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AND DISCLOSURE POLICY:  
WHY IT PAYS TO BE OPTIMISTIC**

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## **ABSTRACT**

### **Central Bank Forecasts and Disclosure Policy: Why it Pays to be Optimistic**

In a simple macromodel with forward-looking expectations, this Paper looks into disclosure policy when a central bank has private information on future shocks. The main result is that advance disclosure of forecasts of future shocks does not improve welfare, and in some cases is not desirable as it impairs stabilization of current inflation and/or output. This result holds when there is no credibility problem or the central bank's preference is common knowledge. When there is uncertainty about the central bank's preference shock, and this uncertainty is not resolved in the subsequent period, advance disclosure does not matter for current outcomes. The reason lies in the strong dependence of one-period-ahead private sector inflation forecasts on central bank actions, which induces the central bank to focus exclusively on price stability in subsequent periods. Another implication of the model is that, in contrast to forecasts of current period shocks emphasized by the literature, forecasts of future shocks may not be revealed to the public by current policy choices because the central bank refrains from responding to its own forecasts.

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# 1 Introduction

In practice, central banks and the private sector spend a lot of resources in their forecasting activities and in assessing the views and forecasts of each other. For some reasons though, central bank forecasts outperform those of the private sector, an indication perhaps of central bank's superior information about the future state of the economy, including the state of shocks affecting economic activity. In their empirical analysis on differences between commercial and Federal Reserve (Fed for short) forecasts, Romer and Romer (2000) conclude that "the most important finding ... is that the Federal Reserve appears to possess information about the *future* state of the economy that is not known to market participants." (p.455), (emphasis ours).<sup>1</sup>

While surveys of private sector (commercial) forecasts, such as the Fed's "Beige Book" and the ECB's Survey of Professional Forecasters, are frequently released, some central banks are reluctant to disclose without delay their own internal forecasts.<sup>2</sup> Recently, some theoretical research has been done on the welfare effects of disclosing in advance central bank information about the state of the economy.<sup>3</sup> The literature has explored this issue in the context of private information about shocks to *current* inflation and output, with mixed results. In a setup where private sector inflation expectations are not forward looking, Cukierman (2001) shows that a central bank can improve stabilization policy by withholding forecasts of *current* supply shocks.<sup>4</sup> The negative result holds for alternative monetary transmission mechanisms – one with a Lucas-type supply function and the other a variant of the backward-looking model of Svensson (1997) with its main feature of time lags from the policy instrument to policy goals. However, Geraats (2001) reverses the negative results shown in Cukierman (2001) by introducing un-

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<sup>1</sup>In the case of the Federal Reserve, Romer and Romer (2000) discuss some of the reasons for higher quality forecasts, including inside information about future monetary policy, access to official and unofficial data, and enormous devotion of resources.

<sup>2</sup>In this case, for instance, the Beige Book, which summarizes information gathered by each Federal Reserve Bank through reports from Bank and Branch directors and interviews with key business contacts, market experts and other sources, is published immediately. However, the Fed does not disclose immediately its staff forecasts of the U.S. economy, reported in the "Green Book". The Green Book is made public only with a lag of five years.

<sup>3</sup>In the terminology of Geraats (2001), the release of internal forecasts is part of what she calls *economic* transparency. She discusses several aspects of transparency including political (formal goals, numerical targets), economic (data, models, forecasts), operational (control errors, transmission shocks), procedural (minutes of meeting, voting), and policy (statements, inclination).

<sup>4</sup>See also Gersbach (2003) for similar results.

observed inflation targets and credibility issues in a two-period framework. The argument is that, since the public is assumed to observe *current* central bank actions, it is in the interest of the central bank to invest in reputation in the first period in order to have more flexibility in the second period. The signaling quality of current actions about the unobserved inflation target is better if the public has information about current shocks that the central bank is responding to.<sup>5</sup>

In a two-period New-Keynesian framework that features unobserved output target, Jensen (2000) shows how releasing forecasts of *current* shocks distorts stabilization policy, even though it solves the credibility problem. Like Geraats, Jensen assumes that the public observes central bank actions *before* forming inflation expectations, and thus with high degree of transparency about current shocks, inflation expectations become extremely sensitive to the central bank's current action. But, here comes the difference, in order to stabilize inflation expectations, policy tilts heavily towards inflation stabilization, making output very volatile. Thus transparency could be undesirable for a central banker who enjoys good initial reputation.

A common feature of the above cited papers is that, if the central bank's targets for inflation and output are common knowledge, then its forecasts of *current* period shocks can perfectly be inferred from its actions. The reason is that, even if the public does not observe them directly, the central bank reacts to *current* period shocks, as these shocks disrupt the level of *current* inflation and output that the central bank wants to stabilize.<sup>6</sup>

This paper considers instead forecasts of *future* shocks when markets are forward-looking. Disclosure policy on forecasts of future shocks is analyzed

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<sup>5</sup>In a cross-section study using 87 countries Chortareas et al. (2002) find that publication of forecasts reduces average inflation. Geraats and Eijffinger (2004) use time-series data on several aspects of transparency for nine major central banks, based on an index of transparency constructed by Eijffinger and Geraats (2004), and conclude that higher transparency is associated with lower short-term as well as long-term interest rates, thus lending support to the positive reputational effects of releasing forecasts, as argued by Geraats (2001).

<sup>6</sup>Among other things, the paper by Geraats (2001) differs from Jensen (2000) in the effect of direct revelation of the unobserved target. In Geraats (2001), this leads to worse outcomes because the credibility problem would remain unresolved. This result seems at odds with the recent calls for transparency about inflation goals (e.g. Rogoff (2003)). In Jensen (2000), transparency through direct revelation of central bank preferences may dominate transparency through the release of forecasts if the central bank has good reputation and stabilization policy has more importance.

under the New-Keynesian view of the macroeconomy (see for e.g. Clarida et al. (1999), King (2000) and McCallum and Nelson (2000)). It shows that immediate disclosure of these shocks can have implications different from forecasts of current shocks.<sup>7</sup> The main result is that, when there is no credibility problem or the central bank's output target is common knowledge, advance disclosure of future shocks makes the central bank worse off. As such a central bank may have the incentive to delay disclosure until after private sector expectations are formed. In turn this may improve stabilization of *current* inflation and output. For this result to hold, it must be common knowledge that the central bank has better quality signals about future shocks. Advance disclosure of future shocks does not affect current outcomes if the central bank's output target remains private information.

Moreover, in contrast to forecasts of current period shocks, forecasts of future shocks may not be revealed to the public by current policy choices because the central bank refrains from responding to its own forecasts. The central bank may withhold its information about future shocks and imitate the less informed public without the fear of revealing that information by its current actions.

We first present a benchmark case where the central bank's preference is common knowledge. In this environment, transparency about future shocks makes the central bank worse off if the central bank has goals besides price stability. In this case adverse supply shocks affect all goal variables, and knowing this, expected movements in future supply shocks make private sector inflation expectations to be more volatile. This effect passes to *current* prices through expectations of future inflation. It may thus be better from the perspective of the central bank to wait until the information about future supply shocks does not have any value to the private sector. This ensures that public expectations of future shocks are less volatile than when a more accurate information about future shocks is available.<sup>8</sup>

The benchmark case is then modified in some ways. First, instead of discretionary policy, the central bank is assumed to commit credibly to some state contingent rule. However, this modification does not change the neg-

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<sup>7</sup>The strategic role of private information about future shocks increases if the information asymmetry regarding future shocks is more severe than the corresponding asymmetry for current period shocks.

<sup>8</sup>In this sense, this paper agrees with the remark by Mishkin (2004) that even if openness is a virtue, for example when central banks are transparent about their long-term inflation goals, some types of transparency may not further social objectives.

ative result found under the benchmark case. Next, the paper introduces unobservability of central bank preferences and reputational considerations. The effects of this modification depends on whether the uncertainty due to current period shifts in the target is resolved in the next period. If so, then it is not desirable to disclose forecasts of next period supply shocks. On the other hand, if current period shifts in the target are not known in the next period, reputational considerations do not play a role as far as disclosure policy regarding *future* shocks is concerned. Thus, a policy of secrecy weakly dominates a policy of immediate disclosure.

Our discussion proceeds as follows. Section 2 describes the model environment for the New-Keynesian transmission mechanism, where inflation and output are determined by forward looking inflation expectations. In section 3 we analyze optimal monetary policy under discretion, with and without disclosure of information. Moreover, the effects of secrecy on the behavior of the nominal rate of interest is discussed. Section 4 analyzes transparency under limited commitment, where the results are basically similar to the discretionary, full information case of section 3. In section 5, the significance of uncertainty about central bank output target is explored in a multi-period framework with signaling, closely following Jensen (2000). We consider two cases with differing implications on disclosure policy: in the first case, uncertainty about shifts in the current output target are resolved in the next period while in the second case the uncertainty stays during the next period. Concluding remarks are given in section 6.

## 2 Forward-Looking Inflation Expectations

As we indicated in the introduction, the New-Keynesian view of the macroeconomy gives a prominent role to private sector expectations of future inflation and output in the determination of current inflation and output. A detailed description of the workhorse model can be found, for example, in Clarida et al. (1999) and King (2000).

On the supply side, a forward looking Phillips equation determines inflation

$$\pi_t = \beta E_t^p \pi_{t+1} + \lambda x_t + u_t \quad (1)$$

where  $\pi$  is the inflation rate,  $x$  is the output gap, and  $u$  is a zero-mean stochastic shock to inflation. The parameters  $\beta$  and  $\lambda$  satisfy  $0 < \beta < 1$  and  $\lambda > 0$ .  $E_t^p \pi_{t+1}$  stands for private sector (PS) expectations of next period's inflation conditional on available information at time  $t$ . Thus inflation

depends on forward looking PS expectations, the output gap and inflation shock.<sup>9</sup>

Likewise the dynamics of output demand is governed by a forward looking relationship (the so called intertemporal IS equation)

$$x_t = E_t^p x_{t+1} - \phi(i_t - E_t^p \pi_{t+1}) + v_t \quad (2)$$

where  $i$  is the nominal interest rate and  $v$  is an i.i.d shock to aggregate demand. The parameter  $\phi$  satisfies  $\phi > 0$ . Thus the current output gap depends on PS expectations of next period's output gap, the real interest rate,  $i_t - E_t^p \pi_{t+1}$ , and a demand shock.

Optimal policy is characterized as the choice of the current short-term nominal interest rate that minimizes the variability in inflation and output relative to their respective target values. The period  $t$  loss function is typically given by

$$L_t = \pi_t^2 + \alpha x_t^2 \quad (3)$$

with  $\alpha$  denoting the weight the CB places on output stabilization goal relative to inflation stabilization. For simplicity the target rate of inflation is normalized to zero. Moreover since the central bank targets the equilibrium level of output, we also normalize the output gap target to zero. In the model of this section the CB is assumed to have a more accurate forecast of the cost-push shocks  $u_t$  and  $u_{t+1}$  so that it can track their developments better than the PS. For simplicity, the CB has perfect information about both shocks while the PS knows their probability distributions only.<sup>10</sup>

Except for information asymmetry regarding the shocks, and current inflation and output, there is common knowledge of the CB's loss function, including the targets for inflation and output and the preference parameter  $\alpha$ . For the moment we abstract from inflation bias considerations, as the CB targets equilibrium output, which is not unrealistic given the widely accepted assertions about the prestige of major CBs.<sup>11</sup> Credibility issues are discussed in section 5.

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<sup>9</sup>When prices are sticky, price setters can not fully adjust to current shocks. Thus expectations about future prices (and therefore inflation) play an important role in affecting current inflation.

<sup>10</sup>This simplification, although not realistic, is innocuous to our result. All we need is for the CB to do better in tracking the movement of shocks.

<sup>11</sup>For some forceful arguments against the literature on inflationary bias, see McCallum (1995) and Blinder (1998). In the case of the Fed, Bernanke (2003) and Romer and Romer (2000) discuss the reputation that the Fed has gained over the past two decades.



### 3 Disclosure policy under discretion

Under discretionary policy, the CB minimizes (3) period-by-period after PS expectations are formed, thus the term  $E_t^p \pi_{t+1}$  in the Phillips equation (1) is taken as a fixed parameter.<sup>12</sup> Since the CB takes PS expectations as given, the following optimality condition holds in both transparent and non transparent regimes<sup>13</sup>

$$x_t = -\frac{\lambda}{\alpha} \pi_t \quad (4)$$

According to (4), in each period, the central bank contracts (expands) current output in response to a higher (lower) rate of inflation. In essence, the CB is reacting to any variable that directly or indirectly affects current inflation. For example if inflation expectations increase for no fundamental reason, current inflation will go up if the CB does not react. The optimality rule ensures that this situation does not materialize because the CB is willing and able to contract current output to ease the burden of the shocks on the current rate of inflation. The above optimality condition is related to what Lars Svensson calls a "targeting rule", a rule expressed in terms of the goal variables (inflation and output), and derived from a well-defined objective function. It differs from an "instrument rule" that describes a reaction function for the nominal rate of interest (the instrument of monetary policy).<sup>14</sup> The next step is to determine PS inflation expectations. Since the PS know the targeting rule of the CB, plug (4) in (1)

$$\pi_t = \frac{\alpha\beta}{\alpha + \lambda^2} E_t^p \pi_{t+1} + \frac{\alpha}{\alpha + \lambda^2} u_t \quad (5)$$

This equation shows clearly that the evolution of actual inflation depends on currently held PS expectations about future inflation and on the current realization of the exogenous shock  $u_t$ . In this setting, PS expectations of  $\pi_{t+1}$  are ultimately determined by their forecasts of  $u_{t+1}$ . Thus the role of forecasts of the shocks is clear, and any information that improves the PS's forecast accuracy with respect to these shocks is valuable. The mechanism by which any private information about forecasts of future shocks affect current

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<sup>12</sup>Thus the timing of events is such that the CB chooses its interest rate policy for the current period after observing PS inflation expectations, and current and next period shocks; see for e.g. Cukierman (2001).

<sup>13</sup>For convenience the problem is solved in two steps. Once the optimal paths for inflation and output are known in the first step, the optimal instrument path for the nominal rate can be found from the IS equation (2).

<sup>14</sup>See for e.g. Svensson (2003).

inflation outcomes can be shown easily for the simple case where the shocks are white noise with mean zero and finite standard deviation.

Disclosing  $u_{t+1} \rightarrow E_t^p \pi_{t+1} = f(u_{t+1}) \rightarrow \pi_t = g(u_{t+1})$

Withholding  $u_{t+1} \rightarrow E_t^p \pi_{t+1} = 0 \rightarrow \pi_t \neq g(u_{t+1})$

### 3.1 Transparency about current and future shocks

First, following the literature, the disclosure of current shocks  $u_t$  is considered. Then we modify this case by allowing disclosure of  $u_{t+1}$ . The shocks are assumed to come from a white noise process, a specification that is common in the transparency literature.<sup>15</sup> But it turns out that with forward looking PS expectations, allowing for some persistence in the shocks matters for the results.<sup>16</sup> It will be shown that under i.i.d shocks the CB is indifferent to disclosing information about  $u_t$  because it knows that the PS is forward looking and the release of information about  $u_t$  does not change the PS's outlook about  $u_{t+1}$ . Accordingly, stabilization policy is not affected by disclosure policy about  $u_t$ .

With this idea in mind, we can now solve the model for  $E_t^p \pi_{t+1}$  and derive the rational expectations equilibrium, where we note that the only relevant state variables are  $u_t$  and  $u_{t+1}$ . Using the commonly used method of undetermined coefficients,<sup>17</sup> we start from equation (5) and guess that

$$\pi_t = \theta_1 u_t + \theta_2 u_{t+1} \tag{6}$$

Then disclosure policy about  $u_t$  and  $u_{t+1}$  and PS rational expectations imply

$$E_t^p \pi_{t+1} = \theta_1 E_t^p u_{t+1} \tag{7}$$

Based on disclosure policy of the CB, we have either  $E_t^p \pi_{t+1} = 0$ , reflecting the fact that the PS takes the expected value of the i.i.d shock when no

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<sup>15</sup>The recent literature on discretion and commitment in a New-Keynesian framework sometimes assumes an i.i.d specification (for instance, Woodford (1999b)).

<sup>16</sup>Thus we touch upon the effects of alternative processes for the shocks. In order to capture the nature of persistence in a simple way, we use a first-order autocorrelation. As a matter of fact, however, using US data, Adam and Milli (2003) find that the persistence parameter is not significantly different from zero.

<sup>17</sup>McCallum (1983) emphasizes on solving the model using only the fundamentals of the economy (in this case  $u_t$  and  $u_{t+1}$ ), avoiding bubble solutions. McCallum calls this the Minimal State Variables (MSV) method.

information is provided by the CB, or  $E_t^p \pi_{t+1} = \theta_1 u_{t+1}$  when information is released. Note in this case that the release of  $u_t$  is redundant as it does not help the PS in forecasting  $u_{t+1}$ . Replacing (7) in (5) under secrecy the actual law of motion of inflation is

$$\pi_t = \frac{\alpha}{\alpha + \lambda^2} u_t \quad (8)$$

which makes it vivid that current inflation is insulated from the effects of next period shocks. Consistency between equation (8) and the guessed form (6) implies  $\theta_1 = \frac{\alpha}{\alpha + \lambda^2}$  and  $\theta_2 = 0$ .

The solution for the output gap is<sup>18</sup>

$$x_t = -\frac{\lambda}{\alpha + \lambda^2} u_t \quad (9)$$

Unlike the PS, which expects zero inflation for the next period, the CB has perfect foresight, so that its inflation expectations fluctuates in tandem with movements in upcoming shocks.

$$E_t^c \pi_{t+1} = \pi_{t+1} = \frac{\alpha}{\alpha + \lambda^2} u_{t+1} \quad (10)$$

Next consider the case of transparency about  $u_{t+1}$ . Since the PS is interested in forecasting  $u_{t+1}$ , any information available to the CB about next period shocks is valuable to the PS. So suppose that in addition to releasing data on  $u_t$ , the CB is considering to disclose forecasts of  $u_{t+1}$ .<sup>19</sup> If the PS has access to CB's information about  $u_{t+1}$ , then (5) will be

$$\pi_t = \frac{\alpha\beta}{\alpha + \lambda^2} \theta_1 u_{t+1} + \frac{\alpha}{\alpha + \lambda^2} u_t \quad (11)$$

Again, matching these coefficients with those of the conjectured solution yields

$$\theta_1 = \frac{\alpha}{\alpha + \lambda^2} \quad \theta_2 = \frac{\alpha^2\beta}{(\alpha + \lambda^2)^2}$$

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<sup>18</sup>These solutions are identical to equations (15) and (16) of McCallum and Nelson (2000).

<sup>19</sup>Note here that we are following the literature in assuming that the shocks are i.i.d, but at the same time differing from it by giving the CB extra advantage in forecasting  $u_{t+1}$ .

The reduced form equations are

$$\pi_t = \frac{\alpha}{\alpha + \lambda^2} u_t + \frac{\alpha^2 \beta}{(\alpha + \lambda^2)^2} u_{t+1} \quad (12)$$

$$x_t = -\frac{\lambda}{\alpha + \lambda^2} u_t - \frac{\alpha \beta \lambda}{(\alpha + \lambda^2)^2} u_{t+1} \quad (13)$$

We can easily see that current inflation and output levels are affected not only by current period shocks, but also by future shocks, as a result of their release to the public. Thus releasing information regarding  $u_{t+1}$  makes current inflation and output more volatile. In equilibrium, PS and CB inflation expectations are

$$E_t^p \pi_{t+1} = E_t^c \pi_{t+1} = \frac{\alpha}{\alpha + \lambda^2} u_{t+1} \quad (14)$$

which differs from the case of secrecy as far as PS expectations are concerned. Note also that, a transparent CB does worse than a secretive CB in forecasting next period's inflation (compare (10) and (14)).

It is straightforward to show that the above negative result also holds when the CB's loss function includes additional goals, such as concerns for instability in interest rates, as emphasized by some, including Cukierman (2001), Goodhart (1998) and Woodford (1999a).

Summarizing, when the shocks are i.i.d, the solutions for inflation and output depend on the degree of transparency about  $u_{t+1}$ , but not about  $u_t$ . The main culprit for the increased volatility under transparency is the variation in PS inflation expectations. Thus it is optimal from the CB's point of view that the PS expects inflation in the next period to be zero although in reality it may not be so. The CB knows the current error in PS forecasts but is not willing to disclose any information before period  $t+1$  arrives or, equivalently, before PS expectations are set and policy actions taken.

The preceding analysis shows that if the shocks are white noise, as the literature on transparency commonly assumes, then disclosure of  $u_t$  is irrelevant for PS forecasts of future inflation. This feature of the forward looking markets is absent in the Lucas-type transmission mechanism. At the same time, unlike our results, early disclosure of future shocks do not matter for optimal stabilization when the model is not forward looking. Another feature that differentiates the forward looking framework from the static one is related to

the properties of the shocks. To be specific, when markets are forward looking, disclosure of  $u_t$  matters if there is persistence in the time series behavior of the shocks. To see this suppose, instead of white noise, the shocks follow a first-order autoregressive (in short AR(1)) process  $u_{t+1} = \rho u_t + \epsilon_{t+1}$  where  $\rho$  is common knowledge and  $\epsilon_{t+1}$  is an i.i.d innovation to time  $t + 1$  shocks. Then if the CB releases data on  $u_t$ , PS forecasts of  $u_{t+1}$  will be  $\rho u_t$ , which is conditional on observing  $u_t$  in period  $t$ . Accordingly, with the shocks showing some persistence overtime, information about current realizations improve our forecasts for the next period. This shows that, in principle, in a forward looking economic environment, the irrelevance of transparency about  $u_t$  is not a general result, and depends on specific assumptions.

### 3.2 Interest rate behavior

As it was indicated in the introduction, the transparency literature focuses on disclosure of current shocks. An implication of this is that current policy choices may partly reveal to the public the CB's private information. In the New-Keynesian framework with private information on future shocks, current period action does not give a signal of the CB's private information for two reasons. First, as the Phillips and IS equations show, optimal policy reacts to PS expectations of inflation and output, which under secrecy do not depend on the CB's information about  $u_{t+1}$ . Second, unlike  $u_t$ , which directly affects current inflation irrespective of PS expectations, the CB does not need to react to  $u_{t+1}$ . As can be seen from the case of secrecy (see (8) and (9)), the information advantage of the CB with respect to  $u_{t+1}$  is not revealed even ex post. Intuitively, under no disclosure policy, the PS does not know the realization of  $u_{t+1}$ , although it knows that the CB has that information. The best it can do is therefore to set expectations based on the unconditional distribution of the shocks.

To see the implications for the nominal interest rate of not releasing the forecasts of  $u_{t+1}$ , use the equilibrium solution for output and PS expectations in the IS equation and solve for the interest rate rule that implements optimal policy. Ignoring the demand shock  $v_t$  for simplicity<sup>20</sup>

$$i_t = \frac{\lambda}{\phi(\alpha + \lambda^2)} u_t$$

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<sup>20</sup>Observe that the demand shock does not give rise to a tradeoff in stabilizing inflation and output since the implied adjustment in interest rates to changes in demand shock moves output and inflation in the same direction. That is why in equilibrium, output and inflation are independent of the demand shock.

Thus in equilibrium the rate of interest depends only on current shocks, reflecting the fact that the CB does not react to its private information about next period shocks. Even if the CB announces its interest rate target for period  $t$ , there is no way that the CB can reveal its private information by its current actions. This is true even if the PS knows as much as the CB about the latter's loss function, including the targets for inflation and output and the relative weight on output stabilization. In this respect, Svensson (2003) argues that the best way to make the CB's forecasts observable to the public is by revealing the CB's model, information, assumptions and judgments. In previous studies on transparency of current shocks, knowledge of the loss function enables the PS to infer ex post the CB's private information. In our case, revelation of its loss function may not help at all in knowing the CB's private information about future shocks.

## 4 Disclosure policy under limited commitment

The classic theory of time-inconsistency in monetary policy rationalizes the high inflation period of the 1970s by the discretionary behavior of CBs. The term "inflation bias" was coined to underscore the implication of the theory that absent rules based monetary policy, equilibrium inflation turns out to be above the socially optimal level. The reason lies in the temptation of monetary authorities (due to unrealistic output or employment target) to renege on their plans once PS expectations are set. With forward looking expectations emphasized by the New-Keynesian view of the macroeconomy, we may have not only an inflation bias, but also a "stabilization bias" as a result of discretionary policy. Even without the inflation bias problem, monetary authorities would like the PS to believe that policy will be strongly anti-inflationary in the sense of stabilizing inflation but once PS inflation expectations are manipulated this way, the authorities will have an incentive (if they are free to do so) not to stabilize inflation strongly, contrary to their plans. Knowing this fact, the PS will set inflation expectations such that the discretionary equilibrium is the only result.

If the CB can not credibly commit to keeping inflation variability low in the future there by losing power to anchor inflation expectations, then policy ends up being discretionary, in effect minimizing current period's welfare levels. The crucial observation we made in the case of discretionary policy is that the CB would like to see that fluctuations in PS inflation expectations are minimized. In this situation the CB will do anything that makes inflation

expectations less variable. If it has private information about future developments of the economy, it will refrain from disclosing those information to the public, as we have shown in the case of cost-push shocks.

This section shows that the undesirable property of transparency about future shocks is not unique to discretionary policy. Even if the CB were to follow a policy based on some rules, it would still favor secrecy. The reason lies on the fact that transparency always impairs the CB's ability to stabilize current inflation and output because PS expectations add volatility to current inflation irrespective of the policy regime.

#### 4.1 Commitment for a transparent CB

A simple way to appreciate the gains from some form of commitment would be to consider a transparent regime about the shock  $u_{t+1}$ . The question is then, can the CB improve stabilization policy if it has the ability to commit to a given policy rule? The answer is, yes. To make it specific, suppose the CB can commit credibly to a simple policy rule that takes the same form as (13). Although this is a sort of limited commitment, as we have constrained the CB to follow a rule that has a particular form, it serves to show the benefits from commitment. The idea is to see if a transparent CB can improve welfare by committing to a simple rule within the same class of rules derived under discretion. Thus consider a commitment to the following rule

$$x_t = -Au_t - Bu_{t+1} \tag{15}$$

where the weights  $A$  and  $B$  are to be chosen optimally by the CB. Then from (15) (and see Appendix) PS expectations for output and inflation follow

$$E_t^p x_{t+1} = -Au_{t+1} \quad E_t^p \pi_{t+1} = (1 - \lambda A)u_{t+1}$$

These expressions show clearly that the CB's choice of a particular value for  $A$  will directly affect PS inflation and output expectations, and via the Phillips and IS equations, current inflation and output. Using the expression for  $E_t^p \pi_{t+1}$  in the Phillips equation (1) the reduced form expression for inflation, under commitment to the simple rule, will be

$$\pi_t = (1 - \lambda A)u_t + (\beta(1 - \lambda A) - \lambda B)u_{t+1} \tag{16}$$

Given the choices for the values of  $A$  and  $B$ , the dynamics of output and inflation is governed by (15) and (16). We can now express the expected loss as a function of the parameters  $A$  and  $B$

$$EL_t = ((1 - \lambda A)^2 + \alpha A^2 + (\beta(1 - \lambda A) - \lambda B)^2 + \alpha B^2) \sigma_u^2 \quad (17)$$

The central bank minimizes (17) with respect to  $A$  and  $B$  with the optimal values given by

$$A^* = \frac{\lambda[\lambda^2 + \alpha(1 + \beta^2)]}{\alpha\lambda^2\beta^2 + (\alpha + \lambda^2)^2} = \left(1 + \frac{\alpha^2\beta^2}{(\alpha + \lambda^2)^2 + \alpha\beta^2\lambda^2}\right) \frac{\lambda}{\alpha + \lambda^2}$$

$$B^* = \frac{\alpha\beta\lambda}{\alpha\lambda^2\beta^2 + (\alpha + \lambda^2)^2}$$

The first observation is that both of these coefficients differ from their counterparts under discretion with transparency (see equation (13)), showing the CB could improve up on the discretionary equilibrium by following a simple state-contingent rule that takes the same form as the discretionary solution but with different weights placed on the current versus forecasted shocks. Moreover, as long as  $\alpha \neq 0$ , that is the CB cares about output stabilization as well as inflation stabilization,  $A^*$  is larger than its corresponding coefficient while  $B^*$  is smaller than its corresponding coefficient. This means that under commitment to the simple target rule (15) policy responds more aggressively to current shock realizations  $u_t$  but less aggressively to upcoming shock innovations  $u_{t+1}$ . The intuition for this result is that with partial commitment, a more aggressive policy in terms of contracting aggregate demand in reaction to current shocks leads the PS to expect aggressive policy in the next period, thus lowering their inflation expectations. This in turn dampens the effect of future shocks on current inflation. Thus the CB can afford to be less aggressive with respect to future shocks because the PS does part of the job by adjusting its expectations. Knowing the value of  $A^*$ , the reduced-form of PS inflation expectations is

$$E_t^p \pi_{t+1} = \frac{H\alpha}{\alpha + \lambda^2} u_{t+1} \quad H \equiv 1 - \frac{\alpha\beta^2\lambda^2}{\alpha\beta^2\lambda^2 + (\alpha + \lambda^2)^2}$$

Since  $H$  satisfies  $0 < H < 1$ , PS inflation expectations respond less strongly to future shocks than is the case under discretion. This outcome arises from the CB's commitment to react more strongly to current shocks. If this commitment is credible, the PS expects a strong reaction to next period shocks when the time arrives. This in turn lowers inflation expectations and current



inflation.

For equilibrium inflation we have

$$\pi_t = \frac{\alpha}{(\alpha + \lambda^2) + (\alpha + \lambda^2)^{-1}\alpha\beta^2\lambda^2}u_t + \frac{\alpha^2\beta}{(\alpha + \lambda^2)^2 + \alpha\beta^2\lambda^2}u_{t+1} \quad (18)$$

Note that, compared to discretion, a policy of limited commitment results in less variability in the dynamics of inflation (compare (12) and (18)). This behavior contrasts with output, which is more volatile with respect to the current shock but responds less strongly to next period's shocks. Although this might make one conclude that the net effect of limited commitment on CB loss function is not clear, it should be obvious that limited commitment improves welfare. Why else would the CB choose different coefficients under limited commitment although the simple rule (15) falls under the class of rules derived from the discretionary solution? For the sake of completeness, however, we compare the expected losses in both regimes. Let  $T$  stand for transparency and  $i = d(\text{discretion}), c(\text{commitment})$

$$EL_i^T = Q_i^T \sigma_u^2$$

$$\text{where} \quad Q_c^T \equiv \frac{\alpha^2(1 + \beta^2) + \alpha\lambda^2}{(\alpha + \lambda^2)^2 + \alpha\beta^2\lambda^2} \quad Q_d^T \equiv \frac{\alpha(\alpha^2\beta^2 + (\alpha + \lambda^2)^2)}{(\alpha + \lambda^2)^3}$$

Next, evaluate the ratio  $Q_d^T/Q_c^T$

$$\frac{Q_d^T}{Q_c^T} = 1 + \frac{\alpha^3\beta^4\lambda^2}{(\alpha(1 + \beta^2) + \lambda^2)(\alpha + \lambda^2)^3} > 1$$

## 4.2 The gains from secrecy under limited commitment

What we have shown so far is that given its decision to release internal forecasts, especially about  $u_{t+1}$ , to the public, the CB is able to improve macroeconomic outcomes by credibly committing to a simple rule that reacts to those shocks. But, can the CB do even better by not releasing information about  $u_{t+1}$  and committing to a simpler rule? We can easily show that this is possible. For instance, the CB will gain by not releasing  $u_{t+1}$  and simply announcing the following policy rule

$$x_t = -Au_t \quad (19)$$

which is nothing but has the same form as the solution for discretion without transparency about  $u_{+1}$ . As it turns out, the CB will optimally choose a

value for  $A$  that is identical to the corresponding coefficient under discretion. Why? The reason lies in the fact that PS inflation expectations are always zero because of the policy of secrecy by the CB, it is fairly easy to show that the CB's incentives do not change by this form of change in policy regime. To see this take PS expectations of output

$$E_t^p x_{t+1} = -AE_t^p u_{t+1} = 0$$

No matter what value the CB assigns to  $A$ , the PS always expect next period's output gap to be zero. In other words the CB can choose to be, say, more aggressive in responding to today's realizations of the cost push shock than it did under discretion. Nevertheless, the PS can not be made to expect anything other than a zero level of output for tomorrow since its forecast of zero cost-push shocks makes the CB's aggressive behavior with respect to  $u_t$  to be irrelevant in affecting expectations of future inflation. Moreover, PS inflation expectations are zero (see Appendix)

$$E_t^p \pi_{t+1} = (1 - \lambda A)E_t^p u_{t+1} = 0$$

Given the fact that PS expectations of inflation and output are zero, the CB will choose a value for  $A$  equal to the value realized under discretion,  $\lambda/(\alpha + \lambda^2)$ . With the simple rule (19) followed by the CB, inflation will take the form

$$\pi_t = (1 - \lambda A)u_t$$

Expressing the expected loss as a function of  $A$

$$EL_t = ((1 - \lambda A)^2 + \alpha A^2)\sigma_u^2 \quad (20)$$

and minimizing (20) with respect to  $A$ , it is easy to show that the optimal value of  $A$  is  $\lambda/(\alpha + \lambda^2)$ . This outcome is better than the case with limited commitment and information disclosure of  $u_{t+1}$ . Thus if the CB is ever to commit to a simple rule, it will choose not to include  $u_{t+1}$  and not be transparent about its realization, showing that the gains from not releasing private information about  $u_{t+1}$  is not particular to discretionary settings.

It is possible to generalize the commitment case by considering the unconstrained commitment solution; that is the optimal policy rule under commitment is not constrained to take the functional form of the rule under limited commitment. In that case, it can be shown that the targeting rule is

$$x_t = x_{t-1} - \frac{\lambda}{\alpha}\pi_t$$

which looks similar to the discretionary case, except that now there is an additional lagged term,  $x_{t-1}$ , indicating history dependence (see for example Woodford (1999a)). The desirability of secrecy about  $u_{t+1}$  holds true also under unconstrained commitment. It is also interesting to see that when  $\alpha = \lambda$  the above rule is identical that derived from a discretionary policy that targets the nominal income growth (for a thorough discussion of nominal income targeting, see Hall and Mankiw (1994)). Thus our results also go through for nominal income targeting.

## 5 Unobserved CB preferences, credibility and signaling

This section modifies section 3 in two ways. First, as in Faust and Svensson (1999) and Jensen (2000), the model includes unobserved shifts in the CB's output target. This introduces an inflation bias as the output target can differ from the natural rate, assumed to be zero. In addition, the timing of events is such that the CB chooses its policy before PS inflation expectations are set. In principle, this implies that the PS can infer in part the output target from CB actions.

As will be shown below, the relevance of disclosing forecasts of future shocks is not clear cut and depends on specific assumptions about the unobserved output target. Specifically, the CB is better off by withholding its private information about future shocks if the shift in output target is observed with a one period lag. On the other hand if the output target is not revealed in subsequent periods, disclosure policy is irrelevant for period- $t$  outcomes. In any case, however, advance disclosure is not optimal.

Suppose in period  $t$  the CB has private information about the supply shock  $u_{t+1}$  while  $u_t$  is common knowledge. Somewhat similar to Jensen (2000), the policy game is played for three periods where the Phillips equation for period  $t$  is given by

$$\pi_t = E_t^p \pi_{t+1} + \lambda x_t + u_t \quad t = 1, 2, 3 \quad u_1 = u_3 = 0$$

In Jensen (2000), the subject of interest lies in  $u_1$ , which is assumed to be private information of the CB while (implicitly)  $u_2$  is unknown in period 1; its value is set to zero as period 2 is interpreted to be the long-run.<sup>21</sup> Suppose

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<sup>21</sup>Thus Jensen considers only two periods.

instead that in period 1,  $u_1$  is common knowledge ( $u_1 = 0$  for simplicity) while  $u_2$  is CB's private information, in line with our interest in forecasts of future shocks. Period 3 has  $u_3 = 0$ , as it represents the long-run.

Without loss of generality, ignore discounting and take the CB loss function defined over three periods

$$U = L_1 + L_2 + L_3$$

$$L_t = \pi_t^2 + \alpha(x_t - x_c^*)^2 \quad t = 1, 2, 3$$

where  $x_c^* = x_0^* + \theta$ ,  $x_0^* > 0$  and  $\theta \sim N(0, \sigma_\theta^2)$ . While the PS knows the parameter  $x_0^*$ , which is the CB's output target determined in period 0, a persistent shock  $\theta$  to the output target occurs in period 1 and is private information of the CB.<sup>22</sup> Thus in period 1, the PS faces uncertainty about the preference shock  $\theta$  and the CB's forecast of  $u_2$ . The model is solved backward starting from period 3. Since the policy horizon is finite and markets are forward-looking, a terminal condition for inflation expectations must be assumed for period 3 (see Jensen (2000) in this regard). The economy stays in a full information steady state from period 3 onwards, implying  $\pi_3 = \pi_4$ ,  $E_3^p \pi_4 = \pi_4$  and  $x_3 = 0$ . Consistent with this idea, assume  $E_3^p \pi_4 = \frac{\alpha}{\lambda} x_c^*$ .<sup>23</sup> Then the CB minimizes

$$E_3^c \left[ \left( \frac{\alpha}{\lambda} (x_0^* + \theta) + \lambda x_3 \right)^2 + \alpha (x_3 - x_0^* - \theta)^2 \right]$$

with respect to  $x_3$ . It is easy to get the solution for  $x_3$ , and in turn for  $\pi_3$

$$x_3 = 0 \quad \pi_3 = \frac{\alpha}{\lambda} x_c^* \quad (21)$$

These are the steady state values for output and inflation. There is an inflation bias as long as  $x_c^* > 0$ .

Next consider period 2. First  $E_2^p \pi_3$  follows from the solution for  $\pi_3$  in (21). We consider two cases based on the PS's knowledge of  $\theta$  in period 2. It turns out that the welfare effects of disclosing  $u_2$  in period 1 depends on the case considered.

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<sup>22</sup>The shock to the output target may represent political pressures on the CB or changes in the composition of the decision making committee of the CB. See for e.g. Faust and Svensson (1999).

<sup>23</sup>As Jensen rightly points out, the exact expression for the terminal condition is not that important for the desirability of the release of forecasts in period 1. The particular value chosen for the terminal period simplifies the algebra.

## case 1: $\theta$ is known in period 2

When  $\theta$  is common knowledge in period 2,  $E_2^p \pi_3 = \alpha(x_0^* + \theta)/\lambda = E_3^p \pi_4$ . In other words, PS inflation expectations are identical in periods 2 and 3. The solution for  $x_2$  is similar to that in period 3, except for the fact that  $u_2$  is not necessarily zero. Analogous to period 3, the solutions for  $x_2$  and  $\pi_2$  are

$$x_2 = -\frac{\lambda}{\alpha + \lambda^2} u_2 \quad \pi_2 = \frac{\alpha}{\lambda}(x_0^* + \theta) + \frac{\alpha}{\alpha + \lambda^2} u_2 \quad (22)$$

The implication of (22) for period 1 is that, the PS has to forecast not only  $\theta$  but also  $u_2$ . Since the state variables are  $\theta$  and  $u_2$ , the conjecture for  $x_1$  is

$$x_1 = h_0 + h_2 u_2 + h_\theta \theta \quad (23)$$

where the coefficients will be determined later. Since the PS observes  $x_1$  but not  $u_2$  and  $\theta$ , it can construct a signal  $s_1$  from (23) to infer about  $u_2$  and  $\theta$

$$s_1 \equiv x_1 - h_0 = h_2 u_2 + h_\theta \theta \quad (24)$$

PS expectations of  $u_2$  and  $\theta$  given its signal  $s_1$  are given by

$$\begin{aligned} E_1^p \theta &= S_\theta s_1 \\ E_1^p u_2 &= S_u s_1 \end{aligned} \quad (25)$$

where  $S_\theta \equiv \frac{h_\theta \sigma_\theta^2}{h_\theta^2 \sigma_\theta^2 + h_2^2 \sigma_u^2}$  and  $S_u \equiv \frac{h_2 \sigma_u^2}{h_\theta^2 \sigma_\theta^2 + h_2^2 \sigma_u^2}$ .

Then it follows that

$$E_1^p \pi_2 = \frac{\alpha}{\lambda}(x_0^* + S_\theta s_1) + \frac{\alpha}{\alpha + \lambda^2} S_u s_1 \quad (26)$$

Anticipating the conjecture and the signal extraction problem solved by the PS, the CB chooses a value for  $x_1$  that minimizes

$$E_1^c \left[ \left( \frac{\alpha}{\lambda}(x_0^* + S_\theta s_1) + \frac{\alpha}{\alpha + \lambda^2} S_u s_1 + \lambda x_1 \right)^2 + \alpha(x_1 - x_c^*)^2 \right]$$

The first order condition, bearing in mind that  $s_2$  is a function of  $x_2$ , is

$$0 = E_1^c \left[ \left( \frac{\alpha}{\lambda}(x_0^* + S_\theta s_1) + \frac{\alpha S_u s_1}{\alpha + \lambda^2} + \lambda x_1 \right) \left( \frac{\alpha}{\lambda} S_\theta + \frac{\alpha S_u}{\alpha + \lambda^2} + \lambda \right) + \alpha(x_1 - x_c^* - \theta) \right]$$

Because the CB observes  $u_2$  and  $\theta$ , it follows that  $E_1^c s_1 = h_2 u_2 + h_\theta \theta$ . Using this fact, the first order condition for  $x_1$  can be expressed as a function of

$u_2$ ,  $\theta$  and a constant. Then the undetermined coefficients must satisfy the following equalities

$$h_0 = -\frac{\alpha^2[(\lambda^2 + \alpha)S_\theta + \lambda S_u]x_0^*}{\lambda^2((\lambda^2 + \alpha)(\lambda^2 + \alpha + \alpha S_\theta) + \alpha \lambda S_u)}$$

$$h_\theta = \frac{\alpha \lambda^2}{\alpha \lambda^2 + (\lambda^2 + \alpha S_\theta)^2 + 2\alpha \lambda(\alpha + \lambda^2)^{-1}(\lambda^2 + \alpha S_\theta)S_u + (\alpha \lambda S_u)^2}$$

$$h_2 = -\frac{h_2 \alpha [(\lambda^2 + \alpha)S_\theta + \lambda S_u][(\lambda^2 + \alpha)(\lambda^2 + \alpha S_\theta) + \alpha \lambda S_u]}{\lambda^2(\lambda^2 + \alpha)((\lambda^2 + \alpha)(\lambda^2 + \alpha + \alpha S_\theta) + \alpha \lambda S_u)}$$

The system of equations can be solved recursively starting with the last equation for  $h_2$ . It can be easily shown that  $h_2 \rightarrow 0$  regardless of the degree of transparency. This means that whether or not it releases its private information, the CB does not respond to  $u_2$  in equilibrium, and the PS expects this to happen. From (25)  $h_2 \rightarrow 0$  implies  $S_u \rightarrow 0$  (the signal  $s_1$  is not informative at all about  $u_2$ ) while  $S_\theta \rightarrow 1/h_\theta$ . Next from the second equation  $h_\theta \rightarrow 0$  and thus  $S_\theta \rightarrow \infty$ . This shows that PS expectations react very strongly to the signal (which is related one-to-one with CB action  $x_1$ ), forcing the CB not to respond to  $\theta$ . Finally, the first equation give the solution for  $h_0$

$$h_0 = -\frac{\alpha}{\lambda^2}x_0^*$$

Combining the above results, equilibrium output in period 1 is

$$x_1 = -\frac{\alpha}{\lambda^2}x_0^* \tag{27}$$

Since  $x_1$  does not respond to  $u_2$  the PS can infer the value of  $\theta$  from the signal  $s_1$ ; this occurs with or without transparency. On the other hand equilibrium inflation in period 1 depends on the release of  $u_2$ . With full transparency,  $\pi_1$  is affected by  $u_2$  via  $E_1^p \pi_2$

$$\pi_1 = \frac{\alpha}{\lambda}\theta + \frac{\alpha}{\alpha + \lambda^2}u_2 \tag{28}$$

If  $u_2$  is made known to PS in period 1,  $E_1^p \pi_2$  is set such that the CB finds it optimal not to react to  $u_2$ ; thus  $u_2$  disrupts only  $\pi_1$ . When  $u_2$  is not disclosed in period 1, the equilibrium level of  $\pi_1$  depends only on  $\theta$

$$\pi_1 = \frac{\alpha}{\lambda}\theta \tag{29}$$

It is clear that communicating  $u_2$  to the PS in period 1 makes inflation more volatile while leaving output unaffected by  $u_2$ . Therefore, the CB does not have the incentive to release its private information about  $u_2$  in period 1, before PS inflation expectations are formed. This is in line with the result in section 3. The CB is better off by not disclosing its forecasts of  $u_{t+1}$  in period  $t$ . The only difference is that now period- $t$  output is not affected by disclosure of  $u_{t+1}$  while in section 3 it was shown to be more volatile with the release of  $u_{t+1}$ .

Next consider the second case.

### case 2: $\theta$ is not known in period 2

This time  $E_2^p \pi_3 = \alpha(x_0^* + E_1^p \theta)/\lambda$  as the PS has to forecast the value of  $\theta$ . Since the relevant state variables are  $\theta$  and  $u_2$ , conjecture the following form for  $x_2$

$$x_2 = h_0 + h_2 u_2 + h_\theta \theta \quad (30)$$

where the coefficients are yet undetermined. Since the PS observes  $x_2$  and  $u_2$ , it can construct a signal  $s_2$  from (30) to make inferences about  $\theta$ .

$$s_2 \equiv x_2 - h_0 - h_2 u_2 = h_\theta \theta \quad (31)$$

It is straightforward to see from (31) that PS expectations of  $\theta$  given the signal  $s_2$  is given by  $E_2^p \theta = S_\theta s_2$  where  $S_\theta \equiv 1/h_\theta$ . Then  $E_2^p \pi_3 = \alpha(x_0^* + S_\theta s_2)/\lambda$ , and the minimization problem for period 2 is

$$E_2^c \left[ \frac{\alpha}{\lambda} (x_0^* + S_\theta s_2) + \lambda x_2 + u_2 \right]^2 + \alpha (x_2 - x_0^* - \theta)^2$$

which gives the first order condition

$$0 = E_2^c \left[ \left( \frac{\alpha}{\lambda} (x_0^* + S_\theta s_2) + \lambda x_2 + u_2 \right) \left( \frac{\alpha}{\lambda} S_\theta + \lambda \right) + \alpha (x_2 - x_0^* - \theta) \right]$$

Using this fact  $E_2^c s_2 = h_\theta \theta$ ,  $x_2$  can be expressed as a function of  $u_2$ ,  $\theta$  and a constant. Then the undetermined coefficients must satisfy

$$h_0 = - \frac{\alpha^2 S_\theta x_0^*}{\lambda^2 (\alpha + \lambda^2 + \alpha S_\theta)}$$

$$h_2 = - \frac{\lambda^2 + \alpha S_\theta}{\lambda (\alpha + \lambda^2 + \alpha S_\theta)}$$

$$h_\theta = \frac{\alpha\lambda^2}{\alpha\lambda^2 + (\lambda^2 + \alpha S_\theta)^2}$$

Solve recursively starting with  $h_\theta$ , which gives the solution  $h_\theta \rightarrow 0$ .<sup>24</sup> It follows that  $S_\theta \rightarrow \infty$ . This shows that PS expectations react very strongly to the signal  $s_2$  (which is related one-to-one with CB action  $x_2$ ), forcing the CB not to respond to its preference shock  $\theta$ . Finally, the first two equations give the solutions for  $h_0$  and  $h_2$

$$h_0 = -\frac{\alpha}{\lambda^2}x_0^* \quad h_2 = -\frac{1}{\lambda}$$

Combining the above results, equilibrium output and inflation in period 2 are

$$x_2 = -\frac{\alpha}{\lambda^2}x_0^* - \frac{1}{\lambda}u_2 \quad \pi_2 = \frac{\alpha}{\lambda}\theta \quad (32)$$

The intuition for this result is as follows. Period 2 output and inflation may deviate from the steady state levels for two reasons. The first one is due to a non-zero realization of  $u_2$ , which is absorbed completely by output.<sup>25</sup> Second, strong dependence of PS inflation expectations on output signals forces the CB care about its reputation. Thus in contrast to case 1, where the PS has full information about  $\theta$ , the fact that the PS expectations are very sensitive to CB action,  $x_2$ , induces the CB not to respond to the preference shock  $\theta$ .

Comparing (22) and (32), we see that the solutions for  $x_1$  and  $\pi_1$  in period 1 depend on the case at hand, because the CB chooses  $x_1$  anticipating the value of  $E_1^p\pi_2$ , which changes from one case to another. Analogous to case 1, first (32) implies  $E_1^p\pi_2 = \alpha(E_1^p\theta)/\lambda$ . Next, as the state variables are  $\theta$  and  $u_2$ , the conjecture and the signaling equations are identical to case 1 (see (23), (24) and (25)). Then  $E_1^p\pi_2$  can be rewritten as  $E_1^p\pi_2 = \frac{\alpha}{\lambda}S_\theta s_1$ .

Next, the CB solves for the optimal level of  $x_1$  by minimizing

$$E_1^c\left[\left(\frac{\alpha}{\lambda}S_\theta s_1 + \lambda x_1\right)^2 + \alpha(x_1 - x_c^*)^2\right]$$

The first order condition for the minimization problem is

$$0 = E_1^c\left[\left(\frac{\alpha}{\lambda}S_\theta s_1 + \lambda x_1\right)\left(\frac{\alpha}{\lambda}S_\theta + \lambda\right) + \alpha(x_1 - x_0^* - \theta)\right]$$

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<sup>24</sup>Note here that there is no role for disclosure of forecasts because  $u_2$  is common knowledge.

<sup>25</sup>compare with (22).



Because the CB observes  $u_2$  and  $\theta$ , we have  $E_1^c s_1 = h_2 u_2 + h_\theta \theta$ . Then  $x_1$  can be expressed as a function of  $u_2$ ,  $\theta$  and a constant; and the undetermined coefficients must satisfy

$$h_0 = -\frac{\alpha x_0^*}{\lambda^2 + \alpha + \alpha S_\theta}$$

$$h_\theta = \frac{\alpha \lambda^2}{\alpha \lambda^2 + (\lambda^2 + \alpha S_\theta)^2}$$

$$h_2 = -\frac{h_2 \alpha S_\theta (\lambda^2 + \alpha S_\theta)}{\lambda^2 (\lambda^2 + \alpha + \alpha S_\theta)}$$

Again, the above equations can be solved recursively starting with the last equation for  $h_2$ , which gives  $h_2 \rightarrow 0$  regardless of the degree of transparency. Moreover,  $h_2 \rightarrow 0$  implies  $S_\theta \rightarrow 1/h_\theta$ . Next from the second equation  $h_\theta \rightarrow 0$  and thus  $S_\theta \rightarrow \infty$ . Thus, as in case 1, PS expectations of  $\theta$  react very strongly to the signal, keeping the CB from responding to  $\theta$ . Finally, the first equation implies  $h_0 = 0$ .

Using the above results, equilibrium output in period 1 is

$$x_1 = 0 \tag{33}$$

Thus, as in case 1,  $x_1$  does not react to  $u_2$ . But there is a difference with respect to  $x_0^*$  because now  $x_1$  is at the natural rate, unaffected by  $x_0^*$ . The intuition for this result is that in period 2, the CB chooses  $x_2$  such that  $\pi_2$  is insulated from the effect of  $x_0^*$ , depending only on  $\theta$ .<sup>26</sup> By contrast, under case 1,  $\pi_2$  is affected by  $x_0^*$ . This effect is anticipated by the PS in period 1 and thus incorporated in setting  $E_1^p \pi_2$  and in turn  $\pi_1$ .

Finally, using the above results in the Phillips equation,  $\pi_1$  becomes

$$\pi_1 = \frac{\alpha}{\lambda} \theta \tag{34}$$

which is not affected by the release of  $u_2$ . Thus communicating  $u_2$  to the PS in period 1 is irrelevant to welfare.

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<sup>26</sup>The CB behaves in this way in period 2 because the PS can infer perfectly the value of  $\theta$  from the signal  $s_1$ .

## 6 Summary and conclusion

Some CBs do not disclose their internal forecasts to the public in a timely manner, and even if they did, it is not clear if they would report their true forecasts, or if they adjust them so as to simply follow the markets, as Romer and Romer (2000) indicated in their study of the Federal Reserve of the U.S. where forecasts are published only with a long time lag so that the value of the published information becomes negligible.

Recent theory on transparency has not settled the question about welfare gains from advance disclosure of CB forecasts. Existing research has analyzed this question assuming private information about *current* shocks, as these shocks have direct impact on *current* economic variables, such as inflation and output, that a CB is interested in stabilizing. Based on this notion of private information, a few empirical studies on transparency lend support to the argument that disclosure of CB forecasts can enhance the reputation and flexibility of monetary policy.

This paper explored the significance of private information on *future* shocks as forecasts of future shocks are crucial when inflation expectations are forward looking. The main result is that advance disclosure of forecasts of future shocks does not improve welfare, and in some cases not desirable as it impairs stabilization of current inflation and/or output. This result holds when there is no credibility problem or the CB's output target is common knowledge. When there is uncertainty about the CB's current output target, and this uncertainty is not resolved in the subsequent period, advance disclosure does not matter for current outcomes. The reason lies in the strong dependence of one-period-ahead PS inflation forecasts on CB actions, which induces the CB to focus exclusively on price stability in subsequent periods. Another implication of the model is that, in contrast to forecasts of *current* period shocks emphasized by the literature, forecasts of future shocks may not be revealed to the public by current policy choices because the CB refrains from responding to its own forecasts.

With respect to the signaling role of current policy actions about internal forecasts, private information about future shocks has a different policy implication than that of current shocks. While current shocks may be revealed by current CB actions, this may not be true for forecasts of future shocks. The intuition is that forecasts of future shocks do not influence the setting of current policy if the public is not aware of them; the CB responds to current shocks only. If it has information about market expectations, it is opti-

mal from the CB's perspective to announce only what the markets already know.

Even though disclosing information seems counter-intuitive, as it improves the accuracy of PS inflation forecast, the negative result on welfare is a consequence of the CB having objectives other than price stability. With multiple macroeconomic goals, releasing internal forecasts before the public has currently formed expectations of future shocks, and thus future inflation, can actually impair overall stabilization efforts.

The result about the destabilizing effect of early disclosure of forecasts goes through for some alternative specifications, as long as there is full information regarding CB preferences. In the case of the New-Keynesian model, the results go through for a loss function that includes interest rate stabilization objective, on top of inflation and output; or if the CB targets nominal income growth, instead of inflation and output, as proposed by some economists. Moreover, whether policy is conducted under discretion or some form of commitment is inconsequential to the main result. Our conjecture is that the results also apply if we drop rational expectations and assume in line with the learning literature that the PS and/or the CB adaptively learn about the structure of the economy, adjusting their forecasts with the arrival of new data. All that is needed for our results is that the CB has superior information about future supply shocks.

## Appendix: Expected inflation when the CB adopts a policy of limited commitment

$$\begin{aligned}
\pi_t &= \lambda x_t + u_t + \beta E_t \pi_{t+1} \\
&= E_t \sum_{k=0}^{\infty} \beta^k [\lambda x_{t+k} + u_{t+k}] \\
&= E_t \sum_{k=0}^{\infty} \beta^k [\lambda(-A_c u_{t+k} - B_c u_{t+k+1}) + u_{t+k}] \\
&= E_t \sum_{k=0}^{\infty} \beta^k [(1 - \lambda A_c) u_{t+k} - \lambda B_c u_{t+k+1}] \\
&= (1 - \lambda A_c) u_t - \lambda B_c E_t u_{t+1} + \beta [(1 - \lambda A_c) E_t u_{t+1} - \lambda B_c E_t u_{t+2}] + \dots
\end{aligned}$$

Since the shocks are white noise, PS inflation expectations when the CB fully discloses the value of  $u_{t+1}$  is given by

$$E_t \pi_{t+1} = (1 - \lambda A_c) u_{t+1}$$

which is the expression following equation (15) in the main text.

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