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Abstract

This paper considers an institutional arrangement, in which the government assigns a publicly announced inflation target to an instrument independent central bank, but retains the discretion to revise the target after wages have been set. We argue that since this arrangement is perfectly transparent, it resolves Canzoneri's private information problem, ensures perfect monitoring of the government, and enhances the effectiveness of reputational forces. The paper characterizes cases in which, for this reason, inflation targeting mitigates the inflationary bias of monetary policy.

KEYWORDS: Central Bank Independence; Inflation Targeting; Private Information; Reputation; Transparency.

JEL CLASSIFICATION: E52, F33.

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1 Introduction

The impact of the central bank's institutional status on monetary policy making has recently received considerable attention, both theoretically and empirically; for reviews, see Cukierman (1992,1995), Walsh (1993) and Herrendorf (1995a). Perhaps the most important issue in this context is whether or not a properly designed institutional set–up can resolve the time consistency problem of optimal monetary policy making.[1] A decade ago, Rogoff (1985) made the first serious attempt to tackle the problem from an institutional angle. His suggestion was to grant institutional independence to a *conservative* central banker, who assigns a larger weight to the cost of inflation than society. Appointing a conservative central banker reduces the inflationary bias, but distorts stabilization of the real economy and, therefore, involves a cost.

For many years, Rogoff's proposal was dominating the debate; see, for instance, Lohmann (1992), Waller (1992) and Lockwood, Miller and Zhang (1994). Only recently has Walsh (1995c) employed results from the principal–agent literature, suggesting that the government [principal] may design a performance contract for the head of the central bank [agent], which specifies the latter's remuneration depending on realized inflation [bonus payments]. Since thereby the government can optimally shape the incentives that the central banker faces, the time consistency problem can be resolved and the ex ante optimal outcome be achieved; see also Persson and Tabellini (1993), Fratianni, von Hagen and Waller (1995) and Lockwood (1995).

Although central bank contracts with bonus payments for the central bank governor are not observed in reality, Walsh's insight is very important, because it leads to the identification of the optimal incentive structure. Moreover, it turns out that the optimal incentive structure may also be generated through either of the following, perhaps more practicable, alternatives: (i) to implement a properly chosen dismissal rule with the threat to fire the central banker under certain conditions, see Walsh (1995b); (ii) to implement an inflation or output targeting procedure, which grants independence to

[1] The time consistency problem leads to a suboptimally large inflation bias under the time consistent equilibrium policy [Barro and Gordon (1983)].

the central bank in the conduct monetary policy, but not in the choice of the inflation or output target, see Svensson (1995) and Herrendorf and Lockwood (1996). To sum up, the recent literature suggests that an appropriately chosen institutional setting for the central bank can in principle ensure the time consistency of the ex ante optimal monetary policy and resolve the time consistency problem.

While an institutional reform may indeed induce time consistent behavior on the part of the central bank, it is not clear, however, why it should induce time consistent behavior on the part of the *government*. For example, providing the government also appreciates the consequences of surprise inflation [i.e. stimulation of economic activity or additional seigniorage revenues], why should it actually carry out the threat to fire the central banker after he has engineered surprise inflation, or why should it stick to an inflation or output target after wage contracts have been signed? This point has forcefully been raised by McCallum (1995, p.110): "Indeed if the absence of any precommitment technology is actually the problem, then it must apply to the consolidated CB–government entity just as it would to an entirely independent CB. If the precommitment technology does not exist, then it does not exist."

One obvious reaction to McCallum's point is that an institutional solution has the advantage of being implementable through a legislated central bank law, by which the discretionary influence of the government is limited. Yet, the possibility to change the central bank law remains. This may even be desirable, since any legislated institutional set–up is incomplete in that it does not account all possible contingencies; see Herrendorf and Lockwood (1996) for further discussion. Moreover, as was pointed out by Walsh (1995b) in his assessment of the recent central bank reform in New Zealand, time inconsistent behavior on the part of the government remains a critical issue whenever the legislated institutional arrangement leaves some discretion. For example, the New Zealand central bank act allows for revisions of the inflation target after wages have been set.

The present paper suggests that the problem of time inconsistent behavior on part of the government, though existing, is likely to be less severe than previously claimed, the reason being the possible effect of an institutional arrangement on reputational forces. [In contrast, the literature has typically viewed institutional solutions as an *alternative* rather than as a *supplement* to reputation.] In order to explain the argument, we first reproduce the outcome when the central bank is institutionally dependent on the government, implying that they act as if one policy maker was in charge. Monetary policy is then subject to a private information problem [Canzoneri (1985)]. In particular, since it is not incentive compatible to reveal planned inflation truthfully, the private sector will in general be in doubt whether or not an inflation surprise was generated by a positive realization of a velocity shock or by an attempt of the policy maker to stimulate output. Consequently, the monitoring of policy actions becomes imperfect and reputational forces loose part of their bite.

We then consider an inflation targeting arrangement of the form suggested by Svensson (1995), in which the government assigns a publicly announced inflation target to an *instrument independent*, but *not goal independent* central bank. These two terms are due to Fischer (1995) and mean that, while the central bank may conduct daily monetary policy as it wishes [instrument independence], the ultimate target of its' policy is set by the government [goal dependence]. We concentrate on the benchmark case in which the government cannot precommit to the inflation target, but may revise it after wages have been set. However, we do require that the inflation target and any revisions of it are publicly announced.[2] It turns out that such an arrangement resolves the private information problem, allows the private sector to monitor closely the actions of the government, and helps to discipline the government not to behave in a time inconsistent way. In particular, it is shown that adopting an inflation targeting arrangement may reduce equilibrium inflation. However, we find that when the government has discretion to revise the target after nominal wage contracts have been signed, reputational forces

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[2] It should be mentioned that this targeting arrangement is distinct from those studied in the literature. On one hand, Rogoff (1985), Canzoneri (1985) and Garfinkel and Oh (1993) suggested targeting rules to which the central bank is precommitted by legislation, whereas we assume here that the government announces inflation targets without precommiting to them. On the other hand, Walsh (1995a) considered the case in which the central bank announces its' own inflation target, and showed that thereby it can reveal some private information about its' preferences or about the state of the economy.

are not strong enough to achieve the ex ante optimal outcome.

The plan for the remainder of the paper is as follows: in section 2, the model is presented; section 3 shows how the private information problem affects the functioning of reputational effects; the resolution of the private information problem through inflation targeting is discussed in section 4; finally, section 5 concludes.

2 The Model

The model is a variant of that of Barro and Gordon (1983). As in al Nowaihi and Levine (1994) [aN–L henceforth], we assume the existence of a single trade union, which, at the end of any period, sets the nominal wage for the next period so as to achieve equilibrium real output, $\bar{y}$. [The assumption that a trade union coordinates the wage bargaining process appears to be a reasonable approximation to the situation in many countries, especially in Europe; see Driffill and Schultz (1992) for further discussion.] As is standard, the rate of deviation of real output, y_t, from its' equilibrium, $\bar{y}$, is determined by an *expectations–augmented Phillips curve*, the slope of which is normalized to one for simplicity,

$$y_t - \bar{y} = \pi_t - \pi_t^e. \tag{1}$$

In (1), π_t and π_t^e represent realized inflation and the rational inflation expectation formed at the end of period t–1, i.e. $\pi_t^e = E_{t-1}\pi_t$.

The *rate of inflation* is defined as the logarithmic difference between the current and the last period's price level, $\pi_t = p_t - p_{t-1}$. Prices are assumed to be perfectly flexible and to result from the equilibrium in the money market, which is described by a permanent–income–based *quantity equation*,

$$m_t + \nu_t = \bar{y} + p_t, \tag{2}$$

where m_t and ν_t stand for the the logs of base money and velocity. Following Canzoneri (1985), we suppose that ν_t follows a random walk. The relation between inflation and the growth rate of money, g_t, which is the *policy maker's instrument*, is then found to be

$$\pi_t = g_t + \mu_t, \tag{3}$$

where $\mu_t = \nu_t - \nu_{t-1}$ is an i.i.d. disturbance with zero mean and a finite variance.

In order to introduce a role for stabilization policy, we suppose that, after nominal wages have been set, but before the rate of money growth is chosen at the beginning of period t, the policy maker receives a signal, φ_t, about the velocity shock, μ_t; consequently,

$$\mu_t = \varphi_t + \psi_t, \tag{4}$$

where $E_{t-1}\varphi_t = 0$ and ψ_t is an i.i.d. shock with zero mean and finite variance. Moreover, ψ_t is assumed to be orthogonal to φ_t and uniformly distributed with compact support $[-s, s]$. Realized inflation may now be expressed in terms of *planned inflation*, π_t^p,

$$\pi_t = \pi_t^p + \psi_t, \quad \text{where} \quad \pi_t^p \equiv g_t + \varphi_t. \tag{5}$$

The description of the model is completed by the specification of the objective functions of both players, which are as in aN–L. Denoting the discount factor by δ $[\delta \in (0,1)]$, the *government's objective* is

$$V \equiv \sum_{t=0}^{\infty} \delta^t v_t \equiv \sum_{t=0}^{\infty} \delta^t [a(y_t - \bar{y}) - \frac{1}{2}\pi_t^2] = \sum_{t=0}^{\infty} \delta^t [a(\pi_t^p - \pi_t^e + \psi_t) - \frac{1}{2}(\pi_t^p + \psi_t)^2], \tag{6}$$

where $a > 0$, and use has been made of (1) and (5). Specification (6) captures the standard notion that the government suffers a loss of utility from inflation, while gaining from positive deviations of real output from its' equilibrium value.[3] If not mentioned specifically, it is assumed that the central bank is institutionally *dependent* on the government, implying that it shares the objective function (6) and that both of them can be treated as a single player, the policy maker.

[3] Note that the output term is *linear*, as in the initial paper of Barro and Gordon. Consequently, the government does not care about stabilizing output here. This is as in aN–L and greatly simplifies the algebra, without affecting the results.

The specification of the *trade union's utility* reflects the assumption that the union aims for equilibrium output and dislikes inflation,

$$U \equiv \sum_{t=0}^{\infty} \delta^t u_t \equiv -\sum_{t=0}^{\infty} \delta^t [b(y_t - \bar{y})^2 + \pi_t^2] = -\sum_{t=0}^{\infty} \delta^t [b(\pi_t^p - \pi_t^e + \psi_t)^2 + (\pi_t^p + \psi_t)^2], \quad (7)$$

where $b > 0$, and the last equality follows from (1) and (5) as before. Note that, for simplicity, δ is taken to be the discount factor of both the government and the trade union. Allowing their discount rates to be different would not add much insight here; see aN–L for a discussion of this case.

(6) and (7) imply that we may analyze the policy game in terms of planned and expected inflation, which is analytically most convenient. As a benchmark case, we consider first the *ex ante optimal policy of the one shot game*, which needs to satisfy the constraint that planned inflation equals expected inflation, $\pi_t^p = \pi_t^e$. Maximizing the expectation of (6) subject to this constraint yields[4]

$$\pi^p(opt) = \pi^e(opt) = 0 \quad \text{and} \quad \pi(opt) = \psi. \quad (8)$$

Note that $\pi^p(opt) = 0$ requires $g(opt) = -\varphi$, that is, the policy maker chooses the money supply to offset fully the known component of the velocity shock. For this reason, reductions of utility occur only due to the imprecision in inflation control,

$$\begin{aligned} E[V(opt)] &= \frac{1}{1-\delta} E[v(opt)] = -\frac{1}{1-\delta} \frac{\sigma_\psi^2}{2}, && (9a) \\ E[U(opt)] &= \frac{1}{1-\delta} E[u(opt)] = -\frac{1}{1-\delta} (b+1)\sigma_\psi^2. && (9b) \end{aligned}$$

As is well known, the ex ante optimal policy is time inconsistent in general, that is, a reoptimization at a later point in time does not lead to the policy plan that was initially found to be optimal. If the policy maker cannot precommit to follow the ex

[4] Since the game is repeated in nature, the solution will be the same in any period and we can drop the time indices.

ante optimal policy, the *time consistent Nash–equilibrium* outcome emerges,

$$\pi^p(con) = \pi^e(con) = a \quad \text{and} \quad \pi(con) = a + \psi. \tag{10}$$

The time consistency of the Nash–equilibrium leads to the standard inflationary bias [denoted here by a], and a reduction of the expected utilities compared to the ex ante optimal policy,

$$E[V(con)] = \frac{1}{1-\delta} E[v(con)] = -\frac{1}{1-\delta} \frac{a^2 + \sigma_\psi^2}{2}, \tag{11a}$$

$$E[U(con)] = \frac{1}{1-\delta} E[u(con)] = -\frac{1}{1-\delta} [a^2 + (b+1)\sigma_\psi^2]. \tag{11b}$$

3 Reputational Forces Under Private Information

3.1 Trigger Strategies

It has been often argued that the policy maker's concern about the adverse effects of loosing a good reputation may prevent him from reneging on a policy $\pi^p(rep)$, which is time–inconsistent in the stage–game $[\pi^p(rep) < \pi^p(con)]$, in which reputation cannot have a role. In infinitely repeated games, reputation is typically modelled by Friedman–type (1971) *trigger strategies*. Essentialy, they work as follows: the trade union expects $\pi^p(rep)$ for the current period, if it has not detected a deviation from $\pi^p(rep)$ in the previous period; in contrast, if it has detected a deviation, then it expects $\pi^p(con)$ for some, possibly infinitely many, future periods [the punishment phase], after which it expects $\pi^p(rep)$ again. The policy plan $\pi^p(rep)$ is a subgame–perfect Nash–equilibrium in trigger strategies, if some punishment phase exists such that the expected present discounted value of the utility reduction from the punishment outweighs the expected utility increase in the period of the deviation. It should be mentioned that a necessary condition for this to be possible is that the policy maker starts the game with reputation, which is assumed here.

The application of trigger strategies to monetary policy games has been subject to criticism, because the length of the punishment phase and the expected inflation rate by which the private sector punishes are not unique. Therefore, it is not clear how an *atomistic* private sector may manage to coordinate on playing any particular trigger strategy [Backus and Driffill (1985)]. It is important to realize that this coordination problem does not arise when, as is assumed here, the private sector is represented by a trade union, which acts as a *strategic* player. However, different from an atomistic private sector, a trade union may renegotiate the trigger strategy after a, possibly small, deviation has been detected. Responding to this problem, we employ the equilibrium refinement "chisel–proofness" introduced by aN–L, which prevents certain forms of renegotiation to be specified below.[5]

Since aN–L have studied a situation with *perfect* control over inflation, we will need to generalize their analysis. In particular, under imperfect control over inflation, the inflation rate planned by the policy maker is no longer common knowledge, but inevitably his private information [Canzoneri (1985)]. The reason is that an unexpectedly high realization of inflation may either be caused by a positive realization of the disturbance ψ, or by a deliberate attempt of the policy maker to surprise the private sector. Since an optimizing policy maker will not admit that he has created the surprise, but attempt to blame it on a positive realization of ψ, it is not incentive compatible to reveal planned inflation truthfully. Consequently, the union cannot perfectly monitor the policy maker's actions and the disciplinary effect of reputation becomes weaker.[6]

While the consequences of the existence of private information have already been pointed out by Canzoneri (1985) in a related policy game, he considered an *atomistic* private sector and a trigger strategy with an exogenously given punishment phase of *infinitely* many periods. Thus, we need to apply his analysis to the case of a strategically

[5] Note that "chisel–proofness" cannot be as strong as Farrell and Maskin's (1989) concept of weak renegotiation–proofness, because, in the present model, the only weakly renegotiation–proof equilibrium is the time consistent equilibrium of the stage game [aN–L].

[6] It may be observed that for the derivation of both, the ex ante optimal and the time consistent policy, the private information issue has been irrelevant. The reason is that, by definition, the ex ante optimal policy is derived under the constraint that there is no deviation, whereas, by construction, the time consistent policy does not leave an incentive to deviate.

acting trade union, and also to generalize it by endogenizing the length of the punishment period. To this end, we represent inflation plans as $\pi^p(\alpha) = \alpha a$ with $\alpha \in [0, 1)$. In order to characterize the $\pi^p(\alpha)$ that can be sustained through chisel–proof trigger strategies, we denote deviations from $\pi^p(\alpha)$ by $\pi^p(\alpha, \beta) = \beta a$, where $\beta \in (\alpha, 1]$. For any $\alpha \in [0, 1)$ and any $\beta \in (\alpha, 1]$, we begin by deriving the minimal length of the punishment period, $\underline{\tau}(\alpha, \beta)$, necessary to prevent the policy maker from deviating from $\pi^p(\alpha)$ by planning $\pi^p(\alpha, \beta)$.

3.2 The Minimal Punishment Period Sufficient to Deter Deviations

Since the disturbance ψ was assumed to be uniformly distributed, the trade union can detect a deviation $\pi^p(\alpha, \beta)$ from $\pi^p(\alpha)$ only when the realized inflation rate $[\pi(\alpha, \beta) = \pi^p(\alpha) + a(\beta - \alpha) + \psi]$ exceeds the largest inflation realization that would be possible if the policy maker did not deviate $[\pi^p(\alpha) + s]$, that is, if $\psi > s - a(\beta - \alpha)$. In contrast, if $\psi \leq s - a(\beta - \alpha)$, then the creation of surprise inflation cannot be spotted. However, trigger strategies might still work, even if the trade union punishes the policy maker only when it can detect a deviation. To show this, we need to calculate the policy maker's expected utilities when he does not deviate and when he does deviate.

The policy maker's expected present discounted payoff from planning $\pi^p(\alpha)$ can be shown to equal:

$$E[V(\alpha)] = \sum_{t=0}^{\infty} \delta^t E[v(\alpha)] = -\frac{(\alpha a)^2 + \sigma_\psi^2}{2(1-\delta)}, \tag{12}$$

where

$$\sum_{t=1}^{\tau} \delta^t \equiv \frac{\delta(1-\delta^\tau)}{1-\delta} \quad \forall \tau \in (1, \infty) \quad \text{and} \quad \sum_{t=\tau+1}^{\infty} \delta^t \equiv \frac{\delta^{\tau+1}}{1-\delta} \quad \forall \tau \in [0, \infty). \tag{13}$$

Note that punishment periods will in general be fractional here; see appendix A of aN–L for a detailed discussion.

In order to calculate the policy maker's expected utility after a deviation, we first need to realize that since the future is discounted, it is optimal to deviate as early as possible, provided that a deviation is planned. Without loss of generality, we may therefore concentrate on deviations in period zero. The probability that the deviation is detected equals $a(\beta-\alpha)/2s$, whereas, with probability $1-a(\beta-\alpha)/2s$, the policy maker gets away without punishment. To ensure that these probabilities are well defined, we make the additional assumption that $a < 2s$. Put differently, we restrict attention to cases with a relatively imprecise degree of control over inflation, implying that the monitoring problem is relatively severe. [Since we are interested in studying the consequences of imprecise control over inflation on the effectiveness of reputation, this assumption does not appear to be problematic.]

For a given punishment length $\tau(\alpha,\beta)$, the *expected present discounted payoff after deviating* by planning $\pi^p(\alpha,\beta)$ in the first period is now found to equal:[7]

$$
\begin{aligned}
E[V(\alpha,\beta)] &= E[v(\alpha,\beta)] + \frac{a(\beta-\alpha)}{2s}\sum_{t=1}^{\tau(\alpha,\beta)}\delta^t E[v(con)-v(\alpha)] + \sum_{t=1}^{\infty}\delta^t E[v(\alpha)] \qquad (14)\\
&= E[v(\alpha,\beta)] + \frac{a(\beta-\alpha)}{2s}\,\frac{\delta[1-\delta^{\tau(\alpha,\beta)}]}{1-\delta}\,E[v(con)-v(\alpha)] + \frac{\delta}{1-\delta}\,E[v(\alpha)],
\end{aligned}
$$

where

$$
E[v(\alpha,\beta)] = a^2(\beta-\alpha) - \frac{(\beta a)^2+\sigma_\psi^2}{2}. \qquad (15)
$$

Note that the expected utility reduction through the punishment is smaller, the larger is s, the support of ψ. The intuition is that the information content of the observed inflation realization is lower when s is larger, implying that the union can monitor the policy maker's actions less perfectly.

For any given $\alpha \in [0,1)$, a *punishment phase of* $\tau(\alpha,\beta)$ *periods is sufficient to deter the deviation* $\pi^p(\alpha,\beta)$, if and only if [iff for short] $\pi^p(\alpha,\beta)$ does not increase the policy maker's expected utility, $E[V(\alpha,\beta)] \leq E[V(\alpha)]$. Using (12) and (14), this can be

[7] It should be noted that by the one–stage–deviation principle it is sufficient to consider only one deviation; see Fudenberg and Tirole (1991).

shown to be equivalent to

$$E[v(\alpha,\beta)-v(\alpha)] \leq \frac{a(\beta-\alpha)}{2s}\,\frac{\delta[1-\delta^{\tau(\alpha,\beta)}]}{1-\delta}E[v(\alpha)-v(con)]. \qquad (16)$$

Note that both $E[v(\alpha,\beta)-v(\alpha)]$ and $E[v(\alpha)-v(con)]$ are positive, which follows immediately from (11a), (12) and (15). To understand condition (16) intuitively, we observe that the left hand side shows the expected utility increase in the period of the deviation, whereas the right hand side represents the expected present value of the future utility decrease from the punishment.

We are now in the position to calculate the minimal length of the punishment period, $\underline{\tau}(\alpha,\beta)$, which is sufficient to deter the deviation $\pi_t^p(\alpha,\beta)$ from $\pi_t^p(\alpha)$.

Lemma 1: *Define a function*

$$f(\alpha,\beta) \equiv \frac{2s(2-\alpha-\beta)}{a(1-\alpha^2)+2s(2-\alpha-\beta)}. \qquad (17)$$

Given that planned inflation is the policy maker's private information, the following three cases are possible:

1. *If $\delta > f(\alpha,\beta)$, then any punishment period τ with $\tau \geq \underline{\tau}(\alpha,\beta)$ deters the deviation $\pi_t^p(\alpha,\beta)$, where*

$$\underline{\tau}(\alpha,\beta) \equiv \frac{1}{\ln\delta}\ln\left(1-\frac{2s(1-\delta)(2-\alpha-\beta)}{a\delta(1-\alpha^2)}\right). \qquad (18)$$

2. *If $\delta = f(\alpha,\beta)$, then $\underline{\tau}(\alpha,\beta) \equiv \infty$ is the only punishment period that deters $\pi_t^p(\alpha,\beta)$.*

3. *If $\delta < f(\alpha,\beta)$, then no punishment period deters $\pi_t^p(\alpha,\beta)$.*

Proof: see appendix A.

We may note that if a finite punishment period is sufficient to deter the deviation $\pi^p(\alpha,\beta)$, this period will be longer, the more imprecise is control over inflation, i.e. the larger is s. Furthermore, for a given discount factor, it is less likely that a finite punishment phase can deter a deviation, the larger is s. These two results reflect the fact that the private information problem tends to weaken the effectiveness of reputational forces.

3.3 The Maximal Credible Punishment Period

So far, we have only calculated the length of the punishment phase that would be sufficient to deter a deviation. Now, we will analyze how the trade union forms the trigger strategy, and which punishment phases it will be willing to carry out, that is, which punishment phases are chisel–proof.

A first important issue is that, in principle, the trade union could punish the policy maker also when it has not detected a deviation. To see why such arbitrary punishments cannot be optimal, consider a threshold $\gamma(\alpha)$ $[\gamma(\alpha) \in (\alpha, 1)]$ and assume that the union punishes for $\bar{\tau}$ periods whenever realized inflation exceeds $a\gamma(\alpha)$. In the first period, this would decrease the policy maker's expected utility both with and without a deviation by

$$\frac{a(1-\gamma(\alpha))}{2s}\,\frac{\delta[1-\delta^{\bar{\tau}}]}{1-\delta}\,E[v(con)-v(\alpha)]. \tag{19}$$

Thereafter, punishments with the same resulting reduction in expected utility will occur with probability $[a(1-\gamma(\alpha))]/2s$ in any period, providing that, in this period, the policy maker is not punished already and plans $\pi^p(con)$. Since, after a deviation in the first period, the probability that the policy maker is punished during the first $\bar{\tau}$ periods of the game is by $a(\beta-\alpha)/2s$ larger than without a deviation in the first period, arbitrary punishments will decrease the present discounted value of the policy maker's expected utility by more if he does *not* deviate in the first period. Consequently, arbitrary punishments do not help in disciplining the policy maker not to renege. The trade union, which suffers too from the suboptimally high inflation during punishment phases, will therefore not wish to execute arbitrary punishments, implying that it will set $\gamma(\alpha) = 1$ and punish only when it can detect a deviation. So, it is without loss of generality that, in the previous sections, we have concentrated on punishments triggered by *detected* deviations.

A second issue of critical importance is that, distinct from aN–L, planned inflation is the policy maker's private information in the present paper. In particular, whenever $\pi(\alpha,\beta) > \pi^p(\alpha)+s$ and the trade union can detect that a deviation must have occurred, it faces the signal extraction problem to infer from the observed inflation rate which inflation rate the policy maker has planned. In a minor abuse of notation, we will write

$$\beta^e \equiv \frac{E[\pi^p|\pi(\alpha,\beta) > \pi^p(\alpha)+s]}{a}, \tag{20}$$

where $E[\pi^p|\pi(\alpha,\beta) > \pi^p(\alpha)+s]$ denotes the trade union's rational expectation of planned inflation, given that a deviation must have occurred. Planned inflation then must have been at least $\pi(\alpha,\beta)-s$. Since the union knows that $\pi^p(con)$ is the largest inflation rate that the policy maker would want to plan, the uniformity of ψ implies

$$\beta^e = \frac{\pi^p(con)+\pi(\alpha,\beta)-s}{2a}. \tag{21}$$

It follows that $\beta^e \in (\underline{\beta}^e, \bar{\beta}^e]$, where $\underline{\beta}^e \equiv (1+\alpha)/2$ and $\bar{\beta}^e \equiv (1+\beta)/2$ are the infimum and the maximum of the set of all possible β^e. They are obtained from (21) by setting $\pi^p(\alpha,\beta)$ equal to $\alpha a+s$ and to $\beta a+s$.

To ensure that the punishment threat is credible, we now derive, for any given $\alpha \in [0,1)$ and $\beta^e \in (\alpha,1]$, the longest punishment period, $\bar{\tau}(\alpha,\beta^e)$, which the union is willing to carry out. $\bar{\tau}(\alpha,\beta^e)$ follows from applying the equilibrium refinement chisel–proofness, which requires that the union's expected utility when it does not punish ["acquiesces"] is not larger than that when it punishes [aN–L].

On one hand, *if the trade union punishes the public sector* for $\tau(\alpha,\beta^e)$ future periods, its' expected utility becomes

$$\begin{aligned} E[U(\alpha,\beta^e,pun)] &= E[u(\alpha,\beta^e)] + \sum_{t=1}^{\tau(\alpha,\beta^e)} \delta^t E[u(con)] + \sum_{t=\tau(\alpha,\beta^e)+1}^{\infty} \delta^t E[u(\alpha)] \qquad (22)\\ &= E[u(\alpha,\beta^e)] + \frac{\delta[1-\delta^{\tau(\alpha,\beta^e)}]}{1-\delta} E[u(con)] + \frac{\delta^{\tau(\alpha,\beta^e)+1}}{1-\delta} E[u(\alpha)], \end{aligned}$$

where

$$
\begin{aligned}
E[u(\alpha,\beta^e)] &= -a^2[(\beta^e)^2+b(\beta^e-\alpha)^2]+(b+1)\sigma_\psi^2. &\text{(23a)}\\
E[u(\alpha)] &= -(\alpha a)^2-(b+1)\sigma_\psi^2. &\text{(23b)}
\end{aligned}
$$

One the other hand, *if the union acquiesces*, then its' expected utility is given by

$$
E[U(\alpha,\beta^e,acq)] = \frac{1}{1-\delta}E[u(\alpha,\beta^e)] = -\frac{a^2[(\beta^e)^2+b(\beta^e-\alpha)^2]+(b+1)\sigma_\psi^2}{1-\delta}. \tag{24}
$$

Punishing is preferred by the union, iff the resulting expected utility is not smaller than under acquiescing,

$$
E[U(\alpha,\beta^e,acq)] \leq E[U(\alpha,\beta^e,pun)]. \tag{25}
$$

Using (22) and (23a), this is found to be equivalent to

$$
\frac{\delta[1-\delta^{\tau(\alpha,\beta^e)}]}{1-\delta}E[u(\alpha,\beta^e)-u(con)] \leq \frac{\delta^{[\tau(\alpha,\beta^e)+1]}}{1-\delta}E[u(\alpha)-u(\alpha,\beta^e)]. \tag{26}
$$

The left hand side of (26) shows the expected present value of the cost of punishing, arising since planned inflation during the punishment phase will be $\pi^p(con)$ instead of $\pi^p(\alpha,\beta^e)$. [Note that for large β^e, the expected cost of punishing might become negative.] The right hand side measures the expected present value of the gain from punishing, coming from the fact that planned inflation after the punishment phase will be $\pi^p(\alpha)$ instead of $\pi^p(\alpha,\beta^e)$. [Note that $E[u(\alpha)-u(\alpha,\beta^e)]$ is positive, which is implied by (23a) and (23b).]

Chisel–proofness demands that condition (26) be satisfied for all $\beta^e \in (\underline{\beta}^e,\bar{\beta}^e]$. Rewriting (26) by using (11b), (23a) and (23b), we find

$$
\delta^{\tau(\alpha,\beta^e)} \geq \frac{E[u(\alpha,\beta^e)-u(con)]}{E[u(\alpha)-u(con)]} = \frac{1-(\beta^e)^2-b(\beta^e-\alpha)^2}{1-\alpha^2}. \tag{27}
$$

The right hand side is a quadratic function in β^e, which has an *unconstraint* maximum at $\alpha b/(1+b)$. Since $\underline{\beta}^e=(1+\alpha)/2>\alpha b/(1+b)$, the right hand side takes on its' *constraint* maximum for $\underline{\beta}^e$. Using this, *the necessary and sufficient condition for chisel–proofness*, (27), simplifies to

$$\delta^{\tau(\alpha,\beta^e)} \geq \frac{4-(1+\alpha)^2-b(1-\alpha)^2}{4(1-\alpha^2)}. \tag{28}$$

(28) immediately leads to the following lemma:

Lemma 2: *Provided that planned inflation is the policy maker's private information, the following two cases can occur for a given $\alpha \in [0,1)$:*

1. *If $4 \leq (1+\alpha)^2 + b(1-\alpha)^2$, then all punishment periods are credible, that is,* $\bar{\tau}(\alpha, \beta^e) = \infty$.

2. *If $4 > (1+\alpha)^2 + b(1-\alpha)^2$, then the maximal credible punishment period is*[8]

$$\bar{\tau}(\alpha, \beta^e) = \frac{1}{\ln\delta} \ln\left(\frac{4-(1+\alpha)^2-b(1-\alpha)^2}{4(1-\alpha^2)}\right). \tag{29}$$

Note that, differently from aN–L, the maximal credible punishment period is here *independent* of the size of the actual deviation. This comes about, because the actual deviation is the policy maker's private information and the necessary and sufficient condition for the credibility of the punishment is that punishing is preferred for $\underline{\beta}^e$, which is independent of the actual deviation.

3.4 The Possible Collapse of Reputational Forces Under Private Information

Here, we show that reputational forces can become ineffective when the private information problem is quite severe. A first example follows from case 3 of lemma 1. Using (17) to rewrite condition $\delta < f(\alpha, \beta)$, we find that if for all $\alpha \in [0,1)$, there is a $\beta \in (\alpha, 1]$ such that

$$\frac{\delta a(1-\alpha^2)}{2(1-\delta)(2-\alpha-\beta)} < s, \tag{30}$$

[8] $\bar{\tau}(\alpha, \beta^e)$ is well defined, since, from (28), the second logarithm on the right hand side of (29) must be negative too.

then there exists no $\alpha \in [0,1)$ for which all deviations can be deterred. Since the left hand side of (30) increases in β, we set $\alpha = \beta$, which gives

$$\frac{\delta a(1+\alpha)}{4(1-\delta)} < s. \tag{31}$$

However, this inequality holds for all $\alpha \in [0,1)$, iff it holds for $\alpha = 1$, that is, iff

$$\frac{1}{2}\frac{\delta}{1-\delta}a < s. \tag{32}$$

Using continuity arguments, we can see that (32) is necessary and sufficient to ensure that for all $\alpha \in [0,1)$, there will exist a $\beta \in (\alpha, 1]$ [and close to α] such that (30) is true. Thus, we have the following proposition:

Proposition 1: *If planned inflation is private information and control over inflation is sufficiently imprecise, that is, (32) holds, then no $\pi^p(\alpha)$ other than $\pi^p(con)$ can be a subgame–perfect Nash–equilibrium in trigger strategies.*

Next, we show that even if (32) does not hold true, reputational effects can become ineffective, because the trade union may not be willing to punish severely enough. As we have proved above, $\bar{\tau}(\alpha, \beta^e)$ is the maximal punishment length that the union is ready to impose on the policy maker, given that its' rational forecast of β is β^e. The policy maker, for this reason, knows that the expected punishment phase after choosing $\pi^p(\alpha, \beta)$ does not exceed

$$\int_{(1+\alpha)/2}^{(1+\beta)/2} \bar{\tau}(\alpha, \beta^e) d\beta^e. \tag{33}$$

Consequently, reputational forces also collapse if for all $\alpha \in [0,1)$, there exists a $\beta \in (\alpha, 1]$ such that

$$\underline{\tau}(\alpha, \beta) > \int_{(1+\alpha)/2}^{(1+\beta)/2} \bar{\tau}(\alpha, \beta^e) d\beta^e, \tag{34}$$

that is, the minimal punishment period $\underline{\tau}(\alpha, \beta)$ sufficient to deter the deviation $\pi^p(\alpha, \beta)$ exceeds the policy maker's expectation of the maximal chisel–proof punishment period. In order to obtain an explicit condition for this to true, we first note that $b < 3$ is a necessary and sufficient condition to ensure that $4 > (1+\alpha)^2 + b(1-\alpha)^2$ for all $\alpha \in [0, 1)$, implying that case 2 of lemma 2 is the relevant one. Employing, in addition, equation (18) from case 1 of lemma 1, (34) can be rewritten to

$$1 - \frac{2s(1-\delta)(2-\alpha-\beta)}{a\delta(1-\alpha^2)} < \left[\frac{4-(1+\alpha)^2 - b(1-\alpha)^2}{4(1-\alpha^2)}\right]^{(\beta-\alpha)/2}. \tag{35}$$

Since for $\beta = \alpha$, (35) is satisfied, continuity arguments imply that for all $\alpha \in [0, 1)$, there exists a β close to α for which (34) holds.

Proposition 2: *If planned inflation is private information and the trade union assigns a sufficiently large weight to the loss from inflation, that is, $b < 3$, then the time consistent inflation plan, $\pi^p(con)$, is the only chisel–proof Nash–equilibrium in trigger strategies.*

In conclusion, we have identified situations in which reputational forces completely break down in the present model.[9] This break–down is more likely, the larger is the support s of ψ, the smaller is the discount factor β, and the lower is the relative weight b the union assigns to output deviations. The intuition is as follows. First, if s is large, then the private information problem is severe, since a planned inflation surprise is detected only with a low probability. Second, if β is small, then the policy maker discounts heavily the utility reduction during the punishment phase, making the punishment less effective. Moreover, for a small β, the trade union is less willing to punish, the reason being that the gain from the punishment [i.e. lower inflation after the punishment phase] will occur after the costs [i.e. higher inflation during the punishment phase]. Finally, if b is small, then the trade union attaches a large relative weight to the losses from inflation, implying that it is less willing to create a punishment phase with high inflation.

4 Reputational Forces Under Inflation Targeting

Having shown that the private information problem may render reputational forces ineffective, we now argue that this problem can be resolved. In particular, we suggest

[9] Note that this result is stronger than that in Canzoneri (1985), because, here, reputation does not work whenever $b < 3$, *independently* of the size of the discount factor.

that it vanishes when the government delegates the conduct of monetary policy to an institutionally independent central bank, but retains the power to set *publicly announced inflation targets*. In the language of Fischer (1995), the central bank then enjoys *instrument independence*, but not *goal independence*, implying that the government can influence monetary policy only through a revision of the inflation target. It should be stressed that we do *not* follow the literature in assuming that the government can precommit not to revise the inflation target after the union has signed a nominal wage contract. In contrast, the government here is given full discretion, the only restriction being that any change in the target is made public. Yet, as will become clear below, such an inflation targeting arrangement is perfectly transparent and can reduce the inflationary bias.

In order to analyze formally the effect of inflation targeting, the *central bank's objective function* must be specified. As is standard, we assume a similar functional form for the central bank's objective function as for that of the government,

$$V^{cb} = \sum_{t=0}^{\infty} \delta^t [a(\pi^p - \pi^e + \psi) - \frac{1}{2}(\pi^p - \pi^t + \psi)^2], \tag{36}$$

where the only new item is π^t, i.e. the inflation target set by the government. We will proceed in two steps: first, the Nash–equilibrium is derived under the [provisional] assumption that the inflation target is believed by the trade union; then, we discuss which inflation targets can be implemented as chisel–proof Nash–equilibria in trigger strategies.

If the announced inflation target is believed by the union, the *time consistent Nash–equilibrium* is found as follows: the central bank takes the inflation target and private inflation expectations as given and maximizes (36) with respect to π^p, yielding its' reaction function; taking this reaction function and the inflation target as given, the trade union chooses π^e so as to maximize (7). This results in

$$\pi^p(con, \pi^t) = \pi^e(con, \pi^t) = a + \pi^t \quad \text{and} \quad \pi(con, \pi^t) = a + \pi^t + \psi. \tag{37}$$

As pointed out by Svensson (1995), setting the inflation target $\pi^t = -a$ leads to the ex ante optimal outcome. However, since the government may change the inflation target *after* nominal wage contracts have been signed, we must characterize which inflation targets are indeed credible from the point of view of the trade union. For example, as it stands, $\pi^t = -a$ will not be credible, because the union anticipates the government's incentive to revise the target from $-a$ to 0, thereby engineering an inflation surprise of size a. One might therefore be tempted to conclude that setting an inflation target can only reduce the inflationary bias of the time consistent outcome, if the government can somehow precommit not to revise the target after wages have been set. This appears to be what McCallum (1995) had in mind when criticizing the recent literature for merely reallocating the precommitment problem from the central bank to the government.

In the remainder of this section, we show that this critique is not quite correct. In particular, we argue that the *key advantage of our inflation targeting arrangement* is its' transparency: if the inflation target, and any possible revisions of it, are publicly announced, then π^t is known to the trade union. Recalling (37), one can see that the union then also knows $\pi^p(con, \pi^t)$. Consequently, the private information problem is resolved and the trade union can perfectly monitor monetary policy making. In particular, it can detect the source of unexpected inflation: if the government has not changed the inflation target after wages have been set, then an observed inflation surprise must be due to a positive realization of the disturbance ψ; conversely, if the target has been revised, then the union knows that the government wanted to engineer surprise inflation.

Since inflation targeting resolves the private information problem, one expects an inflation targeting arrangement to strengthen the disciplinary effect of reputational forces. This claim can be proved by going through the same steps as in the last subsection, however, under the changed assumption that planned inflation is now common knowledge. More specifically, one needs to (i) calculate the shortest punishment period, $\underline{\tau}(\alpha, \beta)$, which is sufficient to deter a change in the inflation target in order to engineer a deviation $\pi^p(\alpha, \beta)$ from $\pi^p(\alpha)$; (ii) calculate the longest punishment period, $\bar{\tau}(\alpha, \beta)$, which is chisel–proof; (iii) determine the smallest $\underline{\alpha} \in [0, 1)$ for which $\underline{\tau}(\alpha, \beta)$ does not exceed $\bar{\tau}(\alpha, \beta)$, for all $\beta \in (\alpha, 1]$. $\pi^p(rep) = \underline{\alpha}a$ will then be the smallest inflation plan that is sustainable through chisel–proof trigger strategies under inflation targeting. Since the analysis for this case is essentially identical to that in aN–L [who studied the case of perfect control over inflation and, therefore, did not face a private information problem], we only state the final outcome.

Proposition 3: *Under inflation targeting, the lowest inflation plan that is sustainable as a subgame perfect Nash–equilibrium by chisel–proof trigger strategies is given as* $\underline{\pi}^p(rep) = (1-\delta)a$. *To achieve* $\underline{\pi}^p(rep)$, *the government has to set the inflation target* $\underline{\pi}^t(rep) = -\delta a$.

Proof: for the first statement see the proof of proposition 4 [part (c)] in aN–L; the second statement is immediate from (37). QED

We can see that even if the private information problem of monetary policy making under an institutionally dependent central bank is so severe that reputational forces collapse, a properly designed inflation targeting arrangement can revive reputation and reduce the inflation bias. However, in the absence of an explicit precommitment device, inflation targeting does not lead to the ex ante optimal outcome and an inflationary bias remains, as long as the future is discounted. This result is in contrast to Svensson (1995), who assumed that the government can precommit to the inflation target.

It may be of interest to observe that a Rogoff–type (1985), infinitely conservative central banker with a zero relative weight on output stimulation would eliminate the inflationary bias totally. However, this result is rather artificial, since it stems from the fact that, for analytical simplicity, we have employed a policy objective with a *linear* output term. This is equivalent to saying that the government does not care about output fluctuations. For government objective functions with a *quadratic* output term, appointing a conservative central banker becomes costly due to his suboptimal output stabilization. The optimally chosen central banker then puts a positive weight, which is smaller than that of the government, on output stabilization and fails to achieve the first best outcome. Yet, even if the government cares about output stabilization, appointing a finitely conservative central banker, in addition to inflation targeting, will at least reduce the inflation bias, which inflation targeting leaves.[10]

5 Conclusion

This paper has argued that an inflation targeting arrangement, which gives instrument independence, but not goal independence to the central bank, leads to full transparency and reduces the inflationary bias of optimal monetary policy making. The reason for the latter result is that a transparent arrangement resolves the private information problem of optimal monetary policy and enhances the effectiveness of reputational forces. However, within the model considered here, in which the government has discretion to revise the target, reputational forces cannot completely eliminate the inflationary bias. Hence, an inflation targeting arrangement can only partly substitute for explicit precommitment, and there is need for other explicit precommitment devices. Examples are the appointment of a conservative central banker, or the imposition of legal restrictions on the government's discretion to revise the inflation target after wage contracts have been set.

The paper can explain why recent reforms of the central bank's status in various countries have resulted in reduced average inflation rates.[11] Moreover, the results suggest that the adoption of some form of inflation targeting, e.g. in England or Sweden, has been a sensible response to the break down of the pre–1992 EMS. While inflation targeting preserves the transparency advantage of exchange rate pegging, it avoids the costs of the latter policy regime. These costs come from the import of the center country's monetary policy stance, which is often suboptimal from the point of view of periphery–countries.[12]

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[10] That it can be desirable to supplement an institutional solution by appointing a conservative central banker has independently been developed in Herrendorf and Lockwood (1996) [within a static model for output targeting, inflation targeting, or a central bank contract] and in Svensson (1995) [within a dynamic model for inflation targeting].

[11] For a discussion see Canzoneri, Nolan and Yates (1995), Svensson (1995), and the papers in Leiderman and Svensson (1995). The central bank reform in New Zealand is probably the most prominent example; see Walsh (1995b) for a detailed assessment.

[12] Compare Herrendorf (1994,1995c) for a discussion of reputation under pegged and floating exchange

Appendix: Proof of Lemma 1

Let

$$\tilde{f}(\alpha,\beta) \equiv \frac{2s(1-\delta)E[v(\alpha,\beta)-v(\alpha)]}{a(\beta-\alpha)\delta E[v(\alpha)-v(con)]}. \tag{A.1}$$

(16) can then be rewritten to

$$\delta^{\tau(\alpha,\beta)} \leq 1-\tilde{f}(\alpha,\beta). \tag{A.2}$$

Now, if $\tilde{f}(\alpha,\beta) < 1$, then the smallest $\tau(\alpha,\beta)$ fulfilling (16) is

$$\underline{\tau}(\alpha,\beta) = \frac{\ln(1-\tilde{f}(\alpha,\beta))}{\ln(\delta)}. \tag{A.3}$$

In this case, $\underline{\tau}(\alpha,\beta)$ is finite and positive, because both the numerator and the denominator of the right hand side of (A.3) are negative. Alternatively, if $\tilde{f}(\alpha,\beta)=1$, then the smallest $\tau(\alpha,\beta)$ fulfilling (A.2) is ∞. Finally, if $\tilde{f}(\alpha,\beta)>1$, then (A.2) requires $\delta^{\tau(\alpha,\beta)}<0$, which is impossible. Hence no punishment period deters $\pi_t^p(\alpha,\beta)$.

Since from (11a), (12), and (15),

$$\tilde{f}(\alpha,\beta) = \frac{2s(1-\delta)(2-\alpha-\beta)}{a\delta(1-\alpha^2)}, \tag{A.4}$$

we have

$$\tilde{f}(\alpha,\beta) \lesseqqgtr 1 \iff f(\alpha,\beta) \lesseqqgtr \delta. \tag{A.5}$$

Hence, the claim follows. QED

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rates.

References

al Nowaihi, Ali and Paul Levine, "Can Reputation Resolve the Monetary Credibility Problem?," *Journal of Monetary Economics*, 1994, *33*, 355–380.

Backus, David and John Driffill, "Inflation and Reputation," *American Economic Review*, 1985, *75*, 530–538.

Barro, Robert J. and David Gordon, "Rules, Discretion, and Reputation in a Model of Monetary Policy," *Journal of Monetary Economics*, 1983, *12*, 101–121.

Canzoneri, Matthew B., "Monetary Policy Games and the Role of Private Information," *American Economic Review*, 1985, *75*, 1056–1070.

– , Charles Nolan, and Anthony Yates, "Mechanisms for Achieving Monetary Stability: Inflation Targeting Versus the ERM," Working Paper, Bank of England 1995.

Cukierman, Alex, *Central Bank Strategy, Credibility, and Independence: Theory and Evidence*, Cambridge, MA: MIT Press, 1992.

– , "The Economics of Central Banking," (Paper Prepared for the World Congress of the International Economic Association 1995), Tel–Aviv University, Israel 1995.

Driffill, John and Christian Schultz, "Wage Setting and Stabilization Policy in a Game with Renegotiation," *Oxford Economic Papers*, 1992, *44*, 440–459.

Farrell, Joe and Eric Maskin, "Renegotiation in Repeated Games," *Games and Economic Behaviour*, 1989, *1*, 327–360.

Fischer, Stanley, "Central Bank Independence Revisited," *American Economic Review (Papers and Proceedings)*, 1995, *85*, 201–206.

Fratianni, Michele, Jürgen von Hagen, and Christopher Waller, "Central Banking as a Principal Agent Problem," *Forthcoming: Economic Inquiry*, 1995.

Friedman, James, "A Noncooperative Equilibrium of Supergames," *Review of Economic Studies*, 1971, *38*, 1–12.

Fudenberg, Drew and Jean Tirole, *Game Theory*, Cambridge, MA: MIT Press, 1991.

Garfinkel, Michelle R. and Seonghwan Oh, "Strategic Discipline in Monetary Policy with Private Information: Optimal Targeting Horizons," *American Economic Review*, 1993, *83*, 99–117.

Herrendorf, Berthold, "Importing Credibility Through Exchange Rate Pegging," (Presented at the 9th EEA Congress in Maastricht), European University Institute, Florence, Italy 1994.

– , "Optimal Collection of Time Consistent Seigniorage: A Unifying Framework," *Forth-*

coming: Journal of Economic Surveys, 1995.

– , "Transparency, Reputation, and Credibility Under Floating and Pegged Exchange Rates," (Presented at the 10th EEA Congress in Prague), European University Institute, Florence, Italy 1995.

– **and Ben Lockwood**, "Rogoff's 'Conservative' Central Banker Restored," Discussion Paper (Forthcoming), CEPR, London 1996.

Leiderman, Leonardo and Lars E.O. Svensson, *Inflation Targets*, London: CEPR, 1995.

Lockwood, Ben, "State–Contingent Inflation Contracts and Output Persistence," Discussion Paper 95/13, University of Exeter 1995.

– **, Marcus Miller, and Lei Zhang**, "Designing Monetary Policy when Unemployment Persists," Discussion Paper 94/08, University of Exeter, UK 1994.

Lohmann, Susanne, "Optimal Precommitment in Monetary Policy: Credibility Versus Flexibility," *American Economic Review*, 1992, *82*, 273–286.

McCallum, Bennett T., "Two Fallacies Concerning Central Bank Independence," *American Economic Review (Papers and Proceedings)*, 1995, *85*, 207–211.

Persson, Torsten and Guido Tabellini, "Designing Institutions for Monetary Stability," *Carnegie–Rochester Conference Series on Public Policy*, 1993, *39.*

Rogoff, Kenneth, "The Optimal Degree of Commitment to an Intermediate Target," *Quarterly Journal of Economics*, 1985, *100*, 1169–1190.

Svensson, Lars E.O., "Optimal Inflation Targets, 'Conservative' Central Banks, and Linear Inflation Contracts," Discussion Paper 1249, CEPR, London 1995.

Waller, Christopher J., "The Choice of a Conservative Central Banker in a Multisector Economy," *American Economic Review*, 1992, *82*, 1006–1012.

Walsh, Carl E., "Central Bank Strategies, Credibility, and Independence: A Review Essay," *Journal of Monetary Economics*, 1993, *32*, 287–302.

– , "Announcements, Inflation Targeting and Central Bank Incentives," Mimeo, University of California, Santa Cruz, USA 1995.

– , "Is New Zealand's Reserve Bank Act of 1989 an Optimal Central Bank Contract?," *Forthcoming: Journal of Money, Credit, and Banking*, 1995.

– , "Optimal Contracts for Central Bankers," *American Economic Review*, 1995, *85*, 150–167.