

COSTLY INFORMATION ACQUISITION AND DELEGATION TO A “LIBERAL” CENTRAL BANKER

JOHAN LAGERLÖF*

This paper develops a model of monetary policy in which the central banker can acquire costly information about a supply shock. It is shown that, with this assumption, it may be optimal for society to delegate to a “weight-liberal” central banker, a result which contrasts with that of Rogoff (1985). This result points at a limitation of Rogoff’s argument. It may also explain why the issue of delegating monetary policy to an independent and “weight-conservative” central banker often is politically controversial.

1. INTRODUCTION

SINCE THE work of Kydland and Prescott (1977) and Barro and Gordon (1983), it is well known that monetary policy may suffer from a credibility problem. Rogoff (1985) suggests that this problem and the inflation bias that it gives rise to can be reduced if society delegates the task of conducting monetary policy to an independent and “weight-conservative” central banker. Although Rogoff’s solution to the credibility problem is only second best, it does give a better outcome than having a central banker with the same preferences as the rest of society. Thus, if the theory has empirical content, one should expect countries that do not already have an independent central bank to take the opportunity to reform their monetary institutions. Indeed, in many OECD countries over the last few years, one has been able to observe a move toward a greater central bank independence. As Muscatelli (1999, p. 241) notes, however, “[i]n countries where there has been little or no tradition of [central bank] independence (e.g. the United Kingdom, France) this issue has been hotly debated.” Apparently, delegation to an independent and conservative central banker is not perceived by everybody as something unambiguously good.

An alternative solution to the credibility problem is suggested by Walsh (1995).¹ He points out that the inflation bias can be completely eliminated by

* Correspondence to: Johan Lagerlöf, ECARES, Université Libre de Bruxelles, Av. Roosevelt, 50–CPI 114, B-1050 Brussels, Belgium. E-mail: lagerloef@medea.wz-berlin.de. I have benefited from helpful discussions with and comments from Jonas Björnerstedt, Yeongjae Kang, Nippe Lagerlöf, Susanne Lohmann, César Martinelli, Björn Persson, David Sundén, Karl Wärneryd, Jörgen Weibull, two anonymous referees, and the co-editor in charge Allan Drazen. Financial support from Jan Wallander and Tom Hedelius’ Foundation is gratefully acknowledged. Two major revisions of this paper were carried out as part of a CEPR research network funded by the European Commission under the TMR program (contract no. ERBFMRXCT980203).

¹ See also Persson and Tabellini (1993).

designing a simple performance contract for the central banker. This gives an outcome that is first best. Moreover, now there is no role for a central banker with some particular private preferences. Herrendorf and Lockwood (1997), however, consider a setting in which wage setters have some private information, for instance about a supply shock, prior to setting the nominal wage. They show that if the central banker's contract cannot be made conditional on this information, then the optimal choice of objectives for an independent central banker will include weight-conservatism.² This result indicates that the private preferences of the banker do make a difference, and that Rogoff's delegation story may indeed be useful when thinking about the optimal choice of central bank objectives.

Within his framework of an optimal and complete contract,³ Walsh (1995) also considers the interesting and realistic possibility that the appointed central banker, once in office, gets to see a noisy signal about a supply shock, and by exerting effort she can improve upon the quality of this signal. As Walsh suggests (p. 161), a signal with higher quality may for instance be due to a better forecast, and a better forecast may be more costly to produce because it requires more data-collection, more intensive monitoring of financial-market developments, or greater staff resources devoted to forecasting. Walsh shows that, also with this extension, the inflation bias can be eliminated using a simple performance contract.

In this paper I follow the example of Walsh (1995) and study the incentives for a central banker to make an effort (in particular, to acquire costly information), although in a setting where society *cannot* write a complete contract. For simplicity I take the approach of Rogoff and assume that society's only instrument is to choose to whom it wants to delegate. I thus consider a standard version of Rogoff (1985), extended in a straightforward way to allow for endogenous information acquisition on the part of the central banker.

By using this modeling approach I can in a simple way make the following simple point: Provided the banker chooses how much effort to exert once she is in office, this will alter society's incentives when deciding to whom it should delegate. In particular, the banker's opportunity to make an effort adds an incentive for society to delegate to someone who cares more about employment and less about inflation, relative to what would be the case in Rogoff's model. The reason for this is that a banker who cares more about employment will make a greater effort finding information about the supply shock. If the credibility problem in Rogoff's model is not too severe, this "information-acquisition effect" will offset the incentives to delegate to someone more weight-conservative or even make it optimal to delegate to a banker who is more

² Beetsma and Jensen (1998) and Muscatelli (1999) analyze models with uncertainty about the central banker's preferences and show that this may also make weight-conservatism preferable.

³ Strictly speaking, the optimal contract that Walsh studies is not complete. The important point, however, is that the Walsh contract is sufficiently complete to eliminate the inflation bias whereas the Herrendorf and Lockwood contract is not.

“weight-liberal.” Following Svensson (1997) I also consider an extension of the model in which society is able to choose not only the banker’s relative weight on inflation/employment, but also her inflation target. Under this assumption, society will *always* delegate to a banker who is more weight-liberal (but who also has a lower inflation target) than society itself. These results point at a limitation of Rogoff’s argument. They may also serve as one possible explanation why many people do not want the conduct of monetary policy to be delegated to someone caring less about employment.^{4,5}

The remainder of the paper is organized as follows. In section 2 the basic model is described. Section 3 presents the analysis and the results of that model. Section 4 analyzes the extension that allows for inflation targeting. Section 5 concludes. An appendix contains some algebra that is omitted from the main text.

2. MODEL

The following simple version of Rogoff’s (1985) model closely follows the setting in Persson and Tabellini (1990, 2000), although I add an opportunity for the appointed central banker to make an effort and thereby improve upon the quality of a signal that she gets to see.

Society’s preferences are described by the following quadratic loss function:

$$\widehat{L}(\pi, x) = \pi^2 + \lambda(x - \bar{x})^2, \tag{1}$$

where π is the rate of inflation, x is the level of employment, $\bar{x} \geq 0$ is the most preferred employment level, and $\lambda > 0$ is a weight. The relationship between employment and inflation is given by the following expectations-augmented Phillips curve:

$$x = \beta(\pi - \pi^e) - \varepsilon, \tag{2}$$

where $\beta > 0$ is a fixed parameter, π^e is the expected inflation rate, and ε is a supply shock. Initially the magnitude of the supply shock ε is unknown to everybody; the distribution of ε is known though and in particular that $E(\varepsilon) = 0$. It will be convenient to let $L(\pi)$ denote society’s loss function when the expectations-augmented Phillips curve has been substituted for x in $\widehat{L}(\pi, x)$:

⁴ Muscatelli (1999) also offers an explanation of this phenomenon. His suggested explanation relies on the assumption that the preferences of the prospective central bankers are not perfectly known, which makes delegation more costly. The explanation that is offered in the present paper should be thought of as complementary to Muscatelli’s.

⁵ Another argument for why an optimally chosen central banker should be weight-liberal rather than weight-conservative can be found in Cukierman and Lippi (1999), Guzzo and Velasco (1999), and Lippi (2000). In those papers, wages are assumed to be set not by atomistic agents but by monopolistic unions who act strategically and take into account the monetary policy response to their chosen wages. As a consequence, a weight-conservative banker might be counterproductive since she will tend to accommodate less, which may induce the unions to pursue a more aggressive wage policy.

$$L(\pi) = \pi^2 + \lambda[\beta(\pi - \pi^e) - \varepsilon - \bar{x}]^2. \quad (3)$$

The timing of events is as follows. (i) Society delegates the task of conducting monetary policy to an independent central banker. Prospective central bankers have loss functions that take the form of (1) but differ in their personal values of λ . (ii) The private sector observes the preferences of the appointed banker and then forms its expectations about the inflation rate, π^e . (iii) The banker takes office. Once in office, she first decides on an effort level e ; then she observes a signal, s , that is correlated with the supply shock ε . (iv) The central banker decides on the inflation rate π . (v) The supply shock is realized.

It is assumed that $e \equiv \rho^2$, where ρ is the correlation coefficient between s and ε ; hence $e \in [0, 1]$. Thus, by making a greater effort, the central banker can improve upon the quality of the signal. Making an effort, however, is costly for the central banker; the disutility that she incurs from exerting effort level e equals $C(e)$, where $C' > 0$ and $C'' > 0$ with $C'(0) = 0$. Throughout the paper – the only exception being Example 1 – it is also assumed that the cost function satisfies the Inada condition $\lim_{e \rightarrow 1} C'(e) = \infty$.

Let F be the joint cumulative distribution function of ε and s , with density f . The following notation will be used: $\mu_s = E(s)$, $\sigma_s^2 = \text{var}(s)$, $\sigma^2 = \text{var}(\varepsilon)$, and $\rho = \text{cov}(\varepsilon, s)/(\sigma\sigma_s)$ (where $\sigma\sigma_s \equiv \sqrt{\sigma^2\sigma_s^2}$). (Recall that the expected value of ε equals zero, $E(\varepsilon) = 0$.) Thus, as already mentioned, ρ is the correlation coefficient between s and ε .

It is assumed that, after having observed the signal s , the central banker updates her beliefs about the shock ε using Bayes' rule. Thus, her beliefs are described by the conditional density function $f(\varepsilon|s)$ defined by $f(\varepsilon|s) = f(\varepsilon, s)/f(s)$, where $f(s) = \int f(\varepsilon, s)d\varepsilon$ is the marginal density of s . The conditional expectation function is defined by $E(\varepsilon|s) = \int \varepsilon f(\varepsilon|s)d\varepsilon$. It is assumed that F is such that ε has linear regression with regard to s , i.e., that $E(\varepsilon|s)$ is a linear (affine) function of s .⁶ It is well known that if ε has linear regression with regard to s (and if $E(\varepsilon) = 0$), then

$$E(\varepsilon|s) = \rho \frac{\sigma}{\sigma_s} (s - \mu_s). \quad (4)$$

This relationship will be used later on in the analysis.

It is also assumed that the private sector forms its expectations about the inflation level rationally. That is, the expected rate of inflation, π^e , is given by

$$\pi^e = E_{e,s}(\pi). \quad (5)$$

Hence, π^e equals the expected value of the actual rate of inflation at the stage where only the prior distribution of ε and s is known.

⁶ This is true, for example, for a bivariate normal distribution; see Vives (1999, pp. 63–64) and the references therein.

3. ANALYSIS

Let us denote the central banker’s λ -parameter by λ_B and her (reduced-form) loss function by L_B . That is, L_B is given by (3) but with $\lambda_B \in [0, \infty)$ substituted for λ . At the last stage, the central banker will implement the inflation rate π that minimizes her expected loss conditional on her having observed the signal s , taking into account that a change in π affects the employment level x according to the expectations-augmented Phillips curve. That is, the central banker solves the following problem:

$$\min_{\pi} \int L_B(\pi) f(\varepsilon|s) d\varepsilon. \tag{6}$$

Taking the first-order condition of this problem and then solving for π yield

$$\pi_B^* = \frac{\lambda_B \beta [\beta \pi^e + E(\varepsilon|s) + \bar{x}]}{1 + \lambda_B \beta^2}. \tag{7}$$

The expected rate of inflation is obtained by taking expectations with respect to s of both sides of equation (7), using the fact that $E_s(E(\varepsilon|s)) = E(\varepsilon) = 0$, and then solving for π^e . Doing this yields $\pi^e = \lambda_B \beta \bar{x}$. Substituting this expression for π^e into equation (7) in turn yields

$$\pi_B^* = \lambda_B \beta \bar{x} + \frac{\lambda_B \beta E(\varepsilon|s)}{1 + \lambda_B \beta^2}. \tag{8}$$

That is, on average, the equilibrium rate of inflation equals $\lambda_B \beta \bar{x}$, which typically is greater than zero – the ideal rate according to equation (1). This “inflation bias” arises because an average inflation rate of zero is not credible (or time consistent). The reason for this is that at $\pi = 0$, the marginal benefit of surprise inflation exceeds the marginal cost of inflation. For the marginal cost of inflation just to balance the marginal gain from an increase in employment, it must be that the average inflation equals $\lambda_B \beta \bar{x}$. Thus, the zero rate of inflation would indeed be time consistent if the employment goal, \bar{x} , were equal to the “natural” level of employment, normalized to zero in equation (2).

Let EL_B denote the central banker’s expected loss at the stage where she is to choose the effort level e . At this point in time, she only knows the prior distribution of s and ε . Of course, however, she anticipates that later, when knowing s , she will choose the rate of inflation according to (8). Hence, we get

$$\begin{aligned} EL_B &= \int \int L_B(\pi_B^*) f(\varepsilon, s) d\varepsilon ds + C(e) \\ &= (\lambda_B \beta \bar{x})^2 - \frac{\lambda_B^2 \beta^2 \sigma^2 e}{1 + \lambda_B \beta^2} + \lambda_B (\bar{x}^2 + \sigma^2) + C(e), \end{aligned} \tag{9}$$

where the last term is the postulated cost of exerting effort. The expression after the second equality sign in (9) was obtained by using equations (3), (4), (8), the identity $e = \rho^2$, and carrying out some algebra.⁷

The problem of minimizing EL_B with respect to e subject to the constraint $e \in [0, 1]$ has the solution e^* defined by

$$\frac{\lambda_B^2 \beta^2 \sigma^2}{1 + \lambda_B \beta^2} = C'(e^*). \quad (10)$$

Note for future use that

$$\frac{\partial e^*}{\partial \lambda_B} = \frac{\beta^2 \sigma^2 \lambda_B (2 + \lambda_B \beta^2)}{C''(e^*) (1 + \lambda_B \beta^2)^2} > 0. \quad (11)$$

That is, as expected, a central banker who cares more about employment (has a larger λ_B) makes a greater effort to learn about the supply shock ε .

Now consider society's problem. Let EL denote society's expected loss given that the central banker has parameter λ_B and accordingly exerts effort $e^*(\lambda_B)$. We get

$$\begin{aligned} EL &= \int \int L(\pi_B^*) f(\varepsilon, s) d\varepsilon ds \\ &= (\lambda_B \beta \bar{x})^2 - \frac{\lambda_B \beta^2 e^* \sigma^2}{(1 + \lambda_B \beta^2)^3} [\lambda(2 + \lambda_B \beta^2) - \lambda_B] + \lambda(\sigma^2 + \bar{x}^2), \end{aligned} \quad (12)$$

where the expression after the second equality sign again was obtained by using equations (3), (4), (8), and the identity $e = \rho^2$.

Differentiating EL with respect to λ_B yields

$$\frac{\partial EL}{\partial \lambda_B} = 2\beta^2 \bar{x}^2 \lambda_B - \frac{2\beta e^* \sigma^2 (\lambda - \lambda_B)}{(1 + \lambda_B \beta^2)^3} - \frac{\lambda_B \beta^2 \sigma^2}{(1 + \lambda_B \beta^2)^2} [\lambda(2 + \lambda_B \beta^2) - \lambda_B] \frac{\partial e^*}{\partial \lambda_B}. \quad (13)$$

By inspecting equation (13), we can identify three different effects regarding society's incentives to appoint a central banker with certain preferences, each effect corresponding to one of the three terms on the right-hand side of the equation. The first term is the only one containing \bar{x} , and it vanishes if $\bar{x} = 0$. This term captures the familiar "Rogoff effect," i.e., society's incentives to appoint a central banker who cares less about employment than itself in order to mitigate the inflation bias. The third term captures the "information-acquisition effect." If the condition $\lambda(2 + \lambda_B \beta^2) > \lambda_B$ is met, then this effect counteracts the Rogoff effect; this condition guarantees that it is in society's interest that the

⁷ For details of this algebra as well as the calculations needed for deriving equations (12) and (27) below, see the Appendix.

central banker acquires more information.⁸ If society appoints a central banker who cares more about employment than itself, this banker will exert more effort looking for information and, hence, she will be more able to stabilize employment. This effect would vanish if the quality of the signal were exogenous. The second term in (13) represents the incentives of society to delegate the task of deciding on monetary policy to a central banker who will stabilize employment neither too little nor too much. Indeed, if we had $\bar{x} \equiv \partial e^*/\partial \lambda_B \equiv 0$, then both the first and the third term would vanish, and we would get the result $\lambda_B = \lambda$; that is, society would then appoint a central banker with the same preferences as society itself.

Thus, we can easily retrieve Rogoff’s (1985) result by setting $\partial e^*/\partial \lambda_B = 0$ and $e^* = \rho^2$ in (13). Doing this and setting the resulting expression equal to zero yield

$$\beta \bar{x}^2 \lambda_B - \frac{\rho^2 \sigma^2 (\lambda - \lambda_B)}{(1 + \lambda_B \beta^2)^3} = 0. \tag{14}$$

As Rogoff showed, in this case the optimal λ_B will be strictly smaller than society’s own λ -parameter but strictly greater than zero.

Let us now, momentarily, eliminate the Rogoff effect by setting $\bar{x} = 0$ in (13). Doing this mainly serves the analytical purpose of helping us see in a stark way how the information-acquisition effect works. Setting $\bar{x} = 0$ in this model, however, also seems to be supported by the ideas expressed in Blinder (1998) who, writing as an academic with recent practical experience of central banking, dismisses the time-inconsistency theory while emphasizing the practical importance of the fact that monetary policy is conducted in an environment with substantial uncertainty.

Let λ_B^0 denote a solution to the problem of minimizing EL with respect to λ_B , given $\bar{x} = 0$ and subject to the constraint $\lambda_B \in [0, \infty)$. Moreover, for $\lambda \beta^2 < 1$, let $\hat{\lambda}$ be defined by $\hat{\lambda} \equiv 2\lambda/(1 - \lambda \beta^2)$.

Proposition 1. Suppose that $\bar{x} = 0$ and $\lambda \beta^2 < 1$. Then $\lambda_B^0 \in (\lambda, \hat{\lambda})$ and λ_B^0 satisfies

$$2(\lambda - \lambda_B^0) + (1 + \lambda_B^0 \beta^2)[\lambda(2 + \lambda_B^0 \beta^2) - \lambda_B^0] \eta(\lambda_B^0) = 0, \tag{15}$$

where

$$\eta(\lambda_B) = \frac{\partial e^*}{\partial \lambda_B} \frac{\lambda_B}{e^*}.$$

Proof. Note that the first term in (13) is zero when $\bar{x} = 0$; the second term in (13) has the same sign as $(\lambda_B - \lambda)$; the third term has the same sign as $(\lambda_B - \hat{\lambda})$. Hence, the function EL is strictly decreasing in λ_B for all $\lambda_B \in [0, \lambda]$, and it is

⁸Hence, if the condition is *not* met, an individual with taste parameter λ is worse off when a decision-maker with taste parameter λ_B is better informed. For a discussion of this phenomenon, see Lagerlöf (2000).

strictly increasing in λ_B for all $\lambda_B \in [\hat{\lambda}, \infty)$. This, in turn, means that EL must have at least one minimum with respect to λ_B somewhere on the open interval $(\lambda, \hat{\lambda})$. Moreover, at a point where EL is minimized, we must have

$$\left. \frac{\partial EL}{\partial \lambda_B} \right|_{\bar{x}=0, \lambda_B=\lambda_B^0} = 0. \tag{16}$$

Rewriting this equality yields (15). □

That is, when the Rogoff effect is eliminated (i.e., when $\bar{x} = 0$), society delegates to a central banker who cares more about employment than itself. From Proposition 1 and from a continuity argument it follows that there also must be some $\bar{x} > 0$ such that the optimal λ_B still is greater than λ ; that is, society will delegate to a banker who cares more about employment than itself also in the case where there indeed is a Rogoff effect present, provided this effect (i.e., \bar{x}) is sufficiently small. Another thing one should notice about the proposition is that it assumes that λ and/or β are sufficiently small. If this condition ($\lambda\beta^2 < 1$) is not met, society's optimization problem might not have a solution; this is because then society might want to make λ_B infinitely large.

The following example illustrates the result stated in Proposition 1 and shows that with a quadratic cost function we can get a closed-form solution for λ_B^0 .

Example 1. Suppose that $\bar{x} = 0$, $\lambda\beta^2 < 1$, and that $C(e) = \frac{1}{2}e^2$. Using (10), we then get

$$e^* = \min \left\{ \frac{\beta^2 \sigma^2 (\lambda_B^0)^2}{1 + \beta^2 \lambda_B^0}, 1 \right\}. \tag{17}$$

Assuming that the less-than-unity constraint does not bind,⁹ we also get

$$\eta(\lambda_B^0) = \frac{2 + \beta^2 \lambda_B^0}{1 + \beta^2 \lambda_B^0}. \tag{18}$$

Using (18) in (15) and then simplifying and solving for λ_B^0 in turn yield

$$\lambda_B^0 = \frac{1}{\beta^2} \left[\sqrt{\frac{2(2 + \lambda\beta^2)}{1 - \lambda\beta^2}} - 2 \right]. \tag{19}$$

This expression for λ_B^0 is (strictly) increasing in both λ and β ,¹⁰ which is in line with our intuition. One can also show that $\lim_{\beta \rightarrow 0} \lambda_B^0 = 3\lambda/2$. Hence, in this

⁹ Since it turns out that λ_B^0 is not a function of σ^2 , it is easy to see that this constraint does not bind if σ^2 is sufficiently small. In particular, since we know that $\lambda_B^0 < \hat{\lambda}$, a sufficient condition for this is that

$$\sigma^2 \leq (1 + \beta^2 \hat{\lambda}) / \beta^2 \hat{\lambda}^2 = [1 - (\lambda\beta^2)^2] / 4\lambda^2 \beta^2.$$

¹⁰ In order to check that $\partial \lambda_B^0 / \partial \beta > 0$, it is helpful to first set $\beta^2 \equiv \gamma$ in (19). Then it is fairly straightforward to verify that $\partial^2 \lambda_B^0 / \partial \gamma \partial \lambda > 0$ and that $\lim_{\lambda \rightarrow 0} \partial \lambda_B^0 / \partial \gamma = 0$; these two facts together imply the claim.

example we have $\lambda_B^0 \in (3\lambda/2, \hat{\lambda})$; that is, here it is optimal to delegate to a banker with a λ -parameter that is at least 1.5 times society’s own.

Let us now again allow for the possibility that $\bar{x} > 0$. Let λ_B^* denote a solution to the problem of minimizing EL with respect to λ_B , again subject to the constraint $\lambda_B \in [0, \infty)$ but now not necessarily with $\bar{x} = 0$.¹¹ To see when the information-acquisition effect is stronger than the Rogoff effect, so that $\lambda_B^* > \lambda$, let us evaluate equation (13) at $\lambda_B = \lambda_B^* = \lambda$. Doing this yields

$$\left. \frac{\partial EL}{\partial \lambda_B} \right|_{\lambda_B = \lambda_B^* = \lambda} = -2\lambda\beta^2\bar{x}^2 + \frac{\beta^2\lambda^2\sigma^2}{1 + \lambda\beta^2} \left. \frac{\partial e^*}{\partial \lambda_B} \right|_{\lambda_B = \lambda_B^* = \lambda}. \tag{20}$$

If we assume that society’s expected loss, EL , is quasi-convex in λ_B (i.e., that the second-order condition is met), then we will have $\lambda_B^* > \lambda$ if (and only if) the right-hand side of equation (20) is greater than zero, or equivalently

$$\left. \frac{\partial e^*}{\partial \lambda_B} \right|_{\lambda_B = \lambda_B^* = \lambda} > \frac{2\bar{x}^2(1 + \lambda\beta^2)}{\lambda\sigma^2}. \tag{21}$$

By rewriting this inequality, using the expression for $\partial e^*/\partial \lambda_B$ in (11), we get the following proposition.

Proposition 2. Suppose that EL is quasi-convex in λ_B . Then $\lambda_B^* > \lambda$ if and only if

$$\bar{x}^2 < \frac{\beta^2(\sigma^2)^2\lambda^2(2 + \lambda\beta^2)}{2C''(e^*)(1 + \lambda\beta^2)^3} \equiv \varphi(\beta^2, \sigma^2, \lambda), \tag{22}$$

where e^* is evaluated at $\lambda_B = \lambda_B^* = \lambda$.

Hence, if the employment goal, \bar{x} , is small relative to the right-hand side of (22), φ , and if the second-order condition is met, society will delegate the task of conducting monetary policy to someone more weight-liberal than itself. It is straightforward to see that the function φ is positive if all its arguments are positive. As the following example shows, however, this function is not necessarily monotone in any one of its arguments.

Example 2. Suppose that $C(e) = (1 - \sqrt{1 - e})^2$. Using (10), we get

$$C''(e^*) = \frac{1}{2} \left[\frac{1 + \beta^2\lambda_B(1 + \sigma^2\lambda_B)}{1 + \beta^2\lambda_B} \right]^3. \tag{23}$$

Hence,

$$\varphi(\beta^2, \sigma^2, \lambda) = \frac{\beta^2(\sigma^2)^2\lambda^2(2 + \lambda\beta^2)}{[1 + \beta^2\lambda(1 + \sigma^2\lambda)]^3}. \tag{24}$$

¹¹ In the following it is implicitly assumed that λ_B^* indeed exists. If λ_B^* did not exist, this would be because society has an incentive to make λ_B arbitrarily large.

It is easy to verify that this expression for φ equals zero if any one of its arguments equals zero, and it goes to zero as any one of its arguments goes to infinity. Thus, in this example, φ will obtain its highest value – and thereby make it more likely that inequality (22) holds – for some intermediate value of β , σ^2 , respectively λ .

4. INFLATION TARGETING

So far in the paper I have, following Rogoff (1985), confined attention to the problem of choosing among a set of prospective central bankers who are more or less conservative/liberal; i.e., who differ only with regard to their λ -parameter. Much of the literature the last few years, however, has focused on inflation targeting; see in particular Svensson (1997). The approach of this literature is to think of society as choosing among bankers who differ from each other in two dimensions: their λ -parameter as well as their inflation goal, $\bar{\pi}$.¹² In this section I will use that approach and investigate how some results of Svensson (1997) are affected by the assumption that the appointed central banker can gather costly information.

In order to do this we must first, since the inflation goal $\bar{\pi}$ was set equal to zero in the previous sections, specify the following, slightly more general, reduced-form loss function on the part of society:

$$\tilde{L}(\pi) = (\pi - \bar{\pi})^2 + \lambda[\beta(\pi - \pi^e) - \varepsilon - \bar{x}]^2, \quad (25)$$

where $\bar{\pi} \in \Re$ is society's ideal rate of inflation. The prospective central bankers' loss functions, denoted by $\tilde{L}_B(\pi)$, also have the form of (25) but with $\lambda_B \in [0, \infty)$ substituted for λ and $\bar{\pi}_B \in \Re$ substituted for $\bar{\pi}$. The rest of the model is the same as before (see the model description in section 2), although now society's delegation problem at stage (i) amounts to choosing λ_B and $\bar{\pi}_B$ instead of only λ_B .

Using the same procedure as in the previous section, we can solve for the equilibrium rate of inflation in this modified model, $\tilde{\pi}_B^*$. Doing this yields

$$\tilde{\pi}_B^* = \bar{\pi}_B + \lambda_B \beta \bar{x} + \frac{\lambda_B \beta E(\varepsilon|s)}{1 + \lambda_B \beta^2}. \quad (26)$$

Our next step is to consider the central banker's choice of effort level, e . First notice from (26) that neither the deviation from the inflation goal, $\tilde{\pi}_B^* - \bar{\pi}_B$, nor the non-predictable part of the inflation level, $\tilde{\pi}_B^* - E\tilde{\pi}_B^*$, is a function of $\bar{\pi}_B$.

¹²Svensson's interpretation of this assumption, however, is not that society chooses a central banker with some particular private preferences, but that it simply chooses the goal of the central bank. Here I will stick to the former interpretation. Drazen (2000) emphasizes that this distinction is more than semantic and also argues that the private-preferences interpretation is the realistic one to give to the model (see pp. 152–153 of his book for details of the argument).

Hence, the deviation from the inflation goal as well as the non-predictable part of the inflation level are the same as in the previous section, where we assumed that $\bar{\pi}_B = 0$. Accordingly, the banker’s expected loss at the time of her decision on e must be identical to EL_B as given in equation (9) in the previous section [cf. equation (25)]. Thus, also the optimal effort level, e^* , is the same as before and given by (10).

Let us finally consider society’s delegation problem. Society’s expected loss given that the central banker has the parameters λ_B and $\bar{\pi}_B$ is given by

$$\begin{aligned} \widetilde{EL} &= \int \int L(\bar{\pi}_B^*) f(e, s) de ds \\ &= (\lambda_B \beta \bar{x} + \bar{\pi}_B - \bar{\pi})^2 - \frac{\lambda_B \beta^2 e^* \sigma^2}{(1 + \lambda_B \beta^2)^2} [\lambda(2 + \lambda_B \beta^2) - \lambda_B] + \lambda(\sigma^2 + \bar{x}^2). \end{aligned} \quad (27)$$

Assuming that the second-order condition is met, the optimal choice of λ_B and $\bar{\pi}_B$ will be characterized by the following two first-order conditions:

$$\frac{\partial \widetilde{EL}}{\partial \bar{\pi}_B} = 0 = 2(\lambda_B \beta \bar{x} + \bar{\pi}_B - \bar{\pi}), \quad (28)$$

$$\begin{aligned} \frac{\partial \widetilde{EL}}{\partial \lambda_B} = 0 &= 2\beta \bar{x}(\lambda_B \beta \bar{x} + \bar{\pi}_B - \bar{\pi}) - \frac{2\beta e^* \sigma^2 (\lambda - \lambda_B)}{(1 + \lambda_B \beta^2)^3} \\ &\quad - \frac{\lambda_B \beta^2 \sigma^2}{(1 + \lambda_B \beta^2)^2} [\lambda(2 + \lambda_B \beta^2) - \lambda_B] \frac{\partial e^*}{\partial \lambda_B}. \end{aligned} \quad (29)$$

Equation (28) says that, at the optimum, $\bar{\pi}_B = \bar{\pi} - \lambda_B \beta \bar{x}$; this is the result of Svensson (1997): the banker’s inflation goal is optimally set to make sure that the inflation bias $\bar{\pi}_B - \bar{\pi} + \lambda_B \beta \bar{x}$ is completely eliminated. The second condition, equation (29), corresponds to equation (13) in the previous section, the only difference being that here the first term also contains $(\bar{\pi}_B - \bar{\pi})$. In contrast to the model in the previous section, however, here the first term vanishes when we plug in $\bar{\pi}_B = \bar{\pi} - \lambda_B \beta \bar{x}$ from (28). This means that the results concerning the optimal choice of λ_B that were reported in Proposition 1 apply here as well – but without having to assume that $\bar{x} = 0$. That is, letting $\hat{\lambda} \equiv 2\lambda/(1 - \lambda\beta^2)$ as before, and denoting the optimal choice of $(\lambda_B, \bar{\pi}_B)$ by $(\lambda_B^{**}, \bar{\pi}_B^{**})$, we have the following result.

Proposition 3. Suppose that \widetilde{EL} is quasi-convex in $\bar{\pi}_B$ and λ_B , and that $\lambda\beta^2 < 1$. Then $\bar{\pi}_B^{**} = \bar{\pi} - \lambda_B^{**} \beta \bar{x}$ and $\lambda_B^{**} \in (\lambda, \hat{\lambda})$ where λ_B^{**} satisfies equation (15) (with $\lambda_B^0 = \lambda_B^{**}$).

In other words, provided that society can choose the central banker’s inflation target as well as her λ -parameter, monetary policy will always be delegated to a banker who cares more about employment than society itself does – in the sense of having a greater λ . This central banker, however, also cares more about inflation than society does in the sense of having a lower inflation target.

Put differently, the optimally chosen central banker is weight-liberal but target-conservative. Notice that the results of Example 1 are also valid here (without having to assume that $\bar{x} = 0$). That is, if we assume that the cost function is quadratic and that $\lambda\beta^2 < 1$, there is a closed-form solution for λ_B^{**} which is given by equation (19).

It should be added to this that in the model of Svensson (1997), who considers a dynamic setting with a possibility of employment persistence, there is another effect present: the employment persistence in his model gives rise to a “stabilization bias” (i.e., supply shocks are stabilized too much); moreover, given that the chosen inflation target cannot be made contingent on a shock to the natural employment level, this stabilization bias can only be eliminated by making the banker more weight-conservative than the rest of society. If such an effect were present in the model with endogenous information gathering analyzed here, it would counteract the incentive to delegate to a more weight-liberal banker, and the optimal choice of λ_B would depend on the relative strength of the two effects.

Let me finally mention another caveat that applies to the inflation-targeting model in this section as well as to the model in the previous section. Namely, an optimal contract specifying monetary transfers has not been explicitly modeled in this paper. Instead it was assumed that society’s only instrument is to choose the parameters λ_B respectively λ_B and $\bar{\pi}_B$. This approach was useful in that it helped us see in a simple way how society’s incentives when deciding to whom it should delegate are affected by the appointed central banker’s having an opportunity to acquire information. Yet such an approach begs the questions whether society, by using other instruments like monetary transfers, can give the banker the correct incentives to gather information, and whether under such circumstances it would be optimal to choose an agent with other preferences over inflation and employment than the rest of society. Walsh (1995) only answers the first one of those questions, since he considers a setting in which the private preferences of the banker are given (and identical to the rest of society’s). In a setting like the one Walsh studies, however, in which there is a moral-hazard problem (non-observable information acquisition) as well as an adverse-selection problem (non-observable competency of the banker), it is well known that the principal (i.e., society) must give up rents to the agent (i.e., the banker).¹³ This means that, since in such a setting the size of the rents should depend on the banker’s preferences, we should indeed expect there to be a benefit from choosing a banker with different preferences than society’s own, even when monetary transfers are available. Exploring this possibility, however, is a task that is left for future work.

¹³That is, providing optimal incentives to the banker will be costly for society, and the optimal contract will not be Pareto efficient. See, e.g., Walsh (1995), Laffont and Tirole (1986), and Osband (1989).

5. CONCLUSION

This paper has studied an extension of Rogoff (1985) in which the central banker can choose how much effort to exert and, thereby, how much to learn about a supply shock. It was shown that, with this assumption, society’s incentive to delegate to a banker who is more weight-conservative than itself is mitigated. Indeed, if the credibility problem in Rogoff’s original model (as measured by the size of the difference between the employment goal and the “natural” employment level) is not too severe, it is optimal for society to delegate to a more “weight-liberal” banker. Moreover, in an extension of the model in which society is able to choose not only the banker’s relative weight on inflation/employment but also her inflation target, the optimally chosen banker is always more weight-liberal (but also more target-conservative) than society itself.

Two forces drive these results. First, at least some of the cost of exerting effort (or acquiring information) is incurred by the banker personally. Second, the contract that society can write is sufficiently incomplete. As noted in the introduction, both these assumptions have been made earlier in the literature [by Walsh (1995) respectively Herrendorf and Lockwood (1997)], although not at the same time, and none of the assumptions seems to be unreasonable. The contribution of the present paper has been to show what the two assumptions in conjunction imply for the optimal choice of central bank objectives. It has also been suggested that the results of the paper may explain why many individuals in a large number of countries object to the idea of delegating the conduct of monetary policy to an independent and weight-conservative central banker.

APPENDIX

This appendix goes through some steps in the derivation of equations (9), (12), and (27) that were left out from the main body of the paper. This will be done by first considering the slightly more general specification of the loss function that is used in section 4. From the resulting expressions we can then easily get equations (9) and (12) by setting $\bar{\pi}_B = \bar{\pi} = 0$.

Lemma A1. $E[\varepsilon E(\varepsilon|s)] = \rho^2 \sigma^2 = E[E(\varepsilon|s)]^2$.

Proof. Let us first prove the first equality. We have

$$\begin{aligned} E[\varepsilon E(\varepsilon|s)] &= \rho \frac{\sigma}{\sigma_s} E[\varepsilon(s - \mu_s)] = \rho \frac{\sigma}{\sigma_s} E(\varepsilon s) \\ &= \rho \frac{\sigma}{\sigma_s} [\text{cov}(\varepsilon, s) + E(\varepsilon)E(s)] = \rho \frac{\sigma}{\sigma_s} \rho \sigma \sigma_s = \rho^2 \sigma^2, \end{aligned}$$

where the first equality makes use of (4), the second equality makes use of $E(\varepsilon) = 0$, and the fourth equality makes use of $E(\varepsilon) = 0$ and the fact that, by definition, $\rho = \text{cov}(\varepsilon, s)/\sigma \sigma_s$. Let us now prove the second equality in the lemma. We have

$$E[E(\varepsilon|s)]^2 = E\left[\rho \frac{\sigma}{\sigma_s}(s - \mu_s)\right]^2 = \left(\rho \frac{\sigma}{\sigma_s}\right)^2 E(s - \mu_s)^2 = \left(\rho \frac{\sigma}{\sigma_s}\right)^2 \sigma_s^2 = \rho^2 \sigma^2,$$

where the first equality makes use of (4), and the third equality makes use of the fact that, by definition, $\sigma_s^2 = E(s - \mu_s)^2$. □

Derivation of equations (12) and (27). From (5) and (26) we know that $\pi^e = E_s(\tilde{\pi}_B^*) = \tilde{\pi}_B + \lambda_B \beta \bar{x}$. Hence, using (26), one has

$$\tilde{\pi}_B^* - \pi^e = \frac{\lambda_B \beta E(\varepsilon|s)}{1 + \lambda_B \beta^2}. \tag{A1}$$

Combining (25), (26), and (A1), we can thus write

$$L(\tilde{\pi}_B^*) = \left[\tilde{\pi}_B - \bar{\pi} + \lambda_B \beta \bar{x} + \frac{\lambda_B \beta E(\varepsilon|s)}{1 + \lambda_B \beta^2}\right]^2 + \lambda \left[\beta \left(\frac{\lambda_B \beta E(\varepsilon|s)}{1 + \lambda_B \beta^2}\right) - \varepsilon - \bar{x}\right]^2. \tag{A2}$$

Now, from (A2) one has

$$\begin{aligned} \int \int L(\tilde{\pi}_B^*) f(\varepsilon, s) d\varepsilon ds &= \int \int \left[\tilde{\pi}_B - \bar{\pi} + \lambda_B \beta \bar{x} + \frac{\lambda_B \beta E(\varepsilon|s)}{1 + \lambda_B \beta^2}\right]^2 f(\varepsilon, s) d\varepsilon ds \\ &\quad + \lambda \int \int \left[\frac{\lambda_B \beta^2 E(\varepsilon|s)}{1 + \lambda_B \beta^2} - \bar{x} - \varepsilon\right]^2 f(\varepsilon, s) d\varepsilon ds. \end{aligned} \tag{A3}$$

We can now, one at a time, rewrite the two terms on the right-hand side of (A3). The first term becomes

$$\begin{aligned} &\int \int [\tilde{\pi}_B - \bar{\pi} + \lambda_B \beta \bar{x}]^2 f(\varepsilon, s) d\varepsilon ds \\ &\quad + 2[\tilde{\pi}_B - \bar{\pi} + \lambda_B \beta \bar{x}] \frac{\lambda_B \beta}{1 + \lambda_B \beta^2} \int \int E(\varepsilon|s) f(\varepsilon, s) d\varepsilon ds \\ &\quad + \left[\frac{\lambda_B \beta}{1 + \lambda_B \beta^2}\right]^2 \int \int [E(\varepsilon|s)]^2 f(\varepsilon, s) d\varepsilon ds \\ &= [\tilde{\pi}_B - \bar{\pi} + \lambda_B \beta \bar{x}]^2 + \frac{\lambda_B^2 \beta^2 \rho^2 \sigma^2}{(1 + \lambda_B \beta^2)^2}, \end{aligned} \tag{A4}$$

where the equality makes use of $E_s[E(\varepsilon|s)] = 0$ and Lemma A1. Similarly, the second term in (A3) (for the moment ignoring the constant λ) can be written as

$$\begin{aligned}
 & \int \int \left[\frac{\lambda_B \beta^2 E(\varepsilon|s)}{1 + \lambda_B \beta^2} - \bar{x} \right]^2 f(\varepsilon, s) d\varepsilon ds \\
 & \quad - 2 \int \int \left[\frac{\lambda_B \beta^2 E(\varepsilon|s)}{1 + \lambda_B \beta^2} - \bar{x} \right] \varepsilon f(\varepsilon, s) d\varepsilon ds + \int \int \varepsilon^2 f(\varepsilon, s) d\varepsilon ds \\
 & = \int \int \left[\frac{\lambda_B \beta^2 E(\varepsilon|s)}{1 + \lambda_B \beta^2} \right]^2 f(\varepsilon, s) d\varepsilon ds - 2 \int \int \frac{\lambda_B \beta^2 E(\varepsilon|s)}{1 + \lambda_B \beta^2} \bar{x} f(\varepsilon, s) d\varepsilon ds + \bar{x}^2 \\
 & \quad - 2 \int \int \left[\frac{\lambda_B \beta^2 E(\varepsilon|s)}{1 + \lambda_B \beta^2} - \bar{x} \right] \varepsilon f(\varepsilon, s) d\varepsilon ds + \int \int \varepsilon^2 f(\varepsilon, s) d\varepsilon ds \\
 & = \left[\frac{\lambda_B \beta^2}{1 + \lambda_B \beta^2} \right]^2 \rho^2 \sigma^2 + \bar{x}^2 - 2 \frac{\lambda_B \beta^2}{1 + \lambda_B \beta^2} \rho^2 \sigma^2 + \sigma^2, \tag{A5}
 \end{aligned}$$

where the second equality makes use of $E_s[E(\varepsilon|s)] = 0$, $E(\varepsilon^2) = \sigma^2$, and Lemma A1. Hence, by using (A4) and (A5), we can rewrite (A3) as

$$\begin{aligned}
 & \int \int L(\tilde{\pi}_B^*) f(\varepsilon, s) d\varepsilon ds \\
 & = [\bar{\pi}_B - \bar{\pi} + \lambda_B \beta \bar{x}]^2 + \frac{\lambda_B^2 \beta^2 \rho^2 \sigma^2}{(1 + \lambda_B \beta^2)^2} \\
 & \quad + \lambda \left[\left[\frac{\lambda_B \beta^2}{1 + \lambda_B \beta^2} \right]^2 \rho^2 \sigma^2 + \bar{x}^2 - 2 \frac{\lambda_B \beta^2}{1 + \lambda_B \beta^2} \rho^2 \sigma^2 + \sigma^2 \right] \\
 & = [\bar{\pi}_B - \bar{\pi} + \lambda_B \beta \bar{x}]^2 + \frac{\lambda_B \beta^2 \rho^2 \sigma^2}{(1 + \lambda_B \beta^2)^2} [\lambda_B + \lambda [\lambda_B \beta^2 - 2(1 + \lambda_B \beta^2)]] + \lambda(\bar{x}^2 + \sigma^2) \\
 & = [\bar{\pi}_B - \bar{\pi} + \lambda_B \beta \bar{x}]^2 - \frac{\lambda_B \beta^2 \rho^2 \sigma^2}{(1 + \lambda_B \beta^2)^2} [\lambda(2 + \lambda_B \beta^2) - \lambda_B] + \lambda(\bar{x}^2 + \sigma^2). \tag{A6}
 \end{aligned}$$

Substituting the identity $e \equiv \rho^2$ into (A6) gives us equation (27), and by in addition setting $\bar{\pi}_B = \bar{\pi} = 0$ we get equation (12).

Derivation of equation (9). The simplest way to derive equation (9) is to make use of (A6) above. Substituting λ_B for λ and $\bar{\pi}_B$ for $\bar{\pi}$ in (A6), one has

$$\begin{aligned}
 & \int \int L_B(\pi_B^*) f(\varepsilon, s) d\varepsilon ds \\
 & = \lambda_B^2 \beta^2 \bar{x}^2 - \frac{\lambda_B \beta^2 \rho^2 \sigma^2}{(1 + \lambda_B \beta^2)^2} [\lambda_B(1 + \lambda_B \beta^2)] + \lambda_B(\bar{x}^2 + \sigma^2) \\
 & = \lambda_B^2 \beta^2 \bar{x}^2 - \frac{\lambda_B^2 \beta^2 \rho^2 \sigma^2}{1 + \lambda_B \beta^2} + \lambda_B(\bar{x}^2 + \sigma^2), \tag{A7}
 \end{aligned}$$

Substituting the identity $e \equiv \rho^2$ into (A7) and adding $C(e)$ give us equation (9).

JOHAN LAGERLÖF
 ECARES, Free University of Brussels and
 WZB – Social Science Research Center Berlin

REFERENCES

- Barro, R. J. and D. B. Gordon, 1983, A positive theory of monetary policy in a natural rate model. *Journal of Political Economy* 91, 589–610.
- Beetsma, R. M. W. J. and H. Jensen, 1998, Inflation targets and contracts with uncertain central banker preferences. *Journal of Money, Credit, and Banking* 30, 384–403.
- Blinder, A., 1998, *Central Banking in Theory and Practice* (MIT Press, Cambridge, MA).
- Cukierman, A. and F. Lippi, 1999, Central bank independence, centralization of wage bargaining, inflation and unemployment: theory and some evidence. *European Economic Review* 43, 1395–1434.
- Drazen, A., 2000, *Political Economy in Macroeconomics* (Princeton University Press, Princeton, NJ).
- Guzzo, V. and A. Velasco, 1999, The case for a populist central banker. *European Economic Review* 43, 1317–1344.
- Herrendorf, B. and B. Lockwood, 1997, Rogoff's "conservative" central banker restored. *Journal of Money, Credit, and Banking* 29, 476–495.
- Kydland, F. E. and E. C. Prescott, 1977, Rules rather than discretion: the inconsistency of optimal plans. *Journal of Political Economy* 85, 473–491.
- Laffont, J.-J. and J. Tirole, 1986, Using cost observation to regulate firms. *Journal of Political Economy* 94, 614–641.
- Lagerlöf, J., 2000, Are we better off if our politicians have more information? WZB Discussion Paper No. FS IV 98-7, revised version September 2000.
- Lippi, F., 2000, Revisiting the case for a populist central banker. Mimeo, Banca d'Italia, Rome, to appear in *European Economic Review*.
- Muscattelli, V. A., 1999, Inflation contracts and inflation targets under uncertainty: why we might need conservative central bankers. *Economica* 66, 241–254.
- Osband, K., 1989, Optimal forecasting incentives. *Journal of Political Economy* 97, 1091–1112.
- Persson, T. and G. Tabellini, 1990, *Macroeconomic Policy, Credibility and Politics* (Harwood Academic Publishers, Chur).
- and ———, 1993, Designing institutions for monetary stability. *Carnegie-Rochester Conference Series on Public Policy* 39, 53–84.
- and ———, 2000, Political economics and macroeconomic policy, in: J. Taylor and M. Woodford, eds., *Handbook of Macroeconomics* (North-Holland, Amsterdam).
- Rogoff, K., 1985, The optimal degree of commitment to an intermediate monetary target. *Quarterly Journal of Economics* 100, 1169–1190.
- Svensson, L. E. O., 1997, Optimal inflation targets, "conservative" central banks, and linear inflation contracts. *American Economic Review* 87, 98–114.
- Vives, X., 1999, *Oligopoly Pricing: Old Ideas and New Tools* (MIT Press, Cambridge, MA).
- Walsh, C. E., 1995, Optimal contracts for central bankers. *American Economic Review* 85, 150–167.