Shifts in the Inflation Target and Communication of Central Bank Forecasts

Mewael F. Tesfaselassie*

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Abstract

The paper examines the relationship between communication of central bank forecasts and macroeconomic stabilization when the inflation target is stochastic and unobservable. It shows that the equilibrium outcome without communication maybe associated with an active or passive monetary policy. Features of the economy, namely, the slope of the Phillips curve, the central bank's preference weight and the variability of the inflation target relative to the exogenous cost-push disturbances, determine whether monetary policy is active or passive.

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*Kiel Institute for the World Economy, Duesternbrooker Weg 120, 24105 Kiel, Germany. Tel: +49 431 8814 273, e-mail: mewael.tesfaselassie@ifw-kiel.de. The author would like to thank Felix Hammermann and Kai Carstensen for their helpful comments.

1 Introduction

In recent years, many central banks have moved towards publicly announcing their policy goals and monetary policy decisions as well as publishing their internal (staff) forecasts regarding the state of the economy. However, some central banks are still silent about their inflation targets, thus the move towards transparency has only been partial. For instance, according to Ireland (2005), the Federal Reserve has never explicitly revealed the setting for its inflation target.

What is also important is the fact that the inflation target has been time varying. Ireland (2005) argues that movements of the size and persistence in U.S. inflation could not have taken place without ongoing shifts in the Federal Reserve's inflation target. Among others, Erect and Levin (2003) link the issue of gradual disinflation to private sector learning about the central banks's inflation target and Smets and Wouters (2004) introduce a time-varying inflation target when comparing business cycles in the euro area and the U.S.[1]

This paper analyzes the consequences of partial transparency—one where a central bank discloses its forecasts and policy decisions but not its inflation target—for macroeconomic stabilization. A time-varying and potentially unobservable inflation target is imbedded in a New Keynesian model with cost-push shocks, in which the central bank possesses private information (forecast) about those shocks.[2]

The paper shows that, when changes in the inflation target are persistent and inflation expectations are forward-looking, the release of forecasts helps to stabilize inflation al-

[1]In principle, occasional shifts in central bank preferences may occur for different reasons, including political pressure or changes in the composition of the decision making committee of the central bank (see e.g., Cukierman (1992)). Of course, shifts in the inflation target is not necessarily related to a credibility problem. It could also be attributed to changing notions about the optimal rate of inflation. There could be genuine reasons for changing the long run inflation target at some point, as a result of "new research on measurement bias in the CPI or on the rate of "true" inflation that best promotes long run economic growth and stability"(Bernanke, Laubach, Mishkin and Posen (1999)).

[2]The paper's focus on the source of information asymmetry is closely related to Geraats (2001), which analyzes unobserved inflation targets within a Barro-Gordon type Phillips curve. There is an important difference in the transmission mechanism between a New Keynesian and a Barro-Gordon type model. In a Barro-Gordon model, current inflation depends on past expectations of current inflation, while in the New Keynesian framework, current inflation depends on expectations of future inflation.

though it leads to higher variability in the output gap. Jensen (2002) and Eiffinger and Tesfaselassie (2007) find similar results in the case of unobserved output target. However, an important finding of the paper is that disclosure policy can also determine the uniqueness of equilibria. In particular, it shows that the model with unobserved inflation target features more than one equilibrium in the case of limited disclosure of information by the central bank. In that case, the paper characterizes the selection of an equilibrium by the central bank as a function of the central bank's concern for inflation stabilization relative to output stabilization, the slope of the Phillips curve and the variance of the inflation target relative to the variance of the aggregate cost-push shocks. Moreover, unlike Jensen (2002), the equilibrium with full information (defined as the direct disclosure of the inflation target) dominates the one with full disclosure (indirect disclosure of the inflation target) for all parameter values.

The rest of the paper is organized as follows. Section 2 introduces the model and its information structure. Then Section 3 deals with the private sector's signaling extraction regarding the unobserved inflation target and the central bank's choice of optimal stabilization policy. Section 4 derives optimal policy rules and the corresponding equilibria while Section 5 looks into the effects of disclosure of forecasts on average outcomes by allowing the output target to differ from the natural rate. Section 6 discusses briefly the cases of full information vis-a-vis full transparency. Finally, Section 7 gives concluding remarks.

2 The policy problem

The model economy has two periods where period 1 is interpreted as the short run while period 2 represents the long run.[3] The dynamics of inflation is represented by a New

[3] This interpretation follows Jensen (2002) and Eiffinger and Tesfaselassie (2007).

Keynesian model[4] [5]

$$\pi_1 = E_1^p \pi_2 + \lambda x_1 + \epsilon_1$$
$$\pi_2 = E_2^p \pi_3 + \lambda x_2 \tag{3}$$

where π is the rate of inflation, x is the output gap, measured relative to its natural rate, which is normalized to zero, and ϵ is a random cost-push shock to inflation. The parameter $\lambda > 0$ measures the sensitivity of inflation to the output gap. The term $E_t^p \pi_{t+1}$, $t = 1, 2$, stands for private sector expectations of inflation in period $t+1$ conditional on all available information in period t (i.e., $E_t^p \pi_{t+1} = E(\pi_{t+1}|\Omega_t^p)$, where Ω_t^p is the information set of the private sector in period t).[6] For convenience, the central bank is assumed to have perfect control over x.[7] Following the literature, we assume that ϵ is normally distributed with mean zero and variance σ_ϵ^2. We let $\epsilon_2 = 0$ since in period 2, the economy is assumed to be in a full information (long run) steady state.

The central bank's loss function is defined over two periods, and is given by $E^c(\sum_{t=1}^2 L_t)$ where $L_t = \frac{1}{2}(\pi_t - \pi_t^*)^2 + \frac{\alpha}{2}(x_t - x^*)^2$ and α is the weight on output gap stabilization relative to inflation stabilization. In period 1 there is a random preference shock θ to a known inflation target $\pi^* = 0$. Thus the inflation target in period 1 is given by $\pi_1^* = \pi^* + \theta$, where $\theta \sim N(0, \sigma_\theta^2)$ is uncorrelated with ϵ_1. The precise value of x^* is not relevant for the

[4]The forward-looking nature of inflation is due to the fact that prices are sticky in the sense of Calvo (1983)—in each period only a fraction of firms can reset their prices. In this setting, when a firm has a chance to reset its price, it takes into account its forecasts of future developments in demand and thus prices.

[5]Note that one may also work with a more general model that involves, for e.g., a hybrid New Keynesian Phillips curve

$$\pi_t - \gamma\pi_{t-1} = (E_t^p \pi_{t+1} - \gamma\pi_t) + \lambda x_t + \epsilon_t \tag{1}$$

However, Woodford (2003) shows that this quasi-difference equation is associated with the loss function $L_t = (\pi_t - \gamma\pi_{t-1})^2 + \alpha x_t^2$. In that case, we can rewrite the Phillips curve as

$$\tilde{\pi}_t = E_t^p \tilde{\pi}_{t+1} + \lambda x_t + \epsilon_t \tag{2}$$

with $\tilde{\pi}_t = \pi_t - \gamma\pi_{t-1}$ and the loss function $L_t = \tilde{\pi}_t^2 + \alpha x_t^2$.

[6]The standard New Keynesian model usually attaches a coefficient β to $E_t^p \pi_{t+1}$. Here we set $\beta = 1$ for brevity.

[7]This assumption simplifies the algebra without altering the main message of the paper.

key results of the paper regarding the choice of the disclosure regime, so we set $x^* = 0$. For completeness, however, we discuss the case of $x^* > 0$ in Section 5.

The preference shock θ is assumed to be private information of the central bank and has a persistent nature. To capture this in a simple way, we let $\pi_2^* = \pi_1^*$. To model the choice of the optimal disclosure regime, we suppose that in period 1 the central bank has private information about the cost-push shock in period 1, ϵ_1. Unlike the preference shock, the cost-push shock is temporary, as $\epsilon_2 = 0$.

Since the preference shock to the inflation target is persistent and inflation is forward-looking, disclosure of the cost-push shock serves as a signal for the unobserved preference shock. Even though the public observes monetary policy decisions, it has imperfect information about whether changes in these decisions are in response to the temporary cost-push shock or the persistent preference shock. As it turns out, inflation expectations respond more strongly to policy actions when the central bank releases more information about its forecasts since it becomes easier for the public to infer about the inflation target and thus future inflation.

At the beginning of period 1, the central bank announces the disclosure regime. If the full-disclosure regime is announced, the private sector has full information about ϵ_1 as does the central bank. Otherwise, the central bank decides to keep its private information and the public engages in signal extraction.

The sequence of events and actions is as follows. In period 1, the central bank chooses the disclosure regime.[8] Then, ϵ_1 and θ realize and the central bank chooses x_1. Finally, conditional on x_1, the private sector sets $E_1^p\pi_2$, determining π_1. In period 2, the central bank chooses x_2, and the private sector sets $E_2^p\pi_3$, determining π_2.

The timing of events is such that the central bank chooses its policy before private sector inflation expectations are set. The public observes monetary policy decisions that

[8]Following the literature, disclosure is assumed to be truthful. The paper abstracts from strategic misrepresentation of information. Moreover, for easier exposition and without loss of generality, the central bank is assumed to have perfect knowledge of the cost-push shock.

respond to the central bank's private information. This implies that the private sector can infer in part the inflation target from observed central bank actions.

To get an intuitive explanation of the mechanisms involved consider period 1. The private sector does not observe the preference shock θ but it knows that the central bank responds to θ. Thus, x_1 is useful as a signal for θ, although the signal is noisy due to the presence of the cost-push shock ϵ_1. Using observations on x_1, the private sector solves a signal extraction problem and sets $E_1^p \pi_2$ rationally, which affects π_1 via the Phillips curve. The upshot is that, $E_1^p \pi_2$ responds more strongly to x_1 when the central bank releases more precise information about ϵ_1. In turn, the strong response of $E_1^p \pi_2$ induces the central bank to stabilize inflation more aggressively, given the preference weight α, but this comes at the cost of a more volatile output gap.

3 Signaling via stabilization policy

In choosing its monetary policy, the central bank takes into account the formation of inflation expectations.[9] The model is solved by backward induction starting from period 2. However, since the model horizon is finite and inflation is forward-looking, one needs a terminal condition for inflation expectations that is consistent with the steady state nature of period 2 (see Jensen (2002) in this regard).

The economy is in a full information steady state from period 2 onwards, implying that $\pi_2 = \pi_3$ and $E_2^p \pi_3 = \pi_3$. Consistent with this, the conjecture is $E_2^p \pi_3 = \pi_2^* = \theta$. Actually, the conjecture is identical to that derived from an infinite horizon version of the model with full information about the inflation target (see Appendix).[10] Nevertheless, as pointed out by Jensen (2002), the exact form of the terminal condition is not crucial for the choice of the disclosure regime in period 1. What is important is the public's knowledge

[9] In the parlance of game theory, the central bank is a *Stackelberg leader* while the private sector is a *Stackelberg follower*.

[10] To get an intuition, note that in steady state there is no conflict between inflation stability and output gap stability, and inflation expectations are anchored by the inflation target π_2^*.

that future inflation is a function of the persistent preference shock.

3.1 Period 2: Full information steady state

We start in period 2, where the central bank minimizes the period loss function

$$\frac{1}{2}[(E_2^p\pi_3 + \lambda x_2 - \pi_2^*)^2 + \alpha x_2^2]$$

with respect to x_2 and subject to the constraint $E_2^p\pi_3 = \pi_2^* = \theta$. This leads to the following steady state solution for x_2 and π_2:

$$x_2 = 0; \qquad \pi_2 = \pi_2^* = \theta \tag{4}$$

Note that the conjecture for $E_2^p\pi_3$ is consistent with the equilibrium level of inflation. Moreover, the steady state value of the output gap is equal to its natural rate.[11]

Because inflation expectations are forward-looking, equation (4) has implications for the outcomes of period 1. To be specific, as the steady state inflation rate π_2 depends on θ, it follows that under rational expectations $E_1^p\pi_2$ is a function of any signal about θ. Since π_1 depends on $E_1^p\pi_2$, information disclosure indirectly affects the conduct of stabilization policy in period 1. In the next two sections, we solve the model for period 1 outcomes of the output gap and inflation based on alternative assumptions regarding the information structure about the preference shock θ.

3.2 Period 1: The case of observed inflation target

As a benchmark, consider first the case of full information whereby θ is observed by the public (i.e., $\theta \in \Omega_1^p$, where Ω_1^p is the information set of the private sector in period 1). Then taking expectations of both sides of equation (4), $E_1^p\pi_2 = \theta$ and thus $E_1^p\pi_2$ is set independent of x_1 (the central bank's action).[12] Of course this represents an ideal scenario

[11]Since $x^* = 0$, inflation is at its target (no inflation bias).

[12]In other words, x_1 is redundant as a signal for θ.

for the central bank because inflation expectations are anchored at the new inflation target. The optimal values of x_1 and π_1 are functions of ϵ_1

$$x_1 = -\frac{\lambda}{\alpha + \lambda^2}\epsilon_1; \qquad \pi_1 = \theta + \frac{\alpha}{\alpha + \lambda^2}\epsilon_1 \tag{5}$$

Thus, when there is full information, inflation expectations are independent of policy actions and the central bank achieves optimal stabilization of inflation and output in response to the cost-push disturbance.

3.3 Period 1: The case of unobserved inflation target

Assume now, more realistically, that the preference shock θ and the aggregate cost-push shock ϵ_1 may not be observed by the private sector. Then equation (4) implies that $E_1^p \pi_2 = E_1^p \pi_2^*$. In this case, inflation expectations will depend on the degree of knowledge of ϵ_1 and the choice of x_1.

The central bank's disclosure policy dictates how much information is communicated to the public regarding the realization of the cost-push shock ϵ_1. The precision of communication measures the degree of disclosure or transparency. To formalize the choice of the disclosure regime, we decompose the cost-push shock ϵ_1 into two components. Let ϵ_k be the component that is known to the public and ϵ_u the unknown component. Under asymmetric information, the central bank's and the private sector's information sets are, respectively, $\Omega_1^c = \{\epsilon_k, \epsilon_u, \theta\}$ and $\Omega_1^p = \{\epsilon_k, x_1\}$.

By construction, $\epsilon_1 = \epsilon_k + \epsilon_u$. The two components are assumed to be uncorrelated implying that $\sigma_\epsilon^2 = \sigma_{\epsilon,k}^2 + \sigma_{\epsilon,u}^2$, where $\sigma_{\epsilon,k}^2$ is the variance of ϵ_k and $\sigma_{\epsilon,u}^2$ is the variance of ϵ_u. We can rewrite this in a form that clarifies the choice of disclosure by the central bank: $\sigma_{\epsilon,k}^2 = \tau\sigma_\epsilon^2$ and $\sigma_{\epsilon,u}^2 = (1-\tau)\sigma_\epsilon^2$. The degree of transparency with respect to the central bank's forecasts is measured by the parameter $0 \leq \tau \leq 1$, with the extremes of full transparency and no transparency represented by $\tau = 1$ and $\tau = 0$, respectively. Next, we derive optimal forecasts of the private sector conditional on the disclosure regime announced by the central bank.

Consider stage 3 of period 1 in the sequence of events, where the private sector sets inflation expectations. Under rational expectations, the private sector correctly conjectures that the central bank's equilibrium reaction function takes the form[13]

$$x_1 = h_k \epsilon_k + h_u \epsilon_u + h_\theta \theta \tag{6}$$

where the three coefficients in equation (6) will be determined later. According to equation (6), the public believes that the central bank is responding to three pieces of information—θ, ϵ_k and ϵ_u. After observing x_1 and ϵ_k, the private sector constructs a signal based on equation (6)

$$s_1 = h_u \epsilon_u + h_\theta \theta \tag{7}$$

where $s_1 \equiv x_1 - h_k \epsilon_k$ is the private sector's signal based on which it constructs an optimal forecast of θ. Optimal signal extraction implies that the private sector's conditional forecast of θ is given by $E_1^p \theta = S_\theta s_1$, where $S_\theta \equiv h_\theta \sigma_\theta^2 / (h_\theta^2 \sigma_\theta^2 + h_u^2 \sigma_{\epsilon,u}^2) > 0$ is the optimal weight on the signal that reflects the signal-to-noise ratio.[14] Inflation expectations are then given by

$$E_1^p \pi_2 = S_\theta s_1 \tag{8}$$

Equation (8) shows that under asymmetric information, expected inflation depends on the choice of monetary policy. Likewise, optimal monetary policy will depend on the central bank's anticipation of the public's forecasting rule (8).

[13] In equilibrium, the public's conjectured reaction function must coincide with the actual rule followed by the central bank. Since it anticipates the private sector's conjecture about its action, when optimizing, the central bank takes into account the dependence of $E_1^p \pi_2$ on x_1. Thus, even though monetary policy is discretionary, it does take into account the formation of inflation expectations.

[14] In the limiting case where $\tau = 1$ ($\sigma_{\epsilon,u}^2 = 0$), the signal reveals the central bank's inflation target perfectly.

4 Optimal stabilization policy

In stage 2 of period 1, the central bank solves the following minimization problem, which anticipates the private sector's forecasting rule (8),

$$\min_{x_1} E_1^c\left[\left(S_\theta s_1 + \lambda x_1 + \epsilon_1 - \theta\right)^2 + \alpha x_1^2\right] \tag{9}$$

Differentiating (9) with respect to x_1, and keeping in mind that s_1 depends on x_1, leads to the first order condition $\left(S_\theta E_1^c s_1 + \lambda x_1 + \epsilon_k + \epsilon_u - \theta\right)(\lambda + S_\theta) + \alpha x_1 = 0$, where equation (7) implies $E_1^c s_1 = h_u \epsilon_u + h_\theta \theta$. The optimality condition can now be solved for x_1 and expressed as a reaction function of the three state variables, θ, ϵ_k and ϵ_u

$$x_1 = -\frac{\lambda + S_\theta}{\alpha + \lambda^2 + \lambda S_\theta}\epsilon_k - \frac{\lambda + S_\theta}{\alpha + (\lambda + S_\theta)^2}\epsilon_u + \frac{\lambda + S_\theta}{\alpha + (\lambda + S_\theta)^2}\theta \tag{10}$$

To get the rational expectations solution, we match the coefficients in the first order condition with those conjectured in equation (6). This leads to the following system of equations

$$h_\theta = \frac{\lambda + S_\theta}{\alpha + (\lambda + S_\theta)^2} \equiv F(h_\theta, h_u) > 0 \tag{11}$$

$$h_u = -\frac{\lambda + S_\theta}{\alpha + (\lambda + S_\theta)^2} \equiv -F(h_\theta, h_u) < 0 \tag{12}$$

$$h_k = -\frac{\lambda + S_\theta}{\alpha + \lambda^2 + \lambda S_\theta} < 0 \tag{13}$$

Equations (11) and (12) are solved for h_θ and h_u simultaneously.[15] The solution for h_k then follows recursively from equation (13).

There are two potential solutions of the above system of equations.[16] The first rational expectations solution is characterized by $\bar{h}_\theta = -\bar{h}_u \to 0$ and from equation (13), $\bar{h}_k = -\frac{1}{\lambda}$. We call the policy rule associated with this solution a "passive policy" rule because the central bank does not respond to its private information (θ and ϵ_u). Using this result

[15] Due to the sign restrictions in the two equations, we look for solutions where $h_\theta > 0$ and $h_u < 0$.

[16] This is in contrast to Jensen (2002), where he assumes a known and constant inflation target but time-varying output gap target. In that case, there is a unique solution.

in the Phillips curve, we get period 1's equilibrium output gap and inflation (note that $x^* = 0$)

$$\begin{aligned}
\bar{x}_1 &= -\frac{1}{\lambda}\epsilon_k \\
\bar{\pi}_1 &= H\theta + (1-H)\epsilon_u
\end{aligned} \tag{14}$$

where $0 < H \equiv \sigma_\theta^2/(\sigma_\theta^2 + \sigma_{\epsilon,u}^2) \leq 1$. Note that the central bank's preference weight α does not affect the equilibrium outcome.

The second rational expectations solution, where the central bank responds to its private information, is characterized by an "active policy" rule,

$$\begin{aligned}
\bar{h}_\theta &= \frac{\lambda(1-2H) + \sqrt{4\alpha H(1-H) + \lambda^2}}{2(\alpha+\lambda^2)} > 0 \\
\bar{h}_u &= -\bar{h}_\theta < 0 \\
\bar{h}_k &= -\frac{\lambda\bar{h}_\theta + H}{(\alpha+\lambda^2)\bar{h}_\theta + \lambda H} < 0
\end{aligned} \tag{15}$$

In this case, period 1 equilibrium output gap and inflation are

$$\begin{aligned}
\bar{x}_1 &= \bar{h}_k\epsilon_k + \bar{h}_\theta(\theta - \epsilon_u) \\
\bar{\pi}_1 &= (\lambda\bar{h}_\theta + H)\theta + (1+\lambda\bar{h}_k)\epsilon_k + (1 - H - \lambda\bar{h}_\theta)\epsilon_u
\end{aligned} \tag{16}$$

Note that, both rational expectations solutions have the property that $\bar{h}_u = -\bar{h}_\theta$. Using this property in equation (8) we get

$$E_1^p\pi_2 = S_\theta s_1 = \frac{1}{h_\theta}H(-h_\theta\epsilon_u + h_\theta\theta) = H(\theta - \epsilon_u) \tag{17}$$

Thus, in equilibrium inflation expectations are identical in both solutions and they are determined by the disclosure regime (H and ϵ_u) and the realization of θ. Because θ and ϵ_u are assumed to be uncorrelated, equation (17) implies that the variance of $E_1^p\pi_2$ is, after simplifying, equal to $H\sigma_\theta^2$. As $\partial H/\partial\tau > 0$, the variability of inflation expectations increases with the degree of disclosure.[17] Furthermore, from equation (17) we see that inflation expectations change in a way that reflect the state of the economy. For instance, a positive shock to the inflation target ($\theta > 0$) will be accompanied by an increase in inflation expectations, and a positive realization of the unobserved component of the cost-push shock ($\epsilon_u > 0$) will be associated with a decrease in inflation expectations. Thus, inflation expectations have a stabilizing role. This outcome is interesting, especially in light of the passive policy rule where the central bank abstains from reacting to these shocks.

4.1 Equilibrium under full-disclosure

When a full-disclosure regime is announced, the public has perfect knowledge about the cost-push shock and, therefore, it can infer the inflation target indirectly. From equation (15), we get $\bar{h}_\theta, \bar{h}_u \to 0$ and $\bar{h}_k = -1/\lambda$ when $\tau = 1$. In that case, the equilibrium levels of the output gap and inflation in the two equilibria are the same[18]

$$
\begin{aligned}
\bar{x}_1|_{\tau=1} &= -\frac{1}{\lambda}\epsilon_1 \\
\bar{\pi}_1|_{\tau=1} &= \theta
\end{aligned}
\tag{18}
$$

As can be seen, a full-disclosure regime is associated with an active monetary policy that keeps inflation at its target while inducing high output gap variability in response to the cost-push shock.

[17]Note that when the central does not communicate its private information, $E_1^p \pi_2 = \frac{\sigma_\theta^2}{\sigma_\theta^2+\sigma_\epsilon^2}(\theta - \epsilon_1) \neq 0$ as long as σ_ϵ^2 is finite.

[18]The fact that the private sector precisely knows the realization of ϵ_1 and can, therefore, infer indirectly the value of θ has stark implications for stabilization policy. The equilibrium given by equation (18) reveals that, even if the central bank cares about output gap stabilization ($\alpha > 0$), inflation and inflation expectations are anchored at the central bank's inflation target because the cost-push shock is completely absorbed by the output gap.

4.2 Monetary policy activism under no-disclosure

In the limited-disclosure regime ($0 < \tau < 1$), the question is whether the central bank will adopt an active policy rule or a passive one. It turns out that the choice depends on several features of the economic structure. To show this, we set $\tau = 0$, the case where the central bank does not communicate its forecasts. In that case, the expected loss under the passive policy rule, denoted by $E(L_1^P)$, is

$$E(L_1^P)|_{\tau=0} = (1 - \hat{H})\sigma_\epsilon^2 \tag{19}$$

where $\hat{H} = H|_{\tau=0} = \sigma_\theta^2/(\sigma_\theta^2 + \sigma_\epsilon^2)$. The corresponding expected loss under the active policy rule, denoted by $E(L_1^A)$, is

$$E(L_1^A)|_{\tau=0} = \left(\frac{\alpha}{\alpha + \lambda^2} + \frac{\lambda\left(\lambda - \sqrt{4\alpha(1-\hat{H})\hat{H} + \lambda^2}\right)}{2(\alpha + \lambda^2)(1 - \hat{H})} \right) \sigma_\epsilon^2 \tag{20}$$

The active policy rule dominates the passive policy rule (i.e., $E(L_1^A)|_{\tau=0} < E(L_1^P)|_{\tau=0}$) if the slope of the Phillips curve, λ, is large enough, and the relative weight on output stabilization, α, and the signal-to-noise ratio, $\sigma_\theta^2/\sigma_\epsilon^2$, are small enough. The central bank actively responds to the inflation target and the cost-push shock if

(1) λ is large enough, so that the output cost of reducing inflation variability is very small,

(2) α is small enough, since this means that the overriding priority for monetary policy is stable inflation,

(3) σ_θ^2 is small enough and/or σ_ϵ^2 is large enough, as these conditions imply that the signal (policy action) becomes less informative and, in turn, inflation expectations respond little to policy actions, allowing the central bank to respond to shifts in the inflation target and the cost-push shock.

5 Disclosure policy and average outcomes

The analysis thus far has been done assuming the output target is equal to the long-run average ($x^* = 0$), so that there is no inflation bias in equilibrium. In this section we relax that assumption and assume $x^* > 0$.

5.1 Period 2: Full information steady state

The solution steps for $x^* > 0$ are analogous to those of section 3. In period 2, the policy problem is to minimize $\frac{1}{2}[(E_2^p \pi_3 + \lambda x_2 - \theta)^2 + \alpha(x_2 - x^*)^2]$ with respect to x_2, subject to $E_2^p \pi_3 = \theta + \frac{\alpha}{\lambda} x^*$ (see Appendix). The reduced form solution is

$$\bar{x}_2 = 0; \qquad \bar{\pi}_2 = \theta + \frac{\alpha}{\lambda} x^* \tag{21}$$

which is a standard result in the time-inconsistency literature—the economy is characterized by an inflation bias. That is, the steady state output gap is equal to its natural rate while the average rate of inflation is higher than its target.

5.2 Period 1: The case of observed inflation target

Equation (4) implies $E_1^p \pi_2 = \theta + \alpha x^*/\lambda$, independently of the realization of x_1. The problem is thus similar to that in period 2, except for the presence of a non-zero shock ϵ_1. In equilibrium

$$\bar{x}_1 = -\frac{\lambda}{\alpha + \lambda^2} \epsilon_1; \qquad \bar{\pi}_1 = \theta + \frac{\alpha}{\lambda} x^* + \frac{\alpha}{\alpha + \lambda^2} \epsilon_1 \tag{22}$$

As in period 2, there is an average inflation bias in period 1 under full information (π_1 depends positively on x^*) but since private sector inflation expectations are independent of policy actions, the central bank achieves optimal stabilization of inflation and output in response to ϵ_1.

5.3 Period 1: The case of unobserved inflation target

From period 2's equilibrium inflation, $E_1^p\pi_2 = E_1^p\theta + \alpha x^*/\lambda = S_\theta s_1 + \alpha x^*/\lambda$. As x^* is common knowledge, the signal extraction problem of the public is identical to the case with $x^* = 0$. The only difference is that now the conjectured rule (6) includes a constant term, h_0, due to the presence of x^*. In period 1, the central bank minimizes

$$\min_{x_1} E_1^c\Big[(E_1^p\pi_2 + \lambda x_1 + \epsilon_1 - \theta)^2 + \alpha(x_1 - x^*)^2\Big] \tag{23}$$

subject to $E_1^p\pi_2 = S_\theta s_1 + \frac{\alpha}{\lambda}x^*$. The solution for x_1 and the matching of the coefficients in the solution with those conjectured is similar to the case with $x^* = 0$, although we now have a system with four equations: (11), (12), (13) and

$$h_0 = -\frac{\alpha x^* S_\theta}{\lambda(\alpha + \lambda^2 + \lambda S_\theta)} < 0 \tag{24}$$

where $-\frac{\alpha}{\lambda^2}x^* < h_0 < 0$ depending on $0 < S_\theta < \infty$. The system is again solved recursively starting with equation (11) and equation (12). The active policy rule leads to the following reduced form

$$\begin{aligned} \bar{x}_1 &= \bar{h}_0 + \bar{h}_k\epsilon_k + \bar{h}_\theta(\theta - \epsilon_u) \\ \bar{\pi}_1 &= (\lambda\bar{h}_\theta + H)\theta + \left(\frac{\alpha}{\lambda}x^* + \lambda\bar{h}_0\right) + (\lambda\bar{h}_\theta + H - 1)\epsilon_u \end{aligned} \tag{25}$$

where $\bar{h}_0 = -\frac{\alpha x^* H}{\lambda\bar{h}_\theta(\alpha+\lambda^2)+\lambda^2 H}$, while the passive policy rule leads to the reduced form

$$\begin{aligned} \bar{x}_1 &= \bar{h}_0 + \bar{h}_k\epsilon_k \\ \bar{\pi}_1 &= H\theta + (1 + \bar{h}_k)\epsilon_k + (H - 1)\epsilon_u \end{aligned} \tag{26}$$

where $\bar{h}_\theta \to 0$, irrespective of the degree of transparency, so that $\bar{h}_0 = -\frac{\alpha}{\lambda^2}x^*$.

Recall that under full information, the magnitude of the inflation bias is equal to $\frac{\alpha}{\lambda}x^*$. When there is asymmetric information and the central bank adopts the active policy rule, the inflation bias is $\frac{\alpha x^*}{\lambda} + \lambda\bar{h}_0 < \frac{\alpha x^*}{\lambda}$. Moreover, under the passive policy the inflation bias disappears although the average level of the output gap deviates further from its target.

From equation (25), we see that increased communication by the central bank reduces the average level of inflation (lower inflation bias) but it results in too low an output gap on average. Thus, disclosure policy affects not only the variability tradeoff between inflation and output but also leads to a tradeoff in their average values.

6 Further issues

6.1 Full information vs. full-disclosure

We briefly discuss the issue of full information (defined as the direct disclosure of the inflation target) vs full disclosure (indirect disclosure of the inflation target). We compare the expected losses arising under full-disclosure and full information. The comparison is important since the two regimes lead to different incentives for setting optimal monetary policy.[19]

The expected loss associated with full-disclosure of forecasts, $\tau = 1$, is

$$E(L_1)|_{\tau=1} = \frac{\alpha}{\lambda^2}\sigma_\epsilon^2 \tag{27}$$

Based on the reduced form (5), the expected loss under full information (FI) is

$$E(L_1^{FI}) = \frac{\alpha}{\alpha+\lambda^2}\sigma_\epsilon^2 \tag{28}$$

It is easy to see that $E(L_1^{FI}) < E(L_1)|_{\tau=1}$. This means that the central bank would be better off by revealing changes in the inflation target directly, instead of letting the public indirectly infer the target by disclosing central bank forecasts for the cost-push shock.[20]

[19] Among others, Faust and Svensson (2001) and Jensen (2002) analyze the welfare implications of disclosing the central bank's employment/output target directly and compare the resulting outcome with the case of full transparency about control errors in monetary policy. In Faust and Svensson (2001), full information leads to the worst outcome in terms of the expected loss. In contrast, Jensen (2002) finds that the full information regime dominates the full transparency regime when the central bank has high credibility (i.e., suffers from small inflation bias) and there is a need for stabilization in response to cost-push disturbances (e.g. due to large variance in these shocks).

[20] This result is consistent with the classic signaling models, where the equilibrium with private information (and associated signal extraction) leads to worse outcomes than the corresponding equilibrium under symmetric information.

The reason is that full-disclosure leads to suboptimal policy responses to the cost-push shocks; in particular, the output gap becomes excessively volatile.

6.2 Conservative society and disclosure policy

We have shown that disclosure of forecasts leads to a variability tradeoff, as it lowers inflation variability at the cost of higher output gap variability. Although we do not pursue it here, we remark that full transparency may be beneficial from a societal point of view if one allows for differences in preferences between the central bank and the society. Specifically, if the society has appointed a populist central banker, in the sense that the central bank places less weight on inflation stabilization, then the full-disclosure regime can be welfare improving, as it reduces inflation variability (which is society's main concern).[21]

7 Concluding remarks

The paper examines the consequences of disclosing central bank forecasts for stabilization policy, when the inflation target is unobserved by the public. An important determinant of the resulting outcomes is the nature of inflation expectations. The paper compares alternative disclosure regimes about forecasts and how the degree of policy responsiveness to shocks is determined by factors such as the central bank's preference regarding inflation stabilization versus output stabilization, the slope of the Phillips curve, which measures the sensitivity of inflation to changes in the output gap, and the variability of the inflation target relative to the variability of cost-push shocks.

The paper shows that, given that the public observes monetary policy decisions but not changes in the inflation target, disclosure of forecasts decreases inflation variability but increases output variability. Overall, the central bank is better-off under a no-disclosure regime. This result holds irrespective of whether or not the central bank suffers from an

[21] See e.g., Valesco and Guzzo (1999), Lippi (2002) and Hoeberichts et al. (2008) for a discussion of central bank conservatism and economic performance.

inflation bias. However, the trade-off in the variability of inflation and output implies that a full-disclosure regime can be beneficial for society. In particular, given that society appoints a populist central banker, in the sense that society places more weight on inflation stabilization compared to the central banker, then society could be better off under a full-disclosure regime, as this improves inflation performance.

The paper also shows that directly communicating the inflation target improves overall performance compared to a regime where the public infers the inflation target from central bank forecasts.

Appendix

For an infinite horizon, full information model (see for e.g. Clarida, Gali and Gertler (1999)), the goal of the central bank is to minimize[22]

$$E_1 \sum_{t=1}^{\infty} L_t \tag{A.1}$$

subject to $\pi_t = E_t \pi_{t+1} + \lambda x_t + \epsilon_t$, where $L_t = \frac{1}{2}(\pi_t - \theta)^2 + \frac{\alpha}{2}(x_t - x^*)^2$.

Under discretion, the optimality condition is given by $x_t - x^* = -\frac{\lambda}{\alpha}(\pi_t - \theta)$. Substituting the optimality condition into the Phillips curve and solving for rational expectations, the equilibrium dynamics of the system is given by

$$E_t \pi_{t+1} = \theta + \frac{\alpha}{\lambda} x^*$$

$$x_t = -\frac{\lambda}{\alpha + \lambda} \epsilon_t$$

$$\pi_t = \theta + \frac{\alpha}{\lambda} x^* + \frac{\alpha}{\alpha + \lambda} \epsilon_t$$

In a steady state, there are no disturbances to the system ($\epsilon_t = 0$ for all t) and all variables are equal to their expected value: $\pi = E\pi = \theta + \frac{\alpha}{\lambda} x^*$ and $x = 0$. This is the basis for the steady state, full information solutions for the long run (period 2 in the main text).

[22] Since the central bank and private sector have identical information, we use a common expectation operator E_1.

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