles and Eric Schaling, "Monetary Policy Uncertainty and Central Bank Accountability," Bank of England Working Paper, No. 54, 1997.

Peersman, Gert and Frank Smets, "The Taylor Rule: A Useful Monetary Policy Benchmark for the Euro Area?" International Finance 2 (April 1999), 85-116.

Persson, Torsten and Guido Tabellini, "Designing Institutions for Monetary Stability," Carnegie-Rochester Conference Series on Public Policy 39 (Dec. 1993), 53-84.

Rogoff, Kenneth, "The Optimal Degree of Commitment to an Intermediate Monetary Target," Quarterly Journal of Economics 100 (Nov. 1985), 1169-1189.

Rudebusch, Glenn D., "Is the Fed Too Timid? Monetary Policy in an Uncertain World," Federal Reserve Bank of San Francisco, June 2000, Review of Economics and Statistics, forthcoming.

Ruge-Mucia, Francisco J., "Inflation Targeting under Asymmetric Preferences," University of Montreal, Jan. 2002.

Schaling, Eric, "Inflation Targeting and Performance Incentive Contracts under Uncertainty," Bank of England, Feb. 1997.

Schellekens, Phillip, "Caution and Conservatism in the Making of Monetary Policy," London School of Economics: Financial Markets Group Discussion Paper 284 (1998).

Söderström, Ulf, "Monetary Policy with Uncertain Parameters," European Central Bank Working Paper 13, March 2000, Scandinavian Journal of Economics forthcoming.

Svensson, Lars E.O., "Optimal Inflation Targets, 'Conservative' Central Banks, and Linear Inflation Contracts," American Economic Review 87 (March 1997), 98-114 (a).

Svensson, Lars E.O., "Inflation Forecast Targeting: Implementing and Monitoring Inflation Targets," European Economic Review 41 (June 1997), 1111-1146 (b).

Svensson, Lars E.O., "Inflation Targeting: Some Extensions," Scandinavian Journal of Economics 101 (1999), 337-361.

Svensson, Lars E.O., "Open Economy Inflation Targeting," Journal of International Economics 50 (Feb. 2000), 155-183.

Svensson, Lars E.O., "Inflation Targeting as a Monetary Policy Rule," Journal of Monetary Economics 43 (June 1999), 607-654.

Svensson, Lars E. O. and Michael Woodford, "Implementing Optimal Policy Through Inflation-Forecast Targeting," 1999.

Waller, Christopher J. and Carl E. Walsh, "Central Bank Independence, Economic Behavior and Optimal Term Lengths," American Economic Review 86 (Dec. 1996), 1139-1153.

Walsh, Carl E., "Optimal Contracts for Central Bankers," American Economic Review 85 (March 1995), 150-167 (a).

Walsh, Carl E., "Recent Central Bank Reforms and the Role of Price Stability as the Sole Objective of Monetary Policy," in B. Bernanke and J. Rotemberg (eds.), NBER Macroeconomics Annual, Cambridge, MA: The MIT Press, 1995, 237-252 (b).

Walsh, Carl E., "Is New Zealand's Reserve Bank Act of 1989 an Optimal Central Bank Contract?" Journal of Money, Credit and Banking 27 (Nov. 1995, Part 1), 1179-1191 (c).

Walsh, Carl E., "Announcements, Inflation Targeting, and Central Bank Incentives," Economica 66 (May 1999), 255-269.

Walsh, Carl E., "Speed Limit Policies: The Output Gap and Optimal Monetary Policy," CESifo Working Paper No. 609, Nov. 2001.

Woodford, Michael, "Optimal Policy Inertia," NBER Working Paper 7261, Aug. 1999a.

Woolley, John T., "Nixon, Burns, 1972, and Independence in Practice," UC Santa Barbara, May 1995.

Footnotes

[1] These cases, and other, have been discussed by Ammer and Freeman (1995), McCallum (1998), Bernanke and Mishkin (1997), Bernanke, Laubach, Mishkin, and Posen (1998), and the papers in Leiderman and Svensson (1995).

[2] Muscatelli (1998) and Walsh (1999) analyze situations in which the central bank announces the target inflation rate. Announcements can convey information and reduce the stabilization distortions otherwise introduced by a targeting requirement.

[3] Senate bill S.2807 in the 97th Congress called for annual targets, while H.R. 7218 required monthly targets. H.R. 6967 required that the Fed establish targets for long-term interest rates.

[4] Faust and Svensson (2000a, 2000b) also model central bank preference uncertainty in this manner, and they interpret transparency in terms of the public's ability to learn about serially correlated shifts in the employment target. Dixit (2001) also incorporates stochastic shifts in the desire for expansions; however he does not include a role for stabilization.

[5] The effects on inflation of any non-zero mean for u (the source of the standard inflation bias in the Barro-Gordon model) can be offset through a suitable adjustment of the inflation target (Svensson 1997a). Therefore, it is convenient to set the mean of u equal to zero.

[6] Cukierman (2000) show that if the central bank's preferences are asymmetric, placing more weight on avoiding recessions (negative output gaps) than preventing booms (positive output gaps), a positive average inflation bias reappears. Ruge-Murcia (2002) shows that a deflationary bias can arise if the central bank is more concerned about preventing inflation from overshooting its target than it is with undershooting the target.

[7] See Jensen (2002), Vestin (2000), and Walsh (2001). Dennis (2001) argues that Woodford's timeless precommitment policy is not unique.

[8] Models with stochastic inflation biases include Canzoneri, Nolan, and Yates (1997), Herrendorf and Lockwood (1997), and Walsh (1995c), although these models include a positive mean inflation bias as well.

[9] If e^{cb} is an efficient forecast of e, we can write $e = e^{cb} + v$ where $E(e^{cb}, v) = 0$. Hence, $s_e^2 = s_{cb}^2 + s_v^2$, where s_{cb}^2 is the variance of e^{cb}.

[10] The standard treatment of the optimal degree of central bank conservatism leads to a fourth degree polynomial in the targeting weight t. For a solution to this polynomial, see Eijffinger, Hoeberichts and Schaling (1995). Beetsma and Jensen (1998) study optimal inflation contracts when the central bank's output goal is stochastic (as is the case here) and derive an expression equivalent to equation (8) when the central bank observes e perfectly. In their model, the average inflation bias is eliminated through an inflation contract (Walsh 1995a). Their interpretation, thought, is in terms of a Rogoff conservative central banker, and they do not draw the parallel with incentive systems, monitoring, and accountability that are the focus here.

[11] Details are contained in an appendix available from the author.

[12] When the cost shock is serially correlated, equation (11) becomes

$$t = \left[\frac{l(1-br)+d^2(1+t)}{l+d^2(1+t)}\right]\left[\frac{(l+d^2)E\left(u\frac{\partial x}{\partial t}\right)}{dE\left(e^{cb}\frac{\partial x}{\partial t}\right)}\right].$$

[13] Persson and Tabellini (1993) apply Baker's analysis in the context of a modified Barro-Gordon model.

[14] See Clarida, Galí, and Gertler (1999), Svennson and Woodford (1999) and the discussion of commitment policies by Dennis (2001).

[15] Muscatelli (1998) and Walsh (1999) show that a similar result is obtained when the central bank itself announces the inflation target.

[16] Since the target is announced before *e* is observed, the government announces a menu of targets; the specific value of the inflation target is determined *ex post* upon observing *e*.

[17] With the public observing both output and inflation and using those observations to infer *e*, a target based on *e* is also interpretable as a target that is adjusted to both inflation and output gap realizations.

[18] When the central bank is able to precommit, its problem is to minimize

$$E_t \sum_{i=0}^{\infty} b^i \left[\left(l x_{t+i}^2 + p_{t+i}^2 \right) + 2y_{t+i} \left(p_{t+i} - b p_{t+i+1} - d x_{t+i} - e_{t+i} \right) \right].$$

The first order conditions for this problem are $p_t + (l/d)x_t = 0$ for $i = 0$ and $E_t\left[p_{t+i} + (l/d)(x_{t+i} - x_{t+i-1})\right] = 0$ for $i > 0$. A time-inconsistency problem arises because the first order condition for p_t differs from the first order conditions for p_{t+i} for all $i > 0$. Under the timeless perspective, the period *t* first order condition for inflation is ignored and inflation and output are assumed to be determined by the first order condition for $i = 1$ and the inflation adjustment equation.

[19] That is, the targeting regime establishes a variable to serve as the target but the actual realization of the target is random.

[20] Equation (8) is a special case of (19) with $p^T = 0$ since in this case, (19) becomes

$t^*(0) = lqs_u^2 / q^2 s_{cb}^2 = (l + d^2) s_u^2 / s_{cb}^2$ when it is recalled that *? = ?/(?+d²)*.

[21] General parameter uncertainty need not always produce caution. For example, Söderström (2000) shows that if the policy maker is uncertain about model dynamics, it may pay to react more aggressively to shocks.