Econ. Gov. (2002) ♣ 037

Economics of Governance

When should central bankers be fired?

Carl E. Walsh[*]

Department of Economics, SS1, University of California, Santa Cruz, CA 95060, USA
(831) 459-4082 (e-mail: walshc@cats.ucsc.edu.)

Received: March 26, 1999 / Accepted: September 20, 2001

Abstract. In recent years, a number of countries have changed their central banking institutions. Often these reforms involve granting long terms of office to central bankers. This threatens to limit the extent to which the central bank can be held accountability. Dismissal rules can help ensure accountability, and, in the presence of inflation shocks, the socially optimal commitment policy is supported by a dismissal rule similar to a modified nominal income rule. The government's promise to follow the rule is shown to be credible in a trigger strategy equilibrium for reasonable parameter values.

Key words: Central bank accountability, monetary policy, stabilization policy

JEL Classification: E42, E52, E58

1. Introduction

Beginning with the 1989 central banking reforms in New Zealand, many countries have rewritten their central banking legislation to establish explicit goals of price stability and provide insulation from political influences. These moves are very clear in the structure of the European Central Bank (ECB), whose directors are charged with maintaining price stability, forbidden to take instructions from member governments, and given long, nonrenewable terms of office (8 years) to further distance them from political pressures. However, as emphasized by the title of the Roll (1994) report outlining "a new mandate for the Bank of England," autonomy must be tempered by accountability.

[*] I would like to thank Henrik Jensen, the editor, and the referees for helpful comments, and Wei Chen for research assistance.

The problem of enforcing accountability has received relatively little attention in the literature on monetary policy. One influential view, exemplified by Blinder (1998), McCallum (1995), and Vickers (1998), is that accountability is not an issue. Central bankers, according to this view, strive to do the right thing and are able to avoid the inflation bias that was highlighted in the literature on the time inconsistency problem (Kydland and Prescott 1977, Barro and Gordon 1983). An alternative view is that whenever governments delegate important powers, such as control over monetary policy, they must also be able to assess the performance of the agent. Part of the debate over transparency in monetary policy can be viewed as stressing its role in ensuring accountability by allowing the central bank's actions to be monitored (Walsh 2000, Cukierman 2000).

This paper analyzes how dismissal contracts can ensure accountability when an instrument independent central bank conducts discretionary monetary policy. Following the literature on discretionary monetary policy (see Walsh 1998, Chap. 8 for a survey), it is assumed that the government desires, ex-ante, to commit to the socially optimal inflation rate. However, at this inflation rate, the marginal benefit of a temporary expansion of output exceeds the marginal cost of inflation. The public will expect the government to yield to the resulting temptation, and the government can do no better than to deliver the expected inflation. Delegating control of monetary policy to an independent central bank who shares the government's preferences over employment and inflation does not solve the problem; such a central bank faces the same incentive to inflate as the government. To sustain the optimal commitment policy, the incentives facing the central bank must be changed.

One means of doing so is to tie the central banker's reappointment to actual inflation outcomes. The threat of dismissal then affects the conduct of policy. New Zealand's Reserve Bank Act of 1989 has been analyzed as a form of dismissal rule (Walsh 1995), and Meltzer (1981) had earlier suggested a similar mechanism for the Federal Reserve. However, Walsh (1995c) concludes that dismissal rules that achieve the optimal policy may not always exist and that, in the presence of supply shocks, any dismissal rule would need to be contingent on the underlying shock. Such a dismissal rule would be difficult to implement.

This paper extends that previous analysis in several ways. First, I show that an optimal dismissal rule always exists. This result holds even when the presence of hidden information prevents specifying a complete state contingent rule against which the central bank's actions can be judged. Second, I derive the steady-state properties of the expected length in office and the value of holding office. This treatment of term length differs from that in Waller and Walsh (1996). There, the term length was deterministic and chosen optimally in the institutional design stage. The optimal term length balanced the need to avoid Alesina-type election effects on monetary policy against the need to ensure the central bank's inflation preferences responded to shifts in the public's preferences. Here, term length is stochastic, depending on economic outcomes, and dismissal arises from the need to monitor the central bank's actions. Election effects are absent and the central bank shares the public's preferences for trading off fluctuations in inflation and output. The resulting relationship between inflation and term length is consistent with empirical evidence on central bank turnover and average inflation, but for reasons that differ significantly from those usually stressed. For example, Cukierman (1992) argues that low turnover is a measure of high central bank independence, and this independence leads to low inflation. In the model analyzed in the present paper, a central banker who produces low inflation is reappointed, so low inflation *causes* low turnover.

Third, I show that a type of modified nominal income targeting rule similar to one originally proposed by Taylor (1985) provides the optimal benchmark for accountability in the presence of supply shocks and private central bank information.

Lastly, I show that the government's promise to dismiss the central bank is credible, at least for reasonable values of the model's parameters. The public can more easily observe whether the government has carried out its dismissal threat than whether the central bank has implemented the optimal policy. If the government loses its credibility whenever it fails to dismiss the central banker after an occurrence of excessive inflation, the expected cost of failing to implement the dismissal rule is shown to exceed the expected gain from cheating except when the government places little weight on future outcomes, the social weight on output stability is very small, or the output elasticity of inflation is very large. For parameters in the range found in the empirical literature and used in other calibration exercises, the dismissal rule is credible.

Some economists, including those with direct policy making experience such as Alan Blinder, have argued that the overly ambitious output goal that is the traditional source of an inflation bias in the Barro–Gordon (1983) framework is not relevant for understanding central bank behavior. Central bankers, it is held, have learned from this literature, and they now define any output objectives in terms of the output gap–the difference between actual output and the economy's flexible price equilibrium level of output. As articulated by Svensson, "....there is considerable agreement among academics and central bankers that the appropriate loss function both involves stabilizing inflation around an inflation target and stabilizing the real economy, represented by the output gap" (Svensson 1999). Such a loss function forms a key component of "The Science of Monetary Policy" (Clarida, Galí, and Gertler 1999), and Woodford (1999a) has shown how it can be derived as an approximation to the utility of the representative agent.

The success of most developed economies in reducing inflation rates and sustaining low inflation over the past few years has served to booster the view that central bankers can avoid the inflation bias. As Cukierman (2000) shows, however, an average inflation bias may still arise, even with a strict focus on the output gap, if policy makers prefer output expansions to contractions for a given rate of inflation. And, as Fig. 1 suggests, developing economies still suffer from significant inflation. Thus, it is of interest to examine how specific institutional arrangements might contribute to achieving and maintaining low rates of inflation.

The remainder of the paper is organized as follows. Section 2 reviews the related literature. Section 3 sets out the basic framework. The central bank's objective involves stabilizing the output gap and inflation, but it is assumed that when the output gap is zero and inflation is on target, there is still a positive marginal gain from an economic expansion. Given these preferences, both the optimal commitment policy and the policy that would arise under complete discretion are derived. Section

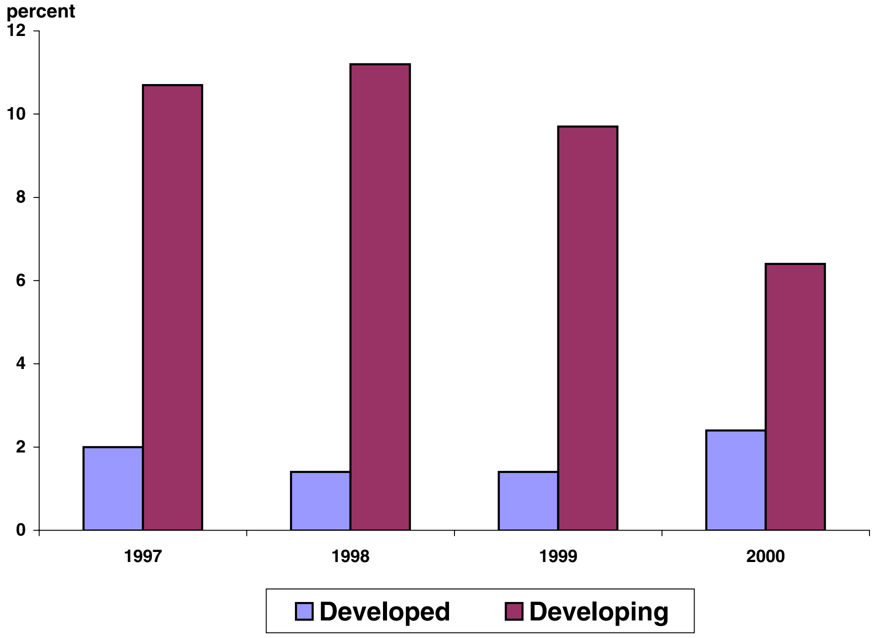

Fig. 1. Consumer price inflation in developed and developing economies (Source: IMF International Financial Statistics, March 2001)

4 then examines the central banker's optimal behavior when she is subject to a dismissal rule. The conditions under which a dismissal rule can implement the socially optimal commitment policy are then derived. In the presence of inflation shocks, the optimal commitment policy can be achieved, but the dismissal rule must depend on actual inflation and output. Section 5 shows how the dismissal contract is affected when the output gap is measured with error. Section 6 derives conditions that ensure the government's commitment to implement the dismissal rule is credible. Conclusions are contained in Sect. 7.

2. Related literature

Appointment and reappointment procedures for central bankers significantly affect the conduct of policy. Chappell, Havrilesky, and McGregor (1993) find that policy votes by members of the Federal Reserve Board of Governors are affected by the President by whom they were appointed. Cukierman, Webb and Neyapti (1992) show that average inflation in developing countries is correlated with the turnover rate of central bank governors, with more rapid turnover associated with higher inflation. They interpret lower rates of turnover as evidence of central bank independence from political pressures. And central banking reforms such as those that grew out of the Maastricht Treaty emphasized the need for long terms of appointment to reduce the degree of political influence on monetary policy.

The manner in which the reappointment process can be used to affect policy, however, has received little formal attention. Fratianni, von Hagen and Waller (1997) assume that a positive inflation bias arises from the desire of the central banker to please the government and thereby gain reappointment. Not surprisingly, the bias is eliminated if the central banker is barred from being reappointed. When policy biases arise from other sources as well, the central banker's desire to be reappointed can make him accountable. This is the role reappointment plays in O'Flaherty (1990). However, he assumes society is able to specify completely a state contingent rule for the central bank to follow. This ignores the informational problems that give rise to a specialized monetary authority in the first place.

Minford (1995) shows that the socially optimal policy can be achieved if the electorate punishes the policy maker whenever policy responds to anything other than "news." Since the optimal policy only involves responding to news, Minford's punishment strategy does not restrict the flexibility of the central banker to respond appropriately to economic disturbances, but it does eliminate any systematic inflation bias. However, if the central bank has private information, as in Canzoneri (1985), voters may not be able to implement their punishment strategy even if they are able, ex post, to observe all the shock realizations. And elections seldom revolve solely as a judgement on the monetary policy actions of the government.

Rogoff (1985) suggests that governments might appoint "conservatives" to head the central bank. Conservative central bankers, defined as those who place greater weight than society on inflation stability, generate a smaller inflation bias but impose a cost by distorting the response of policy to aggregate supply shocks. Lohmann (1992) shows that the government can do better by appointing a conservative but then overriding the central bank if supply shocks are "too large". In effect, the central banker is dismissed in the face of large economic disturbances.

Svensson (1997) has shown how the optimal central bank contract designed to get the central banker's incentives "right" (Persson and Tabellini 1993, Walsh 1995a) is equivalent to an inflation targeting regime. In this case, the government assigns the inflation target. By making the target public, such a regime, like an exchange rate regime, is "transparent," and can support reputational equilibria with low inflation (Herrendorf 1998, al-Nowaihi and Levine 1996). Left unclear in much of this literature, however, is what the consequences are for the central bank if it misses its target.

The present paper studies how the possibility of dismissal affects the conduct of policy. To do so, I abstract from the reappointment process as a means of shifting political preferences (Waller 1992, Chappell et al 1993, Fratianni, von Hagen and Waller 1997, Waller and Walsh 1996) to concentrate on the effect of reappointment on the incentives faced by the central bank and the trade-off between inflation bias and optimal stabilization.

3. The basic model and policy under commitment and under discretion

The description of the economy is deliberately kept simple, consisting of an inflation adjustment equation and an aggregate spending relationship linking output to the real interest rate. The nominal interest rate is treated as the central bank's policy instrument.

Inflation is governed by an expectational Phillips curve of the form

$$\pi_t = \pi_t^e + ax_t + e_t, \tag{1}$$

where π is inflation, π^e is the inflation rate expected by the public, x is the output gap (actual output minus the flexible price equilibrium level of output), and the inflation shock e is taken to be a white noise process.[1] The output gap depends on the real interest rate:

$$x_t = -b\left[i_t - \pi_{t+1}^e\right] + v_t, \tag{2}$$

where i is the nominal interest rate and v is a demand shock.

Governments (Congress, the administration) often have difficulty determining exactly what the central bank knows or what it is doing. Thus, both hidden action (the government cannot verify the central bank's exact policy stance) and hidden information (the central bank's forecasts are unverifiable, private information) are important for the analysis of monetary policy, as the academic debates over measuring monetary policy and the public debate in the U.S. over the release of FOMC minutes illustrates. In the analysis of this paper, I focus on the role of hidden information by following Canzoneri (1985), Garfinkel and Oh (1993) and others in assuming that the central bank has private, unverifiable forecasts v^f of the demand shock and e^f of the inflation shock. This means that the government cannot simply specify a complete state-contingent policy rule (i.e. a value of i for every possible realization of v^f and e^f) and fire the central banker if she deviates from this rule. The central bank is able to condition its policy response on v^f and e^f, but because the government (and the public ex-post) is able to observe only i, x and π, the central bank's forecasts are unverifiable. In addition, in Sect. 5, I will assume the government only observes a noisy indicator of x.

The government aims to minimize the present discounted value of a social loss function that depends on the output gap and inflation. The per-period loss is given by

$$S_t = -\lambda_1 x_t + \frac{1}{2}\lambda_2 x_t^2 + \frac{1}{2}\left(\pi_t - \pi^S\right)^2, \tag{3}$$

where π^S is the socially optimal rate of inflation. The second two terms in this loss function represent the standard quadratic specification widely used in the literature. Unlike the approach in the earlier Barro-Gordon literature, the central bank is concerned with fluctuations of the output gap and not with fluctuations of output around a target value that exceeds the economy's equilibrium output level. The linear term in the output gap, $-\lambda_1 x$, captures the asymmetric pressures policy makers typically face in that "In most situations, the CB will take far more political heat when it

[1] Rudebusch and Svensson (1999) replace expected inflation with lagged inflation to yield a backward looking Phillips curve. New Keynesian specifications lead to the expectation of future inflation appearing in the inflation equation (for example, see Clarida, Galí, and Gertler 1999). For the general points made in this paper, the simpler formulation given in (1) is adequate.

tightens preemptively to avoid higher inflation than when it eases preemptively to avoid high unemployment" (Blinder 1998, pp. 19-20). As Cukierman (2000, p. 17) expresses it, "But it is hard to see why central bankers, social planners or political authorities would consider, *given inflation*, a positive output gap of a given magnitude to be equivalent to a negative output gap of the same magnitude" (emphasis in original). According to (3), if $\pi = \pi^S$, an output gap of 1% is preferred to a gap of -1%.

The optimal commitment policy is the solution to the sequence of single period decision problems of a policy maker whose objective is to minimize the expectation of (3), conditional on the forecast of v and e, and subject to the requirement that the public's expectations be rational, given the assumed information structure and the policy maker's actions. The solution to this problem is an optimal reaction function under commitment, $i^c(v^f, e^f)$, specifying the setting of i as a function of the velocity forecast v^f and e^f. It can be shown that the optimal commitment policy is

$$i_t^c(e_t^f, v_t^f) = \pi^S + \left(\frac{1}{b}\right)\left[\left(\frac{a}{\lambda_2 + a^2}\right)e_t^f + v_t^f\right]. \tag{4}$$

Under this policy, the output gap is

$$x_t^c = -\left(\frac{a}{\lambda_2 + a^2}\right)e_t^f + (v_t - v_t^f), \tag{5}$$

while inflation equals

$$\pi_t^c = \pi^S + \left(\frac{\lambda_2}{\lambda_2 + a^2}\right)e_t^f + a(v_t - v^f) + (e_t - e_t^f). \tag{6}$$

It is not optimal to insulate inflation fully from the central bank's forecast of the inflation shock but to offset partially the expected effect on output. The optimal policy always involves offsetting v^f fully so that it affects neither x nor π.

This policy is not time consistent. Once expectations have been formed on the basis of the policy rule (4), it is no longer optimal for the central bank to follow (4). The time-consistent policy under discretion, obtained by minimizing (3) conditional on the central bank's forecasts and taking π^e as given, is

$$i_t^d(e_t^f, v_t^f) = \pi^S + \left(\frac{\lambda_1}{a}\right) + \left(\frac{1}{b}\right)\left[\left(\frac{a}{\lambda_2 + a^2}\right)e_t^f + v_t^f\right]. \tag{7}$$

Under the optimal discretionary policy, output is equal to

$$x_t^d = -\left(\frac{a}{\lambda_2 + a^2}\right)e_t^f + (v_t - v_t^f) = x_t^c,$$

and inflation is

$$\pi_t^d = \pi^S + \left(\frac{\lambda_1}{a}\right) + \left(\frac{\lambda_2}{\lambda_2 + a^2}\right)e_t^f + a(v_t - v_t^f) + (e_t - e_t^f) > \pi_t^c\ .$$

The optimal policy under discretion includes an inflation bias that is positive on average and equal to λ_1/a.[2] Comparing i^c in Eq. (4) with i^d in Eq. (7) reveals that, despite the presence of the inflation bias, discretionary policy responds optimally to the information contained in the velocity and supply shock forecasts.

In the subsequent analysis, it will prove convenient to view the central bank as choosing planned levels of the output gap and inflation, denoted x^p and π^p. Under pure discretion, $x^p = -\left[a/(\lambda_2 + a^2)\right] e^f$ and $\pi^p = \pi^S + (\lambda_1/a) + \left[\lambda_2/(\lambda_2 + a^2)\right] e^f$.

4. Discretion with reappointment

Assume the government can draw from a pool of identical agents to head the central bank. The government offers a central bank candidate an employment contract on a take it or leave it basis. The contract pays the central banker a fixed wage (and assume the wage is set to ensure she will accept the contract, i.e the individual rationality constraint is satisfied) and grants the central banker complete discretion to conduct monetary policy. In a model without inflation shocks, Walsh (1995c) considers a contract that also specifies a constant rate of inflation π^* such that the central banker is fired whenever inflation exceeds π^*. Since the government is indifferent among central bankers, the threat to fire is credible. In the absence of inflation shocks, there will exist a π^* that induces the central banker to follow the optimal policy given in (4).

When inflation shocks are present, however, a simple dismissal rule based on a fixed π^* cannot support the optimal commitment policy because the optimal inflation rate is state contingent (see Eq. 6). If the central bank forecasts a positive inflation shock, for example, optimal inflation rises above π^S. Without a corresponding increase in π^*, the central bank will not let inflation rise sufficiently, since doing so would make reappointment less likely. Allowing π^* to be a function of e^f or even e could resolve this problem, but e^f is the unverifiable private information of the central bank and defining the dismissal rule ex post on the basis of the realizations of e ignores the difficulty of implementing policy rules that require identifying the true underlying economic disturbances. If the government could adjust π^* after observing e, then the government will essentially be setting π^* contingent on both e and π^e, since expectations are set prior to e being realized. At that point, the government's loss function is minimized if the central bank follows the discretionary outcome. That is, once expectations are set and the government observes e, (4) is no longer optimal from the government's perspective; the time inconsistency problem reappears (McCallum 1995).

While firing the central banker whenever inflation exceeds a constant critical rate is not optimal when inflation shocks can occur, there are dismissal rules that can support the optimal commitment policy. Consider a dismissal rule that specifies

[2] Most estimates of the output elasticity of inflation imply that a is quite small. Hence, the average inflation bias can be quite large even if the weight placed on economic expansions, λ_1, is itself fairly small.

a dismissal rate $\pi^*(x)$ as a linear function of the realized output gap:

$$\pi^*(x) = \beta_0 - \beta_1 x, \tag{8}$$

where β_0 and β_1 are constants to be chosen by the government. That is, the central banker is fired whenever $\pi > \pi^*(x) = \beta_0 - \beta_1 x$. Alternatively expressed, dismissal occurs if $\pi + \beta_1 x > \beta_0$.

This dismissal rule can be interpreted as a type of modified nominal income target. Let y denote actual (log) output and $\bar{y}$ (log) potential output. Nominal income is $p + y$, where p is the log price level. Under a policy of targeting nominal income, the nominal income target for period t would depend on potential output and the period $t-1$ price level adjusted for the socially optimal inflation rate: $p_{t-1} + \pi^S + \bar{y}$. The deviation of nominal income from this target is then equal to

$$(p_t + y_t) - \left(p_{t-1} + \pi^S + \bar{y}\right) = \pi_t + x_t - \pi^S.$$

A dismissal rule based on nominal income would involve firing the central banker whenever the deviation from target, $\pi_t + x_t - \pi^S$, exceeded a critical value, say z, or, equivalently, whenever $\pi_t > z + \pi^S - x_t$. The dismissal rule given by (8) is equivalent to such a nominal income rule if $\beta_0 = z + \pi^S$ and $\beta_1 = 1$. When $\beta_1 \neq 1$, (8) is similar to the modified nominal income targeting rule proposed by Taylor (1985). If the deviation of this modified nominal income measure from target exceeds β_0, the central banker is dismissed.

The dismissal rule has the property that the government chooses a set of fixed parameters before the start of the game; reappointment is then based on observed outcomes. The government sets β_0 and β_1 to minimize the expectation of the cost function (3), subject to the constraint that the public's expectations be consistent with the central bank's choice of i and the assumed information structure. The commitment to a choice of β_0 and β_1 is credible since the government is no worse off by carrying through with the threat to fire if $\pi + \beta_1 x > \beta_0$.[3]

To derive the optimal dismissal rule (the values of β_0 and β_1), however, we need to examine the central bank's decision problem.

4.1. The central banker's decision problem

The possibility of reappointment will only affect the conduct of monetary policy if the central banker values holding office. Following Fratianni, von Hagen and Waller (1997), assume that the central banker cares about social costs as given in (3) and about being in office. Thus, the period t utility of the central banker is equal to $V - cS_t$ where $V > 0$ is the direct per period utility from holding office, S_t is given by (3) and $c > 0$ is a constant. The role of the parameter c is to convert S into units comparable to V (see Dixit and Jensen 2000). V could include the direct

[3] The issue of credibility is addressed more fully in Sect. 6.

salary payment to the central bank (assumed to be fixed), as well as the utility derived from the perks of holding office, the ability to exercise power, etc.[4]

If there is no limit to the number of periods the central banker can potentially serve, the expected present value of the direct utility from holding office at time t, U_t, satisfies

$$U_t = V + \rho\theta_t U_{t+1}, \tag{9}$$

where $0 < \rho < 1$ is a subjective discount factor and θ_t is the period t probability of reappointment, equal to the probability that $\pi \leq \pi^*(x)$. Since the central banker bears the social welfare cost represented by (3) whether in office or not, expected total utility from holding office at time t is equal to

$$U_t - c\sum_{i=0}^{\infty} \rho^i \mathrm{E}^{CB}(S_{t+i}),$$

where $\mathrm{E}^{CB}(.)$ denotes the expectation taken with respect to the central banker's time t information set.[5]

Because of the structure of the model, the central banker's problem is equivalent to a sequence of single-period decision problems that involve choosing the nominal interest rate in period t to maximize $V - \mathrm{E}^{CB}\left[c(S_t) - \rho\theta_t U_{t+1}\right]$. Noting that U_{t+1} does not depend on any time t decisions, the central banker's time t problem is equivalent to that of maximizing

$$W_t = V - c\left[\mathrm{E}^{CB}(S_t) - \rho\theta_t \bar{U}\right], \tag{10}$$

where $\bar{U} = U_{t+1}/c$.[6]

---

[4] This specification of the central banker's objective function presumes that, at the margin, the central banker would consider trading off a tiny bit more inflation for some sufficiently large change in the perks of office. Since we are quite accustom to thinking of elected politicians as responding to personal incentives, it does not seem unreasonable to assume central bankers might do the same. For example, chairmen of the Federal Reserve Board are often viewed as (subtly) lobbying for reappointment. And Richard Nixon clearly thought Arthur Burns would adjust monetary policy in response to changes in V when Burns was Chairman of the Fed; Nixon stopped inviting Burns to White House state dinners in 1972 when the growth rate of money fell (Woolley 1995). Blinder (1998) notes that a dismissed central banker would "suffer a huge pay increase!", but since the individual had chosen to serve as a central banker, one must infer that the pecuniary plus non-pecuniary returns to being a central banker exceed those associated with private employment, even if the pecuniary returns in the private sector are higher. Thus, dismissal does make the individual worse off, even if it raises her salary!

[5] Once out of office, the (former) central banker still cares about the social loss but her strategy changes. Private individuals choose π^e taking all aggregate variables as given. If the central banker cares about S only while in office, as suggested by a referee, the value of being in office satisfies the recursive relationship

$$U_t = V - cS_t + \rho\theta_t U_{t+1},$$

The basic results of the paper continue to hold with this alternative specification.

[6] As discussed below, in a steady state with θ constant, Eq. (9) implies that $\bar{U} = V/c(1-\rho\theta)$. However, in choosing policy at time t, U_{t+1} is unaffected by the central banker's time t decisions. The time t choice affects current output, inflation, and θ_t, the probability of continuing in office. With the alternative specification of footnote 5, the steady-state value of $\bar{U}$ is $[V - c\bar{S}]/c(1-\rho\theta)$, where $\bar{S}$ is the steady-state value of S.

The central bank is assumed to act with discretion, taking as given the public's expectations of inflation. To find the optimal discretionary policy, it is necessary to evaluate θ_t, the probability of reappointment, in terms of the central bank's decision variable. Reappoint occurs if inflation is less than $\pi^*(x_t)$. Using (1) and (8), the probability of reappointment is equal to $\Pr\left[\pi_t^e + ax_t + e_t \leq \beta_0 - \beta_1 x_t\right]$, or

$$\theta_t = F\left[\beta_0 - \pi_t^e - (a+\beta_1)x_t^p - e_t^f\right], \tag{11}$$

where $F(.)$ is the cumulative distribution function of $s \equiv (a+\beta_1)(v_t - v_t^f) + (e_t - e_t^f)$ and x_t^p is the central bank's planned value of the output gap. The random variable s is a combination of the central bank's two forecast errors, with the relative weights attached to each dependent on the government's choice of β_1.

It will be assumed that the density function of the forecast error, $f(s)$, is continuous, symmetric with a maximum at $s = 0$, with $f'(s) > 0$ for $s < 0$ and $f'(s) < 0$ for $s > 0$. From Eq. (11), $\partial\theta/\partial x^p = -(a+\beta_1)f \leq 0$; a planned economic expansion (an increase in x^p), ceteris paribus, increases the probability that actual inflation will exceed $\pi^*(x_t)$ and thereby reduces the probability that the central banker will be reappointed.

Using Eqs. (3), (1) and (11), the first order condition for the central bank's choice of x_t^p to maximize the objective function given by (10), taking π_t^e as given, can be written as[7]

$$x_t^p = \frac{\lambda_1 + a(\pi^S - \pi_t^e) + \rho\bar{U}\frac{\partial\theta}{\partial x^p} - ae_t^f}{\lambda_2 + a^2}. \tag{12}$$

The planned inflation rate equals

$$\begin{aligned} \pi_t^p &= \pi^e + a\left[\frac{\lambda_1 + a(\pi^S - \pi_t^e) + \rho\bar{U}\frac{\partial\theta}{\partial x^p} - ae_t^f}{\lambda_2 + a^2}\right] + e_t^f \\ &= \left(\frac{1}{\lambda_2 + a^2}\right)\left[\lambda_2\pi_t^e + a\lambda_1 + a^2\pi^S + a\rho\bar{U}\frac{\partial\theta}{\partial x^p} + \lambda_2 e_t^f\right]. \end{aligned} \tag{13}$$

In forming their expectations, the public is aware that x^p is set to satisfy (12) and that planned inflation will be given by (13). This last equation implies the public's expectation of inflation is

$$\pi_t^e = \pi^S + \left(\frac{\lambda_1}{a}\right) + \frac{\rho\bar{U}}{a}\mathrm{E}\left(\frac{\partial\theta}{\partial x^p}\right) \leq \pi^S + \left(\frac{\lambda_1}{a}\right), \tag{14}$$

where $\mathrm{E}(.)$ denotes the public's expectations. Since $\mathrm{E}\left(\frac{\partial\theta}{\partial x^p}\right)$ depends on π^e, (14) is not a closed-form solution for expected inflation. However, given the expected marginal effect of x^p on reappointment, π^e is decreasing in $\bar{U}$; an increase in the utility from holding office raises the cost of dismissal to the central banker and results in a lower expected rate of inflation.[8] A fall in the discount rate (a rise in ρ)

[7] The second order condition for the central banker's maximization problem is satisfied as long as $f' \leq (\lambda + a^2)/(a+\beta_1)^2\rho\bar{U}$, where f' is the partial derivative of f.

[8] Recall that $\partial\theta/\partial x^p \leq 0$.

has the same effect by increasing the value the central banker places on remaining in office.

Let $\Psi \equiv \frac{\rho \bar{U}}{a}\left(\frac{\partial \theta}{\partial x^p}\right)$; Ψ is the discounted value of holding office next period times the marginal effect of the output gap on the probability of reappointment, divided by the elasticity of inflation with respect to the output gap. Equation (14) can then be written as $\pi^e = \pi^S + \lambda_1/a + \mathrm{E}(\Psi)$. Substituting this into (12) yields the condition that must be satisfied by the time consistent policy that maximizes central bank utility, given that the public's expectations are consistent with the central bank's decision problem:

$$x_t^p = \frac{a\left[\Psi - \mathrm{E}(\Psi)\right] - ae_t^f}{\lambda_2 + a^2} \tag{15}$$

$$\pi_t^p = \pi^S + \left(\frac{\lambda_1}{a}\right) + \mathrm{E}(\Psi) + \left(\frac{a^2}{\lambda_2 + a^2}\right)\left[\Psi - \mathrm{E}(\Psi)\right] + \left(\frac{\lambda_2}{\lambda_2 + a^2}\right) e_t^f .$$

The nominal interest rate that implements this policy is

$$i_t = \pi^S + \left(\frac{\lambda_1}{a}\right) + \mathrm{E}(\Psi) - \left(\frac{1}{b}\right)\left\{\frac{a\left[\Psi - \mathrm{E}(\Psi)\right] - ae_t^f}{\lambda_2 + a^2} + v_t^f\right\} . \tag{16}$$

Inflation under discretion with reappointment differs from its value under pure discretion due to the terms involving Ψ. The point at which Ψ is evaluated depends on the critical inflation rate $\pi^*(x)$. If $\pi^*(x) \to \infty$, the probability the central banker is reappointed goes to 1 ($\Psi \to 0$), and the central banker's optimal strategy leads to the same average inflation rate as under pure discretion. Similarly, as $\pi^*(x) \to -\infty$, the probability of reappointment goes to 0, and $\Psi \to 0$. With no possibility of reappointment, it is again optimal for the central banker to pick the discretionary inflation rate. Between these bounds, the central bank's policy choice will differ from the pure discretionary outcome.

4.2. The optimal $\pi^*(x)$

The government's objective is to set $\pi^*(x)$ to minimize the expected value of S, subject to the requirement that the public's expectations be consistent with the central bank's actions and that the interest rate setting solves the central banker's optimization problem. However, since i^c minimizes S under commitment, it will be optimal for the government to chose β_0 and β_1 so that $i^{rd} = i^c$ if it can do so. Comparing (16) with (4) reveals that the socially optimal commitment policy can be implemented if there exists β_0 and β_1 such that

$$\Psi = \mathrm{E}(\Psi) = -\frac{\lambda_1}{a} . \tag{17}$$

Under the socially optimal commitment policy, $\pi_t^c = \pi^S + \left(\frac{\lambda_2}{\lambda_2+a^2}\right) e^f + a(v - v^f) + (e - e^f)$ and $\pi^e = \pi^S$, so from the definition of Ψ, Eq. (17) requires

$$f\left(\beta_0 - \pi^S + \frac{a\beta_1 - \lambda_2}{\lambda_2 + a^2} e^f\right) = \frac{\lambda_1}{(\beta_1 + a)\rho\bar{U}} \ . \tag{18}$$

Because the government cannot observe e_t^f, Eq. (18) must hold for all possible realizations of e_t^f. This will be the case if $\beta_1 = \lambda_2/a$, in which case (18) becomes

$$f\left(\beta_0 - \pi^S\right) = \frac{\lambda_1}{(\beta_1 + a)\rho\bar{U}} = \frac{a\lambda_1}{(\lambda_2 + a^2)\,\rho\bar{U}} \ . \tag{19}$$

A solution β_0^* to (19) exists as long as $\frac{\lambda_1}{(\beta_1+a)\rho\bar{U}}$ is not too large, in which case $\beta_0^* = \pi^S + f^{-1}(\frac{\lambda_1}{(\beta_1+a)\rho\bar{U}}) > \pi^S$.[9]

While the central bank takes $\bar{U}$ as given in setting period t policy, $\bar{U}$ is a function of future probabilities of reappointment. Equation (9) implies that in a steady state,

$$\bar{U} = \frac{V}{c\left[1 - \rho F(\beta_0 - \pi^S)\right]} \ . \tag{20}$$

Equation (19) then becomes

$$f\left(\beta_0 - \pi^S\right) = \frac{\lambda_1 ac\left[1 - \rho F(\beta_0 - \pi^S)\right]}{(\lambda_2 + a^2)\rho V} \equiv g\left(\beta_0 - \pi^S\right) . \tag{21}$$

For $\beta_0 > \pi^S$, the left side of (21) is decreasing in β_0 and goes to zero as β_0 goes to infinity. Since the probability of reappointment, $F(\beta_0 - \pi^S)$, is increasing in β_0, the right side is also decreasing in β_0, equalling $\lambda_1(2-\rho)ac/2(\lambda_2 + a^2)\rho V > 0$ for $\beta_0 = \pi^S$ (since $F(0) = 1/2$) and approaching $\lambda_1(1-\rho)ac/(\lambda_2 + a^2)\rho V > 0$ as β_0 goes to infinity. Thus, a solution exists as long as

$$V \geq \frac{\lambda_1(2-\rho)ac}{2(\lambda_2 + a^2)\rho f(0)} \equiv \Lambda \ . \tag{22}$$

Hence, as long as the direct utility of holding office is high enough, a solution exists. Since V would include any direct salary payment, the government can always ensure (22) is satisfied.[10] Consequently, a solution for β_0 exists, and the socially optimal

[9] It follows from (19) and the symmetry of the density function f that both $\beta_0 - \pi^S = q > 0$ and $\beta_0 - \pi^S = -q < 0$ are solutions to (19) if $f(q) = \lambda_1/\left[(\beta_1 + a)\rho\bar{U}\right]$. Attention is restricted to the positive solution for two reasons. First, the second order condition for the central banker's decision problem is definitely satisfied for $f' \leq 0$, which occurs when $\beta_0 > \pi^S$. For the negative solution, $f' > 0$ and the second order condition may not be satisfied. Second, basing dismissal on $\beta_0 < \pi^S$ implies that the central banker will be fired even if realized inflation were to equal the optimal value of π^S. By making the probability of dismissal high, the base salary of the central banker would need to be increased in order to satisfy the individual rationality constraint. Therefore, $\beta_0 > \pi^S$ minimizes the expected cost to the government of the contract payment to the central banker.

[10] I would like to thank Henrik Jensen for pointing out this interpretation of the conditions necessary to ensure a solution for the critical dismissal inflation rate.

commitment policy is supported even when the central bank has private information on the inflation shock.

Since Λ increases in λ_1 and decreases in ρ, direct salary payments must be larger if the inflationary bias under pure discretion is high (a high λ_1) or the central banker has a high discount rate (a low ρ). As (22) also shows, V must be high if $f(0)$ is small. This will occur when the variance of forecast errors is large, and, as a result, the marginal impact of x^p on the probability of reappointment is small. As a result, the return to holding office must be made large enough so that even a small probability of dismissal induces the central banker to reduce inflation appropriately.

The comparative static implications of (21) are straightforward. A fall in the rate at which the future rents from holding office are discounted (a rise in ρ) increases the cost of dismissal to the central banker. This strengthens the disciplinary effect of the dismissal threat, causing the central banker to adopt a more contractionary policy stance. To keep average inflation unchanged, the government can set a higher β_0, widening the gap between the optimal inflation rate (π^S) and the rate that results in the central banker's dismissal. In contrast, a rise in λ_1 increases the temptation to inflate, so the probability of being fired must rise to prevent the central banker from yielding to the temptation. By lowering the critical inflation rate β_0, the increased temptation to inflate is offset by the desire to remain in office.

An improvement in the central bank's ability to control inflation, caused for example by a reduction in its forecast error variances, has two effects on the optimal dismissal rule. A reduction in the variance of s represents a mean preserving contraction of the distribution function F. For $\beta_0 - \pi^S > 0$, the left side of (21) increases for small values of $\beta_0 - \pi^S$ and decreases for larger values. The optimal value of β_0 falls to maintain a constant degree of accountability. However, $F(\beta_0 - \pi^S)$ also increases, reducing the right side of (21). For a given $\beta_0 - \pi^S$, the probability of dismissal (equal to $1 - F(\beta_0 - \pi^S)$) falls, raising the value of holding office. This acts to reduce the need to rely on the disciplinary threat of dismissal, so the optimal β_0 increases. Figure 2 illustrates the impact of a fall in forecast error variances on the optimal value of $\beta_0 - \pi^S$ when s has a normal distribution. The figure plots the functions $f(\beta_0 - \pi^S)$ and $g(\beta_0 - \pi^S)$ for two different values of the variance of s with the dashed lines drawn for a smaller variance.[11] The optimal value of $\beta_0 - \pi^S$ is given by the intersection of the two functions, and it declines with the fall in the variance of s. Conversely, an increase in the variance of s, implying less ability to control inflation, would call for increasing β_0, widening the range of inflation outcomes that would not lead to dismissal.

The expected length of the remaining term in office for a central banker is $1/[1 - F(\beta_0 - \pi^S)]$, since $1 - F(\beta_0 - \pi^S)$ is the probability of dismissal each period. The expected remaining time in office is increasing in β_0. The larger is the output distortion that generates the inflationary bias under pure discretion, the

[11] The figure plots $f\left(\beta_0 - \pi^S\right)$ and $g(\beta_0 - \pi^S) = A\left[1 - \rho F\left(\beta_0 - \pi^S\right)\right]$ for a normal distribution with mean zero and standard deviations equal to either 1 (the solid lines) or .7 (the dashed lines). The value of A is chosen to ensure a solution to Eq. (21) exists.

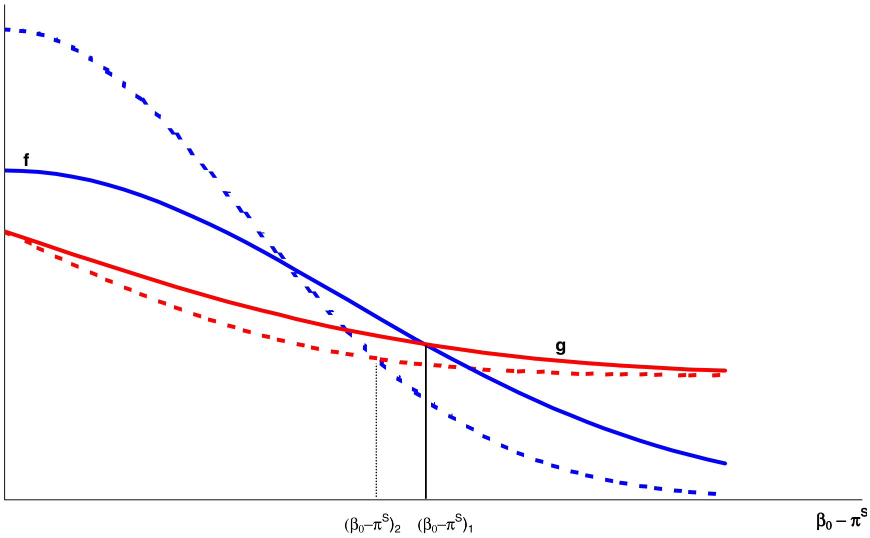

Fig. 2. A fall in forecast error variances shifts both the f and g function in Eq. (21). With smaller forecast error variances, the value of $\beta_0 - \pi^S$, now given by the intersection point of the dashed curves, falls

smaller is β_0 and the shorter is the average term in office.[12] An increase in the discount factor will be associated with longer average terms in office.

The reappointment probability, $F(\beta_0 - \pi^S)$, is independent of the central bank's forecast of the aggregate inflation disturbance, e^f. Because the inflation rate varies with the central bank's forecast of the shock even under the socially optimal policy, the dismissal rule must also vary. Since e^f is private information, the government cannot make dismissal directly contingent on e^f. Despite this, the socially optimal policy can be supported when the optimal dismissal policy is based on the actual realization of inflation *and* output. The critical inflation rate that triggers dismissal is a linear function of the log deviation of output from trend. Hence, it resembles the type of modified nominal income rule proposed by Taylor (1985). Taylor notes that the weight used to define a modified nominal income rule should depend on the weights in the social loss function. As we have shown, the optimal value of β_1 is in fact equal to λ_2/a, the weight on output fluctuations in the social loss function (3) adjusted for the elasticity of inflation with respect to the output gap.[13]

[12] This is consistent with Cukierman, Webb, and Neyapti (1992) who find that among developing countries, high turnover of central bank governors is positively correlated with average inflation.

[13] In Sect. (26), a value of 0.05 for a and 0.25 and 1.0 for λ_2 are used in a calibration exercise. If $a = 0.05$ and $\lambda_2 = 1$, $\beta_1 = 20$, implying that the modified nominal income variable heavily weighs the output gap. This might suggest that a dismissal rule based on x alone could come close to supporting an optimal policy. However, if the central banker is dismissed whenever $x > x^*$ (indicating the central banker had tried to over expand the economy), the critical value that triggers dismissal (x^*) is no longer state contingent and would therefore lead to suboptimal stabilization policy. In the face of a negative inflation shock, the central banker would fail to expand output enough for fear of being dismissed. Dismissal based on $\pi + \beta_1 x$ "works" because, even though both inflation and output should respond to e^f, β_1 can be chosen so that the linear combination $\pi + \beta_1 x$ is independent of e^f.

5. Measurement error in the gap

An objection to the proceeding analysis is that the output gap is not directly observed and is only measured with considerable error. Basing reappointment on x is, therefore, unrealistic. Suppose instead that dismissal is based on an observed measure of the gap x^m that may contain measurement error. Specifically, assume

$$x^m = x + \mu,$$

where μ is a stochastic measurement error. Dismissal occurs whenever actual inflation exceeds a critical value $\pi^*(x^m)$ given by

$$\pi^*(x^m) = \beta_0 - \beta_1 x^m.$$

In addition, let ψ denote the central bank's error in forecasting potential output. Like e^f and v^f, ψ is assumed to be unobserved (or unverifiable) by the government.

In this environment, the actual output gap will differ from the level planned by the central bank because of central bank errors in forecasting the demand shock or errors in forecasting the level of potential. Thus, $x = x^p + (v - v^f) - \psi$.

The probability of dismissal is equal to the probability that $\pi > \pi^*(x^m)$. This can be written as the probability that

$$\pi^e + ax + e > \beta_0 - \beta_1 x^m = \beta_0 - \beta_1(x + \mu).$$

Hence, dismissal occurs if

$$s' > \beta_0 - \pi^e - (a + \beta_1)\, x^p - e^f,$$

where

$$s' \equiv (a + \beta_1)(v - v^f - \psi) + (e - e^f) + \beta_1 \mu$$

With these modifications, the basic results of this paper continue to hold. If H (h) is the cumulative distribution (density) function of s', the probability of reappointment is

$$H\left(\beta_0 - \pi^e - (a + \beta_1)\, x^p - e^f\right). \tag{23}$$

Comparing Eq. (23) with Eq. (11) reveals that the only consequence of the imperfect observability of the output gap is that the distribution function H replaces F. The optimal value of β_1 is still λ_2/a and β_0 satisfies

$$h\left(\beta_0 - \pi^S\right) = \frac{\lambda_1 c\left[1 - \rho H(\beta_0 - \pi^S)\right]}{(\lambda_2 + a^2)\rho V}\ .$$

Since the variance of s' is greater than the variance of s, measurement error in observing value of the output gap (or the central bank's forecast of the gap) affects β_0 in the same manner as an increase in the variance of s as discussed earlier; the optimal β_0 increases.

6. Is delegation credible?

Under the optimal dismissal rule, the central bank is made accountable but is allowed to respond to economic disturbances with complete discretion. For the threat of dismissal to affect the conduct of policy, however, the threat must be credible. As long as there exists a supply of identical potential central bankers, the government is indifferent between firing and reappointing. In this sense, the threat is credible since it is costless for the government to carry out its threat to fire.

A policy of dismissing the central banker if inflation exceeds a critical value is a form of trigger strategy. A large literature has examined the role of reputation in supporting the optimal commitment policy in infinite horizon models. The central bank may refrain from implementing the optimal discretionary policy because it believes it will be punished if it does so, where the punishment takes the form of a higher expected rate of inflation on the part of the public. Reputational models of monetary policy are surveyed in Rogoff (1989) who discusses the problem of multiple trigger strategy equilibria. Canzoneri (1985) shows that the optimal commitment policy can be supported by a trigger strategy equilibrium in a model with private central bank forecasts (but no role for stabilization policies) if the public punishes the central bank by expected high inflation whenever actual inflation exceeds a critical value. However, models that rely on the public coordinating on a punishment strategy have been criticized for failing to explain how the public achieves this coordination (Cukierman 1992).

When it is the government that establishes the critical inflation rate, the problematic coordination issues that arise when the public must set the punishment strategy are absent. Herrendorf (1998) and al-Nowaihi and Levine (1996) show how publicly announced goals can support reputational equilibria by making it easier for the public to determine whether the policy maker has “cheated.” A formal contract between the central bank and the government can also serve to eliminate political monetary cycles for the same reason – it makes cheating easier for the public to discover (al-Nowaihi and Levine 1998)

Suppose, for example, the government “cheats” by privately indicating to the central banker that it will tolerate a policy leading to higher output and will reappoint the central banker even if inflation exceeds $\pi^*(x)$. Under this scenario, the optimal response of the central bank is to act with discretion to minimize the one period loss function. Since the public had excepted that inflation would be π^S (under the announced dismissal rule), the central bank will find it optimal to implement

$$x_t^p = -\left(\frac{a}{\lambda_2 + a^2}\right) e_t^f + \frac{\lambda_1}{\lambda_2 + a^2}$$

and

$$\pi_t^p = \pi^S + \left(\frac{\lambda_2}{\lambda_2 + a^2}\right) e_t^f + \frac{a\lambda_1}{\lambda_2 + a^2}\ .$$

The expected one period gain from this deviation is

$$\frac{1}{2}\frac{\lambda_1^2}{\lambda_2 + a^2} > 0. \tag{24}$$

The cost to the government of ignoring its dismissal rule will depend on how the public reacts. Following Minford (1995), one might assume this cost comes in a reduced probability of re-election. Here, I will focus solely on the costs associated with the economic loss function as given by (3). To do so, assume that once the public detects that the government has failed to implement its firing rule, the public expects that average inflation will equal the discretionary rate $\pi^S + \lambda_1/a$. In the period following a detected deviation, therefore, the best the central bank (and government) can do is again implement the fully discretionary policy. Since the higher inflation rate this entails is now fully anticipated, there is no output gain and the loss (relative to the outcome if the dismissal rule had previously been enforced) is

$$\frac{1}{2}\left(\frac{\lambda_1}{a}\right)^2 . \tag{25}$$

For simplicity, assume that the government is able to reestablish credibility after one period. Longer punishment periods would make it less likely the government would fail to implement its firing rule, so if the dismissal rule is credible with a one period punishment, it will certainly be credible with longer punishment periods.

In comparing the cost in (25) to the gain in (24), two further considerations are relevant. First, from the perspective of a government that is considering ignoring its dismissal rule, the cost occurs in future periods, so it must be discounted at the rate ρ. Second, a central banker may cheat, but if its forecast errors turn out to be negative, actual inflation might still fall below the value that triggers dismissal. In this case, the public would fail to discover that the central bank had cheated. If the central bank cheats, dismissal should occur whenever $s > \beta_0 - \pi^S - \lambda_1/a = \chi$. The probability the public detects that the central bank and government have cheated in the first period they cheat, therefore, is $1 - F(\chi)$. The probability the cheating is first discovered in the second period is $F(\chi)\,[1 - F(\chi)]$. Consequently, the expected discounted cost to the government of releasing the central banker from a threat of dismissal is

$$\frac{1}{2}\rho\left(\frac{\lambda_1}{a}\right)^2 [1 - F(\chi)] \sum_{i=0}^{\infty} \rho^i F(\chi)^i = \frac{1}{2}\rho\left[\frac{1 - F(\chi)}{1 - \rho F(\chi)}\right]\left(\frac{\lambda_1}{a}\right)^2 .$$

Since the central bank and government can continue to collude in ignoring the dismissal rule as long as $s \leq \beta_0 - \pi^S - \lambda_1/a$, the present discounted value of the expected gain is

$$\frac{1}{2}\left(\frac{\lambda_1^2}{\lambda_2 + a^2}\right) \sum_{i=0}^{\infty} \rho^i F(\chi)^i = \frac{1}{2}\left(\frac{1}{1 - \rho F(\chi)}\right)\left(\frac{\lambda_1^2}{\lambda_2 + a^2}\right) .$$

The delegation scheme analyzed in this paper can be supported in a trigger strategy equilibrium as long as the expected cost exceeds the expected gain. This occurs if

$$\rho\,[1 - F(\chi)] > \frac{a^2}{\lambda_2 + a^2} . \tag{26}$$

Thus, as long as the government places sufficient weight on the future (ρ is large enough) or the probability that inflation will exceed π^* if the central bank cheats is sufficiently high ($1 - F(\chi)$ is large enough), the dismissal scheme is credible.

To assess the likelihood of (26) holding, suppose the probability is only 10% that inflation will exceed the critical rate that should trigger dismissal if the central bank actually does cheat (i.e., $1 - F(\chi) = 0.1$). If this occurs, and the government fails to fire the central banker, the public knows the government has deviated from its promised policy. McCallum and Nelson 2000 discuss some of the empirical work estimating a and conclude that it is in the range $[0.01, 0.05]$, based on measuring inflation at quarterly rates. Smets (2000) reports an estimate for a of 0.2 using European data, but he measures inflation at an annual rate so, in terms of quarterly inflation, his point estimate corresponds to a value of 0.05 for a. The literature on targeting rules has generally set the preference parameter λ_2 in the range $[0.25, 1.0]$; Rudebusch and Svensson (1999) set $\lambda_2 = 1$, while McCallum and Nelson (2000), Jensen (2001), and Walsh (2001) use a value of 0.25. McCallum and Nelson (2000) argue 0.25 is appropriate when inflation is measured at a quarterly rate. With $a = 0.05$ and $\lambda_2 = 0.25$, the dismissal rule is sustainable for $\rho > 0.1$; for $\lambda_2 = 1$, the dismissal rule is sustainable for $\rho > 0.025$. If the period is interpreted as a quarter, ρ would be on the order of 0.99. Even if the appropriate "period" of analysis is taken to be as long as four years (16 quarters), the value of ρ should be on the order of $(0.99)^{16} = 0.85$, so that even with a one period punishment and a very low probability the deviation is discovered, the government still has a clear incentive to implement the dismissal rule if inflation actually exceed π^*.[14]

The dismissal rule cannot be supported if the weight on output stabilization is too low or the output elasticity of inflation (a) is too large. For instance, if $\lambda_2 = 0.1$ (and $1 - F(\chi)$ is still 0.1), there is no $\rho < 1$ that satisfies Eq. (26) if $a > 0.1054$. If $\lambda_2 = 0.25$ (1.0), no $\rho < 1$ satisfies Eq. (26) if $a > 0.165$ (0.334).

The idea that a government can commit to institutional arrangements to compensate for the inability of the central banker to commit to a specific policy rule has been criticized by McCallum (1995), among others. Jensen (1997) shows how the ability of an incentive contract for the central banker to solve an inflation bias is weakened when the government can undo the contract ex post. In the present context, reappointing a central banker who had delivered an economic expansion may initially escape detection, but eventually inflation will exceed the rate that should have triggered a dismissal. The expected costs of failing to implement the dismissal rule exceed the expected benefits except for very small values of ρ or λ_2 or very large values of a.

[14] The choice of period length affects the calibration of ρ, but it also effects the values for a and λ_2. If inflation is measured at an annual rate, a would increase to 0.2. The value of λ_2 also would need to be adjusted. If inflation in the social loss function is expressed at a quarterly rate, then the loss function is equivalent to $(\pi^a)^2 + 16\lambda_2 x^2$ where π^a is inflation expressed at an annual rate. Since a and λ_2 only appear in Eq. (26) in the form $a^2/(\lambda_2 + a^2)$, a switch from quarterly rates to annual rates that raises a by a factor of 4 and λ_2 by a factor of 16 leaves $a^2/(\lambda_2 + a^2)$ unaffected.

7. Conclusions

This paper demonstrates that a discretionary central bank will implement the optimal commitment policy if reappointment is based on realized inflation and output. Such a reappointment arrangement preserves the ability of the central bank to respond to its private information and engage in optimal stabilization. The dismissal rule does not require that the central bank's private forecasts of either velocity shocks or the aggregate inflation disturbance be verified, nor does it require the output gap be observed without error.

The results of this paper for the case in which there are aggregate inflation disturbances suggests a connection between optimal dismissal rules and modified versions of nominal income targeting, just as Svensson (1997) has found there to be connections between inflation targeting and optimal central bank contracts.

References

al-Nowaihi, A. Levine, P. (1996) Independent but Accountable: Walsh Contracts and the Creditability Problem. CEPR Working Paper no. 1387

al-Nowaihi, A. Levine, P. (1998) Can Political Business Cycles Be Avoided? *Journal of Monetary Economics*, 42: 525–545

Barro, R.J. Gordon, D.B. (1983) A Positive Theory of Monetary Policy in a Natural Rate Model. *Journal of Political Economy*, 41: 589–610

Blinder, A.S. (1998) *Central Banking in Theory and Practice*, Cambridge: The MIT Press

Canzoneri, M.B. (1985) Monetary Policy Games and the Role of Private Information. *American Economic Review*, 75 (5): 1056–1070

Chappell, H.W. Jr., Havrilesky, T.M., McGregor, R.R. (1993) Partisan Monetary Policies: Presidential Influence Through the Power of Appointment. *Quarterly Journal of Economics*, 108 (1): 185–218

Clarida, R., Galí, J. Gertler, M. (1999) The Science of Monetary Policy: A New Keynesian Perspective. *Journal of Economic Literature*, 37 (4): 1661–1707

Cukierman, A. (1992) *Central Bank Strategy, Credibility, and Independence: Theory and Evidence*. Cambridge: MIT Press

Cukierman, A. (2000) Are Contemporary Central Banks Transparent about Economic Models and Objectives and What Difference Does it Make?

Cukierman, A., Webb, S.B., Neyapti, B. (1992) Measuring the Independence of Central Banks and Its Effects on Policy Outcomes. *The World Bank Economic Review*, 6 (3): 353–398

Dixit, A. Jensen, H. (2000) Equilibrium Contracts for the Central Bank of a Monetary Union. CES–ifo Working Paper No. 400

Fratianni, M., von Hagen, J., Waller, C.J. (1997) Central Banking as a Political Principal-Agent Problem. *Economic Inquiry*, 35 (2): April, 378–393

Garfinkel, M., Oh, S. (1993) Strategic Discipline in Monetary Policy with Private Information: Optimal Targeting Horizons. *American Economic Review*, 83 (1): 99–117

Herrendorf, B. Inflation Targeting as a Way of Precommitment. *Oxford Economic Papers*, 50 (3): July 1998, 431–448

Jensen, H. (1997) Credibility of Optimal Monetary Delegation. *American Economic Review* 87 (5): 911–920

Jensen, H. (2001) Targeting Nominal Income Growth or Inflation? Working Paper, University of Copenhagen, forthcoming, *American Economic Review*

Kydland, F.E. Prescott, E.C. (1997) Rules Rather than Discretion: The Inconsistency of Optimal Plans. *Journal of Political Economy*, 85 (3): 473–491

Lohmann, S. (1992) Optimal Commitment in Monetary Policy: Credibility versus Flexibility. *American Economic Review*, 82 (3): 273–286

McCallum, B.T. (1995) Two Fallacies Concerning Central Bank Independence. *American Economic Review*, 85 (2): 207–211

McCallum, B.T. Nelson, E. (2000) Timeless Perspective vs. Discretionary Monetary Policy in Forward-Looking Models. NBER Working Papers No. 7915

Meltzer, A.H. (1981) Policy Statement. Shadow Open Market Committee

Minford, P. (1995) Time-Inconsistency, Democracy, and Optimal Contingent Rules. *Oxford Economic Papers* 47: 195–210

O'Flaherty, B. (1990) The Care and Handling of Monetary Authorities. *Economics and Politics*, 2 (1): 25–44

Persson, T. Tabellini, G. (1993) Designing Institutions for Monetary Stability. *Carnegie-Rochester Conference Series*, 39: 53–84

Rogoff, K. (1985) The Optimal Degree of Commitment to an Intermediate Monetary Target. *Quarterly Journal of Economics*, 100: 1169–1189

Rogoff, K. (1989) Reputation, Coordination and Monetary Policy. In: Barro, R. (ed.) *Modern Business Cycle Theory*, Cambridge, Harvard University Press

Roll, E. (1994) *Independent and Accountable: A New Mandate for the Bank of England*. The Report of an Independent Panel Chaired by Eric Roll, The Centre for Economic Policy Research

Rudebusch, G.D. Svensson, L.E.O. (1999) Policy Rules for Inflation Targeting. In: Taylor, J.B. (ed.) *Monetary Policy Rules*, Chicago: University of Chicago Press, 203–246

Smets, F. (2000) What Horizon for Price Stability? European Central Bank Working Paper No. 24

Svensson, L.E.O. (1997) Optimal Inflation Targets, 'Conservative' Central Banks, and Linear Inflation Contracts. *American Economic Review*, 87 (1): 98–114

Svensson, L.E.O. (1999) How Should Monetary Policy Be Conducted in an Era of Price Stability. In: *New Challenges for Monetary Policy*, Federal Reserve Bank of Kansas City, 195–259

Taylor, J.B. (1985) What Would Nominal GNP Targeting Do to the Business Cycle? *Carnegie-Rochester Conference Series*, 22: 61–84

Vickers, J. (1998) Inflation Targeting in Practice: The UK Experience. *Bank of England Quarterly Bulletin*, 38 (4): 368–375

Waller, C.J. (1992) A Bargaining Model of Partisan Appointments to the Central Bank. *Journal of Monetary Economics*, 29 (3): 411–428

Waller, C.J., Walsh, C.E. (1996) Central-Bank Independence, Economic Behavior, and Optimal Term Lengths. *American Economic Review* 86 (5): 1139–1153

Walsh, C.E. (1995a) Optimal Contracts for Central Bankers. *American Economic Review*, 85 (1): March, 150–167

Walsh, C.E. (1995b) Is New Zealand's Reserve Bank Act of 1989 an Optimal Central Bank Contract? *Journal of Money, Credit and Banking*, 27 (4): Nov., Pt. 1, 1179–1191

Walsh, C.E. (1998) *Monetary Theory and Policy*, Cambridge, MA: The MIT Press

Walsh, C.E. Accountability, Transparency, and Inflation Targeting. University of California, Santa Cruz, Aug. 2000

Walsh, C.E. (2000) Monetary Policy Design: Institutional Developments from a Contractual Perspective. *International Finance*, 3 (3): 375–389

Walsh, C.E. (2001) The Output Gap and Optimal Monetary Policy. UC Santa Cruz

Woodford, M. (1999) Optimal Policy Inertia. NBER Working Paper 7261

Woolley, J. (1995) Nixon, Burns, 1972, and Independence in Practice. University of California, Santa Barbara